URBAN SUSTAINABLE ENERGY DEVELOPMENT:

A CASE STUDY OF THE CITY OF PHILADELPHIA

by

Iraklis Argyriou

A dissertation submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Energy and Environmental Policy

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LIST OF ACRONYMS

POLICIES AND PROGRAMS

Alternative Energy Portfolio Standard	AEPS
American Recovery and Reinvestment Act	ARRA
Conservation Works Program	CWP
Energy Efficiency Fund	EEF
Energy Efficiency and Conservation Block Grant	EECBG
Green and Healthy Homes Initiative	GHHI
Guaranteed Energy Savings Act	GESA
International Energy Conservation Building Code	IECBC
Low Income Energy Efficiency Program	LEEP
Low Income Home Energy Assistance Program	LIHEAP
Low Income Usage Reduction Program	LIURP
Matching Energy Assistance Fund	MEAF
Solar City Partnership	SCP
Utilities Emergency Services Fund	UESF
Weatherization Assistance Program	WAP

LOCAL AND REGIONAL ACTORS

City of Philadelphia Mayor's Office of Sustainability	MOS
City of Philadelphia Mayor's Office of Transportation and Utilities	MOTU

City of Philadelphia Department of Public Property	DPP
Consortium for Building Energy Innovation	CBEI
Community Development Corporation	CDC
Delaware Regional Valley Planning Commission	DRVPC
Delaware Valley Industrial Resource Center	DVIRC
Energy Coordinating Agency	ECA
Energy Efficient Buildings Hub	EEB Hub
Energy Service Company	ESCO
Greater Philadelphia Innovation Cluster for Energy Efficient Buildings	GPIC
Neighborhood Energy Center	NEC
Non-Governmental Organizations	NGOs
Office of Housing and Community Development	OHCD
Philadelphia Electric Company	PECO
Philadelphia Gas Works	PGW
Philadelphia Housing Authority	PHA
Philadelphia Water Department	PWD
Philadelphia City Planning Commission	PCPC
Philadelphia Citizens Planning Institute	PCPI
Philadelphia Energy Authority	PEA
Philadelphia Industrial Corporation	PIDC
Smart Energy Solutions Team	SES Team
Southwestern Pennsylvania Transportation Authority	SEPTA
The Redevelopment Fund	TRF

STATEWIDE ACTORS

Commonwealth Financing Authority	CFA
Keystone Energy Efficiency Alliance	KEEA
On-Bill Financing Working Group	OBFWG
Pennsylvania Department of Community and Economic Development	DCED
Pennsylvania Department of Environmental Protection	DEP
Pennsylvania Department of Welfare	PDW
Pennsylvania Housing Finance Agency	PHFA
Pennsylvania Public Utility Commission	PUC

NATIONWIDE ACTORS

Lawrence Livermore National Laboratory	LLNL
Pacific Gas & Electric	PG&E
U.S. Department of Energy	D.O.E.
U.S. Energy Information Administration	EIA
U.S. Environmental Protection Agency	U.S. EPA

INTERNATIONAL ACTORS

Greater London Authority	GLA
International Council of Local Environmental Initiative	ICLEI
Intergovernmental Panel on Climate Change	IPCC

TECHNICAL TERMS

Advanced Energy Retrofit	AER
British Thermal Units	Btu
Center for Building Energy Education and Innovation	CBEEI
Center for Building Energy Science and Engineering	CBESE
Center for Building Performance and Diagnostics	CBPD
Combined Heat and Power	CHP
Cubic feet	cf
Greenhouse gases	GHG
Heating, Ventilation and Air Conditioning	HVAC
Kilowatt	KW
Kilowatt hour	KWh
Leadership in Energy and Environmental Design	LEED
Megawatt	MW
Megawatt hour	MWh
National Institute of Standards and Technology	NIST
Network Operations Center	NOC
Pennsylvania	PA
Photovoltaic	PV
Renewable Energy Credit	REC
Renewable Portfolio Standard	RPS
Solar Renewable Energy Credit	SREC
Stakeholder Engagement Platform	SEP
Vehicle miles travelled	VMT

ABSTRACT

This study explores the role of cities in sustainable energy development through a governance-informed analysis. Despite the leading position of municipalities in energy sustainability, cities have been mostly conceptualized as sites where energy development is shaped by external policy scales, i.e. the national level. A growing body of research, however, critiques this analytical perspective, and seeks to better understand the type of factors and dynamics that influence energy sustainability within a multi-level policy context for urban energy. Given that particular circumstances are applicable across cities, a context-specific analysis can provide insight regarding how sustainable energy development takes place in urban areas.

In applying such an analytical perspective on urban energy sustainability, this study undertakes a qualitative case study analysis for the city of Philadelphia, Pennsylvania, by looking at four key local policy initiatives relevant to building energy efficiency and solar electricity development at the municipal government and city-wide level. The evaluation of the initiatives suggests that renewable electricity use has increased substantially in the city over the last years but the installed capacity of local renewable electricity systems, including solar photovoltaics, is low. On the other hand, although the city has made little progress in meeting its building energy efficiency targets, more comprehensive action is taken in this area.

The study finds that the above outcomes have been shaped mainly by four factors. The first is the city government's incremental policy approach aiming to

develop a facilitative context for local action. The second is the role that a diverse set of stakeholders have in local sustainable energy development. The third is the constraints that systemic policy barriers create for solar power development. The fourth is the ways through which the relevant multi-level policy environment structures the city's possibilities on sustainable energy.

In this context, the study identifies four areas of policy recommendation that could enhance Philadelphia's prospects for energy sustainability: integrated municipal energy planning; stable financing for market development; enhanced actor interactions; and multi-level policymaking that facilitates local action. These policy directions could be of interest to a broader body of metropolitan cities regarding their efforts in sustainable energy development.

Chapter 1

INTRODUCTION

1.1. Rationale for the Study

Modern cities use a large share of global energy consumption to provide development and services to their urban communities. As estimated by the International Energy Agency, urban areas account for 67% of the global energy consumption (IEA, 2008). According to the 2011 United Nations World Urbanization Prospects projections, world urban population is expected to increase by around three billion people by 2050 (UN WUP, 2011).

With increasing urban population and economic activity, energy use in urban areas is expected to increase significantly. For example, IEA predicts that over 80% of expected increases in global annual energy demand in future will be driven by cities in non-OECD countries (IEA, 2009). At present, the bulk of energy service provision in urban areas is fossil-fuel based, hence, associated with certain social-economic and environmental implications that pose risks to the prosperity of urban communities and environmental protection. In addition, energy consumption in urban areas is a large contributor to global climate change (Jollands, 2008).

Cities are, thus, an integral part of the current energy regime, and central to any efforts of shifting society away from fossil-fuel sources towards more sustainable systems of energy service provision (Rutter and Keirstead, 2012).

While energy and climate policymaking has been traditionally considered to be the remit of the state and international level, cities have been at the forefront of urban energy sustainability action over the last decades. For example, the first phase of consistent urban climate action is observed in the early 1990s involving predominately small and medium-sized cities in North America and Europe and characterized by individuals within municipal authorities recognizing the importance of climate change and initiatives focused to reduce greenhouse gas emissions from municipal operations. Many of these early urban climate responses were orchestrated through municipal networks of sustainability; for example ICLEI's Cities for Climate Protection (CCP) program, the Climate Alliance and Energie-cities in this time would foster common purpose, creating knowledge, share information, provide technical support, and building capacity to support municipal climate action (Bulkeley & Betsill, 2013).

In addition, many of these early pioneering examples were rooted in the then rising global policymaking agenda on climate change. For instance, policy outcomes and events like the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992 and its Local Agenda 21 which calls for the development of action plans by communities to promote sustainable development, the signing of the United Nations Framework Convention on Climate Change (UNFCCC) in the same year, and the Kyoto Protocol international agreement, linked to the UNFCCC, aiming to limit global greenhouse gas emissions, inspired the adoption of municipal climate action plans in various countries, including the U.S. Some of these municipal climate action plans were incorporated into existing sustainability planning efforts and Local Agenda 21 plans, while other were formed as stand-alone municipal plans (Boswell et al., 2010).

These municipal 'first adopters' were largely motivated to take energy sustainability action by the various benefits that could be accrued for the local community, including energy cost savings, abatement of local emissions impacts from the operation of conventional energy systems, deployment of more self-reliant forms of local energy provision, and sustainable economic development and job creation at the local-regional level (Hammer, 2008; Jollands, 2008).

Throughout the 1990s and onwards, both the cities that have been engaged with climate action, and the urban sustainability networks that support energy sustainability action, have proliferated considerably in geographical terms, i.e. they have spread in Asia, Latin America, and Africa, as well in content and breadth. While the early examples were mostly focusing on the reduction of greenhouse gas emissions from municipal operations, the newer urban energy sustainability responses target diverse urban sectors and infrastructure sites, experiment with new types of initiatives, i.e. carbon markets and greenhouse gas emissions trading schemes, and involve an expanded set of policy and social actors that often take action outside traditional channels of energy sustainability action (i.e. formal municipal policy plans) (Energie Cites, 2012; ICLEI, 2012; C40, 2012; Bulkleley & Betsill, 2013).

This more comprehensive type of local energy sustainability action, which is often led by city government, increasingly encompasses a purposive character, i.e. in terms of explicitly addressing particular energy-related governing goals, and, accordingly, it is more and more linked with broader issues of urban development and maintenance, as well the securitization of critical resources for the long-term viability of cities (While, 2011; Hodson & Marvin, 2010, Bulkeley & Betsill, 2013).

In addition, local energy sustainability action is closely related with issues of energy injustice associated with mainstream systems of energy service provision. As such, urban sustainable energy initiatives can tackle distributional socio-economic impacts of the current energy regime by fostering energy affordability and the well-being of disadvantaged social groups (Hughes, Kurdgelashvili, Byrne et al., 2010; Dubois 2012).

As a result of the evolving local energy sustainability action, cities have accumulated over time substantial experience in putting national and international environmental programs into action, while it is increasingly recognized that they can have an important role in promoting sustainable energy development and climate change mitigation (Jollands, 2008; Bale et al., 2012; Lundqvist & Biel, 2007).

As noted above, local governments have been a leading actor in driving forward the local energy sustainability agenda. In addition to the role of municipalities, a diverse set of public, private and civil actors that range from non-governmental organizations (NGOs) and businesses to quasi-public entities, local neighborhoods, incumbent energy companies, universities and research organizations, third sector organizations, individual pioneers, donor organizations etc., have now become central to urban energy sustainability (Bulkeley & Broto, 2012). This enlarged set of actors develops and implements urban sustainable energy initiatives through various types of governance mechanisms, and networked forms of interaction that draw on diversified resources, expertise and relationships (Broto & Bulkeley, 2013).

What is more, broader issues like an increasing rationale for state carbon control strategies, often linked to questions of energy security and economic competitiveness, the deregulation of energy markets, and wider processes of state restructuring increase the complexities of urban sustainable energy policymaking (Monstadt, 2007; Bulkeley et al., 2010; While, 2011).

Overall hence, a policy landscape of local energy sustainability emerges where cities across the world are increasingly involved in sustainable energy action that takes place in specific urban contexts (i.e. politico-economic, physical, social), through diverse types of interventions, modes of governance, and actor interactions (Bulkeley & Betsill, 2013; Marvin & Hodson, 2010; Aylett, 2010).

While currently the pursued urban energy sustainability action across the various geographical areas and urban contexts cannot be considered collectively as constituting a mainstream practice of urban energy development, they do signify a systemic critique of the current energy regime, and manifest in practice possible ways for an alternative technical and social organization of energy service provision (Coutard & Rutherford, 2011). Despite, nevertheless, deployment of more comprehensive forms of urban sustainable energy development recently, and the wide recognition of the various benefits that energy sustainability action can accrue to cities, at present a large potential of global urban energy sustainability remains untapped, i.e. only few comprehensive urban energy sustainability examples can be identified around the world (Sippel & Till, 2009).

If more cities, then, have intentions of taking widespread action on energy sustainability, the question arises of how sustainable energy development can be effected in urban areas, and with what implications (Jollands, 2008; Bale et al., 2012; Bulkeley et al., 2011).

Due to varying conditions found across cities in relation to sustainable energy development, i.e. politico-economic environment, physical endowment, institutional resources, urban investment strategies, local expertise, built infrastructure, their 'embeddedness' and type of involvement in systems of energy provision and so on, different cities will face different type of governance challenges and opportunities regarding the development and implementation of energy sustainability in their areas. Such conditions, hence, create in their own, and collectively, distinct contexts within which multiple actors act in relation to local sustainable energy development.

In order, then, to gain more understanding of the role of cities on urban sustainable energy development, and assess wider policy implications with respect to this phenomenon, the analysis needs to engage with the diversity of local energy sustainability responses that take place across urban contexts. This research objective can be fostered through the use of analytical frameworks that provide distinct insight on key governance aspects relevant to urban energy sustainability (Hammer et al., 2011; Bulkeley & Broto 2012).

In this respect, an analytical framework that can be applied to explore the multi-actor and multi-scale policy characteristics of urban energy sustainability is the 'multi-level governance perspective' that accounts for the relational policy position of cities in their respective multi-level governance system for energy, including the various ways through which this system structures possibilities for sustainable energy development in the city (Hodson & Marvin, 2011).

On its basis, this analytical perspective involves the state regulatory and multi-level governance relationships, either internal or external to the city, which relationally define how the 'city' is positioned and acts within the broader politico-economic system relevant to local energy development (Hodson & Marvin, 2011). More specifically, different cities are embedded more or less strongly within multi-level governance relationships where particular political factors (i.e. political culture of centralization as in the U.K. or federalism as in Germany) condition the type of relationships between levels of governance. Such conditions and relationships can have a strong impact on the capacity and ability of cities to pursue sustainable energy development through the ways in which the structure powers, responsibilities and opportunities for local sustainable energy action (Hodson & Marvin, 2011).

Nevertheless, policy decisions and relationships within the multi-level governance system are assumed to operate across and within scales of policy action where different sets of power relations influence the relationships between these scales, and where these power relations are variably organized with respect to different cities. Questioning, thus, the relationship between these scales of action enables cities to be perceived not necessarily as a site where energy change is governed by external conditions and processes, but potentially as an entity that can influence its energy pathway within this wider system of governance for local energy development (Bulkeley, Broto & Maasen, 2011; Bulkeley et al. 2011a; Hodson & Marvin, 2011).

In addition to the politico-economic dynamics of urban energy development, given the close connection between, on the one hand cities and energy, and on the other hand, urbanization and infrastructure systems, it is increasingly acknowledged that addressing local energy sustainability challenges requires the transformation of the urban energy infrastructure. In this context, urban energy systems can be considered as ‘socio-technical’, that is they comprise, and are co-produced by, social and technical elements. For example, a solar photovoltaic system comprises a type of energy conversion technology made from materials (i.e. silicon), installed through a particular setting of technical artefacts (i.e. a building integrated system) within the context of political and legal institutions (i.e. planning requirements), processes of design (i.e. house building) and social practices (i.e. domestic use of energy) (Bulkeley et al., 2011).

While there are various approaches to study the transformation of socio-technical urban energy systems, the one that has up-to-date engaged more explicitly with the challenges of sustainability, is based on the ‘multi-level’ analysis of energy systems in transition. In this approach, the dynamics of change that energy systems undergo are conceptualized through processes and interactions that take place across, and within, three interrelated ‘distinct levels’, those of ‘landscape’, ‘regime’, and ‘niche’ (Hodson & Marvin 2011). More specifically, the ‘landscape level’ represents the broader cultural values, institutions, norms and persistent socio-technical structures of society at the macro-level. The ‘regime level’ reflects the existing global energy system and its dynamically stable practices, institutions, regulations etc., organized at the meso-level. The ‘niche level’ represents spaces where innovation leads to technological and social learning occurs. Facilitated by ‘landscape’ pressures on the regime, niche innovation challenges the logic of the current system, and competes to become a mainstream practice in the regime (Hodson & Marvin 2011).

In addition to typical aspects assessed in socio-technical analysis of sustainability issues, such as technical innovation, social learning, capacity building, etc., a particular line of this analytical perspective on urban energy places explicit emphasis on the political dimensions of energy change, as well the relevant role of everyday practices (political, economic, and social) that take place at the more micro-level within the city (Bulkeley, Broto, & Maasen, 2011).

In order, then, to evaluate the role of cities on urban sustainable energy development through a broader basis, the study uses as a framework of analysis the above-described governance-informed analytical perspective for urban energy, as well draws on key elements of the socio-technical analysis of urban energy systems (i.e. political nature, micro-level interactions). In doing so, it assesses sustainable energy development in a particular urban context, that of the city of Philadelphia, Pennsylvania, along three parts. First, it maps the key technical, institutional and market characteristics of the governance environment within which cities pursue energy sustainability, such as the sources and production methods of the energy that is consumed in the city; who supplies the energy, how the energy is consumed, basic characteristics of the urban energy infrastructure, the energy regulatory and market structure within which the city operates, the division of formal policy responsibilities in relation to local energy, and the main actors and initiatives for sustainable energy development in the city.

Once the key governance characteristics for the case-studied city have been identified, the study seeks to identify key policy factors that determine the city's performance against its energy sustainability targets. Towards this objective, the analysis discusses constraints and opportunities that the city faces in developing and implementing key energy sustainability initiatives, how encountered constraints have been overcome, and what type of actor interactions have influenced the development and performance of the initiatives.

Lastly, by using the first two parts of the analysis (policy context; key policy factors, progress, actors input) as basis for further discussion, the study seeks to gain insight on the type of policy dynamics that shape sustainable energy development in the city, i.e. in terms of multi-level policy interactions and networking relationships, and to identify policy directions that could enhance the city's possibilities on sustainable energy development. Given the broader body of major metropolitan cities developing sustainable energy policies, the basic issues, problems and future policy directions identified in Philadelphia's case can contribute to the broader discourse of urban sustainable energy development.

In conclusion, the study identifies topics for future research on urban sustainable energy development based on the Philadelphia case study. Section 1.2 describes the rationale for studying the city of Philadelphia as a case of study on sustainable energy development.

1.2. The City of Philadelphia as a Case-of-Study in Urban Sustainable Energy Development

1.2.1. Why Studying the City of Philadelphia

As described in the previous section, urban energy sustainability takes place across diverse contexts and locales. Cities throughout the world that are involved in energy sustainability initiatives vary across several dimensions including their size, political organization, economic structure and day to day economic activities, urban form and built environment, climatic conditions and resource endowments. Policy and regulatory realities vary too across cities, as do market structures, technology decisions and the type of energy system within which they are embedded (Hammer et al., 2011). As such, different urban areas face different challenges and opportunities with respect to sustainable energy development.

City governments have a long history in employing various strategies to promote energy sustainability in their areas, and influence patterns of local energy supply and demand. However, because cities have limited control over processes that influence local energy service provisions, working with partners including the public, non-governmental organizations and civic society groups, the private sector, and different scales of government is vital for the development and application of comprehensive local energy sustainability policies (Hammer et al., 2011). There is evidence that cities, both in developed and developing countries, are taking energy sustainability action through such kind of more collaborative forms of actor interaction (Hammer et al., 2011, Broto & Bulkeley 2013).

In the context of this emerging policy diversity on urban energy sustainability, research analysis has been mostly concerned with the 'early adopters' of urban energy sustainability, and those cities where particular conditions facilitate the development of capacity for sustainable energy development, and its translation into on the ground action, i.e. a long-standing local political commitment, a sizeable institutional resource-base, an active citizenry that demands environmental action, the presence of local NGOs with relevant expertise, and so on. Such conditions, for instance, are evident in the case of 'world cities' that pursue energy sustainability and climate action as a way of fostering more self-reliant forms of urbanism (Hodson & Marvin 2010).

As a result, studies up-to-date have paid little attention to more diverse examples of urban sustainable energy action, for instance with regards to examples other than the ‘early adopters’ or cities that lack favorable energy-related politico-economic and cultural conditions such as those highlighted above. In order, then, to gain more insight on questions of why, how and with what effect and implications energy sustainability action takes place in urban areas, there is a need to assess this phenomenon across diverse urban contexts (Bulkeley & Broto, 2013).

Philadelphia is a major U.S. city which over the last five years has taken systematic action on energy sustainability within the context of its municipal sustainability plan. Despite the range of the city’s energy sustainability initiatives, which are pursued in the absence of ‘rooted’ supportive politico-economic and cultural conditions, Philadelphia has not been acknowledged as a leading example of urban energy sustainability, i.e. at the national or international level, nor has it been the subject of an in-depth analysis with respect to the policy approach that it adopts on sustainable energy. As such, it offers a case of study through which to gain more understanding of the various types of factors and dynamics that give rise to sustainable energy development in urban areas.

More specifically, Philadelphia is the fifth largest urban area in the U.S. and has adopted the goal of becoming the greenest city of the country by 2015. Since 2009, Philadelphia has been taking a range of sustainable energy initiatives both at the municipal and citywide level[1] within the context of its municipal sustainability plan *Greenworks Philadelphia*. This includes the development of a technical basis for monitoring progress of energy sustainability measures; planning, financial legislative provisions to facilitate energy sustainability action by other actors; research and innovation activities to accelerate the market diffusion of sustainable energy systems; and actor collaborations on energy sustainability (MOS, 2009; 2012, 2013).

Many of these initiatives are led, supported, or coordinated, by the city government of Philadelphia[2] that since the mid-2000s has adopted a more strategic approach on energy sustainability. For example, the City published in 2007 its Climate Change Action Plan that contains energy measures to achieve greenhouse gas emissions reductions many of which were taken into account in *Greenworks Philadelphia*. In addition, the City monitors regularly its municipal and citywide greenhouse emissions with inventories having published for years 1990, 1997, 2006 and 2010 (City of Philadelphia, 2007a; City of Philadelphia, 2007b; MOS, 2012; MOS, 2013).

As mentioned, building on its climate action plan, the City published in 2009 its sustainability plan *Greenworks Philadelphia* to serve as the policy framework for the monitoring and coordination of sustainability action across the city. The plan

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[1]Throughout the text the term 'municipal' refers to the city government level, while the term 'citywide' refers to the overall city level.

[2] Philadelphia is a consolidated city-county. This means that it is simultaneously a city (municipality), and a county, which is an administrative division of a state, having the powers and responsibilities of both types of entities (U.S. National Association of Counties, 2014). Hence, the terms 'county' and 'city' are used interchangeably in the study. Also, for brevity the 'city government of Philadelphia' will be referred to as the 'City'.

contains five areas of action, including energy sustainability, and it is administered by the City of Philadelphia Mayor's Office of Sustainability. In particular, it specifies energy efficiency targets at the municipal (energy use reduction) and citywide level (building energy use reduction), a citywide renewable electricity use target, and a residential building energy retrofit target; monitors progress against the adopted targets; and suggests measures towards meeting the targets (MOS, 2009).

Furthermore, in June 2010, the City established the Philadelphia Energy Authority (PEA), a quasi-public agency with a mission to contribute towards the improvement of the general welfare of the city through activities that facilitate the adoption of cost-effective opportunities on municipal energy efficiency, promote renewable energy use in the city, and educate consumers about choices available in the energy market[3] (PEA, 2013).

What is more, in March 2008, Philadelphia was designated by the U.S. Department of Energy (D.O.E.) as a Solar America City. This gave the opportunity for the development of the Philadelphia Solar City Partnership (SCP) which aims to facilitate the development of 57.8 MW of local solar electricity capacity by 2021 (D.O.E. EERE, 2011). Following-up on action taken in the context of SCP, in June 2012, Philadelphia was named by the U.S. Environmental Protection Agency (EPA) as a Green Power Community in acknowledgment of its efforts to promote renewable energy development at the citywide level (City of Philadelphia, 2012).

In addition, in June 2012, the City passed legislation (Energy Benchmarking Ordinance) which requires large commercial buildings to publicly report their annual

[3] The City owns also the largest municipal gas utility in the country, Philadelphia Gas Works (PGW), which offers several energy efficiency programs to residential, business and industrial customers (MOS, 2009).

energy consumption as a way of motivating greater adoption of energy efficiency by the commercial sector (State Impact, 2012).

Besides activities led by the city government, various other actors are involved in sustainable energy development in Philadelphia. For example, the Commonwealth of Pennsylvania passed Act 129 in 2008 to protect against potential energy price increases likely to take place in the state as a result of the deregulation of the energy industry. The Act requires all energy utilities in the state to reduce their retail electricity sales by certain percent by 2016 through the development and application of in-house energy conservation portfolios (PA DEP, 2009). To comply with Act 129, Philadelphia Electric Company (PECO), the private regional energy utility that serves electricity and gas to the Southwestern Pennsylvania region, has developed energy efficiency programs that are available to residents, businesses, and the industry (MOS, 2009).

In addition to policy-driven initiatives for energy sustainability such as those described above, local civic sector entities such as the non-profit Philadelphia Energy Coordinating Agency (ECA), and the city's network of Neighborhood Energy Centers (NECs) that are part of local Community Development Corporations and coordinated by ECA, promote residential energy affordability in Philadelphia by offering services, incentives and education on energy conservation to local neighborhoods (ECA, 2010).

Furthermore, the Energy Efficient Buildings Hub (EEB Hub) national innovation center was established by the U.S. federal administration at the Philadelphia Navy Yard in 2011 as a five-year performance-driven public-private partnership with the aim to foster technology innovation and market acceleration of energy efficiency in the commercial sector by using the Greater Philadelphia Area as a test-bed (Solar Power World, 2011). In 2014, the EEB Hub transitioned to a new public-private partnership, the Consortium for Building Energy Innovation (CBEI), which focuses on technical demonstration and market diffusion of energy efficiency in the commercial sector of the Philadelphia region, and nationally, through close collaboration with D.O.E.'s Building Technologies Office, as opposed to operating as a wider innovation cluster, like its predecessor (CBEI, 2014a).

In this context for sustainable energy development in Philadelphia, examining a diverse set of key local sustainable energy initiatives in more detail can offer insight on the type of challenges and opportunities that shape the city's ability to promote sustainable energy, the city's progress on its energy sustainability targets, the different ways through which sustainable energy is pursued in the city, and the type of policy action that could enhance the city's possibilities on energy sustainability.

In order to address such analytical issues, the basis of the analysis is placed on constraints and opportunities that Philadelphia faces in energy sustainability, the relevant role of a diverse body of actors[4], and the nature of policy dynamics that shape sustainable energy development in the city. In doing so, the study evaluates initiatives directly related to the energy infrastructure at the citywide level, and to established

[4] In this respect, based on Sippel & Till (2009) which reviewed the literature of local climate policy action in several cases around the world and suggest that institutional barriers are among the most important ones in local climate mitigation policy, and given the range of policy activities on energy sustainability taken in Philadelphia, the analysis places emphasis on institutional aspects in relation to local sustainable energy development.

patterns of local energy supply and demand[5]. Section 1.2.2, provides more information on the analytical focus of the case-study.

1.2.2. The Analytical Focus of the Case-Study

Philadelphia pursues diverse sustainable activities that are developed within a particular multi-level policy context for local energy sustainability. In alignment with the study's analytical perspective described in the previous section, the analysis examines in more detail a set of four key local sustainable energy initiatives that aim to promote energy efficiency and renewable electricity at the municipal and citywide level. In doing so, it assesses policy factors that constrain and enable the development of the initiatives, what the initiatives have achieved so far, the role of relevant actor on the development and implementation of the initiatives, and how the initiatives can be further promoted. Towards this objective, the analysis identifies the overall energy-related governance context within which the initiatives are situated, identifies key actors involved in the initiatives, and assesses the actual practice of these actors in relation to the development and implementation of the initiatives.

The rationale for selecting the particular set of initiatives for further discussion in the study is as follows. The city government of Philadelphia is a key actor on local energy sustainability through *Greenworks Philadelphia* sustainability plan. Therefore, the study evaluates two key initiatives pursued in the context of *Greenworks*

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[5] Although many examples of innovative local energy action are taken at the 'grassroot' level (Moloney et al., 2010; Späth & Rohracher, 2010, Martnensson & Westerberg, 2007; Seyfang, 2010), wide change in urban energy systems involves initiatives that feed directly into existing patterns of local energy supply and demand, and efforts to achieve energy transformation at the citywide level (Droege, 2008). Hence, the focus of the analysis is placed on the urban energy infrastructure at the large scale.

Philadelphia, and coordinated by the city government. These are the energy efficiency portfolio of the City of Philadelphia Mayor's Office of Sustainability, and the Philadelphia Solar City Partnership (SCP) initiative led by the City of Philadelphia Mayor's Office of Transportation and Utilities (MOTU). These initiatives involve ambitious targets for energy efficiency development at the municipal and citywide level, and greater solar electricity use at the citywide level. In addition, making progress on both initiatives requires the active involvement of a range of city government agencies, and actors from within and outside the city. Thus, their evaluation can offer insight on the capacity and ability of the city government to mobilize and coordinate action for making progress on the city's formal energy sustainability targets. Furthermore, it can add understanding of the ways through which the city government interacts with other actors on energy sustainability, and the type of cooperative or conflicting policy dynamics in place concerning the role of the public and private sector in relation to local sustainable energy development.

In addition to assessing the relevant role of the city government, the study extends its focus on two key local sustainable energy initiatives that are led by the private and civic sector. The first is residential affordable energy development, an important social issue for Philadelphia due to the city's relatively large needs for improvement in household energy affordability.

Traditionally, local civic entities and neighborhoods have played a key role on affordable energy development in Philadelphia. Two such entities are the Philadelphia Energy Coordinating Agency, a local non-profit organization which is active in financial and technical support, workforce development, policymaking and advocacy with respect to residential energy affordability for over thirty years; and the city's network of fourteen Neighborhood Energy Centers which offers energy conservation services and education to local neighborhoods. Each NEC is part of a local Community Development Corporation; these are non-profit entities which promote economic development and offer several social services to local neighborhoods. The work of the NECs is coordinated and by ECA (ECA, 2010; Walker, 2010). Examining, hence, the action of ECA and NECs can provide understanding regarding the role of the local civic sector in residential energy affordability in Philadelphia, and the type of socio-policy dynamics relevant to issues of energy justice in the city.

The fourth initiative that the case-study analysis examines is the role of the former Energy Efficient Buildings Hub on the market adoption of commercial energy efficiency in the Philadelphia area and beyond. Established at the Philadelphia Navy Yard as a national innovation center, the Hub aimed to offer replicable and scalable energy efficiency solutions for existing small and medium-sized commercial sites by using the Greater Philadelphia area as a test-bed area. In addition, it aimed to contribute to job creation and sustainable economic development at the regional level (GPIC, 2010). In April 2014, the Hub changed organizational structure and agenda, transitioning to a partnership that focuses on demonstrating technical and market energy efficiency solutions that can be adopted by small and medium sized businesses, and scaled-up nationally (CBEI, 2014a).

Assessing, thus, the role of the EEB Hub on energy innovation over its operation period (February 2011 to April 2014) offers an opportunity to gain insight regarding how the Philadelphia area acted as a site for the development of energy innovation targeting the commercial sector, what was the role of local and regional actors in relevant activities, and the extent to which the pursued innovation managed to catalyze wide adoption of energy efficiency, as envisaged when setting-up the initiative, at the regional and national level. The discussion focuses on the activities of the EEB Hub rather than its successor, CBEI, since the organizational transition took place on April 2014 and as a result there is yet no adequate basis upon which to assess the performance of the new partnership.

In order to evaluate the analytical aspects described above, the study employs a qualitative research method which uses primary data from semi-structured interviews with actors involved in the four energy initiatives discussed in the case-study, and secondary data from various sources. Section 1.3. provides information on the methodology and data of the study.

1.3. Research Methodologies, Data Sources and Evaluation

Robson (2002) suggests that qualitative research methods are the best way to draw insight on the perspective of insiders, or how actors themselves define a situation, including cases where complex social phenomena are explored. In-depth information taken from a small number of people can be valuable in analysing case-studies that are rich in content (Robson, 2002).

Bale et al. (2012) explored the topic of strategic municipal energy planning within the U.K. context by using the City of Leeds as a case of study. This included interviews with local practitioners. Bulkeley and Betsill (2003) performed interviews with city government officials to supplement their analysis of local government climate policymaking across a sample of cities in the U.S., Europe and Australia. Chu and Schroeder (2010) explored barriers and drivers for corporate climate action in Hong Kong by conducting semi-structured interviews with local companies. Guy

(2006) explored the role of urban knowledge in the formulation of perspectives regarding energy use in buildings, and suggests that more qualitative research is needed to bridge the social and technical aspects of this topic.

Based on the above, the study used the method of semi-structured interviews to elicit the insight of actors relevant to the examined energy initiatives of the case-study. In particular, fourteen semi-structured interviews were conducted, over the period of March 2013 to June 2013, with fifteen individuals from the city government of Philadelphia and local actors. In addition, a follow-up interview was conducted in April 2014 with two staff of the local research community (University of Pennsylvania) involved in a municipal energy activity, launched in June 2013, in order to get relevant information.

The people interviewed were as follows. For the Mayor's Office of Sustainability and Solar City Partnership initiatives, staff from MOS and MOTU were interviewed respectively. The follow-up interview with the University of Pennsylvania staff was conducted to inform the evaluation of the MOS initiative.

Interviews with staff from the Philadelphia Energy Coordinating Agency, Southwest Community Development Corporation Neighborhood Energy Center and New Kensington Community Development Corporation Neighborhood Energy Center were conducted for the affordable energy development initiative. Staff from the EEB Hub were interviewed for the EEB Hub initiative.

In addition, interviews with staff from the Philadelphia City Planning Commission, Philadelphia Zoning Planning Commission, Philadelphia Department of Licenses & Inspections, and PECO's Division of Energy Policy and Marketing were conducted to complement the main interviews, and draw background information on the study.

The vocational background of the interviewees ranged from city government personnel such as the Director and Energy Conservation Officer of MOS, the Energy Manager of the City, and the Director of the City's Zoning Planning Commission, to key staff such as Executive Directors or Heads of Teams in the private and civic actors interviewed (ECA, EEB Hub, NECs, PECO).

Most interviews lasted between 30 to 45 minutes. The interviews were semi-structured and based on open-ended questions aiming to offer context for the discussion of more specific issues. The open-ended questions referred to the issues like the overall context for the pursued initiatives; progress achieved up-to-date; opportunities and constraints faced in the development and implementation of the initiatives; if, and how, constraints were overcome; actor interactions relevant to the initiatives; and future directions.

The interviews were recorded, transcribed and used in the analysis both in an aggregated and analytical way. A list of the individuals who participated in the interviews, and the template interview questionnaire of the study are provided in Appendices A & B (pp.394-395).

In addition to the interviews, the study used data from secondary sources such as peer-reviewed analysis, consulting reports, local government reports and minutes, and the press, including: energy data from *Greenworks Philadelphia* and its annual progress reports (MOS, 2009; MOS, 2012; MOS, 2013); the city's greenhouse gas inventory which reports energy consumption data at the municipal government level (buildings, vehicle fleets, waste and water management) and citywide level (residential, commercial, industrial, transportation sectors) for year 2010 (MOS, 2013); the D.O.E. (2011) report *Challenges and Successes on the Path towards a Solar-Powered Community - Solar in Action, Philadelphia: Pennsylvania* which includes information about the Philadelphia Solar City Partnership initiative; the annual report of the Philadelphia Energy Coordinating Agency (affordable energy development initiative) (ECA, 2010); the Research Digest web portal of the EEB Hub that includes background information, data, and reports on Hub activities; and the local press.

1.4. What Type of Evaluation?

The evaluation of the energy initiatives of the case-study is structured on two components. First, an indicator-based evaluation of policy effectiveness which assesses the extent to which aims, objectives and aspirations of the energy initiative are achieved over time (Hodson & Marvin, 2011). The indicators that are used for this type of evaluation are the *Greenworks Philadelphia* energy sustainability targets of 30% municipal energy use reduction by 2015; 10% citywide building energy use reduction by 2015; and 15% energy efficiency retrofitting of the city's housing stock by 2015; and the Solar City Partnership target of 57.8MWs solar power development in Philadelphia by 2021.

Although an outcome-based evaluation of policy success allows keeping focus on the vision and objectives of the energy initiative in question, it tells little about the processes through which the initiative achieves, or fails to achieve, resonance among a variety of stakeholders, and translation into practice. Assessing, thus, the extent to which the aims and aspirations of the initiative become embedded in energy-related socio-political practices offers a more processual and contextual view of its 'effectiveness' (Hodson & Marvin, 2011).

Such a kind of evaluation involves assessing the extent to which actors that are deemed as necessary for the application of the initiative are engaged in the process, as well the ways in which controversies over the translation of the initiative into reality are, or are not, resolved; for example, this could involve controversies over where to locate a proposed technology project, or difficulties in securing funding for the development of the project. Hence, assessing how and by whom such issues are addressed or not becomes important in getting insight on the extent to which the processes of energy development in the city are broad. In addition, it would include discussions on the kind of action that could address the emerged controversies. For instance, funding limitations might require developing dialogue with different funding agencies, while lack of political support for the project may require engagement with political interests that are located at different policy scales (Hodson & Marvin, 2011).

In this context, a particular signifier of policy effectiveness relates to the level of achieved coordination of capacity and agency that are central for the realization of the initiative. For instance, an 'absolutely effective' process would have on board a fully coordinated constituency along the way to the end point of the initiative, with controversies and challenges having been addressed through the involvement of necessary actors and resources (Hodson & Marvin, 2011).

An 'absolutely ineffective' process, on the other hand, would fail to engage and coordinate the necessary interests and resources, and solve controversies that emerged over the course of the initiative. In practice, it is expected that a local energy initiative will likely be located somewhere in-between these two 'total' points of assessment (Hodson & Marvin, 2011).

Based on the above, a contextual type of evaluation is undertaken in the case-study analysis as a means to identify the factors that determine the Philadelphia's capacity for sustainable energy action, how capacity is translated into action, and what role relevant actors have in these processes.

In order to structure the two types of evaluation used in the case-study according to key governance aspects of urban energy sustainability, the evaluation framework of the study incorporates a definition of 'urban sustainable energy development' along two complementary dimensions. First, since the evaluation of the energy initiatives is applied on a particular urban context, the evaluation incorporates what the term 'urban sustainable energy development' implies for Philadelphia based on the city's formal plan for energy sustainability, *Greenworks Philadelphia*. At the same time, given that 'urban sustainable energy development' can imply different things for different policy actors, social groups etc., a generic definition of 'urban sustainable energy development' is developed, based on the review of the literature, and used in the evaluation complementary to the 'city-based' definition.

More specifically, *Greenworks Philadelphia* contains energy sustainability targets for a particular end year (2015), proposes certain initiatives for making progress on the targets, and monitors performance on the targets and the level of implementation of initiatives (completed, in-progress, future consideration). However, little information is offered on issues like how initiatives are developed and implemented, what the role of relevant actors is, how barriers are overcome and prospects can be enhanced, etc.

Thus, based on the structure and content of *Greenworks Philadelphia*, the energy sustainability targets of the plan and the level of progress achieved against meeting the targets can be seen as the key elements through which the city evaluates its performance on energy sustainability. As such, the progress that is achieved against these indicators is considered by the study to form a core part of the city's definition of 'urban sustainable energy development'.

In addition, making progress on the plan's energy targets is associated with various socio-economic benefits likely accrued to the city, including cost reductions for the city government, local residents and local businesses; protection of energy users against potential rising energy prices; improvements in the quality of life of through affordable energy development; and job creation at the local to regional level. Furthermore, the city government sees energy sustainability action as a way to improve local air quality, and foster economic development, innovation and job creation at the local to regional level (MOS, 2009; MOS, 2012; Greenworks Philadelphia, 2010; A. Agalloco, personal communication, March 26, 2013).

Hence, the above-described contextual-based energy aspects associated with the *Greenworks Philadelpia* plan are also included in the city's definition of 'urban sustainable energy development'.

Regarding the generic definition of 'urban sustainable energy development' used in the evaluation, it is derived as follows. First, an overarching objective of urban sustainable energy development is the promotion of the wider public good (Droege, 2008). In addition, wide energy sustainability involves transitioning away from fossil-fuel energy systems towards energy efficiency and renewable energy-based systems of service provision. Such a transformation of the urban energy system involves a range of socio-spatial, financial and ecological implications that will be likely experienced differently across urban sectors and social groups due to the latter's differentiated ability in shaping the policy agenda, process and outcomes with respect to the newly deployed systems for local energy service provision (Hodson & Marvin, 2011). In this respect, distributional and justice aspects become central in local sustainable energy development, i.e. in terms of the extent to which a diverse set of social interests is incorporated in local energy policymaking, or how costs and benefits associated with initiatives for urban sustainable energy development are distributed among various social groups (While, 2011; Coutard & Rutherford, 2011; Bulkeley & Betsill, 2013; Hammer 2009).

In addition, wide urban energy sustainability is closely associated with the de-fossilization of the energy system through the deployment of systems of local energy service provision that are based on energy efficiency and renewable energy sources, with energy efficiency typically forming the cornerstone of such a transformation (Bulkeley, Broto, & Maasen, 2011; Droege 2008). In this context, urban sustainable energy development should aim towards fostering absolute energy use reductions, particularly over the long-term, in order to more readily address negative implications of the current energy system, foster wider energy-sustainability related benefits, as well tackle broader impacts linked to the functioning of the urban energy system , i.e. the embodied energy associated with products and services consumed in the urban area, or the urban area's contribution to global climate change (Byrne, 2007; Droege, 2008; Harris et al., 2011).

What is more, renewable energy use in urban areas should be primarily associated with generation at the local to regional level, or it should drive renewable energy development additional to business-as-usual, if it is satisfied through energy systems that are located outside the city-region. In that way, local energy self-reliance is likely to be promoted, or local renewable energy demand becomes a driver for additional renewable energy generation elsewhere[6] (Hodson & Marvin, 2010).

Finally, urban sustainable energy development needs to account for the profound changes in the economic base of cities that is likely to take place as a result of expected tighter carbon regulation over time, and, as such, to promote local sustainable economic development within an increasingly carbon-constrained world. As While (2011) suggests, although different national carbon control and energy management contexts will structure, facilitate and constrain different type of responses in different urban contexts, cities, in any case, will be exposed to the pressures and demands entailed by carbon-constrained economies.

The key characteristics of the above-described definitions of 'urban sustainable energy development' that will be used in the evaluation of the study are summarized in Table 1:

[6]This point is associated with the location of the urban system boundary, and the issue of 'additionality' in local sustainable energy development. For example, in its consultation document 'Hong Kong's Climate Change Strategy and Action Plan' released in 2010, the city of Hong Kong proposes to meet its territorial carbon dioxide emissions intensity reduction targets through, among other things, increases in electricity sourced to the city from new nuclear power plants located in Mainland China. However, on current indications this nuclear power will not be extra to China's existing planned capacity. As a result, if power from new plants in the mainland is simply directed to Hong Kong instead of to users within China, then increases in fossil-fueled electricity use in the mainland will presumably cancel a reduction in emissions from the Hong Kong area (Harris et al., 2012). In another example, Hoppe et al. (2011) find that Danish local authorities which participated in a national scheme of local climate mitigation that included energy retrofitting of the existing housing stock, were intentionally selecting to intervene in sites of poor energy performance in order to more easily meet ambitious energy conservation targets, in essence 'plucking the low hanging fruit' as opposed to developing more genuine policy ambitiousness.

Table 1: Definitions of 'urban sustainable energy development' for the evaluation of Philadelphia's energy sustainability approach

Philadelphia's definition	Generic definition
Reduce municipal energy use by 30% between 2008-2015: Cost savings; reduce vulnerability to rising energy prices for the municipality	**Energy as a public good**: Ameliorate the distributional impacts of energy and promote energy affordability and justice; systems of energy service provision that serve the needs of various social groups at large; foster greater saying by local actors over the type of energy systems that serve the urban area
Reduce citywide building energy use by 10% between 2006-2015: Cost savings; reduce vulnerability to rising energy prices for households and businesses; local air pollution abatement; spur energy innovation, sustainable economic development and job creation	**Foster a range of social benefits**: Cost savings; insulation from rising energy prices; improved public health conditions (i.e. local air pollution; healthier indoor environments; tackling heat island effect); energy security
Increase citywide renewable electricity use to 20% between 2006-2015: Local air pollution abatement; renewable energy use in the city increasingly satisfied from energy systems at the local	**Low-energy economic development**: Reduce cost of energy as a factor in the local economy; promote technological innovation, market development and job creation at the local to regional level

to regional level; job creation	
Energy retrofitting of 15% the city's housing stock between 2008-2015: Energy affordability; energy justice; improving quality of life in the local neighborhoods	**De-fossilization of the urban energy system**: Systems of local energy service provision based on energy conservation, energy efficiency and renewable energy; foster absolute energy use reductions
	Promote urban energy self-reliance and ameliorate the wider impacts of local energy use: Localization of sustainable energy exploitation; systemic ability of energy service systems to address local energy needs; interventions additional to 'business as usual'; consumption-based accounting of urban energy use

Source: (MOS, 2009; MOS, 2012; *Greenworks Philadelphia*, 2010; Byrne, 2007; Droege, 2008; Hammer, 2009; Hodson & Marvin, 2011; While, 2011; Harris et al, 2012; Hoppe et al., 2011; Coutard & Rutherford, 2011; Bulkeley & Betsil, 2013; Grubler & Fisk, 2013; K. Gajewski, personal communication, April 03, 2013; L. Robinson, personal communication, April 07, 2013)

In accordance with the type of evaluation described in the beginning of Section 1.4., the characteristics of 'urban sustainable energy development' included in Table 1 will be used through an 'indicator-based assessment', which is mostly the case with the City's extracted definition of energy sustainability, and a 'contextual-based assessment' which is mostly associated with the adopted generic definition of energy sustainability.

The study is organised as follows: Chapter 2 reviews the literature on cities and sustainable energy development to identify the key policy variables of the study, and analytical issues that are offered for further discussion with respect to the case-study. Chapter 3 provides an overview of the policy context for energy sustainability in Philadelphia, and presents key data, actors, and initiatives for sustainable energy development in the city. Chapter 4 presents and evaluates the Mayor's Office of Sustainability energy initiative. Chapter 5 presents and evaluates the Solar City Partnership initiative. Chapter 6 presents and evaluates the affordable energy development initiative. Chapter 7 presents and evaluates the Energy Efficient Buildings Hub initiative. Chapter 8 presents the findings of the study.

Chapter 2

THE REVIEW OF THE LITERATURE

2.1. Energy and Cities: An Overview of the Evolution of Modern Urban Energy Systems

This section offers an overview of the historical development of the modern energy regime in order to highlight the logic behind the organization and function of modern urban energy systems, and to identify whether their current structure and operation are subject to pressures for systemic change. In doing so, a historical evolution of the energy supply and demand system is offered by using Britain as an example in order to highlight at least one route that the development of modern energy systems has taken to the urban environment (Rutter & Keirstead, 2012).

The first settled livings, after the hunter-gathering forms of life, developed energy systems to supply their people with food and fuel. As the population of the settlements was growing in size, the surrounding environment could no longer satisfy their fuel and food needs. To overcome such constraints, new towns were established on navigable rivers or coasts covering a large hinterland radius around their territory that provided a low cost way of bringing food and fuelwood to the urban settlements from the surrounding countryside (Rutter & Keirstead, 2012).

Humans and animals were the predominant sources of mechanical power in those early urban areas, while combustible biomass was used to cover heating needs. Although the scale of energy consumption and relevant technologies improved over time, urban energy systems mainly consisted of biomass that was either burned in a hearth or fed to animals up until the 13th century. To complement their biomass resources, cities and their economies started also exploiting other renewable energy sources such as wind and water[7] (Rutter & Keirstead, 2012).

Although many aspects of 13th century life in London would have seemed extraordinary to a visitor of a Mesopotamian town in 2000BC, the energy system would have look familiar. The reason is that for about 3500 years very little had changed in the ways urban areas were using energy. Since the earliest times and the first urban settlements in Mesopotamia, life in towns and cities was moving slowly and was dependent upon what resources could be grown and harvested over a limited number of years, and what could be transported from local hinterlands through means like human power, horse power and carts or boats (Rutter & Keirstead, 2012).

Due to improvements in technology, and the increased use of renewables, annual energy consumption per capita doubled over time increasing from around 15 Gigajoule (GJ) in 1500 BC Egypt to over 30 Gigajoule in cities of the 17th century (Rutter & Keirstead, 2012).

The next major transition in the urban energy system was the wide use of fossil fuel sources that concentrate hundreds of years of equivalent energy in a compact form. In the U.K., coal was the first fossil fuel to enter the urban energy system in significant quantities. Population increases in cities put strain on fuel wood supply that began to fail while at the same time the price of wood at the London wharves increased substantially. Due to differences in the cost of transportation

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[7]For example, water power was harnessed in the Mediterranean area around 500 BC and was rapidly brought into use for grinding cereals eliminating many thousands of painful repetitive human hours of toil. Water was also powering a variety of machines used, for example in blacksmithing, tanning, fuelling, and wood turning (Rutter & Keirstead, 2012).

between wood and coal, and the latter's higher calorific value, coal became an attractive energy option (Rutter & Keirstead, 2012).

Initially, however, the use of coal faced considerable resistance due to technological and health concerns associated with coal smoke. As a result, it was only after significant technological improvements[8]over a long period, and supportive public regulation[9], that coal use took over biomass in the country by the early eighteenth century[10] (Rutter & Keirstead, 2012).

In the meantime, technological inventions and improvements brought about the development of the steam engine that initially found application in various areas such as water pumping and coal mining drainage, and water and rail road transportation later on. In addition, the development of the railway marked a new age for transportation which had significant impacts on the life of cities; for example, passengers could now travel further over the same time (Rutter & Keirstead, 2012).

In this early age of the industrial city, wind energy and water energy were still important energy sources, for instance by providing the means to mechanize textile manufacture and move it from rural cottages to factories located in urban areas. Nevertheless, they were a small share of the total energy supply. Water power, in particular, was only possible where there was a reliable and sufficient supply of

[8]For example, it took over a century for the development of coke smelting processes that facilitated the substitute of charcoal to coal in the iron manufacture (Rutter & Keirstead, 2012).

[9] For example, wood burning by glass manufacturers was banned by the U.K. Parliament in 1615 (Rutter & Keirstead, 2012).

[10]In continental Europe, the move away from biomass fuels to coal took even longer (Rutter & Keirstead, 2012).

flowing water to turn the water wheels. Steam, which did not face such constraints, allowed later on factories to be located in large population centers that had access to navigable waterways or railways (Rutter & Keirstead, 2012).

Over time, the impact of the Industrial Revolution, initiated in the U.K., spread throughout European countries and the Americas, with each region developing its own pathway towards what is now known to be the modern city. In the U.K., social and economic changes resulted from the Industrial Revolution led to a need for restructuring the system of energy service provision in urban areas. This task was to be taken forward primarily through the development of network infrastructures (Rutter & Keirstead, 2012).

With England and Wales being ahead of the rest of Europe in the pace of urbanization, Britain's population and urban growth increased considerably during the 18th century. The advent of railways revolutionized land transportation and allowed fresh food, fuel and people to enter the center of cities on a daily basis and at a relatively low cost. As such, by 1850, at least 15,000 people travelled to work in London by paddle steamers along Thames River, in addition to train commuters, while in 1863 the city's first underground railway station opened (Rutter & Keirstead, 2012).

These technological innovations increased the city's demand for transport energy, but also impacted significantly the energy demand of other sectors. For example, urban commuters were now able to move out of city centers and live in homes in suburban areas. These were often larger and requiring a higher heating and lighting demand. They also needed to be equipped with new manufactured goods. The growth of urban population highlighted also the health hazards associated with living in urban areas. As a response to this, in the eighteenth and early nineteenth centuries, the U.K. Parliament passed Town Improvement Acts which dictated towns to provide clean water and to clean, pave and light streets (Rutter & Keirstead, 2012).

Lighting, in particular, was an important application that contributed towards the development of networked urban energy services. For example, better street-lighting was seen as necessary to improve the safety of people and to lengthen the working day. At the end of the 18th century, experiments in Britain and France were exploring the use of gases that were produced by heating coal or wood for lighting generation. In 1798, coal-gas was used to light-up a house room in Cornwall, U.K, while the first public demonstrations of gas lighting took place in Paris in 1801, and in London in 1804 (Rutter & Keirstead, 2012).

The advantages of central gas manufacturing were quickly perceived by commercial entities. As a result, by 1829 around a hundred gas companies had been established in the U.K. and gas lighting was serving several large cities throughout the country. However, both the growing domestic and commercial markets for lighting were about to undergo further changes. The burning of expensive whale oil in lamps that was giving out poor light quality was still dominating the domestic market, while demand for use of lubricants in the industry was growing. An opportunity, hence, emerged for the development of a new source of light from oil substances. In1837, Baron Karl von Reichenbach showed that not only gas but also paraffin and other oils and chemicals could be extracted from organic solids such as coal, wood, and shale. Then, in 1850, he patented a process which was describing how to extract coal oil and break it into its component substances. A year later, James Watt opened at Inchgate in central Scotland what would probably be the first oil refinery of the world (Rutter & Keirstead, 2012).

These innovations were spread outside the lighting sector and prepared the ground for the development of oil-based transportation systems in modern cities. Lighting that was produced by gas or oil had improved considerably but was still facing various disadvantages. For example, it was a potential hazard for fire, while its brightness was low especially in the outside environment. In addition, gas was expensive and slowly penetrating the domestic lighting market, and hence it was to be challenged by electricity by the end of the 19th century. In contrast to gas, electric lighting was offering convenience and cleanliness. These aspects, combined with its flexibility as a power source, enabled electricity to become the dominant urban energy source of the twentieth century (Rutter & Keirstead, 2012).

The first practical demonstration of an electric lighting system was made by Jablochkoff in Paris and London in 1878. The lighting system required its own generating system which in this case consisted of a steam engine and two generators. In the meantime, in the U.S., Thomas Edison was already working on various electrical devices and financial backers were supporting his laboratory work at Menlo Park, New Jersey. Edison soon realized the advantages of the central gas production system and developed an equivalent system for electricity generation which provided electricity through copper wires (Rutter and Keirstead 2012).

Edison tried to develop an electric light system that could be used in enclosed spaces more easily than the electric arc. It was the success of his ‘electric bulb’ that allowed him to commercialize his integrated power and lighting systems by building power stations at Holborn in London and Pearl Street in Manhattan. The Pearl Street station was running on coal-fired steam fed into six generating sets each producing 1000 KW which was enough power to light-up one square mile in New York City (Rutter & Keirstead, 2012).

At the same time, in the U.K. the electricity industry was experiencing a boom between 1870 and 1880 with many entrepreneurs entering into this business and substantial investment made by new companies to supply electrical equipment and power. In the meantime, the Metropolis Gas Act that was passed in 1860 allowed existing gas companies to acquire monopoly in their operation districts while in 1882 the Electric Lighting Act gave similar monopolies to U.K. electricity companies. Nevertheless, British towns and cities were initially reluctant to adopt electric lighting based on cost considerations and concerns over the implications of granting monopoly rights to an electric company (Rutter & Keirstead, 2012).

Hence, despite the large activity in the 1880s, electricity expansion weakened in Britain lagging behind electric power installation and use for lighting and other purposes in the U.S. where there seemed to be more public interest in bringing bright electric lighting in the urban centers than concerns over the cost of electricity (Rutter & Keirstead, 2012).

In the meantime, in the U.K. the gas industry's effort to keep its position in the lighting market was assisted by the invention of the incandescent mantle which tripled the efficiency of gas lighting and improved its quality. However, the original patent for the central gas production system had envisaged the use of gas for purposes of heating and cooking, as well as lighting. As a result, by 1950 about 80% of British dwellings were connected to gas supply but the industry was facing strong competition from electricity until the discovery of natural gas reserves in the North Sea (Rutter & Keirstead, 2012).

Furthermore, at the beginning of their expansion in the U.K. in the turn of the twentieth century, both gas and electricity were lacking technical standardization while their integration into larger energy networks had yet to be developed. As a result, as urban energy systems were expanded, several suppliers and technical systems of differentiated specifications were in operation. For example, by 1920 the expansion of the electricity system in the U.K. had resulted in over six hundred suppliers owned by local authorities and private companies that were acting independently (Rutter & Keirstead, 2012).

This resulted in an oversupply of generating capacity by 75% at the national level compared to what was required to meet peak demand. It was becoming clear that these gas and electricity infrastructures could no longer be relied upon. As such, in 1925 a U.K. governmental report suggested that electricity generation should be limited to a small number of power stations that are connected to a national grid (Rutter & Keirstead, 2012).

The grid was then developed throughout the country by 1945, while it took longer to establish the gas national network that was finally completed in 1978. In the meantime, between 1967 to1977, Britain converted its gas supply from coal-gas to natural gas at a cost equivalent to nearly current $8-10 billion (Rutter & Keirstead, 2012).

As a result of the national gas infrastructure, the coal-fired municipal gasworks operating at that time, often located in urban centers, were no longer needed since natural gas was largely drawn from the North Sea and transported through the national grid. By mid-1960s, domestic and industrial demand for electricity in the U.K. was increasing at 7% per year. Much larger power stations were then required to satisfy this demand that were consuming enormous amounts of coal[11], and cooling water that could only be drawn from large rivers or the sea (Rutter & Keirstead, 2012).

The national electricity grid allowed building these stations away from urban centers and close to fuel and water sources. Overall, therefore, the development of the national natural gas and electricity grids marked a radical change in the urban energy system where petrol or diesel for transportation remained the only substantial import of fuels needed to be taken (by road or rail) into the urban centers[12](Rutter & Keirstead, 2012)

As a result of such changes, a substantial portion of energy demand in urban areas was met through electricity and natural gas brought into the city through the wires and pipes of the national grids. Among other things, this new way of energy supply offered to cities the advantage of physically removing various externalities of the energy system from their immediate vicinity (i.e. pollutants from the combustion of fossil fuels). However, the changes in the energy service provision changed also the urban character of the energy systems. Whereas before energy resources were brought into each city from its hinterland region or wider markets on an ad-hoc basis,

[11]A 1GW coal power plant burns about 3 million tons of coal per year (Rutter & Keirstead, 2012).

[12] In a sense, this resembles the case in the past of the transportation to the city of the oats required for horses and coal for the power stations that were producing electricity for the trams and underground (Rutter & Keirstead, 2012).

cities were now part of an interconnected national energy system (Rutter & Keirstead, 2012).

In addition to becoming part of a national energy network, as the U.K. experience suggests, throughout the world urban energy systems became over time indispensable with almost every aspect of life in modern cities by supporting their economic, social and environmental activities. In this regard, urban electricity, gas, and heating systems have become vital for the operation of nearly all production, service and infrastructure sectors in cities (Monstadt, 2007).

In addition, modern energy utilities are typically sizeable companies that exert significant influence at the local to regional level, for example by employing a large workforce, undertaking capital investments, or having a major input in the quality of energy service, the level of energy tariffs, and the type of energy infrastructure, aspects which have implications in the performance of local economies (Monstadt 2007).

Urban energy systems are also a major part of the socio-ecological metabolism of cities by mediating material and energy flows which contribute to environmental problems ranging from air, soil and water pollution to the release of greenhouse gas emissions and risks associated with the use of nuclear power (Monstadt, 2007).

As described before, as urban energy systems were evolving over time, the new organizations of energy supply and demand were able to address certain deficiencies associated with energy service provision (i.e. technical inefficiencies of the energy systems, low quality of energy, cost of energy, in-city pollution), and produce socio-economic benefits for the society.

However, modern energy systems have also created, or become closely associated, with socio-economic and environmental externalities that individually, and combined, challenge social well-being and the viability of environmental systems (i.e. socio-distributional aspects of energy affordability, energy resource constraints, concerns over climate change) (Droege, 2008). At the same time, their growing size and complexity have become a source of systemic technical inefficiencies (Rutter & Keirstead, 2012), as well risk to the society at large as evident by the accidents in the nuclear power sites of Three Mile Island (U.S), Chernobyl (Ukraine), and Fukushima (Japan) (Srinivasan & Rethinaraj, 2013).

For such reasons, the current energy regime is increasingly put under critique, while as a response alternative forms of energy service provision in urban areas (i.e. energy efficiency and renewable energy) are gaining prominence as solutions to such challenges (Coutard & Rutherford, 2011).

These alternative types of energy service provision involve changes in the ways that energy is produced and consumed. As such, they challenge the existing socio-technical, economic and organizational aspects pertinent to the current urban energy system (Byrne et al., 2007; Hodson & Marvin, 2010).

As a result, the development and operation of alternative energy service provisions to meet urban energy needs involve financial, socio-spatial, ecological and governance implications that have to be evaluated critically (Coutard & Rutherford, 2011).

In order to offer an overview of what aspects of the current energy system might be subject to change as a result of the greater use of alternative energy service provisions in urban areas, Section 2.2. summarizes current key technical, organizational, market and social planning aspects that are related to established and alternative energy systems by focusing on the electricity grid.

2.2. Overview of the Urban Energy System: Key Technical, Organizational, Market and Planning Aspects

2.2.1. Technical and Organizational Characteristics of the Urban Electricity System

Electricity and gas amount to the bulk of energy use of the residential, commercial and industrial sectors in urban areas. These energy sources are transported to cities through the wires and pipes of a regional or national grid, leaving petrol or diesel fuels, primarily for use in the transportation sector, as the only large energy imports that need to be brought into the urban community by road or rail (Rutter & Keirstead, 2012).

The need to satisfy dense energy needs of populated urban areas resulted over time into the development of centralised and concentrated systems of energy service provision. With energy demand in urban areas escalating to vast levels, the cost of infrastructure expansion of the centralized energy system has been progressively grown to such high levels that surpass other cost components of the energy system such as the cost of extraction of energy sources or the operational cost of power stations (Scheer, 2008).

In addition, the energy costs of the conventional energy system are sensitive to the volume of energy fed into the grid. Hence, with smaller quantities of fossil-based energy supplied into the system, the cost of energy supplied in the urban area increases considerably. As a result, overall, when renewable energy is substituted for fossil fuel energy, the economic performance of the conventional system deteriorates. Partly for this reason, the current energy regime resists the greater use of alternative energy sources (Scheer, 2008).

Figure 1 offers a representation of the current energy system where typically the bulk of energy supply is derived from conventional energy sources (i.e. coal, gas, oil), and energy production is spatially disconnected from energy consumption:

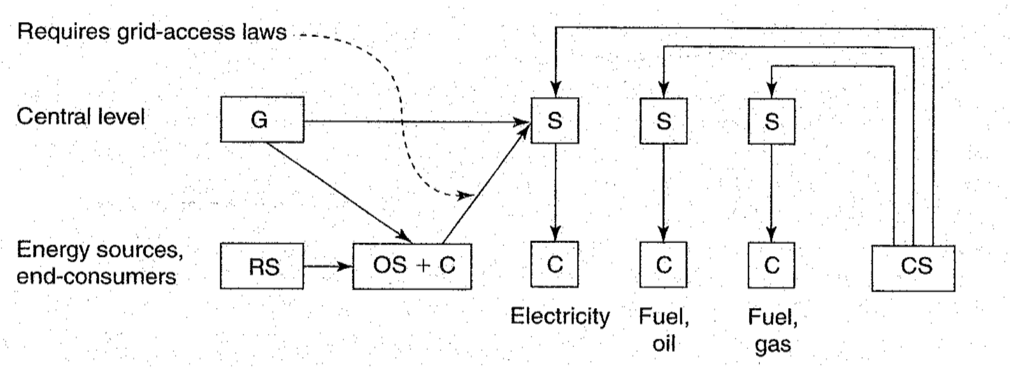

Figure 1: Hierarchical divisions within the conventional energy system between sources and consumers

Note: RS: Renewable energy; OS+C: owner supply and consumer; C: consumer; CS: conventional sources; S: supplier; G: generation plant

Source: (Scheer, 2008)

As noted above, in response to challenges and constraints associated with the conventional energy system, alternative systems of energy service provision based on energy efficiency and renewable energy sources are increasingly used to satisfy energy supply and demand in urban areas. The technical and organizational characteristics of these systems are fundamentally different from those of conventional energy systems. Renewable energy systems are typically deployed at small-scale level and implemented on a modular basis and lower spatial scale, for example at the individual building (i.e. solar photovoltaics, mini wind turbines), at the neighbourhood level (solar photovoltaics, mini-wind turbines, small-scale combined heat and power) or at the citywide level (i.e. large combined heat and power plants, wind farms located at the city-regional level) (Hoffman & Pippert, 2007; Lund 2012).

They are typically intermittent sources (i.e. wind or solar), so any excessive electricity or heat needs to be stored or exploited through integrated resource management techniques; for example by converting surplus generated renewable electricity into thermal energy which often constitutes a major part of end-use energy in cities (Scheer, 2008; Lund 2012).

Renewable energy and energy efficiency systems involve fundamentally different technological and resource characteristics than conventional energy system[13] (Bulkeley et al., 2011a, Coutard & Rutherford, 2011). The level of change required in the technical basis of the current energy system, as a result of the greater use of renewable energy, depends on the level of the use of this energy source. For example, renewable electricity use of up to 50% of total electricity demand does not involve large modifications in the technical structure of the electricity grid. For higher than 50% renewable electricity use, however, the grid needs to be transformed fundamentally, and converted into a group of decentralized and interconnected systems where energy flow is controlled and coordinated (Watson, 2008).

To offer an example, one of the key components of Denmark's national energy vision for a 100% renewable energy use by 2050 is the development of an

[13]For example, different characteristics between conventional and sustainable energy systems involve: finite stocks versus renewable flows; linear metabolism: tapping>supply>disposal versus circular metabolism: recycling, reuse, retrieval; decoupling between local resource availability and use versus recoupling between resource availability and use; concentrated energy use through large-scale technology versus diffuse energy use through smaller-scale technology (Bulkeley, Broto, & Maasen, 2011; Coutard & Rutherford, 2011).

intelligent grid that would improve system efficiencies and allow the integrated management of energy sources (Sperling et al., 2009).

Figure 2 offers a view of an urban energy system that is based on energy efficiency and renewable energy service provision:

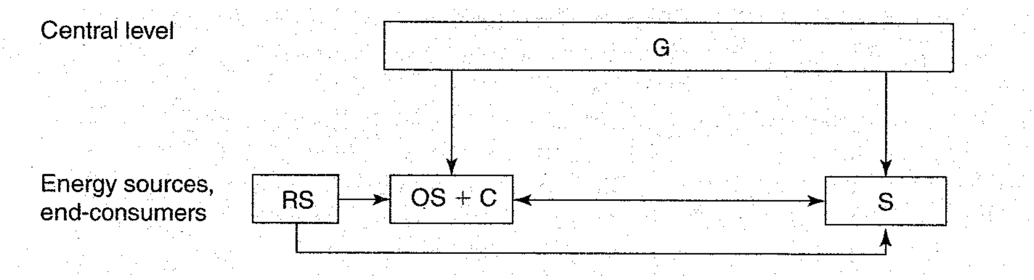

Figure 2: Integrated distributed energy supplies using renewable energy

Note: RS: Renewable energy; OS+C: owner supply and consumer; C: consumer; S: supplier; G: generation plant

Source: (Scheer, 2008)

Figure 2 shows how an urban energy system that is based on energy efficiency and renewable energy sources differs, generically, from a conventional energy system in the organization of energy supply and demand (Figure 1, p.44). For example, here a direct two-way flow of energy can take place between consumers and suppliers. This implies a blurring of divisions between the supply and demand-side of the system, with final energy-users potentially able to take on an active role in the operation of the system (Scheer, 2008).

In addition to technical changes, greater use of energy efficiency and renewable energy implies new markets and planning policies (Hoffman & Pippert, 2007; Scheer, 2008). Such aspects are briefly discussed in Sections 2.2.2. and 2.2.3.

2.2.2. Energy Markets and Urban Sustainable Energy Development

Cities represent a huge market for sustainable energy and the public sector in western countries accounts itself for approximately 10% of national energy demand. Local energy policymaking can influence demand for sustainable energy and facilitate the opening of new energy markets. The creation of local energy markets is critical in fostering business competitiveness, technology innovation, and know-how for sustainable energy development. Local energy policies can contribute to cost reduction of sustainable energy, a key factor for the wider commercialization and adoption of these systems (Lund, 2012).

Market and financial barriers often hamper the greater use of sustainable energy systems. These involve aspects such as high upfront cost, lack of familiarity of mainstream financial tools and practices with such type of investments; financial benefits that are spread over the lifetime operation of the system, and a 'non-accounting' of the technical and economic benefits associated with their use (Droege, 2008; Scheer, 2008).

In addressing such challenges, hence, there is a need for appropriate regulatory and market arrangements that will facilitate the wider adoption of sustainable energy systems (Scheer, 2008).

2.2.3. Energy Ownership and Local Participation in Energy Planning

The type of ownership of the energy system is closely related to the role of the public sector in energy planning, and the level of control that public entities can exert over local energy supply and demand. Driven by neoliberal ideas and deficiencies of public utilities, such as lack of productive efficiency, inability to address new customer demands, and poor performance in energy innovation, the energy industry of countries around the world has been undergoing transformations in its organizational structure over the last decades through processes liberalization and privatisation (Monstadt, 2007).

Such changes have implications for energy sustainability at the local level. For example, the liberalization and privatization of the energy industry in Germany have diminished the financial, administrative and regulatory oversight that local and regional governments can exert on energy supply and demand, for example in relation to energy tariffs or investment and corporate decisions made by energy utilities on aspects such as the fuel mix for power generation, research and development activities, and deployment of sustainable energy systems (Monstadt, 2007).

In the U.S., over 2,900 municipal-owned and cooperative-owned electricity utilities currently operate amounting to 87.5% of the total number of electricity providers in the country, while the 192 investor-owned utilities amount to 5.8% of total providers, and the rest being federal power agencies at 0.3% and power marketers at 6.4%. However, investor-owned utilities dominate the electricity market in terms of number of customers at over 68.5% of total volume, whereas municipal and cooperatives amount to 27.2%, and power marketers to 4.3% (American Public Power Association, 2014).

The ownership structure of the electricity industry in the U.S. is related to the level of control that the public sector and local communities can exert on energy service provisions[14]. As the American Public Power Association notes:

[14]To offer an indicative example, public power utilities in the U.S. figured prominently in the annual 'top 10' lists of the U.S. Solar Electric Power Association

> Since every citizen is an owner with a direct saying in policies, public power systems can emphasize long-term community goals, including local control over special programs (energy conservation, rate relief for certain customer classes etc.), the electric distribution system aesthetics and design, and local control that allows matching local resources to local needs (Hoffman & Pippert 2007: 227)

In practice, however, democratic governance structures and systematic involvement by the average citizen in local energy policymaking is far from straightforward due to lack of appropriate means of participation but also the challenging task of on-going engagement in political processes (Hoffman & Pippert, 2007).

Having examined key characteristics of the current fossil-based energy system and how it differs from an alternative organization of energy in urban areas based on energy efficiency and renewable energy, Section 2.3. describes the policy context within which cities pursue energy sustainability.

2.3. The Nature of the Urban Sustainable Energy Policymaking Process: From Government to Governance

Focusing on the role of the local government, initially, a brief historical overview is offered on the evolution of local energy sustainability action in order to highlight the origins and present nature of this policy area, before wider issues on urban sustainable energy development are discussed.

Local government action on energy sustainability can be traced as back in time as the late 1960s; for instance, Newcastle City Council's (NSW Australia) municipal energy conservation program was developed in 1968 (Bulkeley & Betsill, 2003).

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regarding the level of solar power that utilities added to their system in 2012 (American Public Power Association, 2013).

Further in the 1970s, a small number of local governments from North America and Europe were mobilized to take action on energy efficiency and renewable energy as a response to the oil crises. For example, the city government of Portland, Oregon, made the political decision to reduce the city's dependency on oil-based fuels for road transportation through sustainable transportation policies (Lerch, 2007).

In general, however, urban energy planning policies that were undertaken in those early days in developed countries were based on the assumption that energy supplies are abundant and inexpensive. As a result, the reduction in oil prices in the 1980s, and improvements in the energy intensity of national economies, worked against greater local sustainable energy action. In addition, local energy policies tended to be dominated by environmental considerations rather than the dynamics of the urban energy-economic system (Paez, 2010).

Despite such conditions, in the mid-1980s municipalities from North America, Europe and Australia started taking more coherent action in energy sustainability motivated by the socio-economic benefits produced for the urban communities out of such initiatives (i.e. reduced air-pollution, energy cost savings) (OECD, 1995).

As a result, these local governments acquired over time substantial experience in energy planning, as described, for example, in the 'Urban Energy Management-Good Local Practice' report of the Organization for Economic Cooperation and Development. These early initiatives were focusing on energy efficiency development in city-owned facilities, such as buildings or vehicle fleets, and were assisted by technical knowledge that was developed in the municipalities (OECD, 1995).

Despite these initial examples and the rhetoric of sustainable development that were entering the urban agenda by the late 1990s, municipal government energy sustainability initiatives were remaining sparse, involving a small number of pioneering local governments. In addition, municipalities were able to move forward with individual projects but they were lacking a strategic plan for sustainable energy development at the citywide level (Bulkeley & Betsill, 2003).

Local energy sustainability action has evolved over time to encompass a growing number of cities throughout geographical regions of the world that adopt more comprehensive policy approaches than these early examples. To better understand the key aspects of this evolution, it is helpful to categorize the energy sustainability responses that have been developed by cities in distinct phases. In this regard, two phases can be broadly defined (Bulkeley & Betsill, 2013).

The first phase, which is often termed as 'municipal voluntarism', extended from the early 1990s until the early 2000s, and involved mostly action by small and medium-sized cities in North America and Europe. In these early examples, individuals within local governments were instrumental in recognizing the importance of energy sustainability and climate change, and organizing municipal responses in these areas (Bulkeley & Betsill, 2013).

The rationale of local governments for energy sustainability action in that period was, in certain cases, organized through transnational municipal networks on energy and climate change that were formed around the same time; for example, Energié Cities (Europe), the Cities for Climate Protection (CCP) program of the International Council for Local Environmental Initiatives initially active in North America, Europe and Australia, and Climate Alliance. These networks would facilitate the gathering and sharing of rationale, information, and knowledge towards achieving common local energy sustainability goals (Bulkeley & Betsill, 2013).

The networks, and leader cities with resources and political will to undertake action, developed energy sustainability approaches that were grounded on an integrated, evidence-based approach to municipal planning, a perspective which coincided with a broader direction of local governance at that time where accounting for performance was becoming more important. Over time, these local energy sustainability examples were spread to other cities and regions of the world, including Australia, Asia and Latin America (Bulkeley & Betsill, 2013).

While these policy responses were mainly focused on the reduction of greenhouse gas emissions from municipal operations, they were instrumental in fostering new mechanisms for financing projects, carbon accounting, and technology deployment, as well as increasing political awareness within municipalities about issues of energy sustainability and climate change (Bulkeley & Kern, 2006).

Building on this internal action, and seeking to develop more comprehensive energy sustainability approaches that would extent across the urban community, local governments sought to re-frame climate change as an overarching issue through which other significant municipal agendas (i.e. air pollution, health, congestion, energy security) might be worked out (Bulkeley & Betsill, 2003).

However, because of challenges such as lack of political will and competencies to introduce new forms of regulation, and a minimal role in the organization and functioning of local infrastructure systems and utility services[15],

[15]For example, Allman et al. (2004) assessed the progress of English and Welsh local authorities in addressing climate change in that time through surveys conducted in

local governments tend to promote their wider energy sustainability policy plans primarily through 'enabling' modes of governance, where entities such as the local community and local businesses are encouraged to take action in and on behalf of the city (Bulkeley & Kern, 2006).

The challenges of institutional capacity, and division of authority and responsibilities, that local governments were facing within their respective political-economic environment when seeking to take greater action across the city led to the adoption of a more piecemeal and ad-hoc energy policy approach than initially envisaged (Bulkeley & Betsill, 2013).

While some cities were able to develop capacity and political will to overcome such barriers and involve local actors in a common approach to energy sustainability, many of them encountered a gap between, on the one hand, the rhetoric of the need to take action in this area and, on the other hand, the realities and challenges associated with such kind of action in practice (Bulkeley & Betsill, 2013).

In explaining these early examples of energy sustainability taken by cities, theoretical perspectives, i.e. the so-called 'new urbanism', driven by the lack of attention paid to the role of the local level in environmental policymaking placed focus of the analysis on the local level as a critical site where this kind of policy

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years 2000 and 2002. The authors suggest that while local authorities were successful in bidding for pilot projects and making progress on adding single projects in their record through an 'opportunistic' policy approach, they were found less successful in tackling complex and strategic activities such as preparing a greenhouse gas emissions inventory, developing a citywide energy action plan or engaging with the wider community on sustainable energy activities. The main reasons identified for this outcome include lack of statutory duty on local authorities to take climate change action, lack of accurate energy consumption data at the postcode level, difficulties on inter-departmental cooperation, staff and skill shortages, and challenges in engaging with the wider community in activities to reduce greenhouse gas emissions (Allman et al., 2004).

action is shaped and implemented. Nevertheless, such perspectives treated the ‘local’ as a site that is detached from its wider environment and where socio-political, and where forces critical to realize sustainability are necessarily active, in essence neglecting the role of conditions, processes and actors of the wider environment within which local sustainable energy action takes place (Bulkeley & Betsill, 2013).

Seeking to go beyond such an analytical perspective for the ‘local’ in response to the limitation of these approaches, scholars developed and employed the so-called ‘multi-level governance’ perspective in the analysis of local sustainable energy issues. This research approach attempted to explain the rationale for local energy sustainability action, and the challenges faced in this area (i.e. why action has or has not been taken by cities), by looking at the role relevant actors and processes that take place within and across scales of political organization (Bulkeley & Betsill, 2013).

Due to the predominance of this analytical perspective on local energy issues, and its use in this study, it would be helpful to offer a definition of the terms ‘governance’ and ‘multi-level governance’. While various definitions exist for the concept of ‘governance’, it, overall, refers to the system of structures and processes by which people in society set rules, share power and make decisions. In particular, the concept places emphasis on three aspects: the significance of network relationships between policy actors; the mix of public and private resources in policymaking; the use of portfolio instruments to achieve policy goals (Poocharoen & Sovacool 2012: 410).

With respect to the term ‘multi-level governance’, as originally developed it involves two sets of interrelated, and potentially overlapping, processes through which governing of particular issues takes place. These are the so-called Type-I governance processes which refer to the negotiation and allocation of authority and competencies between levels of government, and the so-called Type-II governance processes which refer to horizontal spheres of authority in policymaking. Mapping and exploring such type of governance processes has been a key approach in analyzing urban energy sustainability action (Bulkeley & Betsill, 2013).

An important contribution of the multi-level governance perspective has been its ability to take into consideration the multiple sites and processes through which local energy sustainability responses are shaped and contested. In particular, its application has identified two key factors regarding how local energy sustainability responses have been interpreted and implemented. These are the powers and competencies of the local government in this area, and the discursive contestation through which the urban energy problem was defined by stakeholders as a policy issue (Bulkeley & Betsill, 2013).

In this regard, this analysis has helped to explore how competencies for urban energy sustainability responses were shared between levels of government. In addition, it added understanding regarding the role of the formal divisions of authority on energy sustainability and what type of action was politically feasible to be taken by local governments (Bulkeley & Betsill, 2013).

What is more, the analysis found that coalitions of actors (i.e. local government, local businesses, labor unions, national policymakers, transnational corporates) extending across policy scales and sites were able to frame their view on the issue at stake, and mobilize socio-political and economic resources and relations across and within policy levels to support their agenda. A common result out of these processes was that energy sustainability issues were often sidelined in policymaking, as they were perceived to be potentially disruptive to business as usual (i.e. in terms of economic growth) (Bulkeley & Betsill, 2013).

As noted before, cities have been taking a more systematic action on energy sustainability since the early 2000s. This signals a second phase of urban energy responses that has been developed partly as a response to the challenges encountered during the initial examples. In this phase, local governments, and other local actors, adopt a more political approach on energy sustainability, often identified as 'strategic urbanism', in which energy and climate change action becomes integral to the pursuit of wider urban policy agendas (Hodson & Marvin, 2010; Bulkeley et al., 2011b).

While 'municipal voluntarism' is still a dominant approach on urban energy sustainability, particularly in smaller cities, this period of action involves additional forms of local energy and climate policymaking, an expanded range of socio-political actors and new governance approaches. This shift in local sustainable energy policymaking has been fueled partly by the inertia of wider levels of government to take more comprehensive action in energy sustainability and climate change (Bulkeley & Betsill, 2013).

For example, that was the case in the U.S. where pioneering local governments started to develop climate action plans in the face of the inertia of the George W. Bush federal administration in this area, and to organize national arrangements to share ideas, networking and create peer support for such type of action. This was evident in the U.S. Mayors Climate Protection Agreement launched in 2005 by Mayor Greg Nickels of Seattle, Washington who challenged mayors across the country to take action on climate change[16] (Bulkeley & Betsill, 2013).

A particular aspect of this more strategic approach that cities have adopted in energy sustainability is the security of resources (i.e. energy, water) deemed as critical for the functioning and prosperity of urban areas. In this context, cities often declare their intention to foster resource independence and infrastructure resilience through policy plans that would reduce their reliance on national systems of energy service provision by means of greater energy efficiency and local renewable energy development (Coutard & Rutherford, 2011).

For instance, this is the case with San Francisco's adopted Energy Independence policy concept, and with London's intention to delink its energy infrastructure from national centralized energy supply to enable a quarter of the city's energy supply to be satisfied 'off the grid' through local decentralized systems by 2025, with the ultimate goal that the bulk of energy needs will be supplied in this way by 2050 (Coutard & Rutherford, 2011).

Such policy plans incorporate ideas of promoting more 'autonomous' socio-technical energy configurations where meeting local energy needs is no longer based on the expansion of urban energy networks to search out resources which are located distant from the city, but rather on a strategy which seeks greater energy reliance

[16] Such an approach of engaging locally-elected politicians with the climate change agenda has been replicated globally over the last years. In 2009, the European Covenant of Mayors was launched which requires signatories to commit to go beyond the EU target of 20% CO_2 reductions by 20% through sustainable energy action. Members of both the U.S. Mayors Agreement and European Covenant Mayors have sought to raise the profile of their cities in national and international climate debates and to put pressure on national governments to take more comprehensive action in climate change (Bulkeley & Betsill, 2013).

through localization of systems of energy service provision and exploitation of local energy resources (Hodson & Marvin, 2011).

In addition to the rationale for self-reliance and security pertaining urban thinking in energy, wider policy issues including the liberalization agenda for energy markets and industries; a growing premise for carbon management incorporated in spatial regulation across all levels of government based on a political imperative for reductions in fossil fuel use; a growing critique of the current energy regime on its ability to tackle energy-related socio-economic and ecological challenges; and a growing demand by the public (i.e. citizens) and private sector for alternative systems of energy service provision based on various aspects (i.e. cost reductions, environmental branding, business innovation and competitiveness), create a new and complex environment for urban sustainable energy development where the governance role of cities is placed under consideration (While, 2011; Coutard & Rutherford, 2011; Hodson & Marvin, 2011; Monstadt, 2007).

Such 'energy' aspects that lead to the new context are complemented by, or linked with, wider socio-political attributes that themselves contribute to a re-defined role for cities in energy sustainability; for example, the changing organizational character of the local government through the incorporation of management practices of the private sector, and the increasingly networking character of policymaking and society (Bulkeley & Kern, 2006; Coutard & Rutherford, 2011; Poocharoen & Sovacool, 2012).

What is more, new modes of governance are now being applied for local sustainable energy action. For example, while 'enabling' is still central in approaches of local governments, what is observed is a growing reliance on various forms of ‘partnership’, the blending of public and private authority, and a renewed interest in the ways in which both public and private actors might provide new forms of low-energy and resilient infrastructure in the city (Hodson & Marvin, 2011; Coutard & Rutherford, 2011).

The types of cities and local responses that now characterize the urban energy sustainability governance landscape are therefore substantially different from those that were taking place initially (i.e. focus on internal municipal energy management; little action across the city; cities from both the North and South are now widely engaged in energy sustainability). Specifically for local governments, this new environment for energy development implies that they adopt organizational aspects of the private sector in their policy approach (i.e. municipal energy utilities need to have a viable business plan in order to be competitive in liberalized energy markets), engage with a variety of external actors (i.e. private and civic sector) on policymaking and implementation, engage with new types of policy initiatives such carbon markets or international climate policy instruments (i.e. participation in emissions trading schemes; landfill gas-capture Clean Development Mechanism project in Sao Paolo) (Bulkeley & Newell, 2010; Hodson & Marvin, 2010; Poocharoen & Sovacool, 2012; Bale et al., 2012; Sperling et al., 2011; Belkeley et al., 2009).

In order hence to add clarification on the potential role of the local government in this policy area, it is helpful to provide a typology of generic responsibilities that they can exercise in sustainable energy policymaking.

A categorization which appears capable of accommodating the diversity of local government energy policy functions without being overly specific, thus risking to miss-out potential dimensions, is offered by Hammer (2009) and includes five policy leverages: rulemaking; regulatory oversight; direct expenditures/procurement; provision of financial incentives; information gathering and dissemination, facilitation and advocacy.

Through such leverages, local governments can apply an array of instruments, techniques, and measures for energy efficiency and renewable energy development, both at the municipal government or citywide level[17] (Hammer, 2009).

While local governments still remain leading actors in energy sustainability (Broto & Bulkeley, 2012), getting a fuller understanding of how urban sustainable energy responses are shaped would require that the role of diverse socio-political entities in this area is examined. This is because a range of private and civic actors have now become central to local energy sustainability (Bulkeley & Betsill, 2013).

This diversity of the type of action and actors in local energy sustainability has been recorded throughout urban contexts and regions. For example, Portney (2013) suggests that while in the early 2000s only a few U.S. cities would take the issue of sustainability seriously beyond simple announcements, at present over fifty large U.S. cities invest significant amounts of time, resources, and political capital to pursue some form of sustainability initiatives, and some of them have become leaders in climate policy.

[17]It should be noted that sustainable energy action at the municipal level involves a considerably lower scale of intervention compared to action at the citywide level. For example, Krause (2012) estimates that the renewable electricity currently used to power the operations of U.S. local governments is best approximated to save 0.07% of annual U.S. carbon dioxide emissions. The estimated savings would reach 0.5% of total emissions at best, if all U.S. local government operations were powered by renewable energy. However, indirect impacts that are generated by local government action such as leadership by example or the procurement of environmental-friendly technologies offer opportunities for wider sustainability benefits, for example by fostering civic leadership for sustainable energy development or promoting a 'market-push' for pro-environmental products respectively (Bale et al., 2012; Krause, 2012).

At the global level, the diversity in local energy sustainability action is illustrated in Figure 3 which presents the results of a survey of urban climate mitigation and adaptation initiatives in different sectors and regions of the world for a sample of 100 cities[18] (Broto & Bulkeley 2013):

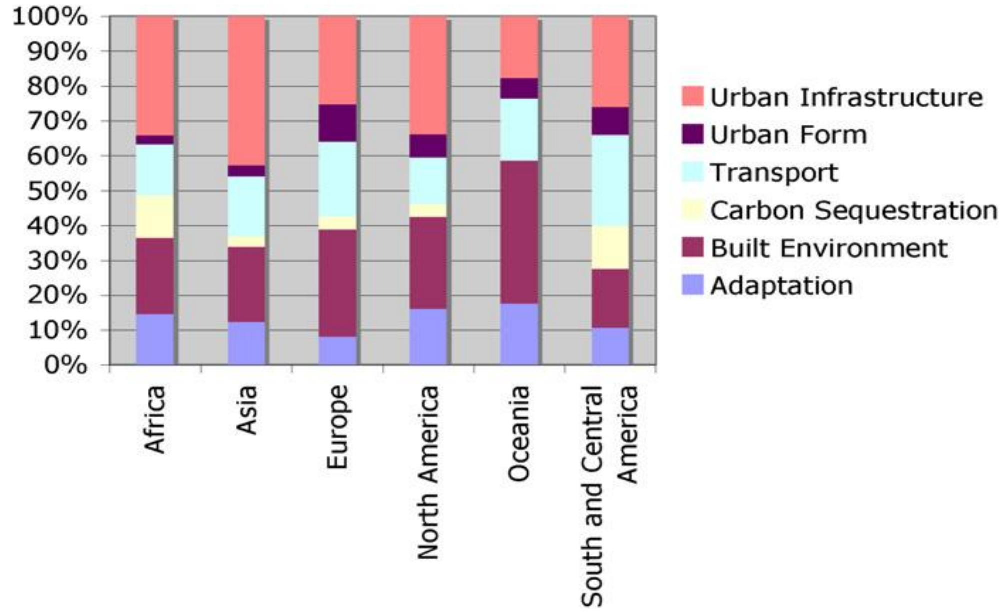

Figure 3: Frequency of climate change initiatives in different sectors and regions of the world for a sample of 100 cities.

Source: (Broto & Bulkeley, 2013)

In addition, the role of cities in energy sustainability is now more widely acknowledged at the international policymaking level. For example, the Intergovernmental Panel on Climate Change's Working Group III - Mitigation of

[18]The sectors of the study that are more related to energy are those of 'urban infrastructure' (i.e. alternative energy supply) and 'built environment' (i.e. building energy efficient design and retrofits). The city of Philadelphia is included in the survey (Broto & Bulkeley, 2013).

Climate Change Fifth Assessment Report released in April 2014 discusses for the first time, as a separate theme, the role of sub-national policies and institutions in climate change mitigation (Bulkeley & Betsill, 2013).

While the above discussion suggests that energy sustainability is increasingly taken into consideration in the wider policy agenda and practice of cities, it, nevertheless, has not still become a mainstream issue in urban development and governance (While, 2011). As such, a fundamental shift in 'urban thinking' in relation to the role of energy sustainability in the development, operation and maintenance of the city cannot be observed yet. In addition, in certain cases the effectiveness of local sustainable energy initiatives can be questioned (Byrne et al., 2007; Droege, 2008; Hodson & Marvin, 2010; While, 2011).

In this context, it appears that if cities want to foster wider benefits through sustainable energy development, they need to take more systematic and comprehensive action in this area than currently the case (Droege, 2008; Scheer, 2008). This would require that cities make choices between a variety of policy instruments, technologies and measures. In this respect, three points appear important:

1. How is the urban energy issue conceptualized? This point is associated with the adoption of the analytical perspective through which key aspects of the urban energy sustainability phenomenon are explored (i.e. structure and characteristics of the examined policy environment, what processes and which actors to study, what is the 'problem area' of the analysis)
2. What policy instruments, powers and measures have local governments at their disposal for sustainable energy development?

3. What policy factors facilitate or constraint local government action in sustainable energy development and in what ways does this take place in local energy policymaking[19]?

These three issues are discussed in sections 2.4., 2.5., and 2.6.

2.4. Analytical Perspectives to Explore Urban Sustainable Energy Development

The way in which the issue of local energy sustainability is conceptualized is closely related to what role is considered as legitimate, or feasible, for cities in this policy area, and the type of action that would be effective to promote sustainable energy.

Three theoretical models have been primarily proposed in the literature to explain the issue of urban sustainable energy development. These are the techno-economic perspective, the governance-informed perspective and the socio-technical perspective. These analytical approaches provide distinct insight on how urban energy development takes place, and what role cities have in these initiatives[20] (Bulkeley & Broto, 2012; Hodson & Marvin, 2010; Guy, 2006).

The techno-economic perspective on local energy development perceives localities as fixed territorial spaces where energy flows and greenhouse gas emissions can be accounted and managed based on information sharing and the transfer of best practices across local areas. This perspective assumes a linear policymaking process

[19]Points 2 and 3 refer to local governments, and not the city at large, since traditionally the former have been the leading actor in local energy sustainability, and there is a substantial body of relevant empirical research that can be helpful to identify key policy variables of the topic.

[20]It is recalled that the analytical approach of the study draws on the governance-informed and socio-technical perspectives.

for local energy development and pays little attention to socio-political dynamics that take place in relation to energy development in urban areas. In essence, it perceives the city as a kind of 'black box' where energy can be managed based on techniques of energy accounting, information and sharing of best practices (Bulkeley & Betsill, 2003).

The governance-informed perspective, as initially applied to explain urban sustainable energy responses, has primarily conceptualized local energy change in terms of the development of new forms of policy and planning, and as such driven mostly by institutional and political processes. In this regard, local energy change is seen through the concept of 'policy change', and how key policy factors, like leadership, capacity, and resources, facilitate or constrain action.

A commonly used analytical approach of the governance-informed perspective has been the 'multi-level governance' framework which diverts from linear policy models of environmental policymaking that pay little attention on the role of policy dynamics[21], and policy premises that inherently match sustainability with local action (i.e. new urbanism), by adopting a more critical view on the role of processes and actor interactions within a multi-level policy environment (Bulkeley & Betsill, 2003).

Contrary to linear policymaking models, in this perspective the multi-level policy scales are not considered as separate entities but as dynamically structuring and reproducing each other (i.e. changes in political and socio-economic relations that

[21] For example, by assuming a top-down policy model where international agreements are translated into national environmental plans which are then implemented at the local level. This conceptualization has its origins in the discipline of international relations; hence the importance that it assigns to the role of the state in global environmental policymaking and the little attention it gives to the urban scale and policy dynamics in local energy policymaking (Bulkeley & Betsill, 2003).

take place in a single scale impact relations in all other scales) (Bulkeley, Broto & Maasen, 2011).

While the multi-level governance perspective has been effective in providing a coherent framework to analyze how authority, responsibility and resources are distributed vertically between levels of government and horizontally between spheres of authority, and the effects of this on how urban energy responses are structured and contested, it has conceptualized local energy change as being mostly the result of decisions and processes located outside the city (Bulkeley, Broto & Maasen, 2011).

In addition, it has mainly focused on the energy role of local governments, and the core policy areas through which energy development in the city is understood (i.e. municipal energy planning, housing, transport). In this regard, it has paid little attention to the various ways through which agency and authority for urban energy development is dynamically developed within the city (i.e. in terms of networked forms of governance, socially-driven initiatives, urban investment strategies, low-carbon local economic development), and the role of a diverse socio-political body of actors in such initiatives (i.e. civic sector, incumbent energy players, academic institutions, local community) ((Bulkeley, Broto & Maasen, 2011).

Based on this body of knowledge, a growing area of scholarly work is recently placing more emphasis on how agency and possibilities for local energy development are shaped by the action of a diverse set of actors that cut across the public, private and civic sectors ((Bulkeley, Broto & Maasen, 2011; Hodson & Marvin, 2011).

At the core of this perspective is the premise that cities, as entities located within a multi-level governance system, are likely to largely shape their energy responses, as opposed to acting solely as ‘receivers’ of energy change from the external environment (Hodson & Marvin, 2011).

In response, thus, to energy and carbon imperatives which increasingly create pressures on cities to take energy sustainability action (i.e. state carbon regulation, demand by local residents and firms for resource use and energy infrastructure that reduce energy costs and environmental impacts; environmental branding of cities; competition between cities for investments on energy sustainability), the relative position of cities within their respective governance system and urban hierarchy (national or global) is critical regarding their differentiated capacity to shape their energy trajectory (While, 2011; Hodson & Marvin, 2011).

From a governance perspective, this raises the point of how are cities conceptualized in relation to urban sustainable energy development. In particular, are cities conceived as a scale which receives energy change from external scales (i.e. the national level)? If so, is it likely that different socio-political interests located within the city can mediate the imposed energy change, for example by accelerating, reshaping or even disrupting its implementation in the local context? If urban socio-political configurations can mediate external energy change, is it possible that they can develop ability to define and put in practice their own urban energy plan that is to an extent independent from external conditions and processes? And, finally, is it even possible to view cities as entities that develop sustainable energy initiatives and standards at the urban level, which are incorporated into external policy contexts and programs (i.e. the national level) that are then downscaled back to the local level? (Hodson & Marvin, 2011).

In this analytical perspective, a key issue is the city's 'location' within the multi-level governance environment in relation to 'energy change', or conversely where is 'urban energy change' located within the multi-level system. In addition, this perspective suggests that agency and power in relation to urban energy are not necessarily bounded to conditions, processes or actors located in a single dominant scale ((Bulkeley, Broto & Maasen, 2011).

It rather suggests that decisions and regulatory and network arrangements in relation to local energy operate across and within scales of action where differentiated sets of power relations define the relationships between these scales of action. In addition, these power relations are variably organized in relations to different cities. Questioning, thus, the relationship between these scales of action enables to have a more accurate representation of the policy dynamics that take place in relation to urban energy development (Hodson & Marvin, 2011, (Bulkeley, Broto & Maasen, 2011, While, 2011).

The socio-technical perspective on urban energy, finally, explores the dynamics of systemic changes that urban energy systems undergo through the lenses of a multi-level analytical perspective[22] that includes three interrelated levels of organization; a broad landscape of institutions and norms, a socio-technical regime which structures the ways in which the energy system operates, and niche experimentation which challenges the dominant practices of the energy regime (Geels & Schot, 2007; Bulkeley et al., 2011a).

[22]Different analytical perspectives have been employed in the analysis of socio-technical systems. The multi-level perspective has been the one more explicitly engaged with the challenges of sustainability and the transformation of energy systems (Bulkeley et al., 2011a).

Socio-technical system change is, hence, achieved through the interactions of these three levels of organization. The socio-technical regime locates existing energy technologies and practices within a dynamically stable configuration of institutions, regulations, and systems of governance at the meso-level, in essence forming what can be called as the global energy system; the broader landscape context of conditions, institutions, norms and persistent structures operates at the macro-level (i.e. political cultures, economic growth, cultural values) and exerts on the energy regime pressure for change; at the micro-level, niche experimentation produces innovation which assisted by opportunities created through landscape pressures aims to enter the regime and become a mainstream energy practice (Geels & Schot, 2007; Hodson & Marvin, 2011).

Although the multi-level perspective on socio-technical system analysis has explicitly engaged with the topics of sustainability and energy systems change, it has paid little attention to issues of scale, context and socio-political sensitivity in explaining energy transformation. For example, it has predominantly adopted a national focus in which urban energy systems are viewed as relatively indistinguishable from the national energy system. In addition, issues of agency and political contexts in the production of socio-technical energy innovation have not been adequately accommodated ((Bulkeley, Broto & Maasen, 2011).

Gaining, hence, more understanding on how systemic change in urban energy systems is undertaken requires the adoption of a more critical perspective on the spatial and socio-political particularities relevant to the transformation of these systems ((Bulkeley, Broto & Maasen, 2011).

The multi-level perspective described to assess the dynamics of urban energy systems forms an overall representation of complex processes through which change takes place in reality. As a result, it should not be perceived to signify an overtly structuralistic or static view of urban energy change. In practice, aspects such as the creation and mobilization of agency within and across these levels, the political aspects of innovation production, and the relationships between the three levels of action (i.e. the influence that also the ‘regime’ may exerts on the ‘landscape’), and the heterogeneous nature of the levels (i.e. the differentiation of the energy regime across nations or cities), need to be taken into account (Späth & Rohracher, 2011; Bulkeley & Broto, 2012).

In addressing such aspects regarding the role of cities in socio-technical energy change, a growing body of analysis places more attention on the underexplored relationship between socio-technical energy change and the urban, by approaching cities as heterogeneous entities where actors, technical artefacts, social learning, material realities etc. may contribute to the formation of distinct urban socio-technical energy trajectories ((Bulkeley, Broto & Maasen, 2011).

Within this broader scholarly work, a particular perspective sees urban energy change as being primarily the result of the mediation of socio-ecological flows by urban socio-technical networks and the everyday practices of the city (i.e. political, social, technical). In that way, an explicit focus is placed on the role of the socio-material realities of cities, and the micro-level action of the myriad of individuals, in relation to urban energy development. This approach, in turn, questions the view that local energy change is primarily determined by the workings of broader politico-economic structures and processes ((Bulkeley, Broto & Maasen, 2011).

At the same time, this type of analysis shifts the attention to a broader spectrum of actors (i.e. mainstream entities such as energy utilities, or non-governmental organizations), and policy issues (i.e. land-use planning and development) regarding local energy change, as opposed, for example, to exclusively positioning the forces of change in socio-technical experimentation. In this regard, a better understanding can be gained regarding the role and action of 'non-traditional' policy actors in urban sustainable energy development which are increasingly acknowledged to have a central position in this area (Bulkeley & Broto, 2012).

This is the case, for example, with the so-called 'intermediary entities' that include both state and non-state actors ranging from government or semi-government energy agencies, non-governmental organizations, utilities, Energy Service Companies, the academic community, trade allies, professional associations, and so on. These entities have an active role in local energy by mediating priorities and interests of stakeholders (policy, social, regulators funders etc.), as well as implementing plans and measures through various tasks (i.e. energy auditing, consulting, project management, awareness raising, network building, training, lobbying etc.). Therefore, assessing the role of such actors in local energy can add insight regarding how urban sustainable energy development takes place, by whom, and with what implications (Hodson & Marvin, 2011).

The three theoretical perspectives on urban energy that were discussed are not mutually exclusive, or in clear-cut boundaries, but they rather have overlapping aspects. For example, While (2011) uses a governance-informed perspective to explore the impact that state rationale for strategic carbon control may have on local political decision-making and financial arrangements related to urban development.

The author discusses the extent to which carbon management currently intersects with urban governance processes and principles that define local development and restructuring[23]. In doing so, the city is conceptualized as an integrated socio-economic space where application of carbon accounting techniques could open-up possibilities for low-carbon strategic local action through the management of local emissions (While, 2011).

Similarly, the socio-technical perspective explores the diversity of urban climate change action through the lenses of 'experimentation'. Here, innovation is seen to involve not only technical advances, or learning and social networks through bottom-up forms of action, but also activities taken by mainstream actors such as governments, firms, donor organizations, mainstream building companies or third sector organizations (Bulkeley & Broto, 2012).

In this context, the analysis also places focus on the political economy aspects of energy experimentation in order to assess how power relations and interests shape such initiatives, and, hence, the ways through which they challenge established power relations regarding local energy (Bulkeley & Broto, 2012).

[23]To offer an example, this kind of analysis would assess the extent to which carbon management considerations drive changes in the things that are valued in an urban context, and in the ways through which the evaluation takes place. For instance, is carbon mitigation becoming solely a new factor in financial cost-benefit analysis of urban decision-making or also an aspect which contributes to a re-organization of economic principles in the decision-making? This example raises the broader issue of the extent to which energy sustainability and climate change can catalyze, and become part of, new methodologies and practices upon which urban governance is exercised (While, 2011).

2.5. 'Problem Area' and Scale in Urban Sustainable Energy Development

If the urban energy issue involves a plethora of actors and practices within a multi-level policy environment, what 'problem area' and scale of action is associated with comprehensive urban sustainable energy development?

The definition of the 'problem area' in urban energy sustainability is closely associated with the setting of the 'action boundary' of the policy area in question, and as a result with the type of policy issues that are constituted as 'visible', hence legitimate or feasible to address. As such, the adopted 'problem area' in urban energy influences the type of policy instruments that can be employed to address the policy issues at stake.

Overall so, the chosen 'problem area' of the analysis becomes critical for the evaluation of urban sustainable energy policies. To offer an indicative example, if cities perceive their energy responsibility extending within their geographical boundary but no spatially further, then this will likely narrow-down their potential action area and possibilities, as wider policy aspects related to local energy sustainability will not be taken into account.

For example, in discussing the role of the business sector in climate mitigation in Hong Kong, Chu and Schroeder (2010) suggest that the local administration downplays the importance of achieving air pollution and greenhouse emissions reductions through citywide action under the argument that most of the area's manufacturing industry is located at the regional level, hence their operation is out of the responsibility of Hong Hong's administrative jurisdiction. Similarly, Brody et al. (2010) suggest that local climate mitigation should be primarily organized at the regional scale where a large number of greenhouse gas emitters can be affected.

As the above discussion highlights, two aspects need to be taken into account in relation to the definition of the ‘problem area’ in urban energy sustainability: the energy system boundary, and data availability and quality issues in urban energy measurements and assessments (Grubler et al., 2012). These two aspects, which are critical in evaluating, both from a quantitative and policymaking point of view what counts as ‘urban energy’, are summarized below.

With respect to the system boundary, two issues need to be considered in more detail. The first is the spatial and functional definition of the urban energy system under consideration. More specifically, is the city definition referring to the core part of the city alone, or does the assessment include the larger metropolitan area as well? For example, a study of fossil-fuel use in Paris, the suburban area, and the larger Parisian metropolitan region found that per capita consumption was lowest in the city of Paris, and increased as the unit of the analysis was expanding (Grubler et al., 2012).

This result is due to a combination of factors. On the one hand, the lower transportation energy that is required by areas of higher population density (in central Paris compared to its suburbs). On the other hand, with the move towards the metropolitan level more energy-intensive industrial activities located beyond the city center are included in the system boundary (Grubler et al., 2012).

This example, hence, is indicative for the importance of the definition for the ‘urban’ that is used in the accounting of local energy and greenhouse gas emissions. As a result, comparisons across local energy and emissions inventories that have been completed with different spatial scales can be very sensitive to these scales. IEA’s recent estimate that urban areas account for 67% of global energy consumption (for year 2008) has used the United Nations definition of ‘urban’ (Parshall et al., 2009).

United Nations publishes statistics on urban and rural population for each country. However, these data do not use a standardized international definition of ‘urban’, but rather individual countries are asked to establish their own definition in accordance with their needs[24] (Parshall et al., 2009).

In the case of the U.S., several systems for classifying population settlements as ‘urban’ or ‘rural’ have been suggested. For example, the classification system of the Census Bureau divides between ‘urbanized areas’, smaller, less dense ‘urban clusters’ and non-urban based on population sizes and densities[25]. This definition of urban areas gives the most accurate representation of where urban people reside, but its spatial boundaries are not necessarily in alignment with the administrative boundaries of population places, i.e. cities, counties, or towns (Parhsall et al., 2009).

An alternative to the Cencus classification system is the U.S. Office of Management and Budget’s Metropolitan and Micropolitan Statistical Areas classification where areas are constructed based around an urban core and adjacent counties that reveal high economic integration with the core[26] (Parshall et al., 2009).

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[24]The only international spatial dataset that defines urban boundaries is the Global Rural-Urban Mapping Project’s ‘urban extents’, but in the case of U.S. these boundaries do not correspond to any of the definitions of ‘urban’ (Parshall et al., 2009).

[25]The Census classification is: Urbanized areas: > 50,000 people, minimum of 1000 people/mile^{2}population density; Urban clusters: > 2,500 people, minimum of 500 people/mile^2 population density (Parshall et al., 2009).

[26]U.S. metropolitan areas, too, do not separate between urban and rural areas, they may span several states and although they can have an informal role in regional

In addition, county-based classification systems for the ‘urban’ have been proposed in the U.S. that attempt to improve the metropolitan/non-metropolitan division by taking into account features such as population size or whether metropolitan counties are part of the urban core. Nevertheless, most of these systems tend to leave outside a key element of the Census definition of ‘urban’, that is population density thresholds, and as such they do not explicitly distinguish between urban and rural areas (Parshall et al., 2009).

A county-based system that attempts to offer a more clear urban/rural distinction has been proposed by Isserman (2005) as cited in Parshall et al. (2009) which uses the Census definition of urban areas to classify U.S. counties into urban, mixed urban, mixed rural, and rural types. According to this classification, a county is classified as urban if its population density is as least 500 people per square mile and at least 50,000 people of the county live in urban areas making-up minimum 90% of the total population[27] (Parshall et al., 2009).

Depending, then, on the definition of urban that is used when measuring energy consumption attributable to urban activities, the results can vary significantly

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governance they are not recognized as a formal branch of local government, a factor which reduces the value of metropolitan-scale energy data to local policy makers in energy planning. In the U.S., there are approximately 360 metropolitan areas (Parshall et al., 2009).

[27]Similarly, population size and density criteria define mixed-urban counties, rural counties, and mixed-rural counties. This classification system tends to include the core parts of major urban centers but it excludes smaller cities and suburban regions. For instance, in California the system classifies only the urban cores of San Francisco and Los Angeles as urban, although the majority of the state’s counties are within metropolitan areas (Parshall et al., 2009). Philadelphia has a status of both city and urban county (Philadelphia Charter Commission, 2011).

due to differences in the classification systems. For example, assessment of energy consumption in U.S. urban areas based on urban/rural classification systems such as those described above finds direct fuel consumption in buildings and industry to range between 37% and 86%, and on-road gasoline and diesel consumption to range between 37% and 77% depending on how these areas are defined[28] (Parshall et al., 2009).

The authors suggest that a county-based definition of urban is preferable in urban energy accounting compared to other common definitions since counties are the smallest political unit for which energy data are collected in the U.S. Nevertheless, a county scale-inventory would directly support mostly energy initiatives at this scale. Although certain U.S. cities are defined by county boundaries (i.e. San Francisco, Denver, Philadelphia) or groups of counties[29] (i.e. New York City's five counties) and counties are a recognized political unit with some authority to formulate local policies, they rarely have the same powers on energy policy available to local governments (i.e. land-use, transportation planning etc.). Locating, hence, local energy planning to the county-level, rather than to political units of 'populated places' (i.e. cities, towns), would be problematic (Parshall et al., 2009).

Furthermore on the urban energy boundary issue, does the definition of the system include bunker fuels, that is transport fuels which are used outside of the

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[28]The lowest figures of 37% refer to the described system that classifies counties into urban, mixed urban, mixed rural, and rural, and the upper figures refer to the U.S. Census urban/rural classification system (Parshall et al., 2009).

[29]In other cases, counties include multiple cities (i.e. San Diego County) (Parshall et al., 2009).

spatial system boundary, i.e. in national and international territory, or not? Similarly, what is the urban energy system under consideration in the energy accounting approach? For instance, is primary[30] or final[31] energy reported, and to what extent is a lifecycle perspective for the fuels provision followed? (i.e. upstream energy conversion losses and associated emissions) (Grubler et al., 2012).

Furthermore, is the embodied energy[32]that is associated with the use of materials and goods in the urban area (i.e. other than energy carriers that are directly consumed in the area) considered? In this regard, comprehensive urban-energy accounting methodologies would need to add the imported embodied energy to accounts of direct energy use, whereas the embodied energy of exports from the urban area to the outside environment should be subtracted (Grubler et al., 2012).

Adopting, hence, a consumption-based accounting approach is likely to give a very different picture of urban energy use and greenhouse gas emissions compared to production-based methodologies that are currently the standard approach in urban energy accounting, and which normally account for direct energy flows either

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[30]Primary energy comprises all energy forms as extracted from nature (i.e. crude oil) within a system (i.e. city) or imported from outside the system boundary under consideration (i.e. gasoline or biofuel imports to a city) (Grubler & Fisk, 2013).

[31]Final energy is the energy that is consumed by the end-users (i.e. electricity or natural gas for households, businesses or industry). Final energy has usually undergone several stages of transformation, transportation, and final distribution before delivered to the end-user (Grubler & Fisk, 2013).

[32]Embodied energy is the primary energy that is required to produce and transport the goods and services that are imported to and exported from an urban area as opposed to direct energy flows which are used directly as fuels in an urban area (Grubler & Fisk, 2013).

consumed as final energy by households, industry, services and the public sector or used as secondary[33] and primary energy in the upstream energy transformations that deliver the final energy[34] (Grubler & Fisk, 2013).

To offer an indicative example for this likely different picture on urban energy use and emissions under different accounting methodologies, in 'world cities' like New York and London, air and maritime bunker fuels have been estimated to add-up for as much as one-third of direct final energy use (Grubler et al., 2012).

For the city of Seattle, U.S., application of a consumption-based methodology to estimate per capita greenhouse gas emissions put their level for 2008 at about 25 tCO_2e which is several times more than the7 tCO_2 e/per capita estimated for the same year for the city's 'core emission areas' of building energy use, transportation energy use, and waste generated within the city (Lazarus et al., 2013).

Regarding the issues of data quality and availability in relation to urban energy system boundaries, important aspects include whether actual statistics or extrapolated/downscaled data are employed in the analysis, and whether the assessment includes non-commercial energy sources (i.e. traditional biomass or heat recovery from waste incineration) (Grubler & Fisk, 2013).

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[33]Secondary energy is the energy sources that are extracted and/or transformed within the energy sector between the primary and final energy levels. Examples include refined fuel oil products that feed oil-fired electricity generation or natural gas that fuels a district-heating plant (Grubler & Fisk, 2013).

[34]Hence the production-based approach is often referred to as 'territorial' accounting, since its system boundary is defined primarily through the geographic or administrative boundaries of the area in question (Grubler & Fisk, 2013).

Furthermore, what is the spatial and temporal resolution considered in the calculation of the fuel mix for electricity supply in the urban area, and whether differences in aspects such as the technology or efficiency of power plants and other energy conversion processes are recognized in the accounting method[35] (Grubler & Fisk, 2013).

In general, cities use production-based methodologies to develop their energy use and greenhouse gas emissions inventories by typically accounting total final consumption within their local territory, including imported energy such as heat and electricity that is generated outside an urban area, but excluding energy lost in generation, transmission, and distribution (Parshall et al., 2009).

Consumption-based methodologies are sparsely used in urban energy reporting analysis[36], but it is increasingly acknowledged that this kind of methods

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[35]For example, defining which power plants serve a particular local area and in what proportion can be difficult since several power plants may generate electricity, which is transmitted over long distances before consumed in the urban area, and given that different distribution network operators may serve the area. Hence, the statewide average fuel mix is typically used to derive local greenhouse gas emissions estimates from electricity consumption. Analysis for the case of New York City suggests that the state fuel mix can differ substantially from the urban fuel mix since around 57% of the city's electricity demand is met by in-city power plants, nearly all using natural gas, while the remaining electricity is imported from fossil, nuclear, and hydro power plants located in upstate New York, New Jersey, Pennsylvania, and New England. Using statewide averages, hence, can obscure differences achieved in local carbon intensity as a result of local efforts to purchase cleaner sources of electricity or to support cleaner local electricity generation. Developing methodologies that derive local-scale sensitive fuel mix factors could, thus, improve local energy and greenhouse gas emissions inventories (Parhall et al., 2009).

[36]When narrower system boundaries are applied, sensitivity analysis on the effects of inclusion of system components that are omitted can help-out to put reported data into a proper perspective (i.e. complementing final energy use with estimates of corresponding primary energy needs) (Grubler et al, 2012).

should be used in urban energy accounting in order to have a more accurate picture of the true energy use of cities[37] (Grubler et al., 2012).

Finally, data disclosure and documentation of assumptions and methods that are used in the urban energy accounting are necessary not only from the perspective of data quality and reproducibility but also as key information for well-informed policy choices (Grubler et al., 2012).

As the discussion, thus, suggests comprehensive definitions of urban energy systems need to consider the impact that local energy initiatives likely have outside of the city's spatial or administrative boundaries by capturing interactions and

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[37] One of the few available standardized consumption-based energy and greenhouse gas methodologies that allow cross-city comparison, benchmarking and policy assessment is the 2010 United Nations *International Standard for Determining Greenhouse Gas Emissions for Cities* (United Nations Standard) which promotes a harmonized protocol for quantifying greenhouse gas emissions attributable to the local and regional level. On the top of the standard reporting of local greenhouse emissions from energy, industrial processes, waste agriculture, forestry and other land-uses that is widely used in accordance with the Intergovernmental Panel on Climate Change's guidelines for national inventories, the United Nations Standard records domestic and international emissions from aviation and ships carrying passengers or freight away from cities, while it also requires separate reporting of embodied emissions linked to the consumption of imported goods. The application of this methodology for Hong Kong puts the region's per capita greenhouse gas emissions among the highest ones compared to production-based emissions reported by affluent economies of the world (i.e. U.S. and Australia) (Harris et al., 2012). The use of non-standardized methodologies can lead to significant discrepancies in the type of greenhouse gas emissions reported by cities. For example, Kennedy et al. (2012) used the United Nations Standard for reformatting the self-reported emissions inventories of Berlin, London, Boston, New York, Seattle, and Greater Toronto Area. The authors suggest that the results of the analysis should be interpreted with caution due to the different approaches followed by the sampled cities in their self-accounting. For example, regarding waste Seattle reports emissions from closed landfills located within its city boundaries, Toronto and New York include also emissions from waste exported from their area, Berlin totally excludes waste emissions from its inventory, while London is not reporting residential waste emissions (Kennedy et al., 2012).

interdependences of an urban area with its outside environment through the exchange of economic goods, services and people. Ideally urban energy reporting would adopt as wide systems boundaries and complementary accounting frameworks as is reasonably possible and available data allow (Grubler et al., 2012).

With respect to urban energy system boundaries and local energy sustainability policymaking, in certain cases urban sustainable energy initiatives should be organized at the city-regional level for logistic or market reasons, as the analysis by Ogden and Nicholas (2011) on the demand creation for hydrogen-based private transportation in Southern California through ‘cluster infrastructure’ interventions reveals.

In addition to action at the local to regional level, cities participate in horizontal and vertical energy and climate policy networking either at the national or international level; for example, cities form urban sustainability networks where energy is part of the working agenda, while a few world cities like Tokyo or London consider participating in carbon emissions trading schemes (Gore and Robinson, 2009; Bulkeley & Newell, 2010; Salon et al., 2010).

Complementary, thus, with the discussion in sections 2.3 and 2.4 on the conceptualization of the urban energy issue, the above discussion on energy system boundaries and policy organization related to urban sustainable energy development suggests that a more comprehensive analytical view requires that the ‘urban energy area’ is perceived as a dynamic and open policy field where responses are shaped through scalar and networking relationships that take place within a multi-level policy environment and involve society at large (Bulkeley & Schroeder, 2011).

The ‘multi-scalar’ aspect in urban sustainable energy development, however, should not be translated into searching for an ‘appropriate’ scale of action (i.e. the meso-level) in order to maximize policy effectiveness. It rather suggests that urban energy initiatives are formed through actors’ interactions across and within policy scales where identification of potentials for action increases chances for policy success ((Bulkeley, Broto & Maasen, 2011; Geels & Schot, 2007).

Yet, as described in section 2.4, within this multi-level policy environment there are systems of rules and a distinct organizational and energy infrastructure level that are structurally related to wide urban sustainable energy development. This ‘action and infrastructure level’ involves energy development and energy systems configurations at the citywide level (Geels & Schot, 2007).

Placing the analytical focus, overall, at the citywide level can allow examining action and outcomes that take place at various levels of organization (i.e. at the citywide level or topically within the city) by looking at initiatives in diverse urban sectors or sites.

In addition, it resonates with the rationale that cities adopt an overall direction towards fundamental changes in their existing system of energy service provision through reductions in fossil fuel use and greater use of energy efficiency and renewable energy (Droege, 2008).

Based on the above, the study places the scale of the analysis at the citywide level and initiatives that feed directly into the energy infrastructure of the city, i.e. the electricity grid or the built environment of the city.

Section 2.6 discusses the types of policy instruments, powers and measures that cities can typically apply in order to promote energy sustainability.

2.6. Instruments, Powers and Measures for Urban Sustainable Energy Development

Cities have at their disposal various policy instruments, tools and techniques for sustainable energy development and may have accumulated over time large experience in implementing energy efficiency and renewable energy measures (Byrne et al., 2007; Hammer, 2009). Local governments can use legislative, financial and planning instruments or undertake advocacy and outreach initiatives for sustainable energy development across all sectors of the urban economy and types of energy users (Hammer, 2009; Sperling et al., 2011).

Typical examples of sustainable energy measures pursued by local governments include energy efficiency in city-owned buildings; land-use planning for sustainable transportation; planning provisions for the location, or design, of the built environment that promote energy sustainability; financial incentives for energy efficiency and renewable energy uptake, enforcement of the energy conservation specifications of building codes; legislation that encourages or mandates energy efficiency and renewable energy use; procurement of sustainable energy equipment for city-owned facilities; and education, advocacy and outreach activities for sustainable energy development (Hammer, 2009; Bulkeley & Betsill, 2003).

Some of such measures can directly impact the patterns of energy supply and demand in urban areas. For example, the London Borough of Merton adopted in 2008 legislation that mandates new commercial sites to meet certain requirements for on-site renewable energy use. The measure was replicated by other U.K. local authorities before becoming part of national energy legislation and hence being available now to all local authorities that would want to pursue such a measure (The Merton Rule, 2008; Office of Public Sector Information, 2008).

In certain cases, however, local governments are constrained from using direct legislative measures to ban, or impose, a particular energy activity because they lack authority to do so. For instance, improvements in the energy efficiency of the existing building stock offer opportunities for large energy reductions in urban areas. However, local governments are unlikely to have the authority to require existing buildings to meet improved energy performance standards. Local governments would instead have to use collaborative means to promote energy efficiency in existing buildings of their area (Hoppe et al., 2011).

What the above examples highlight is that local authorities may need to adopt a multi-faceted policy role through various modes of agency, i.e. self-governing, regulation, enabling or partnership, in order to contribute to sustainable energy development at the citywide level (Bulkeley & Broto, 2012).

From the range of policy instruments and measures that could be used for urban sustainable energy development, what local governments can actually adopt in practice is closely related to the type of policy constraints and opportunities that they face in their particular context. Sections 2.7. and 2.8. review such constraints and opportunities for local governments by drawing on examples from the international experience.

2.7. Internal and External Policy Constraints for Local Government Sustainable Energy Development

Local governments face constraints in sustainable energy development within a multi-level policy scale. These can be categorized into internal and external ones. Internal constraints are mostly related to the internal conditions and administrative structures of the local government. External constraints are those for which local governments have less or no control over, i.e. they are defined by other actors or by processes that can be little influenced by the local government. Sections 2.7.1. and 2.7.2. overview these two types of constraints.

2.7.1. Internal Constraints

Local governments have accumulated experience in delivering national environmental policymaking while their sectoral expertise can be used for energy and climate policy development (Jollands 2008, Borgstede et al. 2007). Local governments have also developed analytical and practical capacity, such as technical knowledge, administrative skills or strategic planning and tools, for comprehensive action on sustainable energy development (Byrne et al., 2007; Fleming & Webber, 2004; Droege, 2008; Sippel et al., 2011).

Internal institutional constraints, however, can limit the capacity of local governments for sustainable energy action. For instance, lack of time, funding and staff are found to be typical barriers that local governments face in developing or implementing sustainable energy policies (Sippel et al., 2011).

To offer an example, the City Council of Milwaukee appointed in the early 2000s an Environmental Policy Coordinator to promote climate protection across the city administration. This position was hosted in the Department of Public Works where energy management was not part of core duties. This meant that the position had no permanent home or institutional support. At the same time, the coordinator was a political appointee, and this further constrained his work across city-departments (Bulkeley & Betsill, 2003).

Sustainable energy development is also a new type of activity for local governments which requires the adoption of new practices and ways of doing things. It is thus likely to conflict with established local government organizational norms and administrative procedures. For example, the increasing scarcity of public funding pushes local governments to look for alternative ways in order to raise financial resources for energy efficiency and renewable energy development (Bale et al., 2012).

This could include, for instance, novel public-private partnerships to raise the necessary up-front capital for project development or the creation of self-sustaining revenue streams through the city-government for the continuation of projects, for example through the recycling of revenues created by selling own-generated power to the grid[38](i.e. feed-in energy tariff legislation offers such an option to U.K. local authorities). Such practices, however, are likely to sit uncomfortable with the existing cultural ethos of U.K. local governments (Bale et al., 2012).

Due to such kind of constraints, local governments may adopt an ad-hoc approach on energy policy where bid proposals are submitted and projects implemented whenever funding becomes available. For instance, this is the case with

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[38]For example, national legislation offers such an option to U.K. local authorities through feed-in tariff mechanism (Bale et al., 2012).

several U.K. and Danish municipalities where a 'chasing the money' tactic has been largely followed in local energy sustainability. While this approach has been successful in fostering single projects in the record of local governments, it does not tend to contribute towards a more comprehensive municipal energy approach that would promote wider impacts, at the citywide level, through systematic and coordinated policy action[39] (Fleming & Webber, 2004; Sperling et al., 2012).

2.7.2. External Constraints

Local government capacity for sustainable energy development is constrained by external factors over which they have little or no influence. A key such constrain is the lack of legal powers and a statutory duty on energy issues which can significantly limit the ability of local governments to take action in energy sustainability. For example, U.K. local authorities have typically limited authority over patterns of energy supply and demand in their local area, and a main reason for this is the lack of statutory duty that would assign authority and programmatic responsibilities for such type of activities (Foxon et al., 2013; Bale et al., 2012).

This reduced authority of U.K. local authorities over energy policy issues is, among other things, related to the broader national policy frameworks and directions in relation to energy policy. For example, the liberalization policy for the energy industry that was adopted by the U.K. government since the late 1970s has weakened opportunities for local governments on energy service provision through the operation of municipally owned utilities. For reasons such as those described above, energy is a

[39]Various examples of cities that take substantial action on sustainable energy development exist. Relevant information is provided in section 2.8.

domain that in general falls outside the core responsibilities and mainstream action of U.K. local authorities (Foxon, 2013; Bale et al., 2012, Bulkeley & Betsill, 2003).

The influence of the liberalization of energy markets on the ability of local governments to take action in energy sustainability is also observed throughout diverse contexts, for example at the European Union level. For instance, energy market liberalization and the privatization of municipal energy utilities has been a critical factor why the city of Berlin lost its formal power and oversight in regulatory, operational and financial provisions over energy issues (Monstadt, 2007).

In the region of the U.S., state rules on the structure and ownership of the electricity industry passed almost a century ago influence the current capacity of New York City on energy policy matters. More specifically, in 1907, state regulation revoked local control over the electric utility industry by putting it in the authority of state regulators. As a result of such provisions, New York City is currently in a weak policy position regarding decisions on key aspects of the electric industry including the setting of electric price rates, the location of planned power-plants and the type of fuel-mix used for local and regional electricity generation. Currently, the City can provide input to state regulators on such issue, and it actually does, but its ability to establish market rules and structures that would promote local renewable energy development is limited (Hammer, 2008).

Partly for this reason, New York City has primarily adopted a ‘leading by example’ energy policy approach that is based on legislation, guidelines, and voluntary action to promote energy conservation and renewable energy in city-owned facilities (buildings and vehicle fleets) and influence the type of fuel used in those modes of private transportation in cases where it can exercise such regulatory control (i.e. adoption of natural gas and hybrid-electric taxicabs) (Hammer, 2008).

The above examples, hence, reveals the importance of the city's 'location' within its broader energy governance system in relation to the type and level of control that it can exercise over policy issues critical to local sustainable energy development. They also suggest that the relational regulatory relationships between levels of government within the broader governance environment and the dynamics of energy ownership, in general, limit the regulatory, financial and operational powers of cities over energy issues.

However, rather than assuming that such conditions and restructuring processes operate within a 'zero-sum power context' where responsibilities and authority simply transfer between institutional actors, typically at the expense of the public sector, the analysis suggests that the public actors still have a critical role to play in sustainable energy policymaking, albeit one that needs to be re-defined (Monstadt, 2007).

For instance, in the mentioned example of Berlin, although the local and regional governments have now less regulatory control and oversight over energy policy matters, they exert several key functions for local energy sustainability. First, despite the wave of energy liberalization in Germany, municipal energy utilities still possess power, financial resources, information, knowledge and skills to influence economic development, socio-technical innovation and environmental service provision. Second, the delegation of former public responsibilities on energy to the private sector implies new regulatory tasks for the public sector in the Berlin area such as the development of professional contractual management specifications and the evaluation and supervision of the performance of the private sector on the energy projects that they undertake (Monstadt, 2007).

Third, local and regional public policies can play critical role in developing functional regional economic spaces that promote energy sustainability, for example by promoting the professionalization of new market participants in the fields of renewable energy, energy services and technology innovation (Monstadt 2007).

Fourth, the liberalization of energy markets and the development of energy service markets opened new opportunities for improving energy efficiency and purchase management in the public sector of the city where adoption of innovative energy contracting models has contributed to energy efficiency in public buildings, municipal energy costs reductions, and location of innovative energy service companies in the area (Monstadt, 2007).

A second major external constrain for local energy sustainability action is the fragmentation of policy responsibilities and resources across policy levels and actors. For example, in the federal systems of Canada and Australia, cities, as political entities, have been established under the premise of being ‘creatures of the states’. This condition defines their overall position within the hierarchical governance system of which their part of. As a result, in general, cities in these two countries tend to assume a secondary policy role in relation to higher levels of government (Jones, 2012).

In local climate policy, this implies that the federal and state/provincial governments tend to impose policies to the local level rather than cooperating with local governments in such matters. Hence, mayors of large cities in both countries argue that climate policy effectiveness in their urban areas could be improved through policy cooperative mechanisms between levels of government (Jones, 2012).

For instance, the city of Vancouver, Canada argues that it has limited authority over the most significant sources of local greenhouse gas emissions. Melbourne City Council, too, suggests that accountability on citywide carbon dioxide emissions reductions targets should be divided between levels of government (Jones 2012).

Similarly to climate policy, local governments in Australia have also little input in regional transportation planning which is defined primarily at the state level. Hence, they have limited jurisdiction on major issues of transportation development such as the choice of freeway routes. In addition, although Australian cities can own public transportation systems, their management might likely take place at the regional level and, thus, become less sensitive to local transportation needs (Bulkeley & Betsill, 2003).

The New York City's congestion pricing proposal is another example of how progress in sustainable urban transportation can be hampered by divisions in policy responsibility. The proposal needed authorization by the state legislature but did not receive it due to opposition of members from suburban parts of the New York metropolitan region (Schaller, 2010).

Energy management in the built environment of the city of Leicester, U.K., reveals, too, how contradictions between central and local policy contexts can constraint the capacity of local governments to take action on energy. In the 1990s, the central government directed new policy evaluation indicators according to which local councils take into account the environmental impacts of their policy goals and service delivery (Bulkeley & Betsill, 2003).

However, organizational reforms in local governance resulted in decentralization of public services and property management operations to the private sector. Consequently, Leicester City Council lost authority over energy management in city-owned sites while the decentralization of property management eroded the benefits of economies of scale in energy efficiency investments (Bulkeley & Betsill, 2003).

Competing policy interests are also likely to oppose energy reforms promoted by local governments. This is evident in cases where control of local electricity supply is at stake. In San Francisco, California a policy coalition driven by the local government, local NGOs and the local community has sought over the last twenty years to transform the privately operated electricity system of the city into a more sustainable one. As a result of this action, successive state and city legislative provisions offer now the opportunity for municipal electricity production and procurement to cover aggregated customer electricity demand through which greater adoption of energy efficiency and renewable energy is envisaged (Hughes, 2009a).

Such policy arrangements have been opposed over time by Pacific Gas & Electric (PG&E), the private regional energy utility that serves the region. The utility argues that assigning, initially, local residents to the default position of municipal electricity service provision, as the law specifies, raises concerns over market and civil right issues, and potential socio-economic implications for low-income households (Hughes, 2009a; San Francisco Bay Guardian, 2011).

While the policy coalition in San Francisco perceives the grid as a liability asset and expresses no plans for its ownership, in other cases the urban energy system is seen by municipalities as a strategic asset whose ownership can serve public policy energy goals and community well-being. For instance, the city of Austin, Texas owns Austin Energy, a municipal utility which supplies electricity the city. The utility is also part of the city government's administrative structure for energy conservation and renewable energy development and sustainable transportation (Hughes, 2009b).

Conflicting interests in local energy policymaking can also arise in relation to broader urban development plans. For example, in Newcastle, NSW, Australia reductions in car traffic and energy use seem to clash with local economic development plans. The region is a trade and export-oriented hub which is based on port-related activities and tourism. Thus, transportation policies that accommodate an increasing demand are deemed essential for the local economy (Belkeley & Betsill, 2003).

Similar tensions are evident in the energy planning context for the *Paris Il de France* region. While the regional energy goals are commonly shared across political parties, and local and regional public and business entities, controversies emerge over how the overarching policy goals can be achieved. For example, the region's strategic development plan calls for promoting city-compactness to curb urban sprawl. However, what an appropriate, or feasible, level of city-compactness should be in practice is debatable; for example, sub-regional local councils and business organizations have been opposing relevant proposals to restrict private transportation on the basis that such policies will put at risk the economic viability of the region (Coutard & Rutherford, 2007).

2.8. Policy Success Factors for Local Government Sustainable Energy Development

Policy analysis has identified success factors for sustainable energy development in relation to the role of the local government. They can be categorized into those that are more or less important for initial local government energy action, which would normally be at the municipal government level, and those that seem critical for the role of local government to promote energy sustainability across the city.

2.8.1. Policy Success Factors for Initial Action

Certain policy factors appear necessary for the start-off of municipal sustainable energy initiatives. London's case is instructive on the importance of local government leadership for sustainable energy development. Former London's Mayor Ken Livingston was critical in developing the city's energy agenda and institutional initiatives for energy efficiency and renewable energy (Hammer, 2008). Local governments need also initial funding sources to start implementing initiatives, but not necessarily large ones. For example, Woking Borough Council, U.K. started with over $350,000 to develop a revolving funding stream through energy efficiency projects that was later on used to scale-up energy sustainability action in the city (Hammer, 2008).

Empirical evidence suggests, also, that local governments require some level of internal capacity in order to start making decisions and implementing measures on sustainable energy. This includes political leadership, human resources, skills, planning frameworks which incorporate energy considerations, or control over decision making (Bulkeley & Betsill, 2003).

Successful local governments have also developed strong technical knowledge, and project and policy monitoring and evaluation on sustainable energy (Fleming and Webber 2004). Furthermore, clear communication of compelling evidence that things work out is a tactic used by local government practitioners in order to secure funding for sustainable energy initiatives, for example by convincing senior managers of departments to invest in energy efficiency (Bulkeley & Betsill, 2003; Bale et al., 2012).

2.8.2. Policy Success Factors for Action across the City

Once local governments have taken initial energy sustainability action, which would normally be at the municipal level, the next step is to systematize such initiatives and/or engage with the wider community on sustainable energy development. A number of factors appear decisive for making progress in this area. Bulkeley and Newman (2010) suggest that local governments need an expanded policy role, adequate resources, and real power to implement initiatives if the goal is to scale-up their sustainable energy action. Appropriate organizational skills are also required in order that new practices in relation to energy are adopted by city governments (Aylet, 2011).

In addition, solid markets need to be developed for the wider adoption of sustainable energy technologies and systems. Specifically for promoting sustainable energy development at the citywide level, Lund (2011) suggests that policies need to foster market demand, low-cost interventions, and favorable project cost-benefit ratios.

A number of studies have looked from a national and sub-national perspective at the possibilities and barriers for local authorities in energy policy, planning and implementation, while another body of research has explored issues of energy technology implementation at the local level. Both types of analyses suggest that there is interdependence between national and local contexts in relation to local energy sustainability, with the national level either facilitating or constraining action at the local level. In addition, they find that an appropriate level of central government involvement in the form of long-term strategies, legal frameworks, clear guidelines, regional innovation, human resources and funding possibilities have been identified as pre-requisites for solid local energy sustainability action (Sperling et al., 2011; Paez, 2010).

For example, with respect to funding, central level input would involve aspects such as funding provisions to support sustainable energy action (i.e. grants, tax incentives), allocation of federal or state funding conditional on the adoption of sustainability policies (i.e. regional sustainable transportation planning), or policy arrangements that facilitate the development of financial revenue streams for local energy action (i.e. feed-in tariff policy which would allow local authorities to sell renewable electricity to the grid) (Salon et al., 2010; Bale et al., 2012).

In Denmark, the national energy vision for a 100% renewable energy society requires redefinition of the relationship between the central government level and municipalities. This involves that the central government provides clarification on the role of municipalities in this area, and develops a clear energy planning framework and tools for municipalities to facilitate strategic energy action (Sperling et al., 2011).

For example, it would involve aspects such as developing appropriate planning guidelines to support wind power development; offering guidelines and necessary spatial information for integrated heat planning; developing technical standards to support greater penetration of sustainable energy sources (i.e. household appliances, energy storage, flexible electricity/heat tariffs, smart grids, vehicle-to-grid charging); and providing assistance with local energy accounting and measurement through the compilation and release of sub-national energy data and development of consistent methodologies for energy and greenhouse gas emissions inventories (Sperling et al., 2011; Parshall et al., 2010).

In addition, promoting wider local sustainable energy development is facilitated by policy alliances where the role of the local government can be diverse depending on the particular context. For example, it may involve efforts to 're-localize' local energy service provision through public ownership over energy supply and demand in the area, as in the previously-mentioned cases of San Francisco and Woking Borough Council. It may also imply an active involvement by the public sector in energy service through policy coordination and planning as in the case of Stockholm's Hammarby Sjöstad eco-district project that emerged within a context of a municipal government withdrawal from energy service provision[40] (Coutard & Rutherford, 2011).

[40] After selling the municipal electricity utility Stockholm Energi to the transnational energy corporation Fortum (serves Nordic and Baltic countries, Poland and Russia) the municipality of Stockholm managed to involve the private company in

A typical way for assembling policy alliances to promote sustainable energy development at the citywide level is the establishment of public-private partnerships in order to raise the necessary technical, financial, and skills resources for project development and implementation, as in the examples of Woking Borough and Hammarby Sjöstad. Both cases reveal also the critical role of the private sector for large-scale urban energy sustainability projects (Coutard & Rutherford, 2011).

For instance, Woking Borough Council established its own Energy Service Company (ESCO), Thamesway Energy Limited, as a public-private venture to bypass capital controls by the central government on the scale of local government investments that would own and operate a plant for the production of supply and of electricity, and develop and implement technologies for the production and supply of energy (Coutard & Rutherford, 2011).

Through this governance arrangement, Thamesway has mostly used private finance to build and operate several community energy projects, including a small-scale combined heat and power heat and heat-fired absorption cooling system and a private renewable energy system that delivers energy directly to city-owned buildings housing and downtown businesses. Similarly, in Hammarby Sjöstad it was private-based financing that was mainly used for the project (Coutard & Rutherford, 2011).

The use of public-private partnerships was identified as a key delivery mechanism for London's *Green-Light to Clean Power – The Mayor's Energy Strategy* published in 2003 with overarching objectives to reduce the city's contribution to global climate change, help eradicate fuel poverty and contribute to

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environmental service provision projects, including energy. In addition, the municipality kept control of the local heating company (Coutard & Rutherford, 2011).

London's economy through sustainable energy delivery and improvement of the city's building stock (Hammer, 2008).

This point was a reflection of the Greater London Authority's (GLA)[41] limited budgetary powers[42] and the recognition that attainment of the strategy would require the widespread involvement of the local business community. As a result, GLA's funding availability for renewable energy projects in the city is limited, and while funds for such projects could be allocated directly out of the agency's general budget, these would displace funding for other activities and will be subject to scrutiny by the London Assembly (Hammer, 2008).

Hence, the Mayor of London tends to avoid imposing any energy requirements on the functional bodies of GLA, and rather use exhortatory language to 'encourage' agencies to act in certain way. As a response to the limited funding possibilities for sustainable energy interventions through existing institutional mechanisms, the London Climate Change Agency (LCCA) was set up in 2003 in order to provide direct energy services, primarily by recycling energy cost savings from past energy investments into new projects (Hammer, 2008).

[41]GLA is the top-tier administrative body for the Greater London area responsible for strategic regional policy and planning over transport, policing, economic development, and fire and emergency planning. It consists of the Mayor of London and the elected twenty-five seat London Assembly body that scrutinizes the powers of the Mayor regarding annual budgeting and statutory strategies (Heath, 2004).

[42]Although the budget controlled by GLA is large primarily because it includes the budget of Transport for London mayoral agency, in general GLA's fiscal powers are restricted. For example, the mayor of London can raise funds only through a precept charged to local authorities, miscellaneous service charges, and direct grants from the central government; whereas GLA does not have the authority to directly levy any income, property or sales taxes on residents or businesses (Hammer, 2008).

LCCA, which was modeled after Woking Borough Council's ESCO approach, is wholly-owned and controlled by the London Development Agency, and chaired by the Mayor of London. LCCA is affiliated with London ESCO which was set-up with 81% shareholder participation by Électricité De France and 19% participation by LCCA to be the agency's delivery mechanism of energy services (Bulkeley and Schroeder, 2013).

The work of LCCA in the mayor's Energy Strategy is complemented by Renewables Agency, a partnership established in 2003 as a response to another area of limitation regarding the City's power on municipal energy decision-making, the relatively weak position of the Mayor of London in the energy planning process as a result of the division of authority between the regional government (London Assembly) and the 33 Boroughs that make up the Greater London Area (Hammer, 2008).

Although the Mayor retains control over the largest development proposals in London accounting to over 250-300 each year, the boroughs are responsible for many small proposals which total in the order of tens of thousands of planning decisions every year. Hence, the borough's decisions can support, ignore or contradict the energy goals of the Mayor (Hammer, 2008).

As a response then, London Renewable was set-up to provide education and guidance on energy planning and technology aspects to various stakeholders to improve perceptions on sustainable energy systems and investments. The agency was established as an independent body consisted of local university researchers, key policymakers, and businesses participating in various aspects of the renewable industry (Heath, 2004).

More specifically, the agency is comprised of GLA, London Development Agency which is a functional body of the GLA tasked to promote local and regional economic development, the Government Office for London[43], the transnational energy corporation Electricité de France Energy, London First-Imperial College London, and the non-profit entity Creative Environmental Networks (Heath, 2004).

Between 2003 and 2004, the agency conducted surveys on the views of various stakeholders about renewable energy in London. This information was used as a way to defuse potential opposition to renewable energy development by local authority officials arguing that the public is not interested in such projects. In addition, London Renewables has developed background information and policy guidance for a variety of stakeholders ranging from borough councilors and planners to architects, developers and housing associations of the area. Both this and the survey work were seen to be preparing the ground for future renewable energy policies and programs in the London region[44] (Hammer, 2008).

In particular, the guidance for local planners has been particularly detailed aiming to offer education on several aspects of renewable energy, energy conservation, and green building design in order that planners better understand the need for effective energy planning, gain confidence when negotiating energy aspects

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[43]Government Offices for the English Regions were set-up by the central government in 1994 as the primary means by which national policies and programs would be delivered in the regions of England, the highest-tier of sub-national government division at that time. The Offices were abolished in 2011 (The National Archives, 2011).

[44]In 2004, London Renewables was integrated within the larger London Energy Partnership, an independent body with the remit to move forward the London Energy Strategy through a number of Tasks and Project groups (Hammer, 2008).

of development plans, and better assess how well planning applications address such aspects (Hammer, 2008).

What the above discussion, hence, suggests is that local governments need to undertake a detailed mapping of the capacity that they possess to act on sustainable energy within the wider energy policy environment in which they are situated. Such information can be helpful to assess their real power and possibilities for sustainable energy action, and pinpoint to potential ways of circumventing policy constraints (Hammer, 2008).

Finally, forward thinking local governments tend to pursue policy innovation on energy. Barcelona City Council passed the first city thermal ordinance in the world that went into effect in August 2000 and which mandates minimum levels of on-site solar water heating use for newly built, rehabilitated and fully reformed buildings intended for residential, health care, sports, commercial and industrial use (Puig, 2008).

In another example, in Denmark local entrepreneurship and models of cooperative ownership of wind power projects proved instrumental in the wide development of wind power in the country (Sperling et al., 2009).

While not transforming entirely the urban energy system, such type of local initiatives offer practical solutions, exemplary models, or alternative ways of promoting urban sustainable energy development without necessarily involving higher levels of government.

2.9. Urban Sustainable Energy Development –Serving Always a Bright Future?

As described in this Chapter, an increasing number of cities around the world promote sustainable energy development through diverse sets of initiatives. A key question in terms of evaluating this type of action is the extent to which it promotes real sustainability. For instance, urban network infrastructure systems have been fundamental in the development and operation of modern cities. It seems, thus, reasonable to assume that any weakening or changes of these systems and the energy service provisions in cities will have implications for urban life (Coutard & Rutherford, 2011).

With the imperative of sustainable urban development gaining significance, urban sustainable energy initiatives challenge the current energy practice and network paradigm by seeking to deploy decentralized and alternative forms of energy. The question, hence, arises of the extent to which such local energy practices, that can combine different financial, socio-spatial, governance and ecological aspects,[45]are sustainable and beneficial to the society (Coutard & Rutherford, 2011). As a result, the socio-economic and environmental implications of urban sustainable energy

[45]For example, Coutard and Rutherford (2011) provide a typology of post-networked alternative socio-technical energy configurations. This includes the ‘off-grid’ example where traditional centralized networks are bypassed to some extent through services developed on a local level; the ‘circular energy metabolism’ example which similarly to the off-grid example bypass centralized configurations of service provision but where additionally environmental considerations are more explicitly incorporated in the alternative provisions through loop closing methods of resource re-use and recycling; the ‘feed-in to the grid’ example where energy is generated through decentralized techniques that blur the boundaries between energy suppliers and consumers; and the ‘beyond collective energy infrastructure’ example where alternative forms of service provision are deployed normally at the margins of cities where low population densities, low cost performance and technical difficulties over deploying traditional network infrastructure favors consist challenging the deployment of traditional network infrastructure (Coutard & Rutherford 2011).

initiatives need to be critically evaluated within the wider governance environment within which they are pursued (Coutard & Rutherford, 2011; Hodson & Marvin, 2011).

2.10. Conclusion

Local governments have an important role to play in urban sustainable energy development as legitimate actors in fulfilling public policy goals and promoting social well-being. At the same time, energy is just one of the things that local governments can address within their wider responsibilities and portfolio. In addition, urban sustainable energy development appears to take place through contested processes within a changing policy environment where various actors compete for establishing their interests and gain influence over the course of the energy development.

While the benefits accrued to cities through energy efficiency and renewable energy development are well understood and recorded, there is a large potential for local sustainable energy development that remains untapped. An increasing number of cities around the world take action in sustainable energy development through diverse initiatives, technologies, approaches and collaborations that involve a broad body of actors across the public, private and civic sectors. This action is placed within a broader politico-economic context that assigns increasing importance to low-carbon local economic development.

The discussion suggests that in order to gain a more accurate picture on the role of cities in this policy area, two issues appear central. These are the specific ways through which local energy sustainability initiatives are shaped, and the need to explore, from a governance perspective, the role of cities in sustainable energy development within a multi-level analytical framework which pays attention to the relationship between the urban and other scales of policy organization.

In order to explore such issues in more detail, this study undertakes a case-study analysis for the city of Philadelphia by examining four key sustainable energy initiatives that take place in the city. Chapter 3 sets the context of the analysis by describing key data, actors and policies for energy sustainability in the case-studied city.

Chapter 3

THE ENERGY PROFILE OF THE CITY OF PHILADELPHIA: CONTEXT, DATA, ACTORS AND INITIATIVES FOR SUSTAINABLE ENERGY DEVELOPMENT

3.1. The Profile of the City

The city and county of Philadelphia, in the state of Pennsylvania, covers a land area of 134.1 sq. miles. Philadelphia is the fifth largest city of the U.S. with a population of 1,526,006 according to the 2010 U.S. Census. The per capita income for the city is $37,282. The city enjoys a central location within a three-state (Pennsylvania, New Jersey, Delaware), 11-county Greater Philadelphia Region with a population of 6.3 million (PCPC, 2011). Figure 4 provides a map of the city's geographical position within the Greater Philadelphia Region:

Figure 4: The city of Philadelphia within the Greater Philadelphia Region

Source: (PECO, 2013a)

The city's share of the region's population is continuing to decrease albeit at a slower pace than before reflecting the success of the city in recent decades in employment development and neighborhood revitalization. Philadelphia is a dense and diverse urban center with more than 11,000 people per square mile, but the city's residential and employment density are lower compared to thirty years ago. Philadelphia's metropolitan area economy is known for its positive but moderate economic growth and economic diversity (PCPC, 2011).

The city, and the region, share strengths in the areas of education, health care, and government enterprises, yet the city's growth in all other major economic sectors is lower compared to the region as a whole. New jobs in the region are increasingly located in its suburban and ex-urban corridors, while certain areas of Philadelphia such as the Center City, University City, Philadelphia International Airport and the Navy Yard are known for their competitiveness (PCPC, 2011).

While Greater Philadelphia area maintains a historically strong manufacturing basis, knowledge-based industries have become prominent with sectors like education and health services, professional and business services, financial activities, and information technology accounting for 44% of regional employment (GPIC, 2010).

Although the region's median annual household income of $60,515 was nearly 20% up than the national average according to the 2007 American Community Survey, Philadelphia and many of the smaller jurisdictions in the region, including smaller cities and boroughs, have below average incomes. In particular, the Economic Development Administration categorizes the city of Philadelphia as 'distressed' in the areas of income and unemployment rate (GPIC, 2010).

Moving into a service-based economy from being a large manufacturing center for over a century, Philadelphia has been left nowadays with underutilized industrial areas and a large amount of vacant land which are nevertheless considered as assets for spurring development and innovation due to their connection to utilities and proximity to labor and markets. A large share of the city's building stock is aged and of low construction quality and deferred maintenance. At the same time, the city enjoys a large number of district neighborhoods known for their diversity and authenticity whose revitalization and stabilization is a key priority (PCPC, 2011).

3.2. General Governance Structure for the City of Philadelphia

City government powers, role of the Mayor and the City Council

The structure of Philadelphia's municipal government is defined in the Philadelphia Home Rule Charter that serves as the city's 'constitution'. Approved in April 1949, the Philadelphia Home Rule Charter gives broad powers and authority of local self-government (i.e. legislation and administration) in relation to its local government functions to assure the City accrues the fullest possible benefits of self-government (Philadelphia Charter Commission, 2011).

The City of Philadelphia has adopted a strong mayoral form of government that grants extensive power to the Mayor. The executive and administrative structure of the City includes a number of Departmental and Independent Boards and Commissions with scope or activities relevant to energy sustainability (i.e. Philadelphia Energy Authority, Gas Commission, City Planning Commission, Zoning Code Commission, Philadelphia International Airport, School District) (Philadelphia Charter Commission, 2011).

The City Council plays central role in the city government's plans for finance raising and expenditure. The City has several separate budgets that are designated to address different purposes. The three most important ones, which account for over $9.5 billion annually in the recent years, are the Operating Budget (General Fund), the Capital Budget, and the Philadelphia School District Budget (covers the operations of city's public school system (Philadelphia Charter Commission, 2011).

3.3. General Sustainable Energy Governance Structure and Context for Philadelphia

Having described the legislative, executive and administrative governance structure and main functions of the City of Philadelphia, Section 3.3. describes the overall sustainable energy governance framework within which the case-studied city pursues its energy policies and goals. In accordance with the discussion on the study's analytical perspective (Section 2.4.), this is defined based on two interrelated components: the state regulatory and multi-level governance relationships, both internal and external to the city, that relationally structure the city's position and competences in relation to energy sustainability; the organization of the current energy regime, and its relationship to the city (i.e. in terms of the city's role in systems of energy service provision) (Hodson & Marvin, 2011).

More specifically, as described before, the Philadelphia Home Rule Charter gives to the City the power to define its municipal functions and responsibilities in a broad sense, as long as there is no conflict with legislative provisions and conditions defined at the state and federal level. An area relevant to energy sustainability where this principle finds application in the case of Philadelphia is land-use planning where the City largely enjoys autonomy in defining related policies and provisions (i.e. zoning code legislation) (E. Gladstein, personal communication, May 13, 2013). On the other hand, state law prevents the City from entering into the business of electricity generation or supply (K. Sullivan, personal communication, April 14, 2013). In addition, there is no state or federal mandate that would impose any legally binding energy or climate policy targets to the city.

Division of responsibilities between the state and local level might also augment or restrict the city's policy ambitiousness in energy sustainability. For example, although Philadelphia wants to adopt the latest version of the International Energy Conservation Code (IECC) that defines enhanced energy conservation specifications for new buildings, state approval is required which has not been granted up to date. As a result, the City uses the 2009 Code version (M. Flink, personal communication, June 4, 2013).

In addition, the energy industry and market arrangements structure Philadelphia's policy position and ability on energy sustainability. For instance, PECO, the regional private utility, is a large and politically influential entity. As a result, the company's policy directions, and energy-related decisions taken by key state agencies such as the Pennsylvania Public Utility Commission (PUC), have important policy implications for local sustainable energy development (i.e. fuel mix or emissions specification for electricity generation; rules of grid operation; level of electricity tariffs) (K. Sullivan, personal communication, April 14, 2013).

Furthermore, the state's Alternative Energy Portfolio Standard (AEPS) mandates that certain portion of utility electricity sales is renewable energy-based, and can be satisfied through the statewide Renewable Energy Credit[46] (REC) market that has been also established in the state. In addition, the electricity and gas markets were liberalized in Pennsylvania in 1999. As a result, various energy sustainability products and companies are now operating at the regional market (Fein, 2010).

Regarding gas, the City owns the largest municipal gas utility in the country, Philadelphia Gas Works (PGW). As a result, the City has authority over utility policy directions and programs that can promote sustainable energy (i.e. demand-side energy management). On 3 March 2014 the city administration announced that it has signed an agreement to sell Philadelphia Gas Works to UIL Holdings Corporation. The agreement, however, did not proceed to a hearing for bill proposal by the City Council (City of Philadelphia, 2014a). If the agreement is not approved by 31 December 2014, then it terminates automatically (The Philadelphia Inquirer, 2014a).

Philadelphia's possibilities on energy sustainability are also influence by national and state and national policies and initiatives. At the national level, the federal administration supports clean energy development through policy, regulatory and financial provisions such as improved fuel economy standards for the transportation sector, tax incentives for investments in clean energy, research and development programs to reduce the cost of clean energy technology, and the use of public land for renewable energy development (White House, 2012).

President Barack Obama's administration has made the development of indigenous renewable energy sources and improvements in the energy efficiency of the economy priorities of its energy policy agenda. The American Recovery and

[46] One REC equals to 1 MWh of alternative electricity generation (Clean Energy Wins, 2014).

Reinvestment Act 2009 (ARRA 2009) which was enacted in the first term of his administration aims to contribute to a national clean energy economy, reduce energy costs and create domestic clean energy jobs (D.O.E. EERE, 2010).

The federal government promotes also policies that aim to curb greenhouse gas emissions from the energy sector. On June 2, 2014, under President Obama's Climate Action Plan and the authority of the U.S. Clean Air Act, EPA has proposed a nationwide Clean Power Plan rule to cut greenhouse gas emissions from the power sector by 30 percent from 2005 levels (U.S. EPA, 2014a).

In meeting the goals of the rule, EPA is proposing the adoption of state-specific goals for greenhouse gas emissions reductions from the power sector, as well as guidelines for states to follow in developing plans to achieve the state-specific goals (U.S. EPA, 2014b).

EPA has specifically looked at four 'areas of action' that combined could address the emission reductions of the rule, namely renewable energy, energy efficiency, enhanced use of existing Natural Gas Combined Cycle plants, and 'heat rate' improvements (spending less BTUs of heat to generate the same amount of KWh of electricity)[47] (PennFuture, 2014a).

Shortly after the announcement of EPA's proposed rule, Pennsylvania's Governor Tom Corbett released a statement that expressed concerns regarding the

[47] Pennsylvania will ultimately design its own program to meet the requirements of the rule and will not have to necessarily use these areas of action in its program (PennFuture, 2014a).

potential elimination of Pennsylvania jobs (mainly coal-related[48]) as a result of policies in order to meet the greenhouse gas reductions. The statement notes that in April 2014 the Pennsylvania Department of Environmental Protection (DEP) submitted a White Paper to EPA requesting federal officials to take into account state differences and the need for flexibility in emissions guidelines on how state plans can limit carbon emissions from the power sector. DEP's White Paper aims to offer a flexible framework for lowering carbon dioxide emissions from existing fossil-fuel power plants in the state, and recommends EPA to preserve the authority of states in the development and implementation of emission control programs in this sector (Office of the Governor, 2014).

Some federal policy initiatives on clean energy development target cities directly. This is the case with D.O.E.'s Weatherization Assistance Program (WAP), D.O.E.'s Energy Efficiency and Conservation Block Grant[49] (EECB Grant), and D.O.E.'s Better Buildings Neighborhood Program that assists more than forty, competitively selected, state and local governments to develop sustainable energy programs that will upgrade the energy efficiency of over 100,000 buildings in total (D.O.E. EERE, 2013a; U.S. EPA, 2013b).

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[48] Pennsylvania is the fourth largest coal producer in the U.S. The state is also second nationwide in natural gas production, and second in nuclear power generation (PA Gov., 2014).

[49]EECB Grant was established by the U.S. 2007 Energy Independence and Security Act as a $3.2 billion fund to assist cities, communities, states, and tribes to develop, promote and manage energy efficiency and conservation programs that will achieve reductions in energy use, and create clean energy jobs. In 2009, the U.S. ARRA Stimulus Bill authorized funding for this grant (D.O.E., 2009; Parshall et al., 2009).

State legislative and financial arrangements and programs influence also sustainable energy development in Philadelphia. For example, state Act 129 mandates all private regional energy utilities in Pennsylvania to achieve certain reductions in their retail electricity sales within a certain timeframe by designing and implementing energy conservation programs (PUC, 2013).

In addition, the state's 2008 Alternative Energy Investment Act allocates $650 million to support, among other things[50], sustainable energy development through grants, rebates, loans and production tax credits to individuals, small businesses, commercial developers and local governments for a variety of renewable energy projects including wind, biomass, solar and geothermal energy, and energy efficiency projects including low cost energy conservation loans for low-income households (Home Energy Efficiency Loan program) and emergency energy assistance funding (Clark, 2008).

Shifts in state energy policy directions influence the context for sustainable energy development in Philadelphia. For example, the current state administration puts more emphasis on the promotion of natural gas and related technologies, while under the previous administration more funding for energy efficiency development was available to cities (K. Gajewski, personal communication, April 03, 2013).

In addition, many of the state and federal funding sources for sustainable energy development have become less available or terminated. For example, WAP funds were reduced over time, ARRA funds for sustainable energy development are depleted, and the Pennsylvania Sunshine Solar Program that was activated through the

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[50]Twenty five million dollars are allocated for pollution control in coal-fired power stations. The Act classifies solar, wind, biomass, geothermal, waste heat, clean coal and waste coal as 'alternative energy' (Clark, 2008).

state's Alternative Energy Investment Act 2008 closed in December 2013 (Shulock 2012; D.O.E. EERE, 2013b; Liz Robinson, personal communication, April 07, 2013; Clean Energy Wins, 2014).

One of the few new state funding sources for sustainable energy is the Pennsylvania Energy Development Authority[51] anticipated grants of approximately $12.5 million that will be available in summer 2014 to support energy projects and alternative energy manufacturing or production business operations in Pennsylvania. The funding particularly targets solar, wind, hydropower, and biomass projects (PA Energy Development Authority, 2014).

At the regional level, the natural resource endowment and existing energy infrastructure of the Philadelphia region are important factors in the regional energy policy context. For example, the city's world-class transportation infrastructure, its fossil-energy infrastructure such as the two oil refineries[52], regional fossil resources like the Marcellus large shale gas formation (stretching across Pennsylvania, New York West Virginia, Ohio and Maryland) and Greater Philadelphia's close proximity to a geographical area of large energy demand, have been portrayed in the local press as valuable assets for transforming the city into an international hub of fossil fuel innovation and business (Krancer, 2013).

[51]This is an independent public financing authority created in 1982 with a mission to finance clean, advanced energy projects in Pennsylvania. The authority currently can award grants, loans, and loan guarantees (PA Energy Development Authority, 2014).

[52]These are the Philadelphia Energy Solutions, a joint venture between Carlyle Group and Energy Transfer Partners which is the largest oil refining complex on the Eastern seaboard, and Monroe Energy and is a wholly-owned subsidiary of Delta Airlines (Krancer, 2013).

In addition, while the city government has adopted the political aspiration that Philadelphia becomes the greenest city in the U.S., Mayor Michael Nutter has stated that PGW's sell agreement would allow the company to take full advantage of the abundant supply of natural gas in Pennsylvania, and assist Philadelphia and the region to become a prime energy hub (City of Philadelphia, 2014a).

With the booming in Marcellus Shale natural gas production, Philadelphia is seen by business and trade associations like the Greater Philadelphia Chamber of Commerce and the Philadelphia Building and Constructions Trades Council, as potentially able to play a central role in the development of a natural-gas based infrastructure and business activity in the region. For example, both entities have endorsed PGW's privatization as a critical part of the effort to build the area as an energy hub, connecting Philadelphia's ports and businesses with Marcellus Shale production in the western and northern Pennsylvania (The Philadelphia Inquirer, 2014b). In addition, Philadelphia Regional Port Authority, the state agency that owns the land and terminals of an area known as 'Southport' located at the eastern end of the Philadelphia Navy Yard is in the process of leasing this land, with approval by the Philadelphia River Port Authority, to a terminal operator that will partly use for the development of a natural gas Hub. Philadelphia Energy Solutions, a private fossil-based enterprise, has expressed interest in becoming the operator of the site that is envisaged to be connected, through a newly built pipeline, with the Marcellus Shale natural gas field (The Philadelphia Inquirer, 2014c).

In addition, in November 2014, Sunoco Logistics announced its plans for building a 350 mile pipeline with intake points in Ohio, West Virginia, and Western Pennsylvania that will increase the volume of Marcellus Shale natural gas liquids (propane, butane, ethane) to the company's Marcus Hook industrial complex (The Philadelphia Inquirer, 2014d). The Pennsylvania Public Utility Commission decided that the ancillary structures required to house supportive infrastructure, like pumping and valve control stations, are considered reasonably necessary, hence they can be exempted from local zoning approval (The Philadelphia Inquirer, 2014d). Local communities have shown mixed-reactions on the business plan so far. For example, Delaware County sees this as an opportunity for economic growth, while Chester County communities have expressed concerns over the likely public health impacts of the project (The Philadelphia Inquirer, 2014d). Indeed, Chester County communities are challenging PUC's decision in the Commonwealth Court (The Philadelphia Inquirer, 2014e).

As a result, wider policy and business directions in relation to natural gas development in the region may have an indirect impact on Philadelphia's prospects for local energy sustainability, i.e. through aspects like infrastructure lock-in (Lazarus et al., 2013) contribution to low natural gas prices that will work against the financial viability of energy efficiency (personal communication, K. Gajewski, 03 April 2013), or state policy directions that will favor natural-gas electricity generation (i.e. in the context of the Pennsylvania state plan for compliance with EPA's Clean Power Rule plan expected to be in effect in summer 2016).

The region's fossil-based infrastructure legacy (i.e. mines, coal breakers, railroads, freight yards, and docks) has been also portrayed as a valuable asset for new development possibilities that can serve both economic growth and equitable sustainable development as long as a comprehensive energy policy approach is followed (Hughes, M., 2013).

At the international level, finally, the policy community seems to postpone the replacement of Kyoto Protocol with a new policy architecture that will create global leadership in climate change mitigation (Jacobs, 2012), while the current global economic recession may affect the effectiveness of national energy programs with implications for local sustainable energy development[53] (Finney et al., 2012).

3.4. Internal Sustainable Energy Structure of the City Government and Energy-Related Linkages to the Outside Environment

3.4.1. Internal Sustainable Energy Structure

Sustainable development has become a policy issue of growing importance within the city government of Philadelphia. Mayor Michael Nutter shortly after taking office in 2008 released the city's sustainability plan *Greenworks Philadelphia* which aims to make Philadelphia the greenest city in the country by 2015. On the day of the release of *Greenworks Philadelphia Update and 2012 Progress Report*, Mayor Michael Nutter stated (Greenworks Philadelphia, 2012a):

> I am proud to say that Philadelphia has made significant progress in our goal to become America's greenest city. I hope that other cities can learn from our experiences and build-off of them.

Greenworks Philadelphia serves as a reference framework for the city's sustainability initiatives and goals (MOS, 2009). The plan builds on the City's 2007 Local Action Plan for Climate Change that was developed by the city government's

[53]For example, funding cuts and programmatic changes in energy programs of the U.K. Department of Energy, some of which are administered by local authorities or have a local focus, put at risk their energy efficiency and renewable energy deployment rates (Finney et al., 2012).

Sustainability Working Group. It is structured around 15 targets and 167 initiatives on the five areas of Energy, Environment, Equity, Economy and Engagement. Each of the 15 targets is set for 2015, and progress is monitored on an annual or bi-annual basis.

The area of Energy includes four targets: Target 1: Lower city government energy use by 30%; Target 2: Reduce citywide building energy consumption by 10%; Target 3: Retrofit 15% of housing stock with insulation, air sealing and cool roofs; Target 4: Procure and generate 20% of electricity used in Philadelphia from alternative energy sources (MOS, 2009).

The plan aims to develop energy efficiency and renewable energy both at the municipal government and citywide level through a diverse policy portfolio. This includes financial and regulatory instruments, pilot schemes, education and community outreach, and monitoring and evaluation for various types of energy intervention ranging from building energy efficiency to reduction in vehicle miles traveled and the purchase or generation of renewable electricity. The main focus of the plan in the area of energy is on energy efficiency (MOS, 2009; D.O.E. EERE, 2011). The plan's annual update reports trace progress and outline energy initiatives completed, in progress, or for future consideration towards meeting the energy targets (MOS, 2012).

Due to Philadelphia's high share of low-income population, *Greenworks Philadelphia* has a clear focus on residential affordable energy development. Target 3 of the plan calls for retrofitting 15% of the city's housing stock with insulation, air sealing and cool roofs by 2015. This goal is assisted by local entities such as the ECA and the NECs that provide energy services to local residents (ECA, 2010).

Greenworks Philadelphia serves as a point of reference for sustainability plans of local entities such as the Philadelphia Housing Authority (PHA), the University City District, and the regional Southwestern Pennsylvania Transportation Authority (SEPTA) (MOS, 2012).

Philadelphia aims also to become a leader in clean energy development at the regional and national level by developing energy efficiency and renewable energy markets that will create jobs and foster sustainable economic development (D.O.E. EERE, 2011). *Greenworks Philadelphia* is envisaged to facilitate progress on this goal. For example, the plan aims to create more than 10,000 new green jobs in the Philadelphia area by 2015 (AIA, 2012).

Furthermore, in 2007 Philadelphia was designated by EPA as a *Green Power Community* in acknowledgement of its efforts to mobilize local businesses, residents, and institutions to collaborate with the local government on renewable energy development. In the words of the EPA Regional Administration (Greenworks Philadelphia, 2012a):

> As EPA's largest *Green Power Community*, Philadelphia is among only a handful of local governments that have met or exceeded their pledges to our nation's clean energy future by purchasing green, renewable power. I commend Mayor Michael Nutter for his continuous pursuit of numerous, practical ways to make Philadelphia a model green city.

In addition, the City's new Comprehensive Development Plan *Philadelphia2035* and new Zoning Code take into greater consideration energy efficiency and renewable energy. *Philadelphia2035* aims to offers a citywide vision for sustainable development. The plan is set to be executed through eighteen Local District Plans until 2035 (PCPC, 2011).

Greenworks Philadelphia is led by the Mayor's Office of Sustainability that was established in 2008 to carry forward and coordinate the city's sustainability agenda. MOS core responsibility on energy involves the energy efficiency portfolio, while MOTU is responsible for energy supply issues (MOS, 2009).

The City's overall organizational approach to energy sustainability is based on the cooperation of departments and individuals throughout the city government. Due to lack of political rationale for requiring that certain type of energy-related action is taken by departments through formal arrangements (i.e. municipal energy plan that holds the status of a formal planning document and mandates specific programmatic responsibilities), the City adopted a model based on coordination and persuasion as a way of promoting the active involvement of departments in energy sustainability. This kind of organizational framework may create challenges towards developing a comprehensive programmatic municipal agenda on energy, for example by bringing together different municipal policy silos relevant to energy sustainability (air quality, land-use planning, transportation, energy in the built environment etc.) under the remit of a single plan, and exercising formal authority and resources to implement the plan (Hughes, M., 2009).

However, the office is delegated with authority through a strong mayor form of local government to follow a 'pervasive approach' across the administration in order to drive forward the environmental agenda, for example by suggesting to departments that although they are not required to report to the office in relation to sustainability activities, the Mayor is expecting this hence they really need to do it (Hughes, M., 2009).

As noted, undertaking energy initiatives in the context of *Greenworks Philadelphia* requires the involvement of various departments and agencies. To offer, then, an overall view of the City's internal linkages and organizational context in relation to energy sustainability, Tables 2-5 summarize lead city agencies, key partner city agencies, and city government policy initiatives in making progress with the *Greenworks Philadelphia* sustainability targets[54]:

Table 2: Key sustainable energy initiatives, city agencies and partners for the *Greenworks Philadelphia* energy target 1

Target 1: Reduce city government energy use by 30% by 2015		
Baseline (2008) 3.77 trillion BTUs	**Current Performance (FY 2013)** 3.84 trillion BTUs	**Goal (2015)** 2.64 trillion BTUs
Policy Initiative	**Lead City Agency**	**Partner City Agency**
Energy efficient capital investments	MOS	Public Property
Adopt integrated utility bill management system	MOS	MOTU
Apply for all available rebates	MOS	
Implement departmental target energy budgets	MOS	Finance

[54]The summarized initiatives in Tables 2-5 form the bulk of the total measures that *Greenworks Philadelphia* proposes for meeting the four energy targets. A few measures which are more peripheral or complementary to those key ones are not included for space reasons.

Encourage conservation among employees	MOS	MOTU, Public Property
Install energy efficiency lighting	Public Property, Streets Department	MOS, Parks & Recreation
Benchmark large city facilities	MOS	
LEED and cool roof legislation for city buildings	MOS, Law	Licenses & Inspections
Include energy conservation in future building maintenance contracts	Public Property	MOS
Identify less-expensive and alternative electrical sources	MOS	Procurement
Develop energy load/demand management practices	MOS	Public Property
Create capital budget energy guidelines	MOS	Public Property, Finance
Use future energy costs to inform building acquisition/expansion decisions	Public Property	MOS, Finance
City employee car management plan	MOS	
Five year strategic energy plan (Water Department)	Water Department	

Source: (MOS 2009; 2013; 2014)

Table 3: Key sustainable energy initiatives, city agencies and partners for the *Greenworks Philadelphia* energy target 2

Target 2: Reduce citywide building energy use by 10% by 2015		
Baseline (2006) 122.06 trillion BTUs	**Current Performance (FY 2013)** 136.89 trillion BTUs	**Goal (2015)** 109.85 trillion BTUs
Policy Initiative	**Lead City Agency**	**Partner City Agency**
Create a revolving loan fund for Commercial and industrial energy efficiency retrofits	MOS	
Develop energy-efficiency building guidelines	Licenses & Inspections	MOS, City Planning Commission
Grant floor-area ratio bonuses through the zoning system	Planning, Zoning Code Commission	Commerce
Fast track LEED-certified and energy efficient buildings	Licenses & Inspections	
Disclose building energy use during real estate transactions	MOS	Commerce
Create a Sustainable Energy Authority	MOS	Law
Reposition the Philadelphia Home Improvement	Philadelphia Redevelopment	MOS

Loan program	Authority	
Develop power purchase pools for small businesses	Commerce	MOS
Install smart meters	PECO (private regional utility)	
Include feedback on utility bills	Philadelphia Gas Works, PECO	
Develop a citywide energy-efficiency marketing campaign	MOS	Philadelphia Gas Works, PECO
Develop curriculum on sustainability	School District	MOS

Source: (MOS, 2009; 2013; 2014)

Table 4: Key sustainable energy initiatives, city agencies and partners for the *Greenworks Philadelphia* energy target 3

Target 3: Retrofit 15% of citywide housing stock with insulation, air sealing and cool roofs		
Baseline (year 2008) 3,500 Homes Retrofitted	**Current Performance (FY 2013)** 11,669 Homes Retrofitted	**Goal (year 2015)** 84,400 Homes Retrofitted
Policy Initiative	**Lead City Agency**	**Partner City Agency**
Expand current low-income housing weatherization efforts	Philadelphia Housing Development Corporation	Office of Housing and Community Development (OHCD)
Expand scope of PGW’s	Philadelphia Gas Works	

Weatherization Program and increase size		
Build energy-efficiency guidelines into public and low-income housing	Philadelphia Housing Authority, Philadelphia Redevelopment Authority, Office of Housing and Community Development	
Promote green and healthy homes	Public Health	Philadelphia Gas Works

Source: (MOS, 2009; 2013; 2014)

Table 5: Key sustainable energy initiatives, city agencies and partners for the *Greenworks Philadelphia* energy target 4

Target 4: Procure and generate 20% of electricity used citywide in Philadelphia in the form of renewable energy		
Baseline (year 2008) 2.5%	**Current Performance (FY 2013)** 14.8%	**Goal (year 2015)** 20%
Initiative	**Lead City Agency**	**Partner City Agency**
Purchase renewable energy credits (RECs)	MOTU	Procurement
Promote renewable power purchase agreements for public buildings	MOTU	MOS

Reduce regulatory barriers to solar installation	MOTU	MOS, Zoning Code Commission
Write a guide for solar power development	MOTU	MOS
Create biogas cogeneration facility at Northeast cogeneration facility at Northeast	Philadelphia Water Department	
Develop solar land use plan	MOTU	Office of Technology and Innovation

Source: (MOS, 2009; 2013; 2014)

3.4.2. City Government Energy-Related Linkages with the Outside Environment

Apart from inter-departmental collaborations, the City interacts with various public, private and civic actors on energy sustainability. The City procures its electricity through either short-term contracts or the spot market. PECO, the regional private utility that serves the Southeastern area of Pennsylvania, is the main electricity supplier for the city, and a gas supplier for the suburban areas, while PGW serves gas the city. Both utilities are involved in energy efficiency and renewable energy initiatives in Philadelphia. In addition, the City is pursuing utility rebates for energy efficiency through PECO's energy efficiency programs enacted under Act 129 (MOS, 2013).

In addition, the City has close links on energy with ECA. The City's OHCD interacts also with local companies and public entities and real estate businesses that are active in housing energy efficiency development. In addition, MOS and OHED are currently working with public entities like the Philadelphia Redevelopment Authority and Philadelphia Housing Authority to develop energy efficiency requirements and guidelines into public and low-income housing (MOS, 2013).

The City has also interacted with EEB Hub on energy policymaking and implementation for the Energy Benchmarking Ordinance. At the regional level, in partnership with counties of the Southwest Pennsylvania area, the City was awarded federal funding in 2009 to develop the *EnergyWorks* program that provides financial and technical assistance on residential and commercial energy efficiency development and market creation (ECA, 2010).

At the national level, the City endorsed the U.S. Conference of Mayors Climate Protection Agreement in June 2005 under which signatory cities agree to voluntarily meet or surpass the greenhouse gas reduction targets recommended for the U.S. under the Kyoto Protocol Treaty (7% from 1990 levels by 2012), and to lobby state and federal government to enact policies and programs to reduce greenhouse gas emissions (City of Philadelphia, 2007a; The United States Conference of Mayors, 2013).

In addition, in January 2014, Philadelphia was selected to join the City Energy Project (CEP), a national, ten-city effort to support energy efficiency development in large commercial buildings. The initiative is organized by the Natural Resources Defense Council and the Institute for Market Transformation that will offer expertise to participating cities on planning, designing and implementation processes. In particular, CEP aims to mobilize involvement by the private sector (i.e. the real estate industry) and to support the development of a coordinated effort to achieve citywide commercial building energy efficiency (City of Philadelphia, 2014b).

No systematic, or established, energy policy mechanisms with either the state or federal level have been identified to be in place for Philadelphia other than pursuing or receiving financial and technical support for local energy development available through these levels of government[55].

Internationally, Philadelphia has joined the C40 Cities Climate Leadership Group whose members commit to address climate change by developing and implementing policies and programs that generate measurable reductions in both greenhouse gas emissions and climate risks. Sharing lessons and information, and identifying opportunities for joint action are core activities of the network (C40 Cities, 2013a; 2013b).

In addition, in 2011 Philadelphia became a member of the Joint Initiative on Urban Sustainability (JIUS) established by U.S. President Barack Obama and Brazil's President Dilma Rousseff. This is a public-private partnership that aims to support scaled investments in sustainable energy infrastructure. Other than Philadelphia, JIUS partners include U.S. EPA, Brazil's Ministry of Environment, the City of Rio de Janeiro, the State of Rio de Janeiro, Rockefeller Foundation, and the Brazilian Foundation for Sustainable Development (U.S. EPA, 2014c).

Furthermore, in 2013 the city participated in the Carbon Disclosure Cities Project for a third consecutive year. This is a project that invites cities around the world to share their approach on local greenhouse gas inventories and climate mitigation strategies and action (MOS, 2013).

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[55]For example, the latest City's reported interactions with the state level within the context of *Greenworks Philadelphia* involve an intention to lobby the state level on more favorable legislation regarding the viability of the SREC market which is currently at low levels, as well as on the approval of the 2012 International Energy Conservation Code (MOS, 2012; 2013).

Philadelphia is also a member of the *GreenTowns* community of the International Council for Local Environmental Initiatives (ICLEI) urban sustainability network that promotes energy efficiency and renewable energy development through expertise-sharing and peer support (ICLEI, 2013).

3.5. Energy Sources, Energy Consumption and Greenhouse Gas Data, and Energy Sustainability Goals for Philadelphia

Philadelphia uses electricity, natural gas and fuel oil to meet the bulk of its energy needs. Energy consumption data used to produce municipal government and citywide greenhouse gas inventories for 2010 are reported in the *Greenworks Philadelphia* 2012 progress report[56]. These are and the most recent data of municipal government and citywide energy use[57] that are publicly available.

The citywide greenhouse gas emissions inventory reports energy-related emissions based on energy data that are split by energy source for the sectors of Buildings and Stationary Energy Use, Water and Waste Water Treatment, Street Lighting and Traffic Signals. The data are reported in different energy units depending on the end-use and sector, for example KWh (electricity consumption in building sector), gallons (fuel oil consumption in Water Treatment sector), etc. (MOS, 2012).

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[56] For example, the *Greenworks Philadelphia* 2013 progress report presents a figure on sectroral citywide buildings energy use between 2008 and 2012, and reports municipal energy use by General Fund, Water Fund and Street Lighting over the same period (MOS 2013), while the 2014 progress report presents municipal government energy use data by General Fund (59%), Water Fund (35%) and Street Lighting (6%) for 2013 (MOS, 2014).

[57] The terms ‘municipal government’ and ‘citywide’ are used to refer to municipal energy use and total energy use in the city respectively.

In order to offer a comparative view of energy use across sectors, the reported energy data are converted into a common energy unit, the British Thermal Unit (BTU), and aggregated by sector. For the energy conversion, the following energy factors are used:

Table 6: Energy conversion factors to convert Philadelphia's energy consumption data into BTUs

Energy unit	**British thermal unit (BTU) equivalent**
1 KWh	3,412 BTU
10^3 cubic feet of natural gas (average high heating value)	$1.020x10^6$ BTU
1000 gal of U.S. No.2 fuel oil	$140x10^6$ BTU
1lb steam	1,194 BTU

Source: (U.S. EPA, 1998; 1999; 2012a; 2013a)

Based on the *Greenworks Philadelphia* energy-related greenhouse gas emissions data, the citywide energy consumption for 2010 reached 118651,2 billion BTUs[58] in the Buildings and Stationary Energy Use sector[59]and 246,6 billion BTUs in the Street Lights and Traffic Signals sector (MOS, 2012).

[58]Energy-related transportation data are presented separately in Table 9 (p.135).

[59]The Buildings and Stationary Energy Use emissions data in the greenhouse gas inventory include also emissions from the On-site Combustion Residential-Commercial, Combustion-Commercial and Industrial and Steam Loop sectors, without though specifying the amount of energy consumption. Hence, these energy data have not been included in the aggregated figure presented here.

To offer a more disaggregated picture of the energy use in the city, Table 7 presents Philadelphia's 2010 citywide energy consumption by sector and fuel source in percentage shares:

Table 7: Philadelphia's citywide energy consumption by sector and fuel source in percentage shares, 2010

Sector and fuel source	**Energy consumption (% of total)**
Natural Gas	
Residential	30.8
Commercial and Industrial	32.6
Electricity	
Residential	10.8
Commercial and Industrial	25.7
Street Lights and Traffic Signals	0.2

Source: (MOS, 2012)

Table 7 shows that the largest energy use in the city comes is natural gas in the commercial/industrial and residential sectors at around 30%, followed by electricity consumption in these two sectors at around 25% and 10% respectively.

Table 8 presents Philadelphia's municipal government energy consumption by sector in billion BTUs for 2010:

Table 8: Philadelphia's municipal government energy consumption by sector in billion BTUs, 2010

Sector	Energy consumption (billion BTUs)
Buildings (electricity, natural gas, fuel oil, steam)	1546,6 (46%)
Airport facilities (electricity, natural gas)	676,9 (20%)
Water treatment (electricity, natural gas, fuel oil)	466,8 (14%)
Wastewater treatment (electricity, natural gas, fuel oil)	423,5 (13%)
Street lighting and traffic signals[60] (electricity)	246,6 (7%)

Source: (MOS, 2012)

As Table 8 shows, energy consumption in the Buildings sector was the largest contributor to municipal government energy consumption in 2010 at 46%, followed by the Airport Facilities sector at 20%.

Regarding renewable electricity, 14.8% of Philadelphia's citywide electricity use derived from alternative energy sources in 2013 (MOS 2014). This included 11,402MWh of citywide renewable electricity generated on-site, 127,000 MWh through RECs purchased by the city government, and 500,398 MWh through renewable energy credit purchased by the rest of the city. The on-site renewable

[60]This energy source is included in both the municipal government and citywide greenhouse gas emissions inventories (MOS, 2012) hence it is presented in both Tables 7 and 8.

electricity generation and the renewable credits purchased for 2013 are estimated to have resulted in over 276,360 tons of CO_2 eq. savings (MOS, 2014).

In 2013, the renewable electricity credit purchases by the City accounted for over 20% of its total energy needs (MOS, 2013). Five percent of this share came from the City's centralized electricity procurement through the General Fund. Hence, the 5% share, in essence, is derived from the functioning of the state's Alternative Energy Portfolio Standard. On the top of the 5% share, the renewable electricity credits, that make-up the remaining 15% of the City's total energy needs, are wind power-based. The 20% REC share makes the City of Philadelphia the sixth largest user of green power among local governments in the U.S. (MOS, 2012).

Local institutions, other than the City, that purchase RECs voluntarily include the Academy of Natural Sciences, the University of Pennsylvania, and the Philadelphia Eagles[61] and Phillies professional football and baseball teams (MOS, 2012).

Greenworks Philadelphia includes initiatives and targets for the transportation and waste sectors, some of which are related to the plan's Energy component. For example, target 6 of the plan's Environment component involves the improvement of the city's air quality towards attainment of federal standards. Initiatives to achieve this include exhaust improvements and switches to cleaner fuel sources such as biodiesel and compressed natural gas in the city government's vehicle fleet. In addition, both

[61] The Philadelphia Eagles has installed more than 11,000 solar panels and 14 vertical axis wind turbines in the Lincoln Financial Field. The systems are expected to cover 30% of the power used in the stadium while the remaining demand will be met through alternative energy credits (MOS, 2013).

the Port of Philadelphia and the Philadelphia International Airport are expected to take steps to reduce emissions from their operations (MOS, 2009).

Furthermore, target 7 under the Economy component of the plan calls for a reduction of citywide Vehicle Miles Traveled (VMT) by 10% by 2015 through transit-oriented development and expansion of the city's public transit and biking system (MOS, 2009). Other transportation measures of the plan that target fossil fuel reductions include hybrid diesel buses, electric cars and infrastructure, compressed natural gas taxis, and parking policies to encourage the use of public transportation into downtown neighborhoods (MOS, 2009). Table 9 summarizes the city's road transportation activity (VMT) and energy use data for 2010:

Table 9: Municipal and citywide road transportation activity and energy use data for Philadelphia, 2010

Municipal vehicle fleet		**Citywide road transportation**	
Gasoline	3,389,889 gal	On-road vehicles	5,517,486,000 VMT
Diesel	880,589 gal	Public transit-electric trains and trolleys	791,666,549 KWh
Diesel (biodiesel blend)	1,452,572 gal	Off-road vehicles	N/A
Zipcar[62]	45,519 VMT		

Source: (MOS, 2012)

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[62]As part of its City Car Management Plan, the city government is using the Zipcar car sharing and car club service available in Philadelphia to reduce its vehicle fuel use (MOS, 2012; Zipcar, 2014).

As Table 9 shows, energy use in the municipal vehicle fleet is dominated by gasoline, and vehicle miles travelled at the citywide level reached over 5.5 billion in 2010. With respect to waste management, much of Philadelphia's trash contains energy that can be tapped and supply household energy needs. *Greenworks Philadelphia* calls for diverting 70% of all solid waste from landfills by 2015 by increasing the volume of material that is recycled by residents, commercial building owners and contractors, as well as through waste to energy (WTE) disposal options (MOS, 2013).

Philadelphia exceeded the 70% waste diversion goal for a second consecutive year in 2012, the last year for which comprehensive waste data is available. Half of the waste amount was recycled, and another 23% was used for energy production (MOS, 2014).

Greenworks Philadelphia recommends that MOS and MOTU examine WTE practices, and if it proves that the techniques of gasification and anaerobic digestion[63] yield benefits then the City should explore ways to engage with local officials, the federal and state government, and environmental and community organizations in order to work out plans for the adoption of such systems in the city[64] (MOS, 2013).

The City has already in place contracts with solid waste companies that divert nearly 100% of residential solid waste from landfills. Part of this feeds energy-from-

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[63]Anaerobic digestion is a commonly used technology for processing bio-solids collected in wastewater treatment. The methane that is released by the process can fuel turbines or internal combustion engines for power generation. The heat of the engines is returned back to the digestion process (MOS, 2013).

[64]Philadelphia Water Department (PWD) is exploring the feasibility of using food waste digesters at wastewater treatment plants (MOS, 2013).

waste processes to generate electricity. In addition, as of Spring 2013, the City's Recycling Rewards program which has received the 2012 U.S. Conference of Mayors innovative Partnership Award was enrolling over 195,000 households. The City seeks to also reduce the amount of trash that is generated by residents (MOS, 2013).

In addition to transportation and waste management, *Greenworks Philadelphia's* stormwater management and green space initiatives (under the Equity component) are indirectly related to energy and carbon management. For instance, diverting stormwater from wastewater collection and treatment systems lowers the amount of energy required to pump and treat the water[65] (MOS, 2013).

In addition, green space helps to lower ambient temperatures and shade buildings from wide temperature changes decreasing thus energy needs for cooling. *Greenworks Philadelphia* calls also for the intensification of citywide tree planting efforts (i.e. public-tree planting campaign, urban tree management program, greening the School District). Reduced energy demand in buildings and increased carbon sequestration through added vegetation can also result into carbon savings (MOS, 2009).

3.6. Greenhouse Gas Emissions Data for Philadelphia

Philadelphia's activities contribute to global climate change through the release of greenhouse gases. Figure 5 presents the per capita carbon dioxide emissions in Philadelphia and selected U.S. cities in 2010:

[65]For example, preliminary estimates of energy savings from stormwater management in the Tacony-Frankford Creek and Watershed, which includes neighborhoods in North, Northeast, and Northwest Philadelphia, put them at 120 million KWh of electricity and 230 million kBTUs of natural gas with associated carbon reductions at 220,000 tons of CO_2 (MOS, 2009).

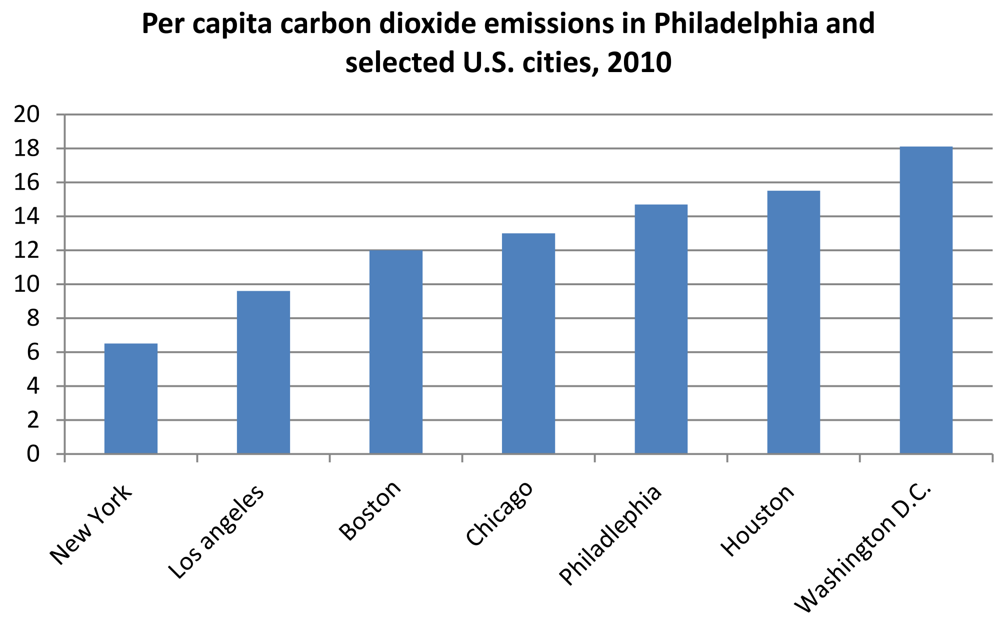

Figure 5: Per capita carbon dioxide emission in Philadelphia and selected U.S. cities, 2010

Source: (MOS, 2012)

As the data show, Philadelphia's 14.7 tons/capita emissions in 2010 were lower compared to those of Houston and Washington D.C., but higher than those of New York, Los Angeles, Boston and Chicago. However, the data have not been produced with the same methodology and using them for accurate comparisons presents difficulties. Table 10 offers Philadelphia's citywide greenhouse gas emissions by sector in 2010[66]:

[66] These are the citywide emissions data reported in *Greenworks Philadelphia* 2012 progress report and have not been updated since then (MOS, 2012; 2014).

Table 10: Philadelphia's citywide greenhouse gas emissions by sector in tons CO_2 eq., 2010

Sector	Greenhouse gas emissions (tons CO_2 eq.)
Buildings and stationary energy use	13,866,748 (62%)
Transportation	3,995,402 (18%)
Waste	1,738,116 (8%)
Industrial processes	1,514,290 (7%)
Fugitive emissions	1,165,473 (5%)
Wastewater treatment	97,976 (0.4%)
Streetlights and traffic signals	40,561 (0.2%)
Land use	-11,394[67]

Source: (MOS, 2012)

Table 10 suggests that the largest share of Philadelphia's citywide greenhouse gas emissions arise from the building sector at around 60%, followed by the transportation sector at 18%.

Philadelphia's citywide greenhouse gas emissions inventory includes Scope 1, 2 and 3 types of emissions, in accordance with the classification of the greenhouse gas emissions reporting protocol of the United Nations of Framework Convention on Climate Change. Scope 1 includes all direct greenhouse gas emissions (i.e. combustion of fuels at the point of consumption). Scope 2 includes indirect greenhouse gas emissions from the purchase of electricity, heat and steam. Scope 3

[67] The category of 'land-use' emissions accounts for greenhouse gas emissions and removals of CO_2, CH_4, and N_2O from forest management, other land-use activities and land-use change, hence overall they can contribute to net emissions reductions (EPA, 2014d).

includes other type of indirect emissions such as those associated with the extraction and production of purchased fuels or waste disposal. The latter is the only Scope 3 type of emissions in Philadelphia's community inventory (MOS, 2012).

The city uses modeling techniques to produce its citywide greenhouse gas emissions inventory. For example, fugitive emissions are modeled while MOS spent substantial time to understand emissions from waste landfill. Regarding fuel oil consumption at the citywide level, there in little information on how much fuel oil is exactly used by commercial entities in the city. MOS applies pro-rata modeling methods to estimate the citywide consumption where an approximate estimate for fuel oil use is derived based on census data and surveys conducted by the American Community on the number of people who use fuel oil in certain geographical areas of the country (A. Agalloco, personal communication, March 26, 2013). Figure 6 presents Philadelphia's citywide greenhouse gas emissions in million tons of CO_2 eq. for 1990 (baseline), 2006, 2010, and the *Greenworks Philadelphia* target for 2015:

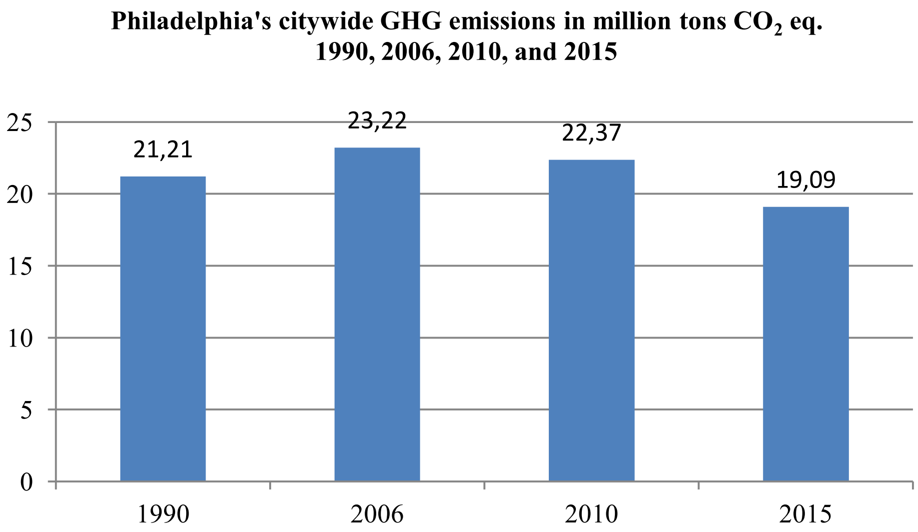

Figure 6: Philadelphia's citywide greenhouse gas emissions in million tons of CO_2 eq., 1990 (baseline), 2006, 2010, and 2015 (target)

Source: (MOS, 2012)

The data show that citywide emissions have increased by 5.4% between 1990 and 2010[68], while they have decreased by 3.6% between 2006 and 2010 primarily due to fuel switching that resulted in reduced share of coal in the energy generation mix for electricity that supplies the city[69]. Table 11 presents Philadelphia's municipal government greenhouse gas emissions by sector for 2010:

Table 11: Philadelphia's municipal government greenhouse gas emissions by sector in million tons CO_2 eq., 2010

Sector	Greenhouse gas emissions (tons CO_2 eq.)
Buildings	158,234 (30%)
Airport facilities	102,145 (20%)
Wastewater treatment	97,977 (19%)
Water treatment	72,360 (14%)
Vehicle fleet	53,320 (10%)
Street lighting and traffic signals	40,561 (8%)

Source: (MOS, 2012)

The municipal government inventory includes greenhouse gas emissions of Scope 1 and 2. The data show that the building sector accounted for the largest share of municipal emissions at 30% in 2010.

[68]The national average greenhouse gas emissions have increased by 10% over the same period (MOS, 2012).

[69]Philadelphia's citywide energy use increased by 14% over the same period (MOS, 2013).

Figure 7 presents Philadelphia's municipal government greenhouse gas emissions for 1990 (baseline year), 2006, 2010, 2012, 2013 and 2015 (target year):

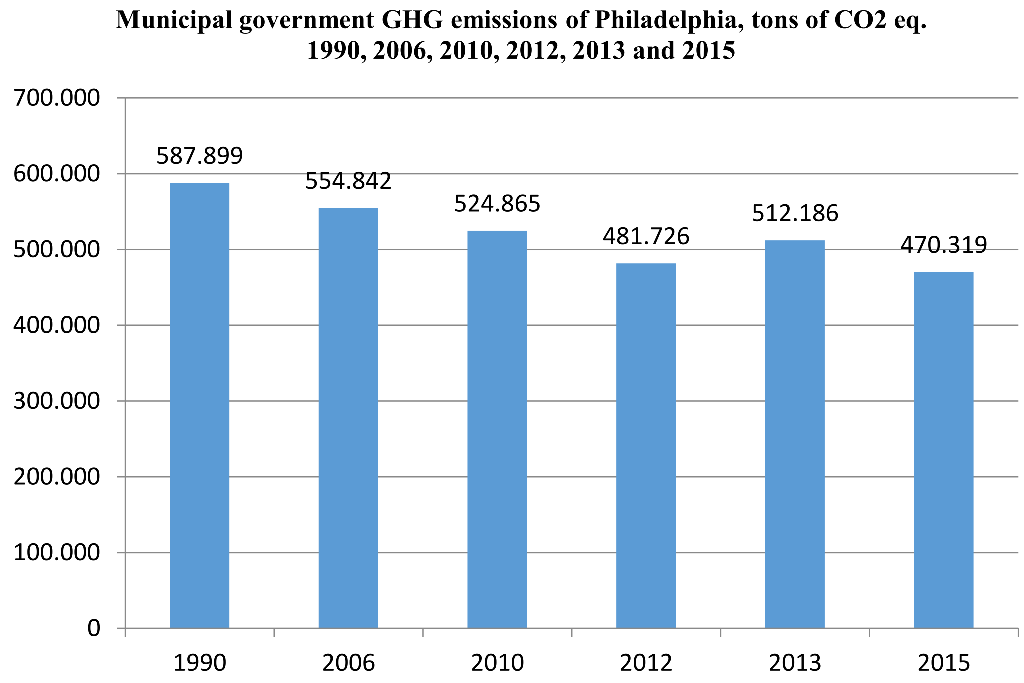

Figure 7: Philadelphia's municipal government greenhouse gas emissions in tons of CO_2 eq. for 1990 (baseline), 2006, 2010, 2012, 2013 and 2015 (target)

Source: (MOS, 2012; 2013; 2014)

Figure 7 shows that municipal government greenhouse gas emissions decreased by 13% between 1990 and 2012, with over half of the reduction achieved after 2006, while they increased in 2013 reaching almost their 2010 level. This was mainly because of higher municipal energy use driven by weather conditions[70] (MOS, 2014).

[70] The *Greenworks Philadelphia* municipal energy use data are not weather-normalized. MOS is working on this aspect in order to provide a more accurate picture of municipal energy use and greenhouse gas emissions in the future (MOS, 2014).

In contrast, Figure 6 suggests that Philadelphia's citywide greenhouse gas emissions have risen progressively since 1990, leading to a 5% increase between that year and 2010. This reveals the challenge that the city faces in reducing its citywide greenhouse gas emissions. It also shows the relative control that the city government has on managing greenhouse gas emissions from its own facilities and operations[71]. A longitudinal analysis of Philadelphia's community and municipal emissions would nevertheless require more historical data.

3.7. Energy Supply in Philadelphia

Energy users in Philadelphia receive the bulk of their electricity from PECO[72]. PECO has a history of more than 100 years of service in the Greater Philadelphia Region (Exelon, 2013). The company owns 500 electric power substations, 29,000 miles of distribution and transmission lines, 29 gas gate stations and 6,000 miles of underground gas mains that serve around 1,600,000 electricity customers and 497,000 natural gas customers in Southwestern Pennsylvania (PECO, 2013b). Around 90% of PECO's customers are residential and 10% commercial and industrial (Exelon, 2013). Much of the electricity that is currently used in Philadelphia is derived from coal and nuclear power that reach the city through the PJM Interconnection grid[73]. Table 12 describes the fuel mix for electricity generation in the entire PJM network[74]:

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[71]Municipal greenhouse emissions amounted to around 2.35% of citywide emissions in 2010 (MOS, 2012).

[72]The company supplies also gas to suburban areas (MOS, 2009).

[73] PJM Interconnection is the regional transmission organization (RTO) that serves the Philadelphia area. It manages the movement of power within and across the thirteen

Table 12: PJM interconnection's fuel sources for electricity generation (MW of installed capacity)

Fuel source	Installed capacity	% share of total capacity
Coal	66,740 MW	39%
Nuclear	30,884 MW	19%
Natural gas	26,438 MW	16%
Gas/other secondary	17,354 MW	10%
Oil	14,485 MW	9%
Hydro	7,612 MW	5%
Other	2,507 MW	2%

Source: (MOS, 2009)

The electricity market in the state of Pennsylvania was deregulated in 1999 under the Energy Choice Program developed by PUC and the state's electricity distribution companies. A special agreement between PECO and PUC mandated that the company's electricity rates remain regulated until January 2011, when its service area became deregulated and customers were offered the option to choose their electricity supplier.

PECO is the main electricity supplier in Philadelphia in the liberalized market. Customers who decide to switch supplier are charged from the new provider for the

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states of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia (PJM, 2013).

[74]The fuel mix which supplies electricity to Philadelphia changes on any given day (MOS, 2009).

generation and transmission part of the transaction while PECO charges for the distribution part of the transaction. All components of the electricity bill (generation, transmission, and distribution) are reviewed and approved by PUC (PECO, 2013c).

As of March 2014, the number of PECO customers (statewide) that have switched to another supplier amount to 548,445 which represents over 34% of its total customer base or 62% of the company's total energy load (PAPowerSwitch, 2014a). PECO is involved in energy efficiency activities the Philadelphia area which include financial incentives, marketing and education. Part of this portfolio targets low-income population (PECO 2013d; 2013e; 2013f; 2013g).

All natural gas services within the limits of Philadelphia are provided by PGW, the largest municipally-owned utility in the country but which is currently in the process of being privatized. Nearly 80% of all households in Philadelphia heat their homes with natural gas, a percentage that is typical of urban environments in northeast U.S. (Shulock, 2012; Philadelphia Business Journal, 2013).

In total, PGW serves around 500,000 residential, industrial, commercial and municipal customers in Philadelphia through a distribution system of approximately 6,000 miles of gas mains and pipelines. PGW's operations are managed by the non-profit corporation Philadelphia Facilities Management Corporation whose board members are appointed by the Mayor of Philadelphia (PGW, 2011a).

Similarly to electricity, PUC created in 1999 the Gas Choice Program with the Natural Gas Choice and Competition Act and customers in Philadelphia have now the option to choose their gas supplier (PECO, 2013c).

In the 1980s and 1990s, PGW experienced a period of financial decline but since the mid-2000s the company has reported no short-term borrowing. Last year the company reported a positive cash flow for the first time over the last fifteen years (PGW, 2011a). As a result of PGW's improved financial situation, the City retained in its FY 2011 budget, for the first time since 2004, the utility's annual dividend payment ($18 million) (PGW, 2011b). The City of Philadelphia started on November 2012 a process of selling the company to the private sector, and on March 4, 2014 the city administration signed an agreement to sell the company to UIL Holdings Corporation[75] for the price of $1.86 billion[76](Philadelphia Business Journal, 2013; City of Philadelphia, 2014a). However, on October 2014 the City Council decided to not consider the introduction of legislation that would authorize the sale on the grounds on the grounds that the risks of selling the utility outweigh stated benefits (The Philadelphia Inquirer, 2014b). If not authorized by 31 December 2014, the agreement terminates automatically (The Philadelphia Inquirer, 2014a).

PGW offers a range of energy efficiency services in Philadelphia including weatherization programs, financial incentives and education (PGW, 2011c).

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[75]With headquarters in New Haven, Connecticut, UIL serves approximately 700,000 electric and natural gas customers in Connecticut and Massachusetts and has combined total assets of over $4 billion. Its holdings comprise of the United Illuminating Company, the Southern Connecticut Gas Company, Connecticut Natural Gas Corporation and The Berkshire Gas Company (City of Philadelphia, 2014a).

[76]The sale, which is estimated to put at least $424 million into the City's pension fund, must still win approval from the City Council and PUC (City of Philadelphia 2014a). Upon finalization of the agreement, Mayor Michael Nutter stated that the terms would benefit Philadelphia taxpayers and PGW customers. The agreement would accomplish this by keeping rates frozen over three years, maintaining PGW's discount programs for low-income families and seniors, safeguarding PGW's employee and retiree pensions, and positioning the company to take full advantage of the abundant supply of natural gas in Pennsylvania assisting in that way the Philadelphia region to become a prime energy hub (City of Philadelphia, 2014a).

3.8. Sustainable Energy Development in Philadelphia: Policies, Initiatives and Actors

This section offers an overview of key policies, initiatives and actors for energy efficiency and renewable energy development in Philadelphia. The information is split by energy efficiency and renewable energy at the municipal government and citywide level, and structured around the energy targets of *Greenworks Philadelphia*.

3.8.1. Municipal Government Energy Efficiency Development

MOS leads energy efficiency development at the municipal level. The Office administers the ambitious target of 30% reduction in municipal energy use by 2015. The main interventions that have been developed towards this goal include reductions of fuel use in the municipal vehicle fleet and the installation of low-energy traffic signals in the city. Some city departments have installed energy efficiency systems in their facilities. The 30% reduction target is taken forward mainly through energy efficiency upgrades in municipal buildings. MOS is involved in a range of activities for the reduction target such as awareness raising, training, funding development, technology demonstration, and policy evaluation. In these tasks, MOS collaborates with several city departments and agencies, local energy companies and trade-allies (MOS, 2009; 2012).

3.8.2. Municipally-Led Policies for Energy Efficiency Development at the Citywide Level

MOS manages the *Greenworks Philadelphia* portfolio for energy efficiency development across the city. A key such initiative is the *EnergyWorks* program for which the Office developed a marketing campaign to inform citizens and local businesses on the options that the program offers (EnergyWorks, 2010; MOS, 2012).

MOS collaborates closely with ECA on energy efficiency policymaking and development (ECA, 2010), while its energy efficiency action is complemented by city agencies such as the City's Office of Housing and Community Development, the Philadelphia City Planning Commission, the Philadelphia Department of Licenses & Inspections, and the Philadelphia Housing Authority, a non-profit corporation active on affordable energy development (MOS, 2012; PHA, 2012).

Several initiatives have been taken to promote building energy efficiency and renewable energy in the city. In 2004, the City published the Philadelphia High-Performance Building Renovation Guidelines as a way to encourage energy conservation and renewable energy use in renovated city-owned buildings (City of Philadelphia, 2004).

In 2009, the City passed two ordinances that promote green building practices. These are the Leadership in Energy and Environmental Design (LEED) Ordinance that requires all new major constructions and renovations of city-owned buildings to be LEED-Silver certified, and the Cool Roof Ordinance which requires that all new constructions in the city adopt cool-roof techniques that meet or surpass the ENERGY-STAR cool roof standards (MOS, 2012).

In June 2012, the City passed legislation that mandates the disclosure of estimated annual energy costs upon the sale of city-owned residential properties. Philadelphia is joining three other U.S. cities and six states that have similar policies in place. The ordinance aims to encourage property buyers to consider the energy costs in their buying decisions, and property owners to adopt energy efficiency systems in their site[77] (KEEA, 2012).

In addition, in August 2012 the City passed the Energy Benchmarking Legislation Bill I20428 which requires all commercial buildings over 50,000 square feet to benchmark and publicly display their annual energy and water use. Effecting last year, the owners of 2,041 commercial buildings had to report the data by November 25, 2013. In case of non-compliance, building owners have to pay a $300 penalty and after 30 days a $100/day fee (Dews, 2013).

The ordinance aims to make available to building owners and tenants baseline information against which to measure the energy and water use performance of their site. It also aims to develop peer pressure for energy and water use reductions. The EEB Hub, and its successor CBEI, as well as the Delaware Valley Green Building Council assist in the implementation of the ordinance (Dews, 2013; Philly.com, 2013a; ECA, 2012).

Furthermore, *Greenworks Philadelphia* has made available to the local business community over $9 million in capital for energy efficiency upgrades in major building renovations and new construction projects through the *Greenwork Loans Fund* and the *Greenworks Rebate Fund* programs (MOS 2012).

Greenworks Loans Fund is offered through the Philadelphia Industrial Development Corporation (PIDC), a non-profit organization jointly founded between

[77]A similar proposal was included in *Greenworks Philadelphia* for all buildings in the city, but it has not been considered further. This is also the case with a few other proposals of the original plan such as the development of a fast-tracking approval process for LEED-certified and energy efficient buildings, and the provision of extra years of property tax abatement for energy efficient building investments (commercial and residential) (MOS, 2009; 2013).

the City of Philadelphia and the Greater Philadelphia Chamber of Commerce which undertakes citywide real estate development, and the Reinvestment Fund (TRF), a community investment group active on neighborhood revitalization projects in the Mid-Atlantic region (Shulock, 2012). The fund offers energy efficiency loans ranging from $100,000 to $1,000,000 at below-market interest rates. *Greenworks Rebate Fund* is, too, administered by PIDC and TRF offering refunds at maximum 50% of the cost of energy retrofits up to $10,000 (Shulock, 2012).

What is more, in January 2014, Philadelphia was selected along with the cities of Atlanta, Boston, Chicago, Denver, Houston, Kansas City, Los Angeles, Orlando, and Salt Lake City to participate in the City Energy Project. This is a national program that aims to assist cities developing commercial energy efficiency through efficient building operations, private investments, transparency in energy performance information, and city government leadership (projects development in municipal sites). Philadelphia's participation is expected to lower energy bills in the commercial sector of the city by around $77 million and reduce carbon emissions equal to the annual footprint of 23,000 Philadelphian homes (City of Philadelphia, 2014b).

Future City plans on building energy efficiency involve the creation of energy efficiency building code guidelines and criteria to encourage and facilitate the construction and renovation of buildings to higher energy conservation standards. At present, the City's building code defines a minimum level of energy-efficiency performance but it does not provide guidance on how to exceed these standards or how to develop an energy efficient building (MOS, 2013).

MOS, the Department of Licenses & Inspections and other city agencies plan to collaborate with public and private partners in order to address this gap by developing guidelines that will give contractors, businesses and residents constructive information on how to build or renovate sites that consume less energy, and make use of green roofs and recycled materials (MOS, 2013).

In this regard, the Department of Licenses & Inspections aims to publish guidelines for third-party certified programs, such as LEED or ENERGY STAR, which exceed existing building code requirements and which are accepted in the development planning process (MOS, 2013).

Additionally, city agencies plan to work with Delaware Valley Green Building Council on customer-friendly guidelines for building materials, equipment and construction practices that could increase the energy performance of building projects in the city (MOS, 2013).

A key municipal agency for energy efficiency development at the citywide level is PGW. The utility's action in this area dates over two decades' time. Back in 1990, PGW developed the Conservation Works Program (CWP). CWP, which became part of Pennsylvania's Statewide Low Income Usage Reduction Program[78] (LIURP), served participants of the utility's low-income bill energy assistance program, known as the Customer Responsibility Program[79] (CRP), by offering energy weatherization and education services. In exploring further opportunities on gas

[78]This is a statewide program which mandates regulated energy utilities to assist low-income households reduce their energy costs and electricity and gas consumption through weatherization and energy education (Shingler, 2009).

[79]Under CRP, which continues operation to date, PGW customers with income at or below 150% of the federal poverty level can pay a percentage of their income for natural gas service irrespective of the amount of gas they use. The remaining cost of the gas service to CRP customers is covered by all other ratepayers of the company (Elliot et al., 2012).

conservation, PGW began to consider options for expanding its CWP program. Hence, a pilot program was introduced in 2006 that increased the range of services offered to customers and allowed more money to be spent in each home (Elliot et al., 2012).

After the initial results of the CWP pilot program, and observant of the state Act 129 which covers electric but not gas utilities, PGW began the process of setting-up a more comprehensive natural gas energy efficiency portfolio. As part of its 2009 gas rate case to PUC, PGW petitioned the commission to approve a portfolio of natural gas energy efficiency programs to be rolled out over five years (Elliot, 2012).

The portfolio, called *EnergySense*, was approved and its core program is an expanded version of PGW's CWP, which is named Enhanced Low Income Retrofit Program[80] (ELIRP) and has received \$20 million, making it the largest program in the portfolio. The full suite of the proposed programs was incorporated into a gas rate case settlement petition that was finally approved by the PUC on July 2010. The portfolio was launched on September 1, 2011 with ELIRP (Elliot, 2012). It is estimated that *EnergySense* will cost around \$58 million, provide \$54 million in net benefits and create over 900 new jobs (Elliot et al., 2012).

EnergySense targets over 100,000 residential (including low-income households), commercial and industrial customers in Philadelphia. Its residential

[80]ELIRP has two main goals. First, to provide cost-effective energy savings to low-income customers who participate in PGW's CRP program, and second to reduce the long-term costs of the CRP as paid by all company's customers. As a result, the program focuses on the volume of cost-effective savings rather than on achieving maximum penetrations. In other words, ELIRP does not aim to transform the market, but to provide the most cost-effective energy savings possible at the individual home level (Elliot, 2012).

programs offer rebates up to $3,000 for home energy improvements[81], rebates between $500 and $1,500 for energy efficient equipment, and construction grants up to $750 for more efficient natural gas equipment (PGW, 2013a).

The commercial and industrial programs offer equipment rebates (between $800 and $8,400), construction grants (up to $60,000 for new and existing buildings) and building grants (up to $75,000 for existing buildings). Home energy improvements supported by the program could be also assisted through low-cost loans from the Keystone HELP, a statewide program on residential energy upgrades. Multi-family residential owners are also eligible to apply to *EnergySense* (PGW, 2013b; Elliot et al., 2012).

Since September 2013, the portfolio offers expanded options to residential customers including weatherization assistance, rebates for energy efficient heating equipment, and high energy efficient constructions (PGW, 2013b).

EnergySense aims to contribute to job creation in the Philadelphia area through training programs in energy efficiency administered between PGW and Philadelphia Workforce Development Corporation (PWD) (PGW 2011c; 2011d). The portfolio supports the energy efficiency goals of *Greenworks Philadelphia,* and it is estimated to result into 1.24 million tons of carbon dioxide emissions reductions over its lifetime. Since 2008, *EnergySense* has completed 5,800 home energy retrofits (MOS, 2014).

[81] When customers invest in a PGW home energy assessment for $150 (worth of $500), and complete eligible energy efficiency work (PGW, 2013a).

3.8.3. Key Local and Regional Actors for Energy Efficiency Development in Philadelphia

Various local and regional entities other than ECA, NECs, PHA, and EEB Hub/CBEI are involved in energy efficiency development in Philadelphia. PECO is one of them offering thirteen energy efficiency programs to residential and commercial/industrial customers under state Act 129. These involve several aspects ranging from rebates for interventions in existing and new housing sites to incentives for energy efficient construction and equipment (commercial and industrial), recycling of energy wasteful residential appliances, support for behavioral changes through information and education (families/students), and assistance to low-income households in bill management (PECO 2013d; 2013e; 2013f; 2013g).

State Act 129 mandates also the utility to deploy advanced metering technology to all of its customers by May 31, 2015. To meet this obligation, the company developed the PECO Smart Meter Program. This new metering technology will be used to provide customers with information on their energy use, to establish a two-way communication between energy-users and the grid, and to offer customers the option to choose time-of-use rates or dynamic pricing in energy consumption (PECO, 2013h).

The Smart Meter Program runs on two phases. Phase 1, which started in 2010, has been completed and involved the deployment of the core underlying metering infrastructure technologies as well as technological basis for the full deployment of the smart metering technology whose installation started in 2013 (Phase II of the program) with timeline of completion the end of 2014[82] (PECO, 2013h).

PECO has also deployed the required technology and completed planning to implement a dynamic pricing and customer acceptance program to determine how customers may use the new pricing options that will be facilitated by smart meters. The energy users are offered the option to choose between three energy pricing options; real time, on/off peak or average pricing (PECO, 2011h). PECO has begun the process of deploying smart meters in municipal buildings in Philadelphia and installation in most facilities is expected to be completed by the end of 2014 (MOS, 2014). PECO partners also with community, governmental, professional associations and non-profit entities on energy efficiency outreach events (PECO, 2013i).

The Delaware Valley Regional Planning Commission (DVRPC), a federally-designated Metropolitan Planning Organization for the Greater Philadelphia Region, is another external actor involved in energy efficiency in the area. DVRPC has provided technical assistance to the City of Philadelphia on the replacement of 85,000 city-traffic signals with LED technology in the form of a technical tool that assesses energy, financial and greenhouse gas impacts of different options (DVRPC, 2013).

Financial and banking entities are also involved in energy efficiency development in Philadelphia. For example, the residential part of *EnergyWorks* was offered through AFC First Financial, a nationwide entity in residential energy-efficiency and renewable lending and rebate programs. Its commercial part is offered

[82]PECO estimates the total cost of the program at approximately $600 million. The company has proposed to recoup this cost through its existing Smart Meter Cost Recovery Surcharge (PECO, 2011h). As of August 2013, around 600,000 PECO customers have been supplied with smart meters service-territory wide (Philly.com, 2013b).

through the Reinvestment Fund, a national leader in the financing of neighborhood revitalization, and Philadelphia Industrial Development Corporation, a city-wide non-profit economic development corporation (Gillen & Uher, 2011).

In addition, three local banks, the Citizens Bank, PNC Bank and TD Bank, offer the PHIL loan for residential energy efficiency improvements. This is a low-interest loan for home improvements, including energy efficiency, whose interest rate ranges between 3 to 5% depending on the level of household income (Shulock, 2012).

Furthermore, local energy entities such as ECA offer technical services on energy efficiency. For example, ECA is a certified-LEED Home Provider; these are local and regional organizations chosen by the U.S. Green Building Council to provide certification on technical services in the energy market (ECA, 2013a). Energy consulting services are also offered by local entities. For instance, in 2011, Econsult Corporation published a feasibility study on behalf of EEB Hub that assesses the market potential for commercial energy retrofits in the Philadelphia region (Gillen & Uher, 2011).

As a result of energy efficiency programs active in the region over the last years, several businesses have been set-up in the Philadelphia area that offer energy efficiency products and services. Veolia Energy North America, a private company active in the area, has also developed one of the few combined heat and power systems that operate in the city. The company's district energy network serves over five hundred local business and university buildings through three steam-production facilities and a chilled-water facility. The company has currently put forward a multi-million dollar investment to convert its district energy network in Philadelphia to 100% steam (Energy Manager Today, 2013).

In addition, the Commonwealth Financing Authority (CFA), an independent agency created to administer state economic stimulus packages, offers to municipalities and counties funding for energy efficiency and renewable energy development through its Alternative and Clean Energy and High Performance Building programs (PA Department of Community and Economic Development, 2013).

In the transportation sector, finally, SEPTA is interested to incorporate energy efficiency and renewable energy in own facilities and operations. The agency aims also to improve its greenhouse gas performance by 5% annually. In 2011, SEPTA released its greenhouse gas inventory for 2009 (baseline year). Alternative fuels such as electric and hydrogen fuel cells, and renewable energy development in its real estate assets, are measures that SEPTA plans to implement towards meeting its greenhouse gas reduction goals (SEPTA, 2011).

3.8.4 State and Federal Input In Relation to Energy Efficiency Development in Philadelphia

The state and federal context has been supportive in certain aspects regarding sustainable energy development in Philadelphia. Former state Governor Edward Rendell enacted in 2004 the state's Alternative Energy Portfolio Standard Act which requires all electric distribution companies and electric generation suppliers to retail electric customers in Pennsylvania to supply 18% of their electricity using alternative energy resources by 2020, 0.5% out of which must derive from solar photovoltaics (DSIRE, 2011).

The state has also passed the Pennsylvania Climate Change Act 2008 accompanied by a detailed climate action plan (PA DEP, 2009). At the administrative level, the Governor's Green Government Council has been set-up to provide guidance to state agencies and employees on the incorporation of environmental considerations in their daily practices and decision-making (PA GGGC, 2012).

In addition, under Act 129 passed in 2008 all electric distribution companies in the state with more than 100,000 customers have to develop a plan to reduce energy demand and consumption within their service territory. The Act mandated minimum 1% retail electricity reductions by May 31, 2011, and minimum 3% retail electricity reductions and 4.5% peak electricity demand reductions by May 31, 2013. Energy conservation plans by energy utilities to assist compliance with Act 129 require approval by PUC (D.O.E. EERE, 2013c).

Independent evaluation of Act 129 suggests that as of May 31, 2011 all but one utility in the state exceeded the 1% energy reduction goal. This resulted in electricity savings of 2,075 gigawatt hours which correspond to over $278 million annual financial savings for ratepayers (Philly.com, 2011).

PUC has initiated a second phase of Act 129 that runs from June 2013 to May 2016 and which includes different energy saving goals for each utility. The Act requires no less than 10% of energy reductions to derive from interventions in federal, state, and local government units (D.O.E. EERE, 2013c).

In 2008, the state passed the Alternative Energy Investment Act which authorized $650 million in grants, loans and tax credits to promote clean energy and reduce carbon dioxide emissions. Of the total amount, $237.5 million are allocated to help customers reduce their electricity consumption and the remaining to support renewable energy development (Office of the Governor 2009). The energy efficiency programs supported by the Act have been further enhanced through funding provided by Act 129 and ARRA 2009[83] (Office of the Governor, 2009).

Recognizing that compliance with environmental regulations can be burdensome for small businesses, the state's Department of Environmental Protection has created the Small Business Assistance Program, a component of which is the Small Business Advantage Grant Program. This provides 50% matching grants, up to $9,500 maximum, to enable small businesses adopt energy efficient or pollution prevention equipment or processes (PA DEP, 2014).

What is more, PUC's Sustainable Development Fund supports energy efficiency initiatives in the state. The program, which is administered by TRF, was created by PUC as part of PECO's restructuring proceeding to support energy efficiency and renewable energy development in the utility's service territory (DSIRE 2012). In 2013, the program allocated $32 million for energy efficiency and renewable energy (TRF, 2014a). TRF was also the administrator of the *Pennsylvania Green Energy Loan Fund*[84] that was offering until recently low-cost energy efficiency financing to commercial, nonprofit, government, multifamily residential and industrial entities. The fund has been fully committed and no more applications can be accepted (TRF, 2014b)

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[83]ARRA 2009 is seen by the state government of Pennsylvania as an opportunity for fostering energy independence, sustainable economic development, job creation, energy cost reductions, environmental improvement and the expansion of local energy production companies (Office of the Governor, 2009).

[84] This was a revolving loan fund available through the ARRA 2009-supported State Energy Program grant offered from the U.S. Department of Energy to the Pennsylvania Department of Environmental Protection to support building energy projects (TRF, 2014b).

In September 2009, MOS was awarded federal funding through EECBG. This included a formula-based grant of $14.1 million for energy efficiency and renewable energy projects[85] (MOS, 2009) and a competitive-based grant of $25 million, called *Better Buildings*, to support the creation of a large-scale energy retrofit market in the Greater Philadelphia area (MOS, 2012).

3.8.5. Key Initiatives and Actors for Renewable Energy Development in Philadelphia

Target 4 of *Greenworks Philadelphia* calls for a 20% citywide electricity use through the generation and/or purchase of alternative energy sources[86]. In 2008, Philadelphia purchased or generated 2.5% of alternative energy sources for citywide electricity use. In 2012, the share increased to 14%. In the same year, 20% of total municipal energy use was renewable energy-based, primarily through the purchase of wind power energy credits (MOS, 2013).

The City is developing renewable electricity in municipal facilities to demonstrate the benefits of using renewable energy systems for electricity generation. In 2011, PWD installed a 250KW solar photovoltaic system at its Southwest Wastewater Treatment Plant (MOS 2012). The facility's anaerobic digesters receive directly deicing fluid from the Philadelphia International Airport whose treatment

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[85] In 2013, the City completed work on twelve energy efficiency programs that were supported through the $14.1 million formula EECBG grant (MOS 2013). A small part of the City's EECBG fund supports renewable energy (MOS, 2012).

[86] Effective January 2011, the electricity market in the state of Pennsylvania has been fully deregulated and as a result all types of customers have access to several renewable energy products and services (Fein, 2010).

reduces operating expenses for the airport, creates revenue for PGW, and produces useful methane (MOS, 2013).

PWD has also developed a five year utility-wide Strategic Energy Plan that is updated annually with project-specific plans (MOS, 2014). In 2012, the department announced an agreement with the local energy company Ameresco for the design and installation of a 5.6 MW biogas-to-energy system for wastewater treatment at the Northeast Water Pollution Control Plant (MOS, 2012). The project was completed in 2013 and it is estimated that the captured biogas will generate 43,000 MWh annually, enough to meet 85% of the plant's heat and electrical demand (MOS, 2013; 2014).

The Philadelphia Energy Authority aims to promote renewable energy development through the purchase or facilitation of energy services on behalf of the City of Philadelphia and external stakeholders (i.e. institutions and businesses), and the provision of information to consumers regarding choices available in the marketplace (PEA, 2013).

In addition, PECO owns no renewable energy generation assets. The company complies with its AEPS requirements by buying renewable energy credits in the state's Solar Alternative Energy Generation (SAEG) market (PECO, 2013h).

As part of Philadelphia's designation of Solar America City by D.O.E. in 2008, the City has developed the Philadelphia Solar City Partnership initiative in collaboration with local, regional and national entities. SCP is led by the Mayor's Office of Transportation and Utilities and aims to develop 57.8 MW of local solar electricity capacity by 2021 (MOS, 2012). Within the context of SCP, the City has developed provisions and guidance to facilitate renewable energy investments by the private sector (MOS, 2009).

Renewable energy development is also supported by the City's new zoning code adopted in 2012. The code allows for the installation of solar and wind energy systems in parts of the city's built environment that could not accommodate them due to legal restrictions, i.e. regarding limits on maximum allowable building heights. The Philadelphia City Planning Commission sees the new zoning code as an opportunity for the development of more sustainable and self-reliant communities and neighborhoods in the city, with renewable energy development considered as potentially contributing to this goal (PCPC, 2011).

Furthermore, the *Philly Buying Power*, a City-endorsed initiative, aggregates renewable electricity demand for small and medium-sized businesses to achieve better prices. The program aims to accelerate the renewable energy market in Philadelphia. In 2012, it was used for more than 400 properties at prices below the default electricity market price leading to purchases of over 46 million KWh of renewable electricity (MOS, 2013).

A few smart-grid projects have been also developed within the city. In 2010, Viridity Energy in partnership with Drexel University developed a project to optimize the operation and energy performance of campus buildings through dynamic load management techniques. In addition, the system seeks revenue creation by bidding realized energy reductions into the wholesale electricity market while future plans include the expansion of the project's applications to other buildings and assets of the campus (Viridity Energy, 2010).

Future city government plans on renewable energy development include the provision of education to the public on benefits associated with the use of locally generated or purchased renewable electricity, and the use of Power Purchase

Agreements to develop renewable energy in municipal sites (once the renewable electricity market in the state improves). The City explores also options for hydroelectric generation at the new design of the Flat Rock Dam at the Schuylkill river that is underway (MOS, 2013).

As of May 2012, nearly 153 solar installations were in operation in Philadelphia at the citywide level with a total capacity of 3.8 MW. The level of investments by private utilities in solar power in order to comply with AEPS obligations is closely related to the operation of the SAEG market which currently experiences low solar renewable energy credit (SREC) prices This factor has lowered the interest of investor-owned utilities for renewable electricity development in the city (MOS, 2012).

At the state level, PUC's Sustainable Development Fund supports renewable energy development throughout the state. The fund which has received approximately $31.8 million over its lifetime targets the commercial, industrial, nonprofit, and school sectors in PECO's territory, and provides commercial loans and equity financing for renewable energy development. Recently the fund received additional budget, through the merger agreement between PECO and Unicom, which supports wind and solar power project development (D.O.E. EERE, 2012c).

In the transportation sector, Philadelphia is investing in alternative fuel charging infrastructure to facilitate the market development of alternative fuel vehicles. MOS is currently developing a pilot program for the installation of twenty electric vehicle chargers in the city through a $140,000 grant from the state's Department of Environmental Protection. Eighteen chargers will be used by members of the *Philly Car Share* program and two will be available for public use (MOS, 2012).

Philadelphia is also developing sustainable transportation infrastructure. In addition to 472 hybrid electric buses already in operation, SEPTA aims to purchase 160 extra hybrid units to replace aging diesel buses. Furthermore, the City is considering the development of demand pricing schemes for parking (MOS, 2013).

SEPTA has been assisted by Viridity Energy on developing an energy optimization project that improves battery charge and discharge while it integrates battery operation with PECO's distribution system and PJM's wholesale power market leading thus to quality improvements and income generation for the Transportation Authority (Zibelman, 2011).

Local alternative transportation is also promoted through the Greater Philadelphia Area Clean Cities Coalition. This is a regional association of public and private actors, including some of the largest utilities, fleets and fuel providers of the area, designated in 1993 by D.O.E. (Greater Philadelphia Clean Cities, 2013a). PWG, PECO, and the Greater Philadelphia Chamber of Commerce are permanent members of the coalition (Greater Philadelphia Clean Cities, 2013b).

3.9. Conclusion

This chapter provided an overview of the key actors, policies and measures for energy efficiency and renewable energy development in Philadelphia. It showed that the city government has adopted a strategic approach on energy sustainability guided by its formal sustainability plan. Following-up on its initial policy initiatives, the City aims to take greater sustainable energy action both at the municipal and citywide level. At the same time, various private and civic entities are undertaking numerous tasks relevant to local energy sustainability. A rather complex and fragmented picture of sustainable energy development in Philadelphia emerges which involves multiple actors, policies and initiatives.

The question is thus raised of how can the city build on its past and current initiatives, and take greater action for sustainable energy development. In assessing this issue, the study assesses the overall governance context within which Philadelphia pursues its energy sustainability policy goals, and explores within it four key local energy policy initiatives by discussing what they have achieved up-to-present, the factors that constrain or facilitate their operation, and how they can be further promoted. The examined initiatives include the role of the City's Mayor's Office of Sustainability in developing and managing a multi-stakeholder policy framework for local energy sustainability, the Philadelphia Solar City Partnership which aims to facilitate the development of solar power capacity in the city, affordable energy development in the residential sector of the city, and the role of the Energy Efficient Buildings Hub in energy efficiency development in the commercial sector at the local to regional level. Chapter 4 presents and evaluates the Mayor's Office of Sustainability energy initiative.

Chapter 4

THE CITY OF PHILADELPHIA MAYORS OFFICE OF SUSTAINABILITY ENERGY INITIATIVE

4.1. Origins of MOS and its General Energy Tasks

The City of Philadelphia Mayor's Office of Sustainability was established in 2009 as the institutional unit of the administration to manage *Greenworks Philadelphia* sustainability plan. Mayor Michael Nutter came into office in 2007 and MOS was established following-up on a campaign promise. The office is staffed with five people, one of which devotes her time between MOS and the Capital Programs Office (A. Agalloco, personal communication, March 26, 2013).

The creation of a municipal sustainability office was a topic that was raised in the city's 2009 mayoral electoral campaign when citizens expressed the view that they want sustainability to be a core area for their next city administration. At the same time, federal ARRA Act 2009 was perceived by the city government as an opportunity for promoting the use of cleaner energy sources and building energy use reductions in the city[87] (K. Gajewski, personal communication, April 03, 2013).

During the mayoral race, a local coalition led by the Next Great City Coalition was active in putting sustainability on the campaign agenda and pushed the mayoral candidates to include sustainability in their proposed political programs. The coalition

[87]ARRA 2009 provided $43 billion in energy-related investments nationwide with approximately a third of the funds supporting building energy efficiency. The City saw an opportunity to pursue and use such funds in order to foster a better future for Philadelphians (MOS, 2009).

was formed in 2007, consisting of over 100 community, faith, environmental, business, and union organizations, with the goal to promote in partnership with the city administration the development of cleaner, safer and healthier neighborhoods in Philadelphia (Next Great City Philadelphia , 2012). In this context, the coalition proposed ten action steps to be adopted by the next mayor which ultimately became the blueprint that was followed for *Greenworks Philadelphia* plan. MOS was, thus, born as part of a 'public push' for greater sustainability action, but also as a best practice that Philadelphia was seeing in other cities of the country either traditionally active in urban sustainability, such as San Francisco and Seattle, or cities, like Chicago and New York, that had started more recently to take action in this area (K. Gajewski, personal communication, April 03, 2013).

Long before MOS, in 1984, the City of Philadelphia had established a Municipal Energy Office to drive down the cost of municipal energy use but the office was operating in an on and off mode. This was mainly due to the volatility in energy prices over the 1980s and 1990s which were making energy efficiency investments in municipal facilities attractive, when energy prices were high, or less favorable, when prices were dropping (K. Gajewski, personal communication, April 03, 2013).

Within this context, the Municipal Energy Office had a robust program during the administration of Mayor Edward Rendell (1992-1999) with a sizeable number of staff people and initiatives being taken or planned. However, during the administration of Mayor John Street (1999-2008) that preceded Mayor Michael Nutter, the office was reduced considerably and left with a small budget and little influence within the administration (K. Gajewski, personal communication, April 03, 2013).

The Energy Office was re-established by the current administration in 2012 and placed within MOTU. The Office is responsible for the energy procurement transactions of the city government and manages the City's relationships with energy utilities. It also administers the City's participation in PJM's Demand Response Program and co-administers, with MOS, the City's utility bill energy management system (MOS, 2012).

What the fate of the Energy Office shows, hence, is that over the last thirty years the focus of the city government on energy management trends closely to changes in energy prices. When prices have been high energy efficiency was firmly on the agenda. However, when prices would drop to low levels, the city administration tended to have a reduced focus on energy management. This suggests that there has been a mixed history on municipal energy management in Philadelphia, with a more strategic focus adopted when there is an opportunity for energy cost savings but with more of an ad-hoc approach when energy prices are low (K. Gajewski, personal communication, April 03, 2013).

As a result of this approach, when MOS was established there was no clear idea of how energy should be treated in its agenda. In the first three years of operation, MOS was undertaking all municipal energy functions, including energy procurement. However, it was then decided that certain tasks, such as energy procurement, renewable energy development and the interaction with energy utilities, fit better under the scope of MOTU as its remit includes the management of utility affairs. This was a direct consequence of the City's executive and administrative structure which defines the core tasks and programmatic responsibilities of departments and agencies (Departments, Offices, Committees, etc.) (K. Gajewski, personal communication, April 03, 2013).

As a result of this re-organization, MOS assumed the municipal energy efficiency portfolio. The split of energy demand and supply between MOS and MOTU was based on the MOS's experience over the first years of its operation. This also provided guidance on which individuals would fit where in the new structure (K. Gajewski, personal communication, April 03, 2013).

In addition, the split of responsibilities between energy demand and supply, and the organizational context within which MOS operates to promote its agenda which is based on inter-departmental collaborations, have resulted in energy being diffused across municipal government units and functions, as a policy issue. While this can be regarded as a constraining factor towards having a more integrated energy policy approach, it gives the opportunity to promote the energy sustainability agenda within the city government through means of coordination and persuasion (K. Gajewski, personal communication, April 03, 2013).

In this context, monthly meetings are held between MOS and MOTU, while MOS interacts with departments whose function is closely related to energy management, and with any municipal agencies that would be interested in getting more involved with energy efficiency (K. Gajewski, personal communication, April 03, 2013).

MOS suggests that the division of energy responsibilities with MOTU is clear and that coordination of energy management issues across the administration is facilitated through the involvement of dedicated individuals (K. Gajewski, personal communication, April 03, 2013).

In May 2014, the City Council passed unanimously Bill No. 130878 to make the Office of Sustainability permanent within the city government. This requires a change to the City Charter which must be approved by voters on the November 2014 ballot (Greenworks Philadelphia 2014). Section 4.2. describes the energy responsibilities of MOS within *Greenworks Philadelphia*.

4.2. MOS Energy Responsibilities within Greenworks Philadelphia Sustainability Plan

4.2.1. The Target of 30% Reduction in Municipal Government Energy Use

Overview

The city government of Philadelphia sees municipal energy efficiency development as a way to promote municipal energy costs reductions, protect the city government against rising energy prices, and encourage energy sustainability action by local actors through 'leading by example' (MOS, 2009). *Greenworks Philadelphia* target 1 calls for a 30% reduction in municipal government energy use[88] by 2015 compared to a 2008 baseline of 3.77 trillion BTUs.

The City procures its energy (i.e. for lighting, heating, cooling, and to run its vehicle fleet) centrally through its General Fund and Water Fund. Energy procurement through the General Fund covers all electricity (including street-

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[88]The municipal energy plan does not include Philadelphia International Airport, which is owned by the City, as the airport has a separate environmental plan. However, MOS collaborates frequently with their personnel on energy efficiency (A. Agalloco, personal communication, March 26, 2013).

lighting), natural gas, steam, heating oil, and gasoline needs other than those of the Philadelphia Water Department which are covered by the Water Fund (MOS, 2009).

The 2008 energy baseline for the 30% energy reduction target is comprised of 2.52 trillion BTUs procured though the General Fund, and 1.25 trillion BTUs procured through the Water Fund. Projections for General Fund and Water Fund energy procurement in 2015 (target year) are estimated at 2.49 trillion BTUs and 1.67 trillion BTUs respectively, totaling over 4.16 trillion BTUs. Meeting the 30% reduction goal requires that municipal energy use reaches 2.64 trillion BTUs in 2015. In 2013, municipal energy use reached 3.84 trillion BTUs. This reflects a 2% increase compared to the baseline (MOS, 2014).

In 2008, the City spent more than $33 million from its General Fund to heat, cool and power its buildings and street lights. This reached $50 million for 2011, and based on projected rate increases and inflation it is estimated to increase to $104 million for 2015 (MOS, 2009; 2014). Meeting the 30% energy target could result in over $36 million municipal energy cost savings in 2015 (MOS 2009).

The largest municipal energy users in the General Fund are the Prison System and the Department of Public Property which both manage several large and complex sites. Although many city departments had reduced their energy demand prior to the introduction of *Greenworks Philadelphia*, this was not a priority issue by the majority of departments. Mainstreaming energy management considerations across city agencies is now considered as critical for making progress on the 30% reduction target (MOS, 2009).

Before the establishment of MOS, the City was lacking a robust internal program on energy efficiency. MOS soon realized that the availability of reliable data on municipal energy use, and in-house technical knowledge on energy, would be necessary for developing a comprehensive approach on municipal energy efficiency. During the first administration of President Barack Obama, funding to support programs on clean energy development became available through federal ARRA 2009 stimulus funding. This financial source was seen by the city government as an opportunity to organize its basic energy efficiency plan (K. Gajewski, personal communication, April 03, 2013).

The City has undertaken exemplar projects within the context of the 30% target. For example, in April 2012, PWD installed a commercial-scale geothermal system that provides heating and cooling using domestic wastewater at the Southwest Wastewater Treatment Plant. PGW has also installed a 200-kilowatt natural gas-fired combined heat and power microturbine system that generates on-site over 40% of the electricity needs of its headquarters. The waste heat of the system is used to heat and cool the facility (MOS, 2012). In the future, the City aims to use municipal buildings as sites for the testing of emerging energy efficiency technologies (MOS, 2013).

Energy data relevant to the 30% municipal energy use reduction target

A key component of the City's municipal energy plan is the availability of systematic data of energy consumption in municipal facilities. In the past years, the City was lacking a way to organize its utility energy consumption data, while no data were available to perform modeling analysis of municipal energy consumption (K. Gajewski, personal communication, April 03, 2013).

With nearly 1000 electric, gas and steam accounts from over 600 facilities of diverse functions and energy loads, MOS spent two years just to organize the municipal energy use data and develop a sophisticated management system that enables tracking and reporting of energy consumption at the facility level (MOS 2014, K. Gajewski, personal communication, April 03, 2013).

The municipal energy database is based on utility energy information. In cases where data are not readily available, i.e. fuel use in the vehicle fleet, MOS models energy use. In order to better understand the energy performance of its building portfolio and prioritize energy efficiency interventions, the City has begun to benchmark energy use in large facilities over 10,000 sq. feet. For this task, the US EPA's ENERGY STAR Portfolio Manager tool[89] is used. This is a free online tool which assigns an energy use score that ranges from 1 to 100 to different building types. The regular benchmarking of building energy use is expected to inform strategic investments in facilities that are high energy-users, and to allow the City to monitor the performance of undertaken energy efficiency projects over time (MOS, 2013).

In 2014, MOS published the benchmarking energy use results for over 250 of its large facilities amounting to nearly 10 million sq. feet of floor area. Their total energy use was estimated at 1.4 million BTUs (MOS, 2014).

Figure 8 presents the sectoral energy use summary for the benchmarked facilities by reporting their ENERGY STAR scores and Energy Usage Intensity index (kBTUs/sf):

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[89]For the 2011 energy benchmarking reporting, basic facility information (i.e. facility type, square footage, hours of operation etc.) and energy and water use information from the City's utility partners has been used as input in the Portfolio Manager tool. In 2013, PECO and Veolia (the company that supplies city-buildings with steam) established automated benchmarking systems that will directly transfer utility data into the software. This is expected to improve energy reporting (MOS, 2014).

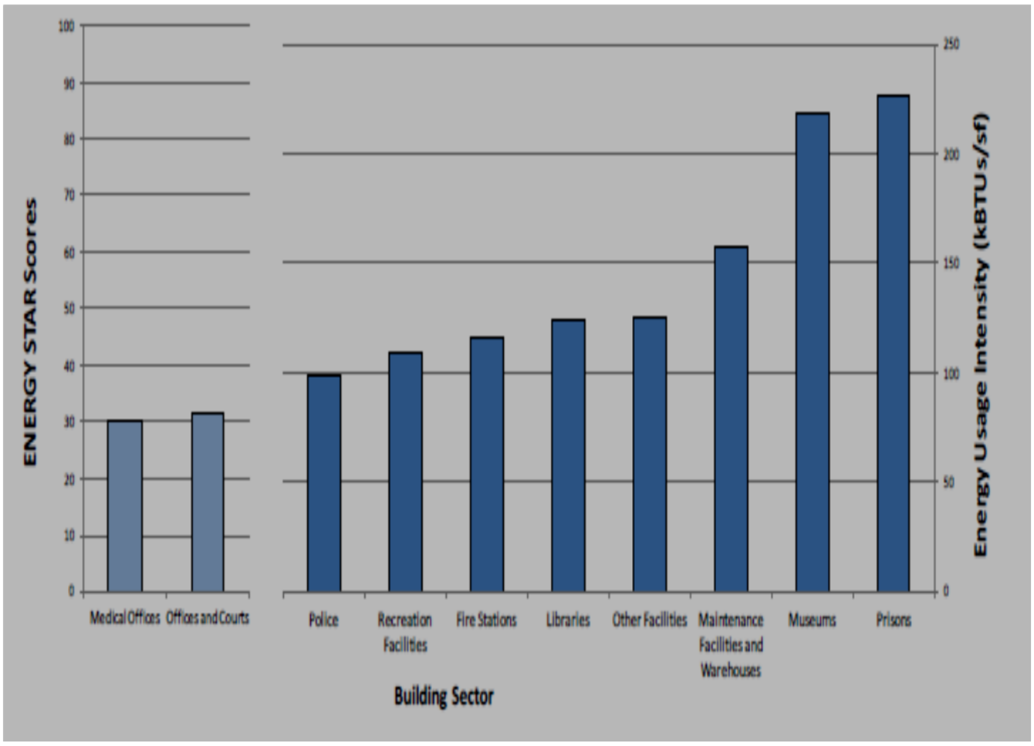

Figure 8: ENERGY STAR scores and Energy Usage Intensity (kBTUs/sf) for municipal benchmarked facilities by building sector, 2011

Source: (MOS, 2014)

As Figure 8 shows, the Prison System, Museums, and Maintenance Facilities and Warehouses sectors had the highest energy use intensity in 2011. In addition, the benchmarking results revealed that twenty buildings in three sectors (offices and courts, prisons and museums) amounted to over 60% of total energy use across the benchmarked facilities. Therefore, these buildings are main candidates for energy efficiency interventions (MOS, 2014).

The municipal energy database assists also MOS to support energy efficiency proposals put forward to the City's Budget Director through the estimation of financial data, i.e. project payback period. This type of information is critical in the view of key decision-makers within the administration regarding the financial viability of proposed energy projects (K. Gajewski, personal communication, April 03, 2013).

In addition, MOTU supplies city departments with monthly reports on their energy use, and MOS offers training to employees on how to track energy use through the energy reports. This information is important for assisting departments to identify opportunities for energy efficiency improvements (MOS, 2012). The municipal energy use data are also used for the production of the municipal greenhouse gas inventory. MOS aims to produce annual estimates of sectoral municipal energy use, and to publish municipal and citywide greenhouse gas inventories bi-annually (A. Agalloco, personal communication, March 26, 2013).

Key initiatives, measures and progress towards the 30% energy reduction target

Philadelphia's municipal government energy efficiency approach targets the city government portfolio of over 600 municipal buildings, 4,000 vehicles, and the city's street-lighting system. Any fuel, or energy source, that fits within these energy users falls within the municipal energy reduction plan for the 30% target. This includes electricity, natural gas, steam, gasoline, diesel, and small quantities of fuels such as biofuels that are sparsely used (Dews, 2013).

The City's building sector is the largest contributor to municipal energy consumption. In deciding how to prioritize energy efficiency action in municipal sites, the projects that maximize the financial payback of investments are prime candidates. These are typically the cases with buildings of low energy performance. For example, the top 50 energy users of the 600 municipal buildings make-up around 77% of the General Fund's energy costs, and the top 10 energy users make-up around 44% of this cost. These sites are, thus, targets for project development as they have a large potential for energy efficiency improvements (Dews, 2013).

Part of MOS's work involves the promotion of energy efficiency across city departments. MOS communicates with individuals across departments to explore opportunities for energy efficiency uptake. The office suggests that departments tend to be more inclined to adopt energy efficiency when there is a need to upgrade their facilities in anyway. When this is not the case, departments are less inclined to undertake energy efficiency upgrades based only on energy considerations. The internal networking that takes place between MOS and departments on energy efficiency is also important for fostering a more integrated energy policy approach within the city government (A. Agalloco, personal communication, March 26, 2013).

As resources for energy efficiency are limited, the City aims to use them effectively. A key source of funding for municipal energy efficiency is the Energy Efficiency Fund (EEF) program, established in 2010, which offers annually to departments, on a competitive basis, over a half million dollars of capital funding for energy upgrades in existing facilities. Proposals are submitted to an interdepartmental selection committee and funding is awarded based on potential energy savings (MOS, 2012). Up to date, EEF has allocated over $2.5 million for energy upgrades that has led to over $480,000 savings annually (MOS, 2014).

Another source of revenue for municipal energy efficiency is rebates that are available to the city government from PECO's Act 129 Smart Ideas Program. In Phase I of PECO Act 129 program, the City received over $3.6 million of such rebates. In June 2013, Phase II of PECO Act 129 program went into effect, and the City applied for these rebates (MOS, 2014).

The City has also develop a $6.25 million bond funding for a large energy and water efficiency investment project known as the Quadplex (K. Gajewski, personal communication, April 03, 2013). The funding for this project was secured through the sale of the City Agreement Revenue Bonds, Series 2012A and Series 2012B on May 31, 2012, which reached over $12.6 million (MOS, 2013).

These are part of the $15 million Federally Taxable Qualified Energy Conservation Bonds (QECB) that were allocated to the City of Philadelphia through federal ARRA 2009 for funding qualified energy conservation projects in public facilities that achieve a minimum of 20% energy use reduction. QECBs are federally taxable credit bonds that qualify for an interest rate subsidy from the U.S. federal government. Due to the City's improved credit trustworthiness as capital lender, the bonds benefited from favorable interest rates resulting in a true interest cost to the City of 2.31% (net of federal subsidy) for the fifteen-year bond period (Greenworks Philadelphia, 2012b; DSIRE, 2012b).

The Quadplex project includes the sites of Criminal Justice Center, Municipal Services Building, One Parkway Building, and City Hall, all large municipal energy users. It is undertaken under the auspices of the state's Guaranteed Energy Savings Act (GESA) which allows municipalities to contract with ESCOs that guarantee energy savings and commit to pay any difference between actual and expected energy costs. The bond transaction to fund the ESCO project went through PEA in order to by-pass municipal legislation that prohibits the City from entering into contracts of more than four year duration (Greenworks Philadelphia, 2012b).

The City has contracted with the private entity NORESCO ESCO for the development of the project. The feasibility study of the project identified nine energy conservation measures for implementation. The installation of the energy upgrades started in October 2012 and included measures like lighting upgrades, weatherization, building controls, and system upgrades. The project is expected to complete over the summer 2014. It is expected that the project will lead to 20% energy use reductions in the four sites, and that its lifetime cost savings will exceed the City's net bond debt service by more than $10.2 million (MOS, 2012; Greenworks Philadelphia, 2012b; MOS, 2014).

An ESCO model of project delivery is seen by MOS, in general, as a key mechanism for raising the necessary finance to develop both small and large-scale municipal energy efficiency projects. Regarding the small-scale facilities, fire stations, police stations and recreation centers are considered as key candidates for ESCO interventions (MOS, 2009).

The 30% reduction target is assisted by municipal legislation on energy. In January 1, 2010, Bill 080025 came into effect which requires that all new building constructions or major renovations in the city achieve LEED Silver-certification when more than 50% of their design and construction costs are funded by the city government [90](MOS, 2013).

The City participates also in PJM's Demand Response Program where departments which reduce their energy consumption in times when the electricity grid is strained receive financial reward for this service that they provide to the grid

[90]'Major renovations' are defined as any major Heating, Ventilation and Air Conditioning(HVAC) renovation, significant building envelope modification and major interior rehabilitation that in total affect more than 50% of the gross floor area of the building space (DSIRE, 2011).

operator. MOTU leads this initiative and the participation of 19 facilities in summer 2013 resulted in a load reduction of 4.8MW (MOS, 2014).

MOTU rolled out in January 2014 a pilot incentives program that offers financial rewards, or imposes penalties, to departments according to their energy performance. The pilot program involves five departments (Parks and Recreation, Fire, Police, Public Property and Health) and runs until July 2014[91]. Internally it is led by MOTU, while the University of Pennsylvania offers support on technical matters and the promotion of the scheme across the participating departments. Whether the program will be fully deployed after the pilot phase will likely depend on the records of energy savings for the participating departments (A. Waegel, personal communication, April 17, 2014).

In addition, the City is piloting the use of building control systems in municipal sites, and their integration with the Information and Technology infrastructure, as a way of assisting with the identification of troubleshooting of building systems remotely and improving the energy performance of sites. CBEI partners with the city government on this initiative (MOS, 2014).

The implementation of measures for the 30% energy target led to energy reductions over the first years of *Greenworks Philadelphia*. Figure 9 presents data on municipal energy use and reductions between FY 2008 and 2011, as well as targeted energy reductions, for the 30% energy reduction target:

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[91]The energy baseline against which performance is measured covers the period June 2013 to July 2014, split in two six-month energy use blocks (A. Waegel, personal communication, April 17, 2014).

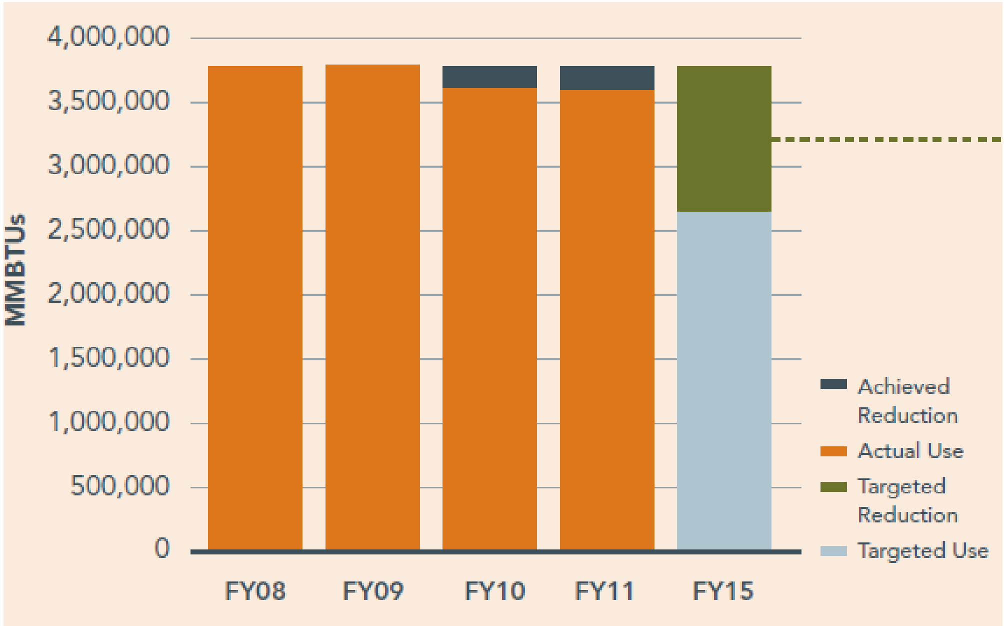

Figure 9: Progress in municipal energy use reduction over FY 2008-2011 and targeted reduction for meeting the 30% target, in million BTUs

Source: (MOS, 2012)

Figure 10 presents completed, in-progress, and future initiatives for meeting the 30% municipal energy use reduction target, as of FY 2011:

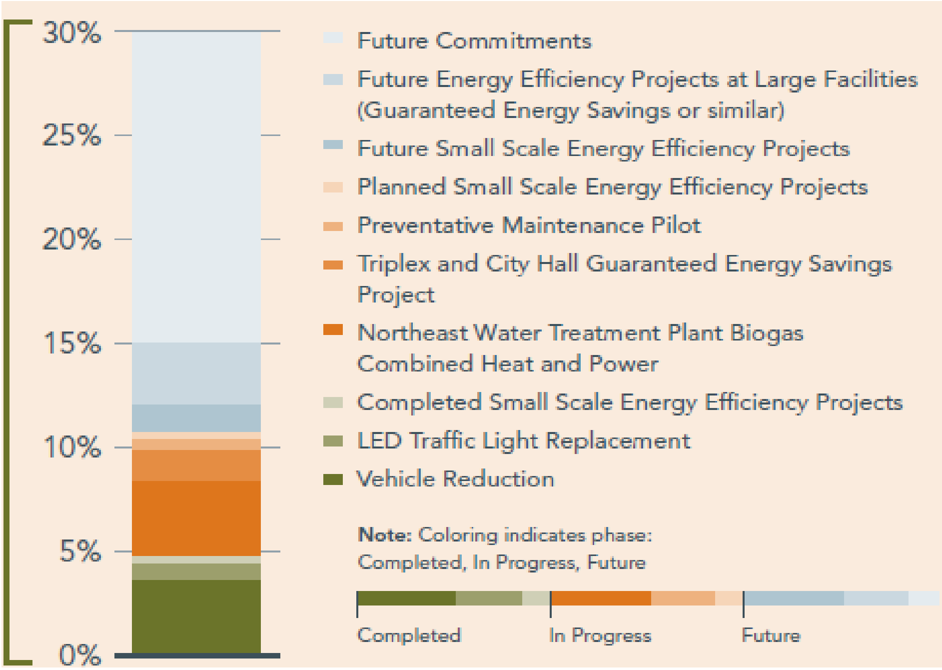

Figure 10: Completed, in-progress and future initiatives for the 30% municipal energy use reduction target, as of FY 2011

Source: (MOS, 2012)

Figure 10 shows that, as of 2011, municipal energy use reductions reached over 5%, while in-progress initiatives (i.e. Quadplex project) are expected to increase energy savings to 10%. Municipal energy reductions achieved between FY2009-2011 helped the City to save over $4 million in energy costs (MOS, 2012). The largest share of these reductions was achieved through the management of fuel use in the municipal vehicle fleet, and the installation of 85,000 low-energy LED bulbs in the city's traffic signal system (MOS, 2012).

Further energy savings to meet the 30% target are expected to add-up from energy efficiency projects in small and large-scale municipal facilities (5%) and future commitments for energy efficiency development (15%) (MOS, 2012).

In FY 2012, municipal energy use reached 3.50 trillion BTUs which was a 7% reduction compared to the baseline, reflecting a continuous decrease in municipal energy use since 2007 (MOS, 2013). However, the trend in municipal energy use reductions was discontinued in 2013 when municipal energy use reached 3.84 trillion BTUs, largely because of that year's weather conditions which increased demand for energy (MOS, 2014). The 2013 municipal energy use reflects a 2% increase over the baseline (MOS, 2014).

Interdepartmental collaboration

MOS collaborates on the 30% target with various departments. For example, the Department of Finance assists with the development of departmental targets on energy cost reductions that are included in the monthly energy reports distributed to departments. The Department of Law works on legislation provisions that promote energy efficiency, while the Department of Public Property (DPP) promotes capital investments for energy efficiency and employee training on energy (City of Philadelphia Department of Public Property, 2013).

DPP is also developing a preventive maintenance program for municipal facilities which is expected to foster energy use reductions. DPP's Facilities Management Division is responsible for maintaining and operating over 4,000,000 square feet of municipal building area (City of Philadelphia Department of Public Property, 2013).

In addition, the City established in 2011 the Task Force on City-Owned Buildings to promote a proactive maintenance management of municipal facilities, including incorporation of energy efficiency in their operation (City of Philadelphia, 2011). In December 2013, the Task Force presented its final recommendations regarding how future energy cost considerations can improve the City's approach on asset and facility management, capital planning, and real estate and utilities payment policies (MOS, 2013). It is estimated that the recommendations could lead to over $70 million savings over a five-year period (MOS, 2014).

Municipal energy efficiency development is also assisted by PEA that has a majority of its Board Members appointed by the Mayor of Philadelphia (PEA 2010). PEA was created in 2010 to facilitate measures for energy cost reductions in City-owned facilities, and to promote renewable energy development and public energy awareness in the city. The agency aims to develop funds for municipal energy efficiency projects through GESA and repay them with realized energy savings (MOS, 2012).

Furthermore, City employees are receiving training in green building design. In 2012, six staff from various departments received such training and got awarded the LEED Green Associate certification, while five individuals are currently enrolled in the City's Building Operator Certification Training (MOS, 2013).

The main way that MOS uses to communicate energy efficiency issues within the city government is the *Greenworks Philadelphia* annual progress reports. A monthly report is, also sent to all departments with information on their energy use. When communicating on energy across the city government, MOS is careful to avoid sending mixed messages, and pays attention to make clear which people departments should contact if they wish to get further information on energy efficiency. MOS reports also about energy in its monthly newsletters, and uses the social media to reach out the general public (A. Agalloco, personal communication, March 26, 2013).

4.2.2. The Target of 10% Citywide Building Energy Use Reduction

Greenworks Philadelphia sees building energy efficiency development as a way to protect local residents and businesses from potential rising energy prices, and foster environmental benefits. Target 2 of the plan calls for a 10% reduction in citywide building energy use by 2015. Residential and commercial buildings in the city are large energy-users and consumes more energy than the industry and transportation sectors. Opportunities, hence, exist to develop building energy efficiency with a relatively low financial risk (MOS, 2009).

The City suggests that it has an important role to play in encouraging energy upgrades by residential and commercial buildings through a policy approach that avoids placing mandates on energy behavior, or increases costs for businesses (MOS, 2009).

Towards this goal, *Greenworks Philadelphia* has introduced financial and technical support to facilitate energy efficiency investments by residents and businesses. For example, in collaboration with the other Metropolitan Caucus counties of the Southeastern Pennsylvania region (Bucks, Chester, Delaware, and Montgomery counties), the City applied to D.O.E.'s Better Buildings program (ARRA 2009 EECB grant) and was awarded $25 million to develop *EnergyWorks*. This is an energy efficiency loan program for residential and commercial energy efficiency improvements (EnergyWorks, 2013).

The program bundles financial support (low-interest loans) and project development expertise (i.e. certified building analysts and qualified contractors) to make resources for energy efficiency development readily affordable and accessible. It also provides information on rebates for residential and commercial energy efficiency that are available through PECO's and PGW's energy efficiency programs (MOS, 2012).

The residential component of *EnergyWorks* expired on September 2013. The program was offering low-cost financing for home energy efficiency improvements[92] through partnership with Keystone HELP. This is a statewide energy efficiency home improvement financing program offered by Pennsylvania Treasury, the state's Department of Environment Protection and AFC First Financial Corporation. Free home energy assessments and a rebate of $50 were also available to *EnergyWorks* customers (EnergyWorks, 2013a).

ECA was a delivery agency for the residential part of *EnergyWorks* in Philadelphia and a monthly meeting was taking place between ECA and MOS on program updates (EnergyWorks, 2013a).

As of August 2013, *EnergyWorks* completed over 1,863 home energy improvements in the five participating counties by providing $14 million of low-cost financing. As reported by the program, estimated energy savings per home project range from 15% to 40%. The program managed to engage 131 energy efficiency professionals to support the regional energy efficiency market, and it offered education to homeowners on the importance of energy efficiency (EnergyWorks, 2013a). In Philadelphia, *EnergyWorks* completed 468 residential energy retrofit projects over its lifetime (MOS, 2014).

[92]For whole home energy improvements, the interest rate is 0.99% fixed for a loan between $1,000 and $15,000, up to a ten year term. For single energy improvements, the interest rate is 4.99% (advanced) or 5.99% fixed for $1,000 to $15,000, up to ten year term (Keystone HELP, 2013).

Although the residential part of *EnergyWorks* has expired, the low-interest rates of the program will continue to be offered for approximately 1 to 2 more years through Keystone HELP. This is in order to enhance the impact of the program on market and business development in the region (EnergyWorks, 2013a).

The commercial part of *EnergyWorks* offers technical and financial support for energy improvements that would achieve at least 25% energy use reductions. The program is available to businesses, non-profits, governmental agencies, multi-family residential buildings and industrial entities (EnergyWorks, 2013b). It offers step-by-step support throughout the whole energy retrofit process, from energy audit and proposed measures to project financing and development (EnergyWorks, 2013c).

TRF and PIDC administer the financial support offered to commercial customers which includes construction loans, term loans and lease financing of $100,000 to $2.5 million with an interest rate as low as 3.5% for up to a 15-year loan term. Eligible interventions include retrofits, energy efficient equipment, and on-site renewable energy systems and combined heat and power systems that are part of a larger energy efficiency work (EnergyWorks, 2013d).

The *EnergyWorks* commercial program has approved or closed over $18,850,000 of lending for energy retrofitting in the five county area. Independent analysis estimates that these projects will save 71,800 million BTUs per year area-based (MOS 2014), while the annual cost savings as a result of the program are estimated at around $300,000 (MOS, 2012).

The 10% citywide building energy reduction goal is also supported by municipal government legislation. In 2010, the City passed the Cool Roof Bill No. 090023 which requires all new constructions and major renovation projects with lowsloped roofs in the city to install cool-roofs that are ENERGY-STAR certified. During the permit process, the City's Department of Licenses & Inspections supplies relevant information to contractors (MOS, 2012).

In addition, in 2012 the City passed the Energy Benchmarking Bill No. 120428 that requires large commercial facilities to publicly display their annual energy consumption. By publishing the results in an open and searchable database, the city hopes to encourage energy efficiency improvements in commercial buildings (Actman, 2013). Several entities collaborated for this initiative, including Department of Law and MOS (MOS 2012), ECA and DVGBC which provided testimonies before the City Council's Committee on the Environment on the bill proposal (Stabenow 2012, Milkman 2012), and the EEB Hub which testified to this Committee regarding the implementation of the ordinance (Actman, 2013).

Furthermore, MOS interacted with the City's Planning Commission and Zoning Code Commission on the development of the City's Comprehensive Development Plan *Philadelphia2035* and Zoning Code adopted in 2011 to replace an outdated development planning and zoning system dated back in the 1960s (E. Gladstein, personal communication, May 13, 2013).

Philadelphia2035 and the Zoning Code offer an overall planning framework within which the city's future growth and facilities for the housing, transportation, distribution, health and welfare of its population will be pursued. Broader policy recommendations, what is called the Citywide Vision, were adopted as a first component of the Comprehensive Plan. In addition, spatially specific recommendations are contained within eighteen Local District Plans which are being prepared for every section of the city (2011 – 2017) (PCPC, 2011).

The types of land use development and density of development are factors which related to patterns of residential energy consumption in urban areas. For example, Ewing and Rong (2008) find that there is correlation between urban sprawl in U.S. metropolitan areas and bigger and detached types of houses, with both housing aspects contributing overall to higher building energy consumption. Hence, *Philadelphia2035*, the Local District Plans, and the Zoning Code can be used as vehicles towards energy efficient patterns of development in the city (PCPC, 2011).

Indeed, the new Zoning Code includes provisions that promote more energy-efficient urban forms (i.e. mixed-use development; density increases) and facilitate the installation of sustainable energy systems in the city's built environment (E. Gladstein, personal communication, May 13, 2013). In addition, it offers some incentives for green building practices. For example, if proposed constructions meet Gold or Platinum LEED standards, developers receive a density bonus (E. Gladstein, personal communication, May 13, 2013).

The City signed in March 2014 a Memorandum of Understanding with the Institute for Market Transformation on the City Energy Project which aims to promote building energy efficiency in the commercial sector. Expected annual energy cost savings out of the project, which is scheduled to run until November 2017, are estimated at $77 million (philly.com, 2014).

The City's plan for driving forward the project is based on four action items: the expansion of eligible commercial buildings for participation in the project, in terms of floor space area, than those currently targeted by the City's Energy Benchmarking Ordinance; the provision of incentives for energy efficiency upgrades; availability of options for energy use certification on a voluntarily basis initially, but with the intent to consider mandatory compliance for specific levels of performance in the future; a guidance document to assist building owners and tenants to take advantage of the resources that the project offers (PEA, 2014a).

An aspect that is considered by the City as critical for the success of the project is energy data quality. The City will seek the involvement of private consultants for driving forward the action items, while focus groups will be undertaken regarding implementation issues in order to get feedback that will be used to improve the project (PEA, 2014a).

As noted previously, several local actors, other than the City, like PECO (state Act 129), PGW (*EnergySense* program), the EEB Hub and Philadelphia Housing Authority have been involved in initiatives relevant to the 10% citywide building energy reduction target.

Summing all these activities for building energy efficiency development, what is the city's progress in meeting the *Greenworks Philadelphia* target?

The baseline number for the target is 122.06 trillion BTUs (year 2006), and the citywide building energy use reached 136.89 trillion BTUs in 2013. This is an increase of over 12% compared to the baseline (MOS 2014). The 10% target sets energy use at 109.85 trillion BTUs for 2015. If the baseline is put at 2013 (latest available data), a 25% energy reduction is then required to meet the target.

Section 4.3 evaluates Philadelphia's progress towards meeting the *Greenworks Philadelphia* targets on municipal energy use and citywide building energy use reduction, by looking at the constraints and opportunities that the city faces in this area.

4.3. The Evaluation of *Greenworks Philadelphia* Targets on Municipal Energy Use and Citywide Building Energy Use Reduction

4.3.1. Challenges in Making Progress with the 30% Municipal Energy Use Reduction Target

As described in Section 4.2.1, various initiatives have been undertaken, or planned, by the city government on municipal energy efficiency development. However, certain challenges constrain progress towards meeting the 30% energy reduction target. These are described below.

Disincentives to devolve energy accountability inter-departmentally

A key challenge towards greater municipal energy efficiency development in Philadelphia is related to the way that the city government procures its energy. The City pays for its electricity and gas through its General Fund. This centralized arrangement allows the City to negotiate for lower energy prices. However, as the energy costs are paid centrally, departments do not pay out of their budget for the energy that they consume and do not necessarily see any of that energy cost as a factor in their operation or expansion decisions (A. Agalloco, personal communication, March 26, 2013).

To tackle this issue, MOS has developed internal programs on raising awareness regarding the energy costs incurred by departments in order to pass the message that these are real costs, and as such the City would benefit if they are better managed (A. Agalloco, personal communication, March 26, 2013).

At the same time, compounding this problem is the lack of energy use guidelines for the City's contracted maintenance workers who control a large amount of night and weekend usage of municipal facilities and, in essence, treat energy as a free good. The City, hence, aims to standardize the inclusion of energy conservation considerations in future building maintenance contracts[93]. This is underway for the maintenance contracts of the facilities of the Quadplex energy efficiency project which is expected to be completed by the end of summer 2014 (MOS, 2013; PEA, 2014a).

In fostering greater departmental accountability on energy use, proposals of decentralized energy management have been discussed several times within the administration in the past. One such is the application of an incentives-based program where departments which achieve energy savings compared to an established benchmarking are financially rewarded in the form of capital, while those that exceed the benchmarking level are penalized by paying a fee out of their budget (MOS, 2013).

A pilot project of this type was launched in June 2013 with the five departments of Parks and Recreation, Fire, Police, Public Property, and Health as participants. The scheme which runs until July 2014 is led by MOTU while external support on technical aspects and inter-departmental promotion is offered by the University of Pennsylvania (A. Waegel, personal communication, April 17, 2014).

The pilot project has three main components. The technical part which involves the establishment of comprehensive benchmarking data based on a three-year period of historical energy use against which to assess future energy

[93]Towards this direction MOS and MOTU are currently developing with the Department of Public Property an asset management tool that incorporates energy management aspects (PEA, 2014a)

consumption; the outreach part which involves the promotion of the project to the participating departments; and the internal politics part which relates with whether the pilot project will be fully deployed across departments. Combined these three parts suggest that designing and managing such a project across the city administration would likely be a challenging task[94] (A. Waegel, personal communication, April 17, 2014).

Conversations on what would be an effective energy management model for the City have been going on many times in the past in Philadelphia. However, due to challenges such as those described above, changes in the way that energy costs are treated across the administration, and more decentralized forms of energy accountability, were not adopted (K. Gajewski, personal communication, April 03, 2013).

Limited availability of resources

A key challenge that the City faces on greater municipal energy efficiency development is lack of funding. MOS suggests that an ESCO model under the auspices GESA would be a viable financial mechanism to tackle financial shortages for municipal energy efficiency. This mechanism was recently followed by the Philadelphia International Airport in its energy efficiency program. SEPTA is, too, looking at an ESCO model as a way to streamline energy efficiency projects (K. Gajewski, personal communication, April 03, 2013).

[94] More information on the pilot project is offered in Chapter 8.

Limited resources affect also the City's initiatives on energy conservation education. Energy education and the incorporation of energy efficiency into the everyday practices of the administration are seen by MOS as critical towards the 30% energy reduction target. In this direction, MOS devised an energy conservation plan for city employees. The idea is that once an energy upgrade has been implemented in a municipal site, MOS would follow-up to provide information and training on the nature of the measure that was installed, why the measure was implemented, and how users of the site could contribute to energy savings through this measure. Lack of resources, however, put obstacles in the wide implementation of the project which was finally launched recently at the Fire Department and the Department of Parks & Recreation (MOS, 2014).

Many municipal facilities, finally, need basic non-energy upgrade, for example in building components or systems, before energy interventions could be installed (A. Agalloco, personal communication, March 26, 2013).

4.3.2. Challenges in Making Progress with the 10% Citywide Building Energy Reduction Target

Various types of initiatives are undertaken in Philadelphia in relation to the *Greenworks Philadelphia* 10% citywide building energy use reduction target. Little progress, however, has been made up -to-date on this target. The key challenges that the city faces on this are presented below[95].

[95]The discussion in this Chapter is looking at the challenges for the 10% energy reduction goal from the perspective of *Greenworks Philadelphia*. The affordable energy development and EEB Hub initiatives that are discussed separately in the study are linked also with 10% building energy use target.

Financial constraints

The City of Philadelphia is involved in various initiatives to promote citywide building energy efficiency development. A key one is the *EnergyWorks* program that offers low-cost financing, and quality assurance to improve residential and commercial building energy efficiency in Southwestern Pennsylvania area. The program was launched in 2010 with federal funding, and aims to provide a scalable and sustainable model for streamlining energy retrofit in the residential and commercial sectors. However, the residential component of *EnergyWorks* expired in September 2013 and the City plans to recapitalize it through private sector funds (MOS, 2013).

In addition, ECA suggests that PECO's Act 129 and PGW's *EnergySense* programs[96] will be the key mechanism to drive forward building energy efficiency development in the city (MOS 2013). PECO's Act 129 portfolio is valid through May 2016. The company is looking forward to participate in a future Act 129 round, if the state government legislation decides on its continuation (F. Jiruska, personal communication, June 06, 2013).

However, the above three programs offer little assistance on energy efficiency for certain sectors of the city. For instance, this is the case with the so-called MUSH sector (Municipalities, Universities, Schools, Hospitals) which includes public sector

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[96]ECA is involved in both programs. The agency is an approved contractor for PGW Home Rebates *EnergySense* program and PECO Smart House Call which is part of the Act 129 Smart Ideas Program (ECA 2013a, PECO 2014a). PECO Smart Home Call program is offered to electric heating residential customers and includes agreed prices with all approved contractors on energy efficiency interventions (PECO, 2014a).

buildings typically held by municipal governments or non-profit organizations. In Philadelphia, this is a sector that needs to reduce its energy consumption and there is indeed some available support for such energy efficiency interventions (L. Robinson, personal communication, April 07, 2013).

EnergyWorks supports energy efficiency in non-profit entities and governmental agencies, and PECO's Act 129 portfolio needs to achieve a minimum 10% of total energy consumption reductions from interventions in the governmental, institutional and non-profit sector (Jiruska, 2013).

However, both programs can only cover part of the energy efficiency needs of the MUSE sector while access to finance for such investments can be problematic. For example, the School District of Philadelphia has been struggling financially over the last several decades yet many of its buildings are largely energy wasteful[97].

However, due to its poor financial condition the School District does not qualify for loan support that could be used to finance energy upgrades. This is an example where both availability and access to funds put constraints for greater energy efficiency development in the city (L. Robinson, personal communication, April 07, 2013).

In addition, although PGW's *EnergySense* program offers a range of services and incentives for building energy efficiency, the recent decision by the city

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[97]The discussion on the Philadelphia School District budget for 2014 illustrates this point. On May 31, 2013, the Philadelphia School Reform Commission approved a $2.4 billion budget that includes cuts over which concerns have been raised for their impact on the programs and operation of the area's schools (The Philadelphia Inquirer, 2013).

administration to sell PGW raises questions over likely changes in the utility's policy on energy efficiency (Shulock, 2012).

What is more, with respect to the effectiveness of *EnergyWorks* in catalyzing market demand for residential energy efficiency, ECA suggests that although the program offered financial assistance to customers through low-interest loans, it was not providing any kind of incentives, such as rebates or tax incentives, which appear necessary for the wider adoption of energy efficiency. At the same time, out of the total businesses that became active in the region due to the *EnergyWorks* program, over 70% did not manage to stay in the market, after three and a half years from the start of the program which indicates the difficulties of these businesses to survive in the current market environment (A. Kleeman, personal communication, April, 20, 2013).

Finance availability for local energy efficiency development is also related to policy directions at the state level. During the administration of Governor Edward Rendell significant state funding was available for local energy efficiency development, while there was a close interaction between the City and the state on how best to use these programs. With the transition to the administration of Governor Tom Corbett, however, many of these energy programs are no longer available, and the majority of state funding on energy is currently directed to support natural gas and related technologies (i.e. compressed natural gas for transportation) (K. Gajewski, personal communication, April 03, 2013).

In the face of such financial shortages, alternative options for financing energy efficiency projects in the city are explored by local actors. For example, ECA's Smart Energy Solutions (SES) team which leads the agency's commercial energy efficiency portfolio is in discussions with institutional investors and highly-networked individuals for raising a $10 million fund for commercial energy efficiency (A. Kleeman, personal communication, April, 20, 2013).

SES suggests that although state and federal funding would be helpful, this is not necessarily the main way to finance energy efficiency in the city. Rather, private capital can be used to fund such projects. However, lack of financial instruments to simplify access to available capital funding, limit possibilities for developing such funds for energy efficiency. Hence, even if the payback period for potential commercial energy efficiency investments appears satisfactory, appropriate financial tools are needed to facilitate their realization (A. Kleeman, personal communication, April, 20, 2013).

A particular challenge in this respect is the diffused ownership and tenancy of the city's building stock, and the small scale of interventions that can be developed in individual commercial sites. Such aspects make the identification of commercial energy efficiency projects a diligent task and their financial validity and revenue streams non-captured in mainstream methods of project financing (Shulock 2012).

SES suggests that such challenges require the development of financial instruments to streamline commercial energy efficiency development, which should be coupled with the creation of market demand. Here, aggregating demand for energy efficiency interventions across a number of commercial entities through an ESCO model can be an effective (A. Kleeman, personal communication, April, 20, 2013). An ESCO model can be also helpful in raising the necessary capital for such projects, as it seems challenging to persuade local businesses to spend capital on energy efficiency interventions (A. Kleeman, personal communication, April, 20, 2013).

Another alternative financial tool that could facilitate building energy efficiency development in the city is the so-called 'on-bill financing' mechanism where a surcharge is placed on monthly energy utility bills to recover the up-front cost of energy investments undertaken by the utility or some other entity (i.e. a third party financial institution) (L. Robinson, personal communication, April 07, 2013). The mechanism can work complementary with other forms of energy financing, i.e. rebates (Shulock, 2012).

Application of on-bill financing in Pennsylvania would require approval by PUC. In 2012, PUC established an On-Bill Financing Working Group (OBFWG) to examine existing on bill programs in the U.S. and assess the suitability of introducing a pilot program for small commercial and multi-family buildings in Pennsylvania, as this is a sector that largely needs additional access to energy efficiency financing (Robinson, 2013). ECA (through KEEA), Sustainable Energy Fund (SEF)[98], Citizens for Pennsylvania's Future[99] and Sierra Club actively promoted the establishment of the OBFWG, in which the EEB Hub and PECO also participated (L. Robinson, personal communication, April 07, 2013).

The first meeting of the working group took place in November 2012 aiming to identify key issues relevant to potential project development expenses. Participants

[98]The Sustainable Energy Fund is a private non-profit organization active at the statewide level in Pennsylvania that promotes clean and renewable energy technologies, energy conservation, energy efficiency and sustainable energy enterprises through research, policy and advocacy (SEF, 2014).

[99] PennFuture was created by the Pew Charitable Trusts and the Heinz Endowments in 1998 to conduct professional advocacy for strong environmental and public health policies. The organization is active on clean energy development through advocacy, policy and legal analysis and services (PennFuture, 2014b).

were also asked to submit proposals for on-bill financing and repayment methods, as well as potential pilot models that would demonstrate the viability of these models in Pennsylvania. In the second OBFWG meeting on January 2013, a pilot model, developed jointly by several stakeholder groups led by SEF, which focuses on the small commercial sector was presented (PUC, 2014a).

The final meeting of the working group was held at the EEB Hub on May 2013. In the meeting. Hub staff provided an overview of on-bill financing and repayment methods including benefits, disadvantages and successful programs that have been implemented in other states. A pilot model was also presented by the Pennsylvania Housing Finance Agency (PHFA) which focuses on the multifamily sector. Both SEF and PHFA models combine off-bill financing with on-bill repayment. In each model, a program administrator gathers capital, provides loans and manages the implementation of the energy efficiency programs (off-bill financing component), while utilities are responsible for processing the repayments (on-bill repayment component) (PUC, 2014a).

In discussing both pilot models, participants suggested that a potential application of on-bill financing in Pennsylvania should be tied, but not limited, to existing Act 129 energy efficiency programs in order to maintain simplicity initially, and avoid creating competition for customers and market confusion. In addition, they suggested that both models should provide 100% financing for remaining customer costs after any Act 129 rebates have been applied (PUC, 2014a).

The Sustainable Energy Fund has also suggested in the meetings that on-bill financing could be an effective way to tackle some of the limitations of Act 129 programs including that they leave a remaining investment net of the rebate for the customer; recover costs from the entire rate class and not just those directly benefited from the program; tend to favor measures with low capital cost and short payback periods which are often not the best measures from a technical or economic point of view but simply the cheapest upfront cost option (SEF, 2012).

In contrast, the on-bill financing model seeks to recover 100% of the investment's up-front costs, capture program costs directly from the beneficiaries, lower the overall utility bills of participants, and cover program and capital costs directly from utility bill reductions. In that way, larger energy efficiency interventions can be promoted which would also help utilities to meet their Act 129 obligations (SEF, 2012).

However, other views question the potential of on-bill financing for fostering larger energy savings by arguing that this mechanism typically stretches financial cost over a long period in order to make repayments equal to or less than the savings. As a result, energy efficiency improvements tend to be relatively modest as more expensive investments that could lead to larger energy savings are difficult to get financed under such economic criteria (Shulock, 2012).

Furthermore, concerns have been raised by private energy utilities in the U.S., including PECO, over the suitability of on-bill financing for promoting energy efficiency on the basis that utilities will have to absorb lending responsibilities that lie outside of their core competencies. What is more, residential real estate professionals in the U.S. have been reluctant to support such a mechanism in general by arguing that new tenants or buyers of a house are often unfamiliar with, or apprehensive about, the obligations that they will have to comply with as a result of the on-bill financing mechanism tied with the site (Shulock, 2012).

In its final meeting, the OBFWG suggested that the two pilot models as presented may require modifications before any potential implementation. For example, specific program design details and parameters such as cost concerns related to utility billing system upgrades, and cost recovery methods remain unresolved (PUC, 2014a).

In addition to financial issues, information and procedural aspects are identified to influence the effectiveness of energy efficiency programs. This is the case with the *EnergyWorks* residential program where households that expressed an interest in participating experienced difficulties in navigating throughout the process in terms of what exactly they should do to improve the energy performance of their home, who to contact, and how to secure funding. That was despite the fact that relevant information was spelled-out clearly, according to ECA. Thus, it appears that the whole process proved too complicated for engaging as many residential customers as the agency thought it could enroll in the program (A. Kleeman, personal communication, April, 20, 2013).

Concerns over increases in the cost of development within the city

The city government's approach to commercial energy efficiency development takes into account the cost of development. Although some U.S. cities have mandated LEED certification for new construction in their area, MOS argues that a mandated approach on commercial energy efficiency cannot be currently justified in Philadelphia, as it would likely increase substantially the cost of development (K. Gajewski, personal communication, April 03, 2013).

At this stage, the City should focus on getting a better understanding of the energy efficiency needs of the commercial sector, and use this information to create a more supportive context for their involvement with energy efficiency (K. Gajewski, personal communication, April 03, 2013).

EnergyWorks is helpful in this regard, as MOS gets through the program a better idea on the energy efficiency needs of the commercial sector and what an energy efficiency product should look like in order to be responsive to these needs. Hence, MOS still develops understanding on the market barriers that constrain greater adoption of energy efficiency by the commercial sector (K. Gajewski, personal communication, April 03, 2013).

Instead then of a mandated approach on energy efficiency, MOS favors initiatives that would facilitate and persuade businesses to take action on energy efficiency such as the City’s Energy Benchmarking Ordinance (K. Gajewski, personal communication, April 03, 2013).

MOS suggests that motivating and assisting, through the ordinance, at least a part of the commercial sector to implement energy efficiency would be important for the city’s efforts on citywide energy efficiency development this sector, and particularly its large buildings, is one of the largest energy users in the city (K. Gajewski, personal communication, April 03, 2013).

The ordinance is expected to foster a comprehensible and reasonable path forward for commercial energy efficiency development by bringing together various elements of the project development process (i.e. relevant people to contact, or how to raise finance). MOS wants also get an idea of how commercial entities responds to the ordinance, before the introduction of costly energy measures in this sector is considered (K. Gajewski, personal communication, April 03, 2013).

Concerns over potential increases in local development costs as a result of energy efficiency specification are also found at the state level. For example, although the City is interested in adopting the 2012 International Energy Conservation Code, PUC has not yet approved this version for Pennsylvania due to concerns over increases in the cost of development (M. Flink, personal communication, June 4, 2013).

Energy efficiency in relation to the city's wider development plans and practices

The re-classified zoning system allows denser types of development in certain areas of the city by increasing the floor-to-area ratio of the development. For example, it mandates that the development density of areas attached to the main train stations of the city (30th Street Station; Suburban Station; and Market East) increases. The code allows also local neighborhoods which used to be manufacturing or warehousing sites, and which are now vacant, to host domestic buildings and use minimum lot sizes that are lower than those in general defined by the code[100]. In that way, more density is allowed in areas of the city that are already dense (A. Urek, personal communication, June 02, 2013).

Each of the city's eighteen Local District Plans contains a set of recommendations about changes to the zoning classification of the areas in question in order to promote certain types of development. Many of the plans foster higher development densities and energy conservation through land-use rezoning. However, proposed zoning classifications needs to be approved by the City Council. This makes

[100] Specifications on minimum lot sizes have been left unchanged in the new zoning code.

land-use planning and development in the city a strongly political process (E. Gladstein, personal communication, May 13, 2013).

Indeed, certain proposals for adopting higher density of development did not pass in the new zoning system for areas of the city outside the core due to oppositions by City Council members in relation to socio-economic and class issues, suggesting that more dense and mixed-use development would make neighborhoods more heterogeneous and diverse while people in these areas are used into certain lifestyle aspects that would not like to see changing (E. Gladstein, personal communication, May 13, 2013).

Municipal policies for citywide building energy efficiency development need to also explicitly take into account the city's inherited built form and infrastructure, and what it might mean in relation to this area. Although a large part of the city's building stock is several decades old and many abandoned and vacant lots are currently found throughout the city, such conditions can be perceived as 'historical assets' that could facilitate the transition to a more sustainable energy infrastructure by offering opportunities for extensive energy interventions and the foundation for energy-efficient compact forms of development (Hughes, M., 2009).

For example, a particular type of technology that could take advantage of the city's dense built environment and contribute to large scale building energy efficiency is cogeneration. The city government, nevertheless, has currently no plans for cogeneration development at the citywide level (M. Dietze, personal communication, May 22, 2013).

Up-to-date, there are a few larger scale green development projects in the city. One such is under construction in the Newbold neighborhood in South Philadelphia (mixed residential and commercial site). The developer of the project will seek LEED platinum certification for the housing units aiming to set a standard for green construction in the area (Philly.com, 2013c).

Two other green redevelopment projects are the 'Carpenter Square' in the abandoned city block at 17th and Carpenter Streets built to the LEED Platinum standard, and the 'Paseo Verde' led by the non-profit Latino community group Asociación de Puertorriqueños en Marcha which is a Gold LEED-certified transit-oriented development project adjacent to the SEPTA Temple University train station. This latter will be the first LEED-certified neighborhood development project in the city (APM, 2014).

In an era of rising energy prices and radical transportation change, hence, Philadelphia's dense built form and existing fabric with its inherent historical value can also acquire instrumental value within a context for sustainable development that aims to balance preservation with expansion. A point, however, here is the extent to which such a premise is widely shared in the city, where it appears that it is only recently that such a type of 'preservation argument' is developing (Hughes, M., 2009).

4.4. MOS as a Catalyst for Energy Sustainability in Philadelphia?

The discussion in the previous sections of Chapter 4 suggests that MOS has been a key actor for energy sustainability in Philadelphia along diverse activities that foster policymaking, implementation and monitoring, technical knowledge, funding opportunities, and actor interactions for sustainable energy development both at the municipal and citywide level. In addition, MOS has been recently promoting wider initiatives on energy sustainability, i.e. City Energy Project.

However, several factors related to the policy role, resource availability, and policy and legislative powers of the Office with respect to sustainable energy appear to constrain its capacity for promoting more systematic and comprehensive energy sustainability action in Philadelphia (Bulkeley & Newell, 2010; Hammer, 2008).

More specifically, MOS comprises of five staff, including an Energy Conservation Officer. Given the range of activities involved in *Greenworks Philadelphia* (five separate policy areas), it appears that more institutional resources would likely be required for MOS in order to better catalyze the type and scale of action that would assist the city to make significant progress on the *Greenworks Philadelphia* energy sustainability goals.

Complementary to the issue of institutional resources is the organizational role of MOS with respect to its formal responsibilities on energy sustainability. Given that *Greenworks Philadelphia* does not have the status of a formal municipal planning document, which, for example, would require certain type of action by city government departments in relation to energy (i.e. by making use of powers derived from a statutory mandate), the Office pursues its objectives through an approach that is based on means like persuasion, and collaboration. While this approach draws on the City's strong mayoral form of government as a way of eliciting the active involvement of city government agencies and individuals on energy issues (Hughes, M. 2009), it remains to be seen the extent to which wider incorporation of energy sustainability considerations in municipal planning and development policies can be progressed without assigning to MOS an expanded role.

Further adding constraints towards a more systematic energy policy approach by MOS are two issues relevant to the organizational context for sustainable energy policymaking in the city administration. The first involves the coordination of the municipal energy agenda between all the separate city departments, agencies, and commissions that are either directly or indirectly related to municipal energy sustainability policymaking. To offer an indicative example, PEA plays a facilitative role for sustainable energy development in the city, while the agency's current Work Plan aims to foster dialogue and interactions between various city government and local actors on sustainable energy. Hence, in a scenario where energy sustainability activities of both MOS and PEA increase, issues of policy efficacy and coordination may arise. In broader terms, this point raises the question of whether the current energy-related organizational structure and arrangements of the city government are well-suited to drive forward a more comprehensive municipal agenda on energy sustainability, as well what specifically would the role of MOS involve in a modified framework that aims to further promote local energy sustainability, particularly in relation to wider interventions across the city and the local sustainable energy agenda of other entities.

4.5. Conclusion

This chapter discussed the role of the Philadelphia Mayor's Office of Sustainability to promote sustainable energy activities at the municipal and citywide level through the city's sustainability plan, by looking at the case of building energy efficiency. MOS has been taking, or coordinating, activities that address institutional, technical, and market aspects of sustainable energy development in the city. The discussion suggests that the Office has been successful in catalyzing certain outcomes, including the development of a technical and policy basis for sustainable energy initiatives in the city; greater awareness and knowledge (i.e. training; education) for energy sustainability issues within the city administration; municipal project implementation and energy cost savings; facilitation of energy sustainability uptake by local residents and businesses, and fostering of wider interactions between local actors on energy sustainability.

However, at the same time the discussion suggests that policy and organizational aspects relevant to the role, resources, and powers of the Office hinder its ability to undertake a more comprehensive approach that would be more in alignment with the type and scale of change required in order to meet the energy efficiency targets of *Greenworks Philadelphia*. In this context, the discussion suggests that three policy aspects appear key for further promoting the city's possibilities in this policy area; greater incorporation of energy considerations in municipal planning and development policies, availability of stable financing, and more targeted and larger-scale interventions in the city's building infrastructure.

While the above are not to suggest that MOS has been less successful on its energy sustainability mission, they rather point that if the city government wants to scale-up its impact on energy sustainability, then policy modifications would likely have to be considered in order to enhance the capacity of MOS to mobilize and coordinate those actors, resources, and expertise that would be necessary for the undertake of more systematic and widespread sustainable energy initiatives in the city.

In particular, an area of municipal energy policymaking where the need for a more concerted approach is manifested involves solar power development. Although in the early days of MOS both city government energy supply and demand-side tasks were under its responsibilities, an administrative provision which according to MOS facilitates the adoption of more integrated forms of municipal energy planning, the energy supply functions were subsequently transferred to the Mayor's Office of Transportation and Utilities. As a result, city government initiatives on renewable energy development are separately administered by MOTU. A key such initiative that aims to facilitate solar electricity development in the city is the Philadelphia Solar City Partnership, which is the topic of Chapter 5.

Chapter 5

THE PHILADELPHIA SOLAR CITY PARTNERSHIP INITIATIVE

5.1. Overview

On March 2008, Philadelphia was designated by D.O.E. as Solar America City[101]. Participation in the program was seen by the City as an opportunity to address market barriers for solar power development in Philadelphia. At that time, a number of factors were creating a favorable environment for the city to take action in this area, including being located in a large electricity load center in the Mid-Atlantic region; surrounded by an electricity distribution network of constrained capacity; availability of land to host such projects; the presence of research and technology development centers related to solar energy in the region; and municipal government rationale for smart-growth planning (D.O.E. EERE, 2011).

Through its participation in the Solar America Cities program, the City received funding and technical assistance to launch in 2008 the Philadelphia Solar City Partnership (SCP) initiative that aims to develop 57.8 MW of solar power capacity in the city by 2021. Philadelphia was one of the twenty-five cities to receive the D.O.E. grant. This included $200,000 that was used by the City to hire the SCP Coordinator, who is also the Energy Manager of the City situated at the Mayor's

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[101]Building on the successful program for the twenty-five Solar America Cities designated in 2007 and 2008, D.O.E. decided to expand the scope of this initiative by launching in 2010 a national outreach effort called Solar America Outreach Partnership. This program was then renamed as Solar America Communities to reflect D.O.E.'s commitment to assist with solar power development all types of local jurisdictions (D.O.E. EERE, 2011).

Office of Transportation and Utilities. It also included $250,000 for technical support through the U.S. National Renewable Energy Laboratory and private consultants that were contracted through the federal government (K. Sullivan, personal communication, April 14, 2013).

SCP aims to bring together a group of actors of varying perspectives in order to address market barriers for solar power development in the city. As a first step to drive forward the initiative, the City created a Solar Partnership Advisory Board with the goal to develop and put in practice a policy plan that will be fully integrated with citywide plans and institutional processes that guide land use, economic development and infrastructure investment in Philadelphia (D.O.E. EERE, 2011).

Board members include representatives from the City Council of Philadelphia, the City of Philadelphia Planning Commission, the Philadelphia Industrial Development Corporation, the Delaware Valley Regional Planning Commission, Ben Franklin Technology Partners, the Philadelphia Energy Coordinating Agency, Villanova University, the City of Pittsburgh Office of Sustainability, and the Southeastern Pennsylvania Smart Energy Initiative[102](D.O.E. EERE, 2009).

All these entities apart from Villanova University are Working Partners in the SCP, as well as PECO, Exelon (private energy utility), AFC First Financial, Solar Alliance (California based solar systems installer) , Celentano Energy Services (Pennsylvania based solar photovoltaic industry consultant), and Independence Solar (solar systems developer in Mid-Atlantic) (D.O.E EERE, 2011).

[102] This is an Industry Partnership that supports the region's sustainable energy industry by providing comprehensive workforce and business development services to partnering energy organizations (SEI, 2014).

Since the launching of the SCP, several activities have been undertaken by the City to establish a more favorable environment for local solar power development. For example, with assistance from the SCP advisory board and the National Renewable Energy Laboratory, the City published the Philadelphia Solar Installation Guidebook to serve as reference point for stakeholders in relation to solar power development (i.e. land or property owners, tenants, and developers, project financiers, contractors) (D.O.E. EERE, 2011).

This includes information on the permit process such as the steps that should be followed, timeline, and associated fees. In particular, the permit process for small scale projects has been streamlined and the number of days required getting the permit decreased. Furthermore, Bills 110533 and 110829 passed under the new Zoning Code exclude the costs of the solar panels and inverters from the electrical and building permit fees of the system. This reduces the total permit fee by around 50% (D.O.E. EERE, 2011).

The Solar Installation Guidebook has been updated with information on the permit process for the installation of solar hot water systems. In addition, municipal planning and guidelines have been introduced to facilitative project development. For example, the new zoning code allows solar systems to be installed above regulated building height limits. Similarly, installation of such systems is now allowed in the yard areas of houses (MOS, 2012).

What is more, MOTU with the help of the City's Office of Technology and Innovation undertakes a technical assessment of the city's solar potential to map sites promising for solar power development. In addition, web information has been made available for local residents and businesses that would like to get more informed about solar power development in Philadelphia. This includes five Solar Tutorial videos, a Virtual Solar Tour which is continually updated to include new solar installations developed in the city, and a web version of the Philadelphia Solar Installation Guidebook. The information can be found at the Mayor's Office of Sustainability website www.phila.gov/green/solar.html. (D.O.E. EERE, 2011).

The Solar America Cities program offered also technical assistance for the first municipal government solar photovoltaic project in Philadelphia, a 250 KW solar array at PWD's Southwest Wastewater Pollution Control Plant. MOS and PECO were partners of this project which was financed with $850,000 from the EECBG grant awarded to the City and the same amount by PWD (PGW, 2011c).

In addition, a 1.3 MW photovoltaic system is currently being developed on a 7-acre brownfield site at the Philadelphia Navy Yard (MOS 2012). This initiative is privately financed through a partnership between Conergy (manufacturing business) and Exelon (private energy utility). The project which has also received approval by D.O.E. to receive funding through the Pennsylvania State Energy Plan is still under construction (U.S. EPA, 2011; Conergy, 2014). Both the PWD and the Navy Yard solar projects have been strategically selected through the SCP as part of the effort to developing large-scale solar arrays on city-owned facilities and land. Their installed capacity forms part of the SCP 2021 goal (D.O.E. EERE, 2011).

As noted previously, under the state's AEPS, regional private energy utilities in Pennsylvania are obliged to meet certain portion of their retail electricity sales through renewable energy. The solar portion of the AEPS has been set at 0.5% for 2021. According to the 'Shining Cities: At the Forefront of America's Solar Energy Revolution' report published by PennEnvironment, as of end 2013, the total installed capacity of solar photovoltaics in Philadelphia (citywide) reached 9MW[103] (MOS, 2012).

SCP assists the City to make progress on the *Greenworks Philadelphia* target of 20% citywide renewable electricity use by 2015 (MOS, 2012). In addition to solar power, other technologies identified as eligible for the 20% target include wind energy, biogas, geothermal, and large and small hydroelectric. For wind power, *Greenworks Philadelphia* suggests that there are less opportunities for local generation compared to solar, as wind farms are typically located at the city-regional level and supply power to the wider region. MOS will be monitoring the technological progress on small-scale wind turbine systems (i.e. mini-turbines) as an option for local renewable electricity generation. Hence, the city's focus on wind power is put at the procurement renewable energy credits rather than fostering local generation, while solar energy is seen as a more suitable source for local electricity generation (MOS, 2009).

Biogas sources are mostly considered for use in municipal facilities (i.e. PWD plans to generate biogas from materials recycled by city departments and use the biogas to generate electricity for own use). Similarly, geothermal power is considered

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[103] PennEnvironment is a PA statewide citizen-based environmental advocacy organization that undertakes policy analysis and public education on environment issues. The report assesses, and compares, solar installed capacity in 57 major American cities. Philadelphia ranks 22nd among the sampled cities. The surveyed cities were selected from 38 U.S. states shown to have installed solar capacity more than 1.5 MW by the end of 2012. Different sources have been used to compile the data, and adjustments were adopted to develop a more comprehensive comparative dataset. The authors suggest that the data analysis is sufficiently accurate to enable comparisons between cities, and that data quality issues could have minor impacts on the ranking of individual cities (PennEnvironment, 2014). The latest available data by *Greenworks Philadelphia* report a 3.8MW solar photovoltaic capacity installed citywide as of 2012 (MOS, 2012).

for municipal use, for example to supply PGW's Sewer Maintenance Facilities (MOS, 2009). Hydropower is considered as an energy source to increase the 'green image' of the City rather than meeting wider energy needs. MOS has recommended that PWD coordinates with other city agencies to assess the feasibility of hydroelectricity generation from regional resources such as the Schuylkill River Fairmount Dam or Flat Rock Dam, acknowledging the political, historical, cultural and legal challenges associated with such a project (MOS, 2009).

But how does the SCP initiative, and solar power development, fit within the *Greenworks Philadelphia* target for 20% renewable electricity use by 2015?

Figure 11 shows the conventional and alternative energy purchases and generation for electricity use in Philadelphia between FY 2008 and 2011, the targeted conventional and alternative energy contributions for meeting the 20% renewable electricity use target (left side of figure), and the mix of completed, under progress, and planned initiatives to achieve the target (right side of figure):

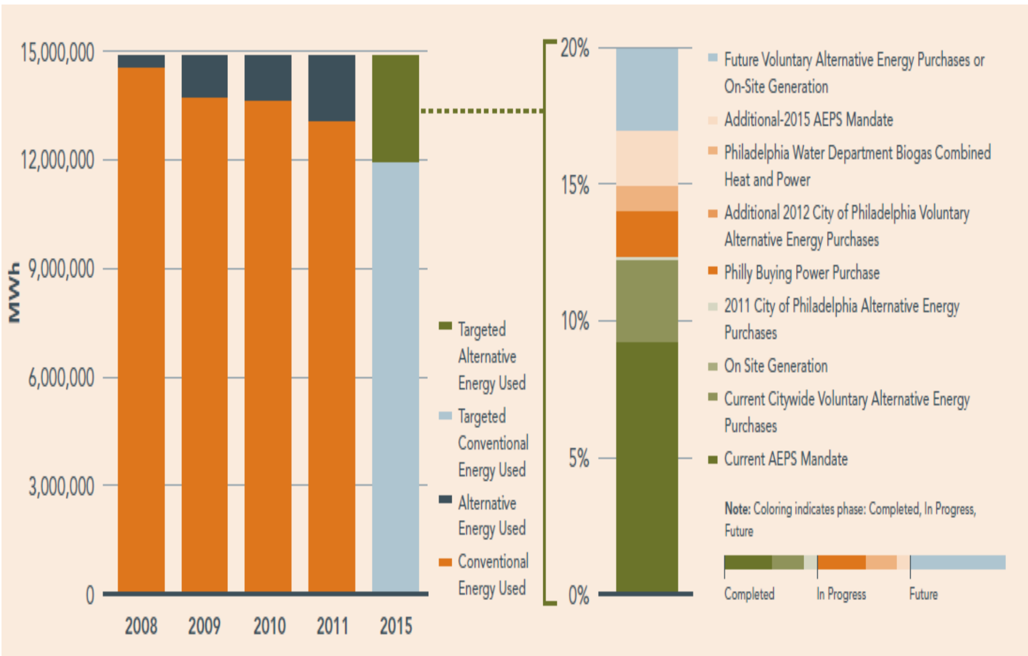

Figure 11: Completed, in-progress and future initiatives to support alternative energy purchases and generation in Philadelphia, and their respective energy contribution in MWh for the 20% citywide renewable electricity use target, 2008-2015

Source: (MOS, 2012)

As Figure 11 shows, the 14% citywide renewable electricity use for 2012, and the planned initiatives to reach the 20% target for 2015, are mostly associated with purchases of RECs, and the AEPS mandate, rather than on-site local renewable electricity generation, which is the focus of the SCP.

In addition, the 14% share of renewable electricity use in 2012 derived from 5,437MWh of citywide renewable electricity generation, and 596,317MWh RECs procured (AEPS mandate and citywide voluntary purchases). Hence, in 2012, local renewable electricity generation amounted to 9% of all RECs procured. In 2013, citywide renewable electricity use increased to 14.8%. Due to slight increases in REC market prices, citywide renewable electricity generation doubled in 2013 reaching 11,402 MWh, or 18.2% of all 697,398MWh RECs procured[104]. This added local capacity came from smaller private solar installations and larger institutional co-generation projects (MOS, 2014).

Overall, hence, the contribution of local solar power systems in the doubling of the local renewable electricity generation for 2013 suggest that Philadelphia has recently made substantial progress in solar power development. However, a number

[104] The *Greenworks Philadelphia* progress reports do not disaggregate local renewable electricity generation and RECs by energy source (i.e. solar, wind, etc.).

of challenges seem to constrain the effective implementation of the SCP initiative. These are discussed in Section 5.2.

5.2. The Evaluation of the SCP Initiative: Challenges in Making Progress with Solar Power Development in Philadelphia

5.2.1. The Role of the State in Solar Power Development in Philadelphia

As described above, the SCP has taken steps to make Philadelphia a friendlier site for solar power development. However, six years after the launching of the initiative the installation of solar MWs in the city remains at low levels. This outcome is largely attributed to systemic policy and market barriers. In this regard, the city's ability on solar appears closely dependent on wider policy conditions with a key one involving the role of PUC and PECO in relation to local solar power development (K. Sullivan, personal communication, April 14, 2013).

More specifically, although PECO and PUC do not openly oppose renewable energy systems, their position is not much supportive either partly due to aspects such as their traditional opposition in the use of financial assistance to support energy systems (i.e. rewards like RECs; subsidies). Hence, PECO and PUC tend to perceive solar panels as systems which mostly take advantage of the grid by drawing energy whenever they need back-up support, and sending energy back when they produce surplus electricity (K. Sullivan, personal communication, April 14, 2013).

As a result, a distributed generator is seen as a system that uses the grid more intensely than typical ratepayers who just pull-out electricity from the grid when they need it, while the former can also feed electricity into the grid and get financial rewards for doing so. PECO and PUC, thus, seem to pay less attention to the overall contribution of distributed generators to system efficiency improvements, for example through reductions in energy needs during peak-load demand (K. Sullivan, personal communication, April 14, 2013).

In addition, PECO seems to treat differently conventional and renewable energy sources when they seek grid connection. Whereas conventional energy supplies do not have to assume the cost of any required technical upgrades, renewable electricity developers are asked to contribute to the cost of such upgrades, i.e. installation of new transformers. PECO argues that it applies state guidelines on this matter although it appears that there is a degree of flexibility regarding how they are interpreted in practice (K. Sullivan, personal communication, April 14, 2013).

Furthermore, PECO opposed the bill proposal put forward by the City of Philadelphia for the creation of PEA on the grounds that the agency might be involved in the task of electricity generation for the city which would likely hurt the company's bonding rate. This could, in turn, increase electricity prices in the city. PECO argues also that state regulation prevents public entities, like PEA, to operate as energy brokers or suppliers. The City replied that the task of electricity generation by municipal entities is not allowed by state regulation. Despite PECO's opposition, the City passed unanimously the proposal with 17-0 voting (The Philadelphia Inquirer, 2010).

The above discussion suggests, hence, that policy conditions which are defined primarily at the state level, as well as the role of PUC and PECO, critically influence Philadelphia's possibilities for local solar power development. As MOTU suggests, unless PECO is mandated by PUC, as in the case of Pacific Gas & Electric private utility and California Public Utility Commission, it seems unlikely that the utility will be more supportive regarding solar electricity development in Philadelphia. At present, however, there are no indications that this is likely to take place (K. Sullivan, personal communication, April 14, 2013).

In addition to policy and regulatory conditions, market aspects strongly influence possibilities for solar power development in Philadelphia. As noted, Pennsylvania adopted the 2004 Alternative Portfolio Standard which mandates private electric distribution companies and electric generation suppliers to retail electric customers in the state to comply with certain requirements of renewable energy share in their electricity sales (Clean Energy Wins, 2014).

To facilitate compliance, an AEPS Renewable Energy Credit market was set up in the state. Over the first years of its operation SREC prices were at high levels peaking up in early 2010 at over $300/SREC. However, the rate of installed capacity statewide soon outstripped demand for SRECs. The prospects for high SREC prices, coupled with solar power development in other states and incentives offered through the Pennsylvania Sunshine Rebate program[105], created an oversupply of SRECs in Pennsylvania. As a result, SREC prices have remained under $2/credit for most of the past four years (Clean Energy Wins, 2014). This dramatic drop in SREC prices has greatly reduced the financial viability of solar power development for the private sector (households, businesses) (K. Sullivan, personal communication, April 14, 2013).

[105] The Pennsylvania Sunshine Solar Program was activated through the Pennsylvania Alternative Energy Investment Act 2008. The program provided rebates ranging from $1.75 to $0.75 per installed watt of solar photovoltaic to residential and small commercial customers that installed photovoltaic and/or solar thermal systems. From May 2009 to December 2013, the program supported over 8,000 solar thermal and photovoltaic projects, distributing nearly $100 million. The program closed in December 2013 since all funds were exhausted (Clean Energy Wins, 2014).

Low SREC prices constrain also solar power development in municipal sites. For example, following-up on the 250-KW solar photovoltaic project at the Northeast Wastewater Treatment plant, MOTU put forward in May 2011 a Request for Proposal (RfP) for a 3 MW solar power system at the Baxter Water Treatment facility. In the meantime, as a result of the excessive supply of SRECs, by the time that RfP responses were due the prices shrunk from $250/SREC to nearly $25/SREC and the project could not proceed. MOTU keeps the RfP in stand-by mode and is ready to put it out once the SREC market picks-up again (K. Sullivan, personal communication, April 14, 2013). As of May 2014, the RfP was closed (MOS, 2014).

In 2014, the SREC market in Pennsylvania continues to be oversupplied with credits that derive from the operation of state solar power systems located both in-state and out-of state. In particular, the out-of-state supply in the market is sizeable largely because Pennsylvania does not have any mandate to stipulate SRECs generated within the border of the state to be absorbed for 'in-house' AEPS compliance. Thus, any solar power project within the 13-state PJM Interconnection electricity grid can generate SRECs that can be used for AEPS compliance in Pennsylvania. As the state has no border restrictions in the trading of SRECs, solar projects that operate in Ohio, New Jersey, Delaware, Maryland, Virginia, West Virginia, Washington, D.C., and within certain utility service territories in Indiana, Illinois, Kentucky, Tennessee, Michigan and North Carolina, can sell credits in Pennsylvania (Clean Energy Wins, 2014).

However, SRECs generated in Pennsylvania can only be sold in Ohio for a portion of that state's Renewable Portfolio Standard compliance (Clean Energy Wins, 2014). Any increase to the solar AEPS share, and subsequent increase in SREC demand, could, therefore, be easily satisfied by out-of-state solar projects. Actually, the potential for continued oversupply in the market is greater than currently the case, as many out-of-state power installations that are eligible to sell RECs into Pennsylvania have not yet registered to do so (Clean Energy Wins, 2014).

In addition to the low SREC prices, in December 2013 the last grant funds that were available from the Pennsylvania Sunshine Solar program were exhausted, and statewide public funds to drive in-state solar capacity development have been diminished (Clean Energy Wins, 2014).

Furthermore, the currently low SREC prices, other things being equal, do not seem to create any major comparative advantage in favor of solar electricity procurement in the statewide market. Effective from 1 July, 2013, the AEPS cost of compliance is incorporated in the generation component of electricity prices. With respect to PECO, the AEPS cost is only a fraction of the company's generation charges which themselves form the bulk share of total electricity prices (PECO, 2014b)[106]. For example, regarding the Residential Class ratepayers, PECO's generation, AEPS, and transmission charges for the period April 2011-June 2011were 9.31cents/KWh, 0.12 cents/KWh, and 0.73 cents/KWh respectively (PECO, 2011).

In order to give an indication of the comparative price of renewable-based electricity supply in Pennsylvania, Table 13 presents the 'generation charges'

[106] The other cost components of the final electricity price are the transmission and distribution charges which are regulated by PUC and Federal Regulatory Energy Commission, and PUC respectively. These charges are the same irrespective of the electricity supplier hence they do not change the relative savings that customers can have by switching supplier (PAPower Switch, 2014b).

component of PECO and selected electricity suppliers of variable renewable energy share in their product for Residential Class ratepayers, as of 30 July, 2014[107]:

Table 13: Generation charges by various electricity suppliers in Pennsylvania with variable renewable electricity share in their product (data updated as of July 30, 2014)

Electricity Supplier	**Generation charge (cents/KWh)**	**% Renewable Share**
PECO	8.58 (through August 2014)	5% AEPS share of which 0.014% is solar
AEP Energy	9.29 (18 month fixed rate)	100%
Ambit Energy	11.50 (monthly variable price)	100%
American Power & Gas of PA	7.30 (monthly variable price) 10.30 (monthly variable price)	Standard mix 100%
Green Mountain Energy Company	8.40 (monthly variable price)	100% national wind
North American Power	9.49 (six month term)	25%
Stream Energy Pennsylvania, LLC	9.18 (one year term)	12%
Verde Energy USA, Inc.	8.49 (six month term)	100%
The Energy Co-op	11.59 (fixed through July '15)	25%

[107] Data that disaggregate the renewable energy share by source (i.e. wind, solar etc.) were not found in public information.

Source: (PA Office of Consumer Advocate, 2014)

As the data in Table 13 indicatively suggest, despite the currently low SREC prices in Pennsylvania, the 'generation charges' cost component of electricity supply that is heavily based on renewable energy is at best competitive with the 'generation charges' component of standard electricity supply (i.e. PECO's).

Given then the importance of wider policy conditions like AEPS and SREC market for solar power development in Philadelphia, as described above, policy reforms at the state level to address identified market failures could create a more favorable context for solar power development in the city. For example, increases in the overall AEPS renewable energy requirements and the corresponding solar energy share, could contribute to creation of market demand for solar power development at the state level. A relevant proposal put forward by PennFuture policy advocacy organization suggests that Pennsylvania's AEPS mandate is raised from 8% by 2021, as currently specified in the law, to 20% by 2030, with a corresponding increase in the AEPS solar share from the existing 0.5% by 2021 to 1.25% by 2021, 2.0% by 2026, and 3% by 2030 (Clean Energy Wins, 2014).

In addition, the introduction of a 'distributed generation requirement' that would oblige Electric Distribution Companies in the state to meet a portion of their updated AEPS mandate with SRECs that are produced through 'on-site' energy systems located within the boundaries of Pennsylvania could be considered as a policy response. This provision could partly insulate the state from an overflow of out-of state generated RECs, which can easily fill-up new REC demand (Clean Energy Wins, 2014).

In the Philadelphia context, one of the few activities that promotes such a more localized approach on solar power generation is found in the *EcoChoice* program of The Energy Co-op, a cooperative-owned nonprofit Philadelphia-based energy supplier that offers supply products of renewable electricity that is generated within the state of Pennsylvania. In particular the program has two choices; *EcoChoice100* which offers 100% renewable electricity at a mix of 99% wind and 1% solar power, and *EcoChoice25* which offers 25% renewable-based electricity at a mix of 24.75% wind and 0.025% solar power[108] (The Energy Co-op, 2014).

Furthermore, state policies that promote long-term contracting for REC credits could reduce the cost of solar electricity generation throughout the state by contributing to reductions in the cost of project development. However, in Pennsylvania's deregulated electricity market where electricity generators compete in a wholesale market and electricity distributors are offered a guaranteed rate of return for their service, long-term contracting is challenging. The reason is that most competitive retail electricity supply and AEPS credits tend to be purchased through short-term contracts, and in the spot market. This creates challenges for new solar power project developers due to the long time-frames needed to recover capital investments and the lack of guaranteed investment recovery, as well financial difficulties like securing funding for the initial cost of project construction (Clean Energy Wins, 2014).

[108] In April 2014, The Energy Co-op launched a new product called *Solar Leader*. Households that enroll in this scheme agree to absorb SRECs from potential solar photovoltaic systems, lowering in that way the financial risk of the prospective investment. For every twenty households enrolled in the scheme, one new solar array is developed on a domestic roof within Philadelphia, and 5% of the electricity use of the households is offset by power generated through the new system (The Energy Co-op, 2014).

In addressing such challenges, state policies could consider to promote long-term contracting of RECs by requiring electric generation and distribution companies to procure credits in their service territories. PUC has actually recognized the value of long-term RECs contracting in its 'Policy Statement in Support of Pennsylvania Solar Projects' and has approved several utility plans for REC procurement through contracts that extend up to ten years, including PECO's procurement of 8,000 SRECs per year for a ten-year period approved in 2010. Extending such provisions at the statewide level would contribute to more predictable and guaranteed SREC prices for customers, and a more stable market environment for renewable electricity investments (Clean Energy Wins, 2014). Policy arrangement such as those described above can, in turn, enhance prospects for solar power generation in Philadelphia.

5.2.2. The City Government's Approach to Energy Deregulation: Opportunities for Local Renewable Electricity Development and how much 'Local' would it be?

The electricity market in the state of Pennsylvania was fully deregulated in January 2011 and all types of customers have now access to alternative energy products and services. Regarding the effect of the deregulated electricity market on the SCP, MOTU suggests that the market will not likely serve as a key driver for solar power development in Philadelphia, but rather factors such as political will and social acceptance of renewable energy will determine the level of renewable electricity development in the city (K. Sullivan, personal communication, April 14, 2013).

Nevertheless, energy deregulation and the opening of the electricity market to competition have bred the development of new products and services that were not typically available in the previously monopoly structured market. As a result, businesses, schools, hospitals, universities and other entities in Pennsylvania have now greater access to cost-effective alternative energy services[109] (Fein, 2010).

But what is the city government's approach to renewable electricity development within a deregulated energy market? As noted, the City of Philadelphia aggregates its electricity demand in order to achieve better procurement rates. From the total electricity that is procured by the City, 5% is renewable energy-based, in essence as a result of the state's AEPS (A. Agalloco, personal communication, March 26, 2013).

On the top of that share, the City purchases wind power credits that raise its renewable electricity use to 20% of total municipal energy use. In the future, the City wants to see an increasing share of sustainable energy fuels in its energy balance, particularly locally-generated renewable energy. Renewable electricity is seen by the City as potentially contributing to this goal. The City sees also the use of locally-generated renewable electricity as a way to further ameliorate local air pollution, which has been a major issue for Philadelphia in the past (A. Agalloco, personal communication, March 26, 2013).

In this context, the City defines as local renewable electricity not only those sources that are generated within the geographical boundaries of Philadelphia, but also those deployed at nearby areas, or even states adjacent to Pennsylvania (A. Agalloco, personal communication, March 26, 2013).

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[109] Currently, eleven electric distribution companies operate in the state of Pennsylvania (PAPowerSwitch, 2014c). The role of eco-entrepreneurialism in urban sustainable energy development has been documented for the case of the city of Berlin, Germany where energy deregulation has created opportunities for private companies and individuals to offer energy efficiency and renewable energy products and services at the city to regional level (Monstadt, 2007).

Until recently, the City was procuring RECs mostly at the national level. Starting in 2013, the City began purchasing RECs from projects that are located closer to Philadelphia as a way of emphasizing the tie of this more locally generated renewable energy to the city, and contributing to solar power market development at the regional level. At the very least, in the near future the City would like to have its RECs from power generators that operate within the boundaries of PJM's system (A. Agalloco, personal communication, March 26, 2013; MOS, 2014).

Regarding plans for entering into electricity generation and supply services as a vehicle to foster greater renewable electricity use at the citywide level, MOS suggests these type of activities are wholly different tasks compared to municipal renewable energy development. In this regard, the City perceives electricity generation as a risky and complex area to be involved with, and the deregulation of the electricity industry as primarily an opportunity to achieve lower municipal energy prices[110](A. Agalloco, personal communication, March 26, 2013).

This is also evident in the working agenda of PEA. Section 1 of Bill No. 100163-AA that was passed in July 2010 to create the agency states (PEA, 2014b):

> The Authority's responsibilities shall be limited to actions for and concerning the development or facilitation of energy generation projects, […] and the purchase or facilitation of energy supply and energy services on behalf of the City of Philadelphia, government agencies, institutions and businesses as well as the education of consumers regarding choices available in the marketplace.

In practice, PEA focuses on the procurement and facilitation of energy supply and services as a way of fostering energy sustainability (i.e. by allowing access to

[110]The City is actually procuring electricity and gas in the market.

long-term energy agreements and contracts as in the case of the Quadplex ESCO project) (PEA, 2013). In addition, PEA's Work Plan 2014-2015 does not include any action item regarding renewable electricity development in the city. It rather calls for the establishment of a vetting process to facilitate the review by local civic entities of ideas and unsolicited proposals on energy development that reach the agency (PEA, 2014b).

5.2.3. Local Factors Influencing Solar Power Development in Philadelphia

In addition to the role of the wider policy framework as described in Section 5.2.1, more local factors related to the politico-economic context for development in the city, and characteristics of the urban built infrastructure and form, influence Philadelphia's possibilities for solar power development.

More specifically, plans for local development may intersect with the performance of solar power systems. For example, future development projects in areas surrounding to solar power systems may reduce their energy performance by blocking their access to the solar potential. Such a scenario seems particularly relevant with respect to the central area of the city where businesses typically want to locate their activities and personnel. In these cases, tall buildings developed to host the businesses will be shading nearby sites from access to solar energy (K. Sullivan, personal communication, April 14, 2013).

This constraining factor for solar power development could be ameliorated by legislation that would provide financial compensation in cases where electricity production by the solar systems is reduced due to lower access to the energy resource. Such a kind of 'solar access law' has been considered by the City but the proposal has not proceeded because of the importance of having the center-city area free from factors that could constrain development plans (K. Sullivan, personal communication, April 14, 2013). In order to identify sites where solar power installation would not conflict with potential development plans, MOTU has undertaken, in collaboration with the City's Office of Innovation and Technology, a spatial 'shade mapping' analysis which uses geo-spatial data like the city's building stock distribution, tree coverage, and local solar potential, to pinpoint promising solar spots in the city (K. Sullivan, personal communication, April 14, 2013).

In addition, joint work with PECO matches this analysis with technical information to identify sites of solar power development whose exploitation would be also technically beneficial for the operation of the grid. For example, this is the case with parts of the grid which need technical upgrade irrespective of solar development, i.e. new electrical transformers. Further, since these sites are subject to lower competition for development, subsuming them under a 'solar access' law provision sounds more realistic. The application of such a provision across sites of the city's built environment could then offer to solar developers spatial spots on which to concentrate their activities, and contribute towards wider policy efforts to establish an easier pathway for solar power development in the city (K. Sullivan, personal communication, April 14, 2013).

In addition to challenges associated with the exploitation of the city's physical space, scaling-up solar power development in Philadelphia to meet the SCP goal would require the installation of large-scale projects that exploit economies of scale and add solar capacity in the order of MWs. For this reason, MOTU is interested in identifying sites within the city that can host large-scale solar projects. However, such kind of projects are complicated, not so much in technical terms, but mostly regarding their transaction part where both the generated electricity and SRECs need to be financially absorbed. At present, both of these conditions appear challenging in the case of Philadelphia due to the low SREC prices (K. Sullivan, personal communication, April 14, 2013).

On the other hand, MOTU suggests that the development of small-scale solar power projects in the city is less dependent on factors such as the above. For example, a decision by a homeowner to install or not a solar power system will likely be strongly influenced by the level of electricity and natural gas prices, as they both affect the payback period of solar power investments (K. Sullivan, personal communication, April 14, 2013).

Regarding the deployment of smaller-scale photovoltaic systems as a way to promote citywide solar electricity generation, MOTU suggests the adoption of a policy approach which targets the neighborhood or community level, for example through the implementation of energy systems across residential sites of an area (K. Sullivan, personal communication, April 14, 2013).

Nevertheless, this type of scale-intervention for solar power can be complicated due to socio-demographic and cultural aspects which influence public adoption of solar systems, including income, age, and the ways in which technology users interact with the system (i.e. maintenance), as well as due to technical aspects such as the different built characteristics found across sites (i.e. age of roofs). These factors could challenge the replication of a specific intervention in a targeted area which aims to add aggregated solar MWs in the grid (K. Sullivan, personal communication, April 14, 2013).

Up-to-date, no formal plans for solar power development at the neighborhood scale have been considered in the context of SCP, or *Greenworks Philadelphia*. However, in March 2014, the City Council unanimously passed a non-legally binding resolution in support of increasing solar power generation within Philadelphia (PennEnvironment, 2014a). The resolution, which builds on the SCP initiative, sets a goal for the development of 20,000 solar roofs in the city by 2025, which translates into an equivalent installed capacity of 120MWs[111]. This targeted capacity incorporates the 57.5MW capacity goal of the SCP. The municipal resolution outlines also general policy directions for reaching the 20,000 solar roofs goal, including coupling solar power development with new site construction (residential, commercial, schools and municipal buildings), and facilitating citywide solar power investments through a municipal rebate program (Clean Air Council, 2014).

PennEnvironment, a statewide citizen-based environmental advocacy organization, led the effort for the adoption of the municipal solar power resolution. This included close interaction with Councilwoman Reynolds Brown City, Chair of the Philadelphia City Council Committee on the Environment, as well mobilizing around thousand Philadelphians to sign a petition in support of the proposal (PennEnvironment, 2014b).

PennEnvironment is currently working with a coalition of partners, including PennFuture, Clean Air Council, Solar States and Community Energy[112], to develop a

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[111]The 120MW are not on the top of the 57.5MW SCP goal, but rather overlap.

[112]Clean Air Council is a member-supported, nonprofit environmental organization active in Pennsylvania (Clean Air Council, 2014). Solar States is a local business that develops solar projects on schools, homes, and commercial buildings in Philadelphia, and promotes workforce development in the solar industry (Solar States, 2014).

working group with City Council member Bobby Henon that will mobilize and coordinate initiatives for making progress on the solar goal. In this context, the active involvement of the local community in a common vision for local solar power development is seen by the City Council as key. Thus, the municipal resolution could be considered to be used as a vehicle for greater solar power development at the neighborhood level in Philadelphia (Solar Energy 2014). The adopted municipal solar resolution is an example of a more systematic dialogue on solar power development within the city government of Philadelphia. Having more structured discussions within the administration regarding solar issues, and the greater incorporation of solar power considerations in municipal policy arrangements and plans are considered by MOTU as key factors of a more comprehensive municipal approach on citywide solar power development (M. Dietze, personal communication, May 22, 2013).

5.3. Conclusion

This chapter discussed policy factors that influence solar power development in Philadelphia, and progress in the deployment of local solar power capacity, by examining the Philadelphia Solar City Partnership initiative. Within the context of the SCP, the city has managed to develop a more facilitative technical and policy context for local solar power development. However, six years after the launching of the initiative, the installed local solar photovoltaic capacity remains low. This is despite the fact that the penetration of solar electricity use in the city's energy balance has reached high levels, an outcome that, nevertheless, is attributed to solar electricity procurement, mostly from out-of state sources, as opposed to solar systems operating

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Community Energy is a nationwide clean energy supplier and developer (Community Energy 2014).

at the local to regional level. Factors identified to strongly influence the level of local solar power development include wider energy policy conditions, like the operation of the SREC market, the role of PUC, and PECO's 'non-facilitative' position with respect to solar, which are more or less out of the direct control of the city government.

Recently, new policy initiatives, compatible with the goal of the SCP, such as the municipal resolution for the development of 20,000 solar roofs by 2025 are worked-out, aiming to catalyze the configuration of broader local coalitions in support of local solar power development. Given the present context, however, it is an open question the extent to which these new policy initiatives can promote wide adoption of local solar systems without changes introduced in the broader policy context relevant to solar power development in the city. Chapter 6 evaluates the residential affordable energy development initiative of the case-study.

Chapter 6

THE RESIDENTIAL AFFORDABLE ENERGY DEVELOPMENT INITIATIVE

6.1. Affordable Energy Development in the Residential Sector of Philadelphia

6.1.1. Context

Cities and states across the U.S. are increasing their efforts to boost the energy efficiency of the residential buildings in their communities motivated by factors such energy cost savings, improvements in indoor air quality, and opportunities to create high-quality jobs for lower-income people. In other words, investment and strategies for residential energy affordability, can simultaneously meet social, economic and environmental goals bringing multiple benefits to local communities (Institute for Sustainable Communities, 2011).

At its core, residential energy affordability is concerned with the distribution of access to energy services, rather than energy itself, and in particular to a healthy indoor environment. In a broader context, it links to questions of energy injustice in relation to issues of poverty, the interests of the least advantaged, and inequalities in the capability by different social and demographic groups' to fully participate in society and achieve valued functions (i.e. the various things a person may value doing or being) (Walker and Day, 2012).

In practice, there are three factors that are central regarding a household's ability to secure affordable energy. The first is income where a shortage of wealth is fundamental to energy unaffordability, but, on its own, this factor does not explain its occurrence. Second, and related to income, is the price of energy which is important in determining the relative affordability of energy across income levels. Third is the energy efficiency performance of the housing, heating and other energy consuming technologies which determine the amount of energy that needs to be consumed and finance spent in order to achieve a given level of energy service (i.e. warmth) (Walker and Day, 2012).

Many analysts suggest that it is this third ‘inequality’ element which is most important to residential energy affordability given that poorer and more vulnerable households typically live in worse quality housing, and have minimum resources or opportunities to invest in improvements to its electricity, heating and cooling technology (Walker and Day, 2012).

By means of these interrelated inequalities, households in energy poverty face difficulties to adequately warm their homes, are often unable to pay their fuel bills, or need to spend a high proportion of their income towards energy costs if they do. As a consequence, they might experience not only the direct impacts of insufficient warmth on health and wellbeing but also ability to afford other essentials within their household budget; for example as in situations where they are forced to choose between spending money on energy bills or food bills. Thus, energy affordability can have impacts on the capability of households to achieve a range of valued functions in everyday life (Walker and Day, 2012).

Addressing issues of residential energy affordability, hence, can offer multiple economic, social and environmental benefits to households, and contribute to sustaining the life of local communities at large (L. Robinson, personal communication, April 07, 2013).

In the case of Philadelphia, with respect to residential energy affordability, the city's housing stock contains large homes and historic housing many of which are more than seventy years old (i.e. 240,000 units of the housing stock were built before 1940), and present challenges to energy efficiency improvements (ECA, 2013a). The housing stock (detached, semi-detached, and rowhouse) accounts for nearly half the total building floor area citywide, making-up over 80% of the city's parcels and totaling to over 560,000 occupied housing units, approximately 325,000 of which are owner-occupied (MOS, 2009).

When apartments, condos and coops are accounted, the housing stock makes-up over 68% of the city's building stock. As a result, significant opportunities for energy efficiency development in the city's residential sector exist but also challenges because of the relatively old infrastructure and diffused ownership of this building stock. In addition, Philadelphia has a larger share of households classified as low-income, at 24.5%, compared to the state and U.S. national average which reaches 12.5% and 14.3% respectively (Shulock, 2012).

As a result of its relatively energy inefficient housing stock and larger share of low income population, residential energy affordability is an important social issue for the city of Philadelphia. This is also reflected in the *Greenworks Philadelphia* target of 15% retrofitting of the city's housing stock with insulation, air sealing and cool roofs by 2015 (MOS, 2009).

A milestone event in the historical evolution of residential energy affordability in Philadelphia was the foundation of the non-profit entity Philadelphia Energy Coordination Agency in 1984 which leads local activities in this area over the last 30 years. In the year previous to the establishment of ECA, 1983, residential gas terminations in the city increased from 3,000 to 30,000. Many low income customers could not keep pace with the rapidly rising cost of natural gas and the only bill payment assistance program available, the Low Income Home Energy Assistance Program (LIHEAP), was poorly administered; in that year the state of Pennsylvania failed to spend its federal allocation and returned more than $20 million to the federal government. The Energy Coordinating Agency was founded in 1984 with a grant of $80,000 from the City of Philadelphia to address such issues. One of the first task that the agency undertook was to create a rational service delivery system for energy conservation that would streamline administrative processes, improve access to services, increase accountability, and coordinate services (ECA, 2014a).

A key mechanism, established by ECA, to operationalize these objectives was the foundation of Neighborhood Energy Centers that would act as a focal point of assistance in energy affordability. In 1985, the agency created the first five Neighborhood Energy Centers in the city which serve as one-stop-shops for all low income energy services. Over time, ECA expanded the network of the centers and now fourteen NECs operate across the entire geographical area of the city providing essential energy bill payment assistance, budget counseling, energy education, conservation and stormwater management services to more than 20,000 low income households every year (ECA, 2014a).

Various types of programs support residential energy affordability in Philadelphia. More specifically, the above mentioned Low-Income Home Energy Assistance Program assists households that have difficulties in paying their heating, bill. This is a federally-funded program which is administered statewide by the

Pennsylvania Department of Community and Economic Development (DCED) (PA Department of Public Welfare, 2011).

The program's funds for the state are channeled each year to DCED from the Pennsylvania Department of Welfare. LIHEAP consists of two parts; a cash grant to help households manage their energy bill, and a crisis grant payment to restore or avoid a shut-off in fuel supply; energy weatherization measures that aim to offer long-range solutions in home energy problems. Up to 15% of the LIHEAP funds can be expended for the weatherization measures (PA Department of Public Welfare, 2011). The cash and crisis grant assistance is in the form of a direct payment to vendor utilities (i.e. PGW, PECO). The city's NECs assist households in preparing and submitting a LIHEAP application (The Philadelphia Inquirer, 2013).

Eligible households must have a total income at or below 150% of the federal income poverty level, and they need not having any outstanding energy bill, to qualify for LIHEAP grant assistance. Grants are based on household size, income, and the type of fuel used. For 2013-14, LIHEAP cash and crisis grant assistance were maximum at $1,000 and $400 respectively (U.S. Department of Health and Human Services, 2013).

In last year's round, PECO customers (service territory-wide) received more than 60,000 LIHEAP grants totaling over $14 million (PECO, 2014c), while over 150,000 PGW customers were eligible to apply to the program. In 2012, Philadelphia accounted for nearly 33% of all applications approved statewide. For FY 2013 and 2014 the state's LIHEAP block grant reached $166.03 million and $162.93 million, while the estimated grant for FY 2015 is $203.07 million. These figures include the

15% LIHEAP portion that is diverted to the WAP program and 10% administrative costs (PA Department of Public Welfare, 2012; 2013; 2014).

As noted, another form of support for residential energy affordability in Philadelphia is the D.O.E. Weatherization Assistance Program. In the state of Pennsylvania, DCED applies for, receives and administers these funds which are distributed to local governments, nonprofit organizations (Community Action Agencies) and redevelopment authorities (PA Department of Public Welfare, 2011).

Eligible applicants include low-income individuals at or below 200% of the federal poverty level. The average WAP allowable expenditure per dwelling unit is \$6,500 (PA Department of Community and Economic Development, 2014). Since 2009, WAP D.O.E. funds[113] allocated to Pennsylvania have been fluctuating as shown in Table 14:

Table 14: D.O.E. WAP allocated funds, 2009-2013

Financial Year	D.O.E. WAP funding (in million $)
2009	25,400,552
2010	11,519,998
2011	11,144,041
2012	3,866,228
2013	2,228,808
2014	11,507,165

Source: (WAP Technical Assistance Center, 2014; D.O.E., 2014)

[113] The data include all funding sources used for the WAP program, i.e. they include the 15% LIHEAP fund that is diverted to WAP (D.O.E., 2014a).

On the top of the D.O.E. standard WAP funding, ARRA 2009 allocated $252,793,062 WAP funding to Pennsylvania. The performance period end date of these grant award was end of March 2012 (D.O.E., 2011). ECA and PHDC are contractors for the WAP in Philadelphia. Each agency was awarded $605,805 in the 2014-2015 WAP budget allocation. These funds are expected to support the weatherization of 109 units in each case (NEWPA, 2014).

In addition, the Utility Emergency Services Fund (UESF) offers financial assistance to households in Philadelphia that have difficulties paying their energy bills or face the risk of service disconnection. UESF is a non-profit independent organization that was created in 1983 through a partnership between PGW, PECO and PWD and has allocated over $60 million to households to date. Its portfolio is supported by fifteen organizations, including the City of Philadelphia. The partnership between UESF and the three utilities (PGW, PECO and PWD) works on a dollar-to-dollar basis, and the maximum grant assistance for 2013 was set at $500 (Utility Bill Assistance, 2013).

UESF private fund is offered after all other public sources have been used for gas, electric and water bills. The income eligibility limit for the fund is set at 175% of the federal income poverty guidelines. The applicant must have received a shut-off notice, or be in shut-off status, and applied for LIHEAP assistance, if available, before applying for UESF assistance. Since its inception, the program has been able to assist over 320,000 people in Philadelphia to pay their energy bills or stay connected to the service (Utility Bill Assistance, 2013).

The work of the NECs is sponsored by ECA and UESF. The Centers act as a focal point of information for the WAP, LIHEAP and UESF assistance (ECA, 2014a).

Each NEC is incorporated in a local Community Development Corporation. These entities are nonprofit, community-controlled real estate development organizations which are dedicated to the revitalization of poor neighborhoods. This includes physical revitalization (mostly housing development), as well as economic development, social services, and organizing and advocacy activities (Walker, 2010).

Various types of funding support the work of CDCs including federal, state and local government funds, and private foundation, bank, and corporate financial support. A significant portion of CDCs' funding is funneled through intermediary organizations who raise funds from private and public sources (Walker, 2010). Two such entities are the Local Initiative Support Corporation or Enterprise Community Partners which support CDCs in several U.S. cities, including Philadelphia (Living Cities, 2014).

As noted, the study's discussion on residential energy affordability in Philadelphia focuses on the role of ECA and the NECs. Section 6.1.2. provides an overview of the activities of these entities in this area.

6.1.2. The Role of the Philadelphia Energy Coordinating Agency and Neighborhood Energy Centers for Affordable Energy Development in Philadelphia

ECA's portfolio offers a wide range of energy conservation services for local residents, including technical, financial, and educational assistance. As noted, the agency coordinates the local NECs which act as a focal point for financial assistance, education, and emergency bill management energy services. ECA and NECs see energy affordability not only as an energy issue, but also as a wider service that helps to sustain the life of local neighborhoods at large (L. Robinson, personal communication, April 07, 2013).

ECA is a delivery agency for WAP. The program offers over 3,000 weatherization services in Philadelphia each year, and helps low-income homeowners save between 20-30% on their energy costs[114] (ECA, 2013b). ECA also assists local residents with repairing or replacing their heating systems through its Heater Hotline program that offers nearly 5,000 services annually (ECA, 2013c).

In collaboration with NECs, ECA offers over 7,000 energy conservation workshops annually where qualified NEC counselors work with households to analyze their energy problems, and provide basic energy education to help them reduce their energy expenses. The workshops also include assistance with the application process for the LIHEAP and UESF programs (Shulock, 2012; ECA, 2014b).

In addition, the NECs offer energy budget counseling to low-income households. This includes budget counseling workshops and one-on-one budget counseling to assist households in establishing a realistic budget for all of their necessary household expenses, including mortgage or rent, energy, water, phone food, clothing, and transportation. The goal of the workshops is to help clients retain their energy source and help stop utility shut-offs (ECA 2014b). The NECs are also a point of contact for the Weatherization Assistance Program available to low-income households in Philadelphia (ECA, 2014c).

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[114]In FY2009-2010, ECA received from federal ARRA 2009 over $7 million for the WAP program. ECA surpassed its goal of using half of these funds to weatherize 825 homes by the end of September 2010 (ECA, 2013b).

ECA participates in the delivery of PGW's Conservation Works program that provides heating and water-heating conservation services to low-income residents (ECA 2012). The agency is also an approved contractor for PGW's *EnergySense* and PECO's Act 129 energy conservation programs (ECA, 2013a; PECO, 2014a).

During FY2009, the ECA and NECs offered more than 50,000 energy services to over 20,000 low-income households in Philadelphia, worth almost $28 million (ECA 2010). Since 2008, ECA has completed 2,478 home retrofits in Philadelphia (MOS, 2014).

In addition, ECA promotes stormwater management and the adoption of cool roofs in the city. Cool roofs, although technically not an energy measure, can contribute to energy use reductions by lowering the energy load requirements of the building (ECA, 2010).

In March 2010, ECA launched the Knight Green Jobs Training Center that provides technical training on energy conservation through classroom instruction, field work and hands-on training. The Center has been approved by the state's Department of Labor and Industry as one of the six certified weatherization training centers currently operating in Pennsylvania (ECA, 2012).

The Center has developed collaborations with the School District of Philadelphia on professional opportunities for high-school students in green energy, the Philadelphia Workforce Development Corporation on green energy recruitment and job placement, and the National Community Action Foundation/ExxonMobil on the development of the first federally-approved Weatherization Technician Apprenticeship Program in the U.S. (ECA, 2012).

The agency is also a certified ENERGY STAR Homes rater and provides guidance to architects and developers that want to obtain LEED and ENERGY STAR for Homes certification (ECA, 2012). ECA was recently selected by D.O.E. to test the Home Energy Score, a new tool that can be used to assess the energy performance of domestic buildings, suggest energy upgrades, and calculate investment payback periods (ECA, 2013a).

More recently, ECA has started taking action on commercial energy efficiency development, and wants to expand its impact in this area. ECA provides building energy performance improvements to commercial entities by assessing, recommending, and contracting energy efficiency interventions (ECA, 2013d).

In addition, ECA's Executive Director is a founding member of the Keystone Energy Efficiency Alliance (KEEA). This is a statewide non-profit organization that advocates on behalf of energy efficiency professionals at the local, state, and federal level aiming to grow the energy efficiency market in Pennsylvania. KEEA supported the development and adoption of state Act 129 [115] (Shulock, 2012).

Collaboration at the state and federal level is considered by ECA as critical for Philadelphia's efforts in energy efficiency development. As ECA notes (L. Robinson, personal communication, April 07, 2013):

> A lot of what the city is trying to do depend upon not just its own sheer influence but a broader sheer influence. So, it's really very important to have allies outside of the local government who can work you know with the state and federal government.

[115] KEEA is working with members of the Pennsylvania legislature to draft legislation that would require the state's natural gas utilities to reduce their energy sales through a legislative provision similarly to Act 129 applied to electric utilities (Shulock, 2012).

6.1.3. Key Local Actors for Affordable Energy Development in Philadelphia

Various local actors other than the ECA and NECs are active on affordable energy development in Philadelphia. For example, PGW is a delivery agency for the LIHEAP program. In addition, PGW's Enhanced Low Income Retrofit Program that was launched in January 2011 as part of the *EnergySense* program offers financial assistance for energy retrofits and energy education to households enrolled in the company's Customer Responsibility Program (PGW, 2011d).

The City's Office of Housing and Community Development supports also affordable energy development for low and moderate income people. For example, in 2006 OHCD contributed match-funding to a project that aims to transform a 33,000 square-foot factory in the west area of the city into a three-story building that features seventeen energy efficient units to host homeless people and families in special needs [116] (FHLBank Pittsburg, 2013). OHCD is currently collaborating with MOS, the Philadelphia Redevelopment Authority and the Philadelphia Housing Authority for the adoption of a single green building standard in affordable housing projects that will be undertaken by these entities in the city (MOS, 2014).

[116] Other funding partners for the project included the FHLBank Pittsburgh member Valley Green Bank, City of Philadelphia Housing Trust Fund, City of Philadelphia's McKinney Supportive Housing Program Fund, Pennsylvania Housing Finance Agency, PennHOMES Program, People's Emergency Center development fund and ARRA 2009 (FHLBank Pittsburg, 2013). Part of OHCD's funding for housing affordable energy development is from the federal level, for example through the U.S. Department Housing and Urban Development's HOME program that provides formula grants to States and localities that are used often in partnership with local non-profit groups to fund a wide range of affordable housing activities, including energy affordability (U.S. Department of Housing and Urban Development, 2013).

PECO is also active on energy affordability in the city. Apart from its participation in LIHEAP, the utility's Low Income Energy Efficiency Program (LEEP) running for the period 2013-15 under phase-II of Act 129 offers energy use reduction services and education to low-income households on electricity use reduction. This includes free of charge energy audits, recommendations for energy saving measures and installation of eligible measures[117]. PECO estimates the energy benefits out of the program to reach over 50,000 MWh energy reductions and 3 MW peak saving. The total discounted lifetime cost of the program is estimated at around $22.2 million and the total lifecycle net financial benefits at $11.38 million. The cost of the program is recovered through a recovery mechanism applied to the Residential rate class[118](PECO, 2012).

LEEP builds on the company's Low Income Usage Reduction Program, applied to energy utilities statewide (including gas). For instance, LIURP staff and contractors are used for the delivery of the program. In addition, community groups and PECO's Community Assistance Program staff are used to refer eligible participants to the program (PECO, 2012).

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[117]This involves eleven types of measures. Four measures refer to electric base load and electric heat reduction and include interventions such as such as compact fluorescent bulbs, energy light bulbs, water heater pipe insulation, water heater tank insulation, air-conditioning, refrigerator and electric water heater replacement, and duct and pipe insulation, or programmable thermostat and insulation installation. Nine measures refer to compact fluorescent bulbs. One measure refers to replacement of inefficient refrigerators with ENERGY STAR unit (PECO, 2012).

[118] LEEP is bundled with the other seven energy efficiency programs that are offered to residential customers and their total cost is recovered through a single cost recovery mechanism that applies to the Residential rate class (PECO, 2012).

PECO's CAP Rate program also offers seven discounted electricity and natural gas tariff rates (up to 90%) to low-income residential electric and gas customers whose household income is within 150% of the federal poverty level. Applicants to the program must agree to apply for LIHEAP Cash and Crisis assistance and receive LIURP services from PECO. For customers that were not enrolled in the CAP Rate in the past, once they join the program any past debt to PECO becomes frozen. If CAP bills are paid on time and in full for six consecutive months, then any outstanding past debt is entirely erased. Those enrolled in the CAP Rate cannot be customers of a competitive electric generation or natural gas supplier (PECO, 2014c).

In addition, PECO runs the Matching Energy Assistance Fund (MEAF) which offers grants to low-income customers to prevent shut-off or reconnect energy service. This is a customer pledged mechanism where PECO matches customer contributions. MEAF operates when LIHEAP is closed. The grants are administered by MEAF agencies throughout the state, including UESF (Utility Emergency Services Fund) in Philadelphia. Eligible households are those with income less than 175% of the federal poverty level. Maximum assistance is at $500 per commodity (gas or electric) and can be used toward the payment of the past due utility debt. Applicants must not have received a UESF grant within the past two years, and must have applied for LIHEAP assistance when available. In addition, the MEAF grant must reduce utility bill to zero whether used alone or with other funding sources (PECO, 2014c).

Furthermore, the non-profit Philadelphia Housing Development Corporation undertakes energy retrofitting through its housing preservation programs. Since 2008, PHDC has completed 2,520 home energy retrofits in the city (MOS, 2014).

In addition, the Philadelphia Housing Authority develops energy efficient housing for low and moderate income people (PHA, 2013). The agency, which receives a large share of its capital from the federal level, is active on three areas of energy affordability: construction of ENERGY STAR-qualified affordable housing units; energy education for own staff and housing residents in collaboration with PECO and PUC; installation of energy efficient equipment in homes. PHA administers the *Conserve Energy-Preserve Public Housing* program which aims to reduce the energy costs of the authority's housing portfolio of over 14,000 units (U.S. EPA, 2012b).

Since 2008, PHA has completed 300 home energy retrofits in the city (MOS 2014). The agency plans to develop over 1,500 affordable energy units in Philadelphia within the next five years. This project is expected to result in more than $800,000 annual energy cost savings. PHA received recently a grant of $118,000 from the state of Pennsylvania Energy Development Authority to support its work on 125 ENERGY STAR-qualified new affordable housing units (U.S. EPA, 2012b).

In addition to the retrofit projects developed by ECA, PHDC and PHA, housing energy retrofitting has been undertaken by PGW *EnergySense* (5,800 units), *EnergyWorks* (468 units) and PDPH Green and Healthy Homes initiative (99 units). Adding all the above activities, the number of housing energy retrofits developed since 2008 (baseline year of *Greenworks Philadelphia*) in the city through government, utility and non-profit programs reaches 11,669[119]. This amounts to over

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[119] These are the sources of housing retrofitting that are accounted by *Greenworks Philadelphia* in monitoring progress over the target (Greenworks Philadelphia, 2014).

14% of the *Greenworks Philadelphia* target of 15% citywide housing stock energy retrofitting by 2015 (MOS, 2014).

Local developers are also now involved in affordable energy development in Philadelphia. For example, Columbus Property Management and Development Inc. was awarded $3 million from the U.S. Federal Department of Housing and Urban Development through the Energy Innovation Fund to upgrade the energy performance of 166 affordable housing units across the city and increase their energy efficiency by 20% (MOS, 2012).

The next section assesses the challenges that Philadelphia faces in fostering wider residential affordable energy development[120]by drawing on the interview discussions with ECA and two of the city's NECs; the Southwest Community Development Corporation Neighborhood Energy Center and the New Kensington CDC Neighborhood Energy Center.

6.2. Challenges for Affordable Energy Development in Philadelphia

Philadelphia efforts towards greater residential affordable energy development are influenced by diverse factors including availability and access to finance, the conditions of the housing stock, and the type of policy and networking interactions that take place in this area. These are discussed below.

[120]Affordable energy development can also assist the city towards meeting its *Greenworks Philadelphia* 10% building energy reduction target. However, affordable energy development does not necessarily lead to absolute reductions in energy consumption. As research suggests, lifting-up the energy performance of residential buildings through energy affordability measures typically leaves their energy consumption at around the same levels due to their previously poor energy performance (Betsill & Bulkeley, 2003).

6.2.1. Availability of Resources

As described in Section 6.1., several initiatives for affordable energy development take place in Philadelphia. However, low availability of resources put at risk their enhancement. More specifically, ARRA 2009 has been a sizeable source of funding for sustainable energy programs in Philadelphia. However, these resources have become less available. For example, the residential component of *EnergyWorks* expired on September 2013, while WAP faces financial constraints. The program got an injection of a 5 billion ARRA 2009 funding but the performance period end date of these grant awards was March 31, 2012 (Shulock, 2012; D.O.E., 2011).

In addition to reduced financial resources, lack of access to energy efficiency programs and assistance for low-income people due to poor credit records puts further constraints for wider affordable energy development. In addition to households classified as low-income, there is another group of local residents that do not have good enough credit record to access financial support for energy efficiency, yet their income is not low enough to qualify for energy conservation programs that are offered to low-income households. As funding for energy efficiency development in the city is currently shrinking, it becomes important that resources for energy efficiency interventions which are prominent, ongoing and widespread across socio-economic groups are developed (L. Robinson, personal communication, April 07, 2013).

Due to financial constraints such as those discussed above, alternative financial arrangements for affordable energy development are considered by local actors, i.e. on-bill financing mechanism suggested by ECA (L. Robinson, personal communication, April 07, 2013).

In addition to the finance part, technical characteristics of the city's housing stock create challenges for wider affordable energy development. Philadelphia hosts a large portion of housing buildings, where low income population reside, which need basic repair and maintenance work before energy efficiency interventions can be undertaken. For example, pre-treatment technical work that would address structural construction problems, water infiltration and sewer problems (Shulock, 2012).

Homeowners or renters of such sites have rarely the funding to implement this type of work. As a result, energy efficiency programs that target low-income people, like WAP, cannot progress as expected. Programs and sources of funding to address this basic work are limited. For example, the Basic Systems Repair Program that is administered by PHDC is on a three-year application backlog (Shulock, 2012).

6.2.2. The Role of Local Neighborhoods for Affordable Energy Development in Philadelphia: Community Energy Organization and Practices

Having discussed financial and technical challenges on energy affordability in Philadelphia, this Section is looking at the role of two of the city's Neighborhood Energy Center to gain insight on how these civic entities and their local neighborhoods engage with affordable energy development, the challenges that they face in this area, and steps that could be taken to overcome them. The two NECs have been selected for further discussion based on data availability. All fourteen NECs were contacted for an interview, and a positive response was received from the NECs of the Southwest Community Development Corporation and New Kensington Community Development Corporation.

Southwest Community Development Corporation is such an organization with a mission to improve the quality of life in Southwest Philadelphia area through economic development and supportive services. The organization was created in 1987 around the task of community energy conservation. In that time, local communities in Philadelphia were taking advantage of the UESF and LIHEAP programs that were addressing risks of energy service disconnection for low-income people (D. Henry, personal communication, May 02, 2013).

Although these programs were assisting households to stay on the energy service, they were overshadowing the energy conservation component of local energy affordability regarding aspects like education, water conservation and the installation and maintenance of resource conservation devices. Hence, Southwest NEC was created with the aim to promote energy education and conservation in the neighborhood, and foster long-term energy savings and community resilience (D. Henry, personal communication, May 02, 2013).

The energy services that the Southwest NEC currently offers to the local neighborhood include energy conservation education, and assistance on the preparation and submission of UESF and LIHEAP applications. The closest actor with whom the NEC collaborates is ECA which funds its work through direct contracts on energy conservation education. Occasionally, the NEC offers energy assistance through equipment (i.e. cooling fans) that is donated to the Center (D. Henry, personal communication, May 02, 2013).

All NECs have a monthly meeting with ECA where update on programs and information sharing on best practices takes place. ECA prepares a monthly progress report that is distributed to the NECs so that each one is aware of their peers' work (D. Henry, personal communication, May 02, 2013).

Direct interaction between NECs, or between NECs and the city government, on energy affordability activities is not taking place. Rather, ECA coordinates the work of the Centers across the city, and provides them with information and education for their energy conservation work. This includes training on energy efficiency devices and their installation, information on the kind of products that local residents can use for energy and water conservation, and advice on what the community energy education of the Center should involve. In this interaction, ECA is open to feedback from NECs on their information and education needs (D. Henry, personal communication, May 02, 2013).

As noted, the Southwest NEC serves as a point of contact for UESF and LIHEAP assistance. Many households in the neighborhood rely on these programs to manage their energy bill. In Pennsylvania, state Act 201 of 2004 prohibits PUC-regulated utilities to cut-off utility services of low income customers over the winter period December 1-March 31. For PECO, the moratorium covers households with income at or below 250% of the federal poverty level. In contrast, PGW is allowed to shut off a larger band of customers, those above 150% of the federal poverty level. This special provision was granted to PGW by state legislators because of the utility's poor financial situation in 2004. Despite PGW's improved financial situation, this provision is still on (PUC, 2014b).

As a result, when a household is on gas or electricity supply on December 1, PGW (or PECO) cannot cut-off the service until April 1 of next year, irrespective of whether or not the household can pay-off their bill during this period. In that case, there is a guaranteed access to energy supply for the period December 1 to April 1 which assists households to have heating over the winter period (D. Henry, personal communication, May 02, 2013).

However, if a household cannot pay the gas bill before December 1, then PGW has the right to cut-off the supply, and the utility actually pursues this practice. For example, according to the PUC's Cold Weather Survey, as of Feb. 1, 2013, there were 7,103 PGW households without central heating due to termination of utility service. This figure is 68% of the statewide total of 10,440 households without central heating because of gas utility shut offs, and over half the total of 13,298 households without central heating because of gas or electric utility shut off (PUC, 2014c).

Thus, UESF and LIEHAP programs have a role in assisting these households to pay part of their gas or electricity bill and stay on energy course at least until December 1 when the applied moratorium guarantees energy service until April 1. By that time, the household energy bill might have risen, and the same process has to be followed in order to secure heating supply over the winter period (D. Henry, personal communication, May 02, 2013).

The programs work on a first-come/first-served basis and there is only a certain amount of funding allocated every year which typically cannot cover the needs of the whole Southwest neighborhood (D. Henry, personal communication, May 02, 2013).

Although UESF and LIHEAP programs assist low-income households in the neighborhood to stay on energy service[121], their cyclical yearly use, without the

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[121]PGW reported that in 2012 over 80% of its customers who received LIHEAP grant managed to remain current on their gas bill for the whole year. On the other hand,

adoption of energy efficiency measures or adjustments in energy behavior, accumulates an increasing amount of energy debt that is getting difficult to pay back. Thus, the funding requirements for the programs are increasing year by year (D. Henry, personal communication, May 02, 2013).

At the same time, the Southwest NEC suggests that when local residents cannot make use of UESF of LIHEAP assistance because there is no more available funding in a specific year, they tend to have low interest in receiving education that could reduce their energy bill. It appears that many people in the neighborhood have connected their engagement to energy education with the availability of financial relief for their energy bill[122]. Partly for this reason, there is a reduced motivation by local residents for energy conservation education (D. Henry, personal communication, May 02, 2013).

In addition, the relatively small share that energy savings out of behavioral changes would make-up in the total energy bill tends to reduce motivation for energy efficiency. As many of the households live on financial assistance, or perform their daily transactions on a pay-check way lacking any extra finance, they have almost no

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over 50% of eligible customers who did not receive a grant did not manage to keep up with their bill (NBC Philadelphia, 2013).

[122]In the words of the Executive Director of the Southwest NEC (D. Henry, personal communication, May 02, 2013):

> We have them here, in the building, and when they hear that there is no energy grant available they walk away. They do not even want to listen about how their energy bill is shaped or ways to reduce their household energy consumption.

incentives to cover any up-front cost of energy efficiency systems (D. Henry, personal communication, May 02, 2013).

6.2.3. The Need for a more Comprehensive Policy Approach to Scale-Up Affordable Energy Development in Philadelphia

The discussion with the New Kensington NEC offers insight on the type of challenges that this neighborhood faces on energy affordability, and identifies the importance of having a more comprehensive policy approach for scaling-up residential energy affordability in Philadelphia.

The New Kensington NEC has operated in the city for over twenty-five years, with ECA being one of its first partners. Back in the 1990s, the core mission of the NEC was to provide energy conservation education to the neighborhood. At present, the work of the Center is still focused on energy education but to a lesser extent than before. This is related to wider shifts that took place in the context for local affordable energy development in the city (A. Czajka, personal communication, May 30, 2013).

More specifically, over twenty years ago, a network of local policymakers and agencies (i.e. Mayor's Edward Rendell Housing Task Force; the City's Office of Community and Economic Development; local housing agencies; the Reinvestment Fund; the Urban Affairs Coalition), with a long-term vision for the city's prosperity, was promoting forward-looking policies in the housing sector. This involved a locally-sensitive and networked management approach in this area. For instance, a network of housing agencies was in place and citizens were comfortable to communicate with them and ask for assistance on housing management issues (i.e. budgeting) or special programs like the Urban Affairs Coalition's Delaware Valley

Mortgage Plan (1975-2000) would help many of Philadelphia's lower income and minority communities to have reasonable access to mainstream financial services for the purchase of homes or to refinance housing mortgages (A. Czajka, personal communication, May 30, 2013; Adams et al., 2008).

Energy affordability considerations were incorporated in this wider policy context for the city's housing sector. For example, concerns over likely increases in residential energy prices foreseen to take place in the near future motivated the adoption of programs to ameliorate such potential impacts. For example, various energy conservation pilot programs were developed and implemented offering energy conservation education to households. A key entity in these early activities was PECO with which New Kensington NEC was collaborating closely. For instance, PECO would meet once a month with the advisory board of ECA's Customer Assistance Program, of which the Center was part of, and would discuss updates on its affordable energy activities (A. Czajka, personal communication, May 30, 2013).

In addition, the utility was operating the pilot scheme High-User Program where high-energy users in the neighborhood were identified and offered assistance to reduce their household energy consumption (A. Czajka, personal communication, May 30, 2013). PECO would then inform the New Kensington NEC that energy users who belong to specific energy-use blocks have been identified to show excessive energy consumption in relation to their level of income and average energy needs. PECO would then discuss with the Center the kind of action that could reduce this energy consumption (A. Czajka, personal communication, May 30, 2013).

The Center would communicate with the energy users to inform them about these issues, and a type of 'partner-client' relationship would develop where information and guidance was provided by the Center on how the energy users could reduce their energy consumption This interaction was taking place through intense community outreach where personnel of the Center would go door-to-door in the neighborhood and inform people about the support that the Center could offer them. For people that would decide to engage with energy conservation activities, their progress on energy use reductions was reviewed by the Center regularly (i.e. annually) (A. Czajka, personal communication, May 30, 2013).

If this evaluation would show that energy consumption has not been reduced as expected, the Center would make clear that the households need to follow the energy conservation plan they agreed upon with the Center, or the latter would look like as a kind of 'bad guy' to PECO. This, in turn, would put at risk the Center's energy efficiency activities, and as a result the level of support that could be available for them. Hence, once provided with resources and education, the households were expected to achieve reductions in their energy consumption (A. Czajka, personal communication, May 30, 2013).

The High-User program, and other energy pilot programs of that period, were observed to foster energy behavior modification towards conservation, building-up in that way long-term energy savings for the neighborhoods. Many of these early programs were enhanced over the time and consist part of PECO's current approach in energy efficiency (A. Czajka, personal communication, May 30, 2013).

In that past period, PUC was more included to support affordable energy development throughout the state. For example, informal communication was taking place between NECs and PUC personnel on administrative issues or opportunities for community energy conservation. According to the Center, such interaction is currently lacking partly because PUC has become more business-oriented in its mission (A. Czajka, personal communication, May 30, 2013).

In addition, the Center suggests that the state government had a more proactive position on energy affordability issues; for example officials would express concerns over high energy consumption in local communities and suggest that action needs to be taken to reduce their energy use. This, in turn, was creating pressure on cities to develop programs to assist local neighborhoods reduce their energy consumption[123](A. Czajka, personal communication, May 30, 2013).

As these dense interactions on energy efficiency were weakening over time, so did the city's proactive approach and educational character on community energy conservation. Similarly to the case of Southwest NEC, households in the New Kensington neighborhood are mostly interested in utility bill management energy assistance (A. Czajka, personal communication, May 30, 2013).

Unlike, though, Southwest NEC which reports a low interest for energy education in the absence of utility bill assistance, New Kensington NEC states that in such cases the energy education part just prevails in their interaction with the neighborhood, with households receiving information, in simple terms, on how to reduce their energy consumption (A. Czajka, personal communication, May 30, 2013).

For example, it may be the case where many air-conditioning units operate at the same time in a single household without needing to have all of them on to achieve a desirable level of comfort. The Center will then recommend that there is no need for

[123]However, it should be noted that such a rationale by the state has been central for the adoption of state Act 129, part of which targets residential energy affordability (PUC, 2013).

a simultaneous operation of all these units, and that desired levels of energy comfort can still be achieved through one or two systems (A. Czajka, personal communication, May 30, 2013).

The Center also notes that the seniors appear, overall, more receptive on what steps they need to take in order to conserve energy at home, while the newer generation seems to require more input on this matter. Looking across income bands, it appears that higher income people tend to have a larger ability to adjust their energy behavior compared to lower income people in the neighborhood[124](A. Czajka, personal communication, May 30, 2013).

The Center's energy education work is assisted by external actors other than ECA. Last year, the Center received guidelines and information from PGW on local community energy education. This assistance has a self-help character where, for instance, energy users learn how to change their window in order to reduce heat losses, or how to save energy without sacrificing energy comfort. For example, the Center has observed cases where people would heat their house up to 90F^{o}. The advice offered is that, based on their economic situation, they cannot afford heating their home at such high temperatures (A. Czajka, personal communication, May 30, 2013).

The self-help energy guidance emphasizes proactive action and financial self-reliance in order that households are more prepared in case they have to face an unexpected economic situation. In this regard, the Center advices people to consider

[124]Apart from the effect of socio-demographic and cultural factors in energy behavior, what is also observed in Philadelphia is the typical owner-tenant dilemma in energy efficiency where low-income people who own their home tend to conserve more than those who rent the site (Shulock, 2012).

carefully what their priorities are in enhancing their economic viability, and the need to follow the priority order. Here, the suggestion is that people should, first, find a way to secure their housing asset and protect themselves from any foreclosure risk. Then, they should make sure that they have electricity service, as this can provide both lighting and heating (A. Czajka, personal communication, May 30, 2013).

Furthermore, the Center has observed that every household benefits from a tailored approach on energy conservation. Hence, the Center develops with households an initial plan where preliminary steps are used and modifications are then introduced, if needed. The Center suggests that energy conservation action is facilitated when people have at their disposal, or they are aware of, the various tools and options that are available to reduce their energy consumption. In that case, people will at least be aware of the kind of action that they could take to save energy (A. Czajka, personal communication, May 30, 2013)

What the case of the New Kensington NEC, therefore, reveals is that multiple issues need to be addressed in order to foster energy affordability in the neighborhood, including aspects such as energy education, household budget control, behavioral changes, and adoption of different types of technical interventions. Hence, one of the main priorities of the NEC is to offer, as it currently does, a one-stop-shop service to the local neighborhood where most, or all, of such different aspects, related to energy conservation, can be addressed simultaneously. In addition to the one-stop-shop approach, the Center suggests that more work on energy conservation education would be helpful to increase energy savings in the neighborhood (A. Czajka, personal communication, May 30, 2013).

6.3. Conclusion

This chapter has discussed the ways through which residential energy affordability is pursued in Philadelphia, the progress that has been made over the *Greenworks Philadelphia* relevant target of building energy retrofitting, and key factors that influence the type of action taken in this area. Due to the particular importance of energy affordability for Philadelphia, there is a long history of local activities aiming to promote affordable access to energy that precede the city's sustainability plan. In this context, civic entities, the state of Pennsylvania and the two incumbent energy utilities that serve Philadelphia have been key actors in the development and implementation of policies and programs that support residential energy affordability in the city. Recently, the city government has been also taking a more systematic approach on residential energy in the context of *Greenworks Philadelphia*.

The evaluation of current action for residential energy affordability in the city suggests that a range of technical, financial, and educational services offered to local neighborhoods enables addressing energy bill risks and fostering energy savings through technical interventions and energy conservation education. However, despite the lack of more detailed data that could assist in having a more accurate picture, it appears that currently the scale of policy response on residential energy affordability does not match the scale of local needs, i.e. either in terms of site energy retrofitting, or building long-term household energy savings through behavioral changes.

In addition, the discussion suggests that information provision and education, stable financing and a more proactive and coordinated policy approach that would promote tailored interventions at the household level appear key ingredients for fostering wider energy affordability in the city. In such an organizational context, households would be offered resources and support, but they will be also held more accountable on the outcomes of their energy performance.

Chapter 7

THE ENERGY EFFICIENT BUILDINGS HUB INITIATIVE FOR COMMERCIAL ENERGY EFFICIENCY DEVELOPMENT IN THE GREATER PHILADELPHIA AREA

7.1. Origins and Structure

The Energy Efficient Buildings Hub (EEB Hub) was established by the U.S. federal administration in February 2011 as a national center of research and innovation with the aim to accelerate the adoption of energy efficiency in the commercial building sector[125] by using the Greater Philadelphia Region as a test bed (GPIC, 2010).

The EEB Hub was originally designed as a five-year performance-driven partnership with core members comprised of eleven prestigious universities and centers (Penn State University, University of Pittsburgh, Princeton University, Purdue University, Rutgers University, Carnegie Mellon University, Morgan State University, Virginia Polytechnic Institute and State University, Drexel University, University of Pennsylvania, University of Pittsburgh, and Wharton Small Business Development Center of the University of Pennsylvania), five global industry partners spanning the building and construction industries (Bayer Material Science, PPG Industries, Turner Construction, United Technologies Corporation, IBM Corporation), a D.O.E. laboratory (Lawrence Livermore National Laboratory), four regional

[125]Commercial buildings are defined as sites with more than 50% of floor space used for commercial or industrial activities (D.O.E. EERE, 2010).

economic development agencies (Benjamin Franklin Technology Partners of Southeast Pennsylvania, Philadelphia Industrial Development Corporation, Delaware Valley Resource Center New Jersey Institute of Technology), and five community colleges through the Collegiate Consortium for Workforce and Economic Development[126] (GPIC, 2010).

The EEB Hub was originally set up to operate for a period of five years, from 2011 to 2016, supported by a federal grant of $150 million that would be allocated through annual installments of $25 million each. However, as early as July 2013, the U.S. Senate Appropriations Committee expressed concerns over the effectiveness of the Hub to produce measurable results, and suggested that the Hub terminates its operation. In response to this critique, the Hub leadership argued that agreed deliverables are indeed met on schedule, and that the partnership has the potential to accomplish its programmatic responsibilities. What became a highly politicized process over the evaluation of the Hub's performance, involving also high-level political personnel (a U.S. Senator and two U.S House of Representatives from the state of Pennsylvania), led, finally, to the transition of the Hub away from a clustering innovation center towards a consortium of partners, called the Consortium for Building Energy Innovation (CBEI). Under a new organizational structure and a narrower agenda and resource base, CBEI focuses on the successful demonstration and deployment of technical and market solutions for commercial energy efficiency

[126]The partnership included also a group of sixty partners for which information is provided in p.269.

retrofitting in the Philadelphia region, aiming to also instigate spill-over effects at the national level (CBEI, 2014a).

As mentioned above the EEB Hub remained in operation from February 2011 to April 2014. The mission of the Hub involved the development of a replicable and scalable model for energy use reductions in existing small and medium-sized commercial buildings (GPIC, 2010).

The incorporation of energy efficiency into new construction through building codes allows owners to more readily take in the cost increases associated with greater energy efficiency. New construction offers good opportunities to facilitate cost effective energy efficiency in commercial buildings. However, code enforcement can be difficult and ensuring all new buildings are meeting code requirements can be challenging (i.e. need to train code officials). In addition, building codes do not address the energy challenges of the existing building stock. Hence, wide diffusion of energy efficiency requires interventions in the existing building stock (Center for Energy Efficiency and Sustainability, 2012).

Partly for reasons as the above, the Hub's agenda focused on the energy performance of existing commercial building. This objective was guided by an overall principle of transforming the industry's currently fragmented serial process into systemic, performance-driven, integrated and parallel team processes to drive comprehensive energy efficient retrofitting (Knapp, 2010).

The sizeable building stock of the Greater Philadelphia region was considered as an infrastructural asset upon which to validate and deploy energy efficiency innovation that would be produced through the operation of the Hub. Historically, energy efficiency initiatives in the U.S. have been primarily focused, and successfully employed, along the West Coast of the country, in particular the region of California (GPIC, 2010).

However, less work has been undertaken to advance energy efficient building design processes, modeling tools, and construction techniques in the East Coast area of the country. Due to its highly diversified building stock across industrial sectors and residential environments, the Greater Philadelphia region appeared suitable to serve as a test-bed for research and deployment of energy efficiency technologies that could potentially achieve industrial and market impacts at the national level (GPIC, 2010).

The Hub partnership drew on the extensive technical expertise of the Greater Philadelphia region that hosts over ninety-two colleges and universities a number of which acted as either core members or partners of the initiative. In addition, the Hub used a growing network of professionals that are engaged with green activities in the region (GPIC, 2010).

The Hub was established at the Philadelphia Navy Yard, the city's former historic Navy base that was closed by the federal government in 1996. In March 2000, the City of Philadelphia became the owner of the Navy Yard. The Philadelphia Industrial Development Corporation manages the planning, operation, and development of the Navy Yard on behalf of City (The Navy Yard, 2014).

In 2004, PIDC released the Navy Yard Master Plan that envisions to turn the former industrial site into a vibrant mixed-use commercial and residential campus, based on historic preservation, sustainability, and smart growth. The Master Plan was produced by a team of real estate, development, planning, and design professionals (ULI, 2009).

Currently, the Navy Yard occupies 1,200 acres that house more than 130 companies with over 10,000 employees. From a regional point of view, the Navy Yard is a sizeable area. For example, it occupies more land than the central business and commercial district of Philadelphia and contains 282 buildings, 233 of which are old sites (GPIC, 2010).

A key focus of the Navy Yard's Master Plan has been to establish the site as a national center of excellence for energy research, education and commercialization through innovation in the areas of clean and efficient energy production, storage, and management (GPIC, 2010).

The Navy Yard offered a number of advantages for the accomplishment of the Hub's objectives. This included the co-location of Hub members and strategic partner personnel; proximity to regional research and development organizations; and an un-regulated grid that could be used to test energy technology and policy innovation. In addition, several businesses located at the Yard expressed interest to participate in Hub initiatives (GPIC, 2010).

At the regional level, the venture capital community of the Greater Philadelphia Area was seen as a factor that could facilitate the spread of Hub advances outside traditional channels of adoption of industrial innovation[127]. The incorporation of area-based economic and workforce development entities in the Hub's executive management team, including the Ben Franklin Technology Partners of Southwestern Pennsylvania, the Delaware Valley Industrial Resource Center (DIVRC), the Philadelphia Industrial Development Corporation (PIDC), and the

[127]Based on a study by Pew Charitable Trusts, over $500 million in venture capital spending was devoted between 2006 and 2008 to new clean energy businesses in the states of New Jersey and Pennsylvania (GPIC, 2010).

regional Small Business Development Centers and Workforce Investment Boards of Pennsylvania and New Jersey, was perceived as helpful in this regard (GPIC, 2010).

The organizational structure of the Hub included two blocks. Other than the 'core members' (p.264), the partnership consisted of a 'partners group'. This group included sixty organizations split by 'Industry Partners' (this block includes PECO); 'Industry Associations' (i.e. Delaware Valley Green Building Council, Alliance to Save Energy, New Jersey Technology Council, Sustainable Business Network of Greater Philadelphia); 'Education and Workforce Partners' (i.e. Delaware county Workforce Investment Board); 'Community and Economic Development Partners' (i.e. Economic League of Greater Philadelphia), Government Partners (i.e. City of Philadelphia, Commonwealth of Pennsylvania), 'Labor Organizations' (i.e. National Roofing Contractors Association); 'Philanthropic Foundations' (William Penn Foundations), and 'International Partners' (i.e. Lund University from Sweden) (GPIC, 2010). Figure 12 describes the framework within which the Hub operated in order to address the technical and market tasks of its innovation agenda:

Figure 12: The organizational context for the transformative role of the EEB Hub in energy efficiency innovation

Source: (EEB Hub, 2013a)

The Hub partnership was led by Penn State University, and it was set-up with funding from four federal agencies. Specifically, Penn State's proposal to D.O.E. received $122 million, Philadelphia Industrial Development Corporation's proposal to the U.S. Economic Development Administration received $5 million, Delaware Valley Industrial Resource Center's proposal to the National Institute of Standards and Technology received $1.5 million, and Wharton Small Business Development Center's proposal to the U.S. Small Business Administration received $1.3 million. In addition, the Commonwealth of Pennsylvania committed $30 million of capital funding to support Hub facilities and activities (GIPC, 2010).

At the core of the Hub organizational structure was its Operating Committee comprised of the Task Team Leaders, the Director for Technology and Operations, and the Director for Management and Administration. The Committee met every other week to discuss the work of each task separately[128], and the work of the Hub overall. Ultimate decision making, however, was placed with the Hub Directors and Executive Board (EEB Hub, 2014a).

The Hub Director and Operating Committee was advised by a broadly representative Advisory Committee that served two main functions; the strategic review and assessment of research and development activities, and assistance with the diffusion of the Hub's innovation and practices (GPIC, 2010).

[128]The Hub's research agenda was structured around eight specific tasks which are described in Section 7.3.

The Hub's strategic location in the Greater Philadelphia Area was considered as a facilitating factor in the transfer of the produced innovation to the rest of the country, while offering also access to global markets (GPIC, 2010).

The Hub was portrayed by the City of Philadelphia as an important initiative with the potential to produce impacts at the regional to national level. In October 2010, when it was announced that the U.K. based energy efficiency firm Mark Group will establish its U.S. headquarters at the Philadelphia Navy Yard, Mayor Michael Nutter stated (Greenworks Philadelphia 2010):

> The Navy Yard is becoming a nationally recognized hub for clean technology companies. The Mark Group is one of many innovative energy efficiency and alternative businesses establishing their presence in Philadelphia. These companies are bringing new jobs, new expertise and new ideas to our city.

According to the company, the location of the city as an international and U.S. Northeast transportation hub, and the large number of higher education institutions in the region were important factors in the decision to locate its headquarters in the area (Greenworks Philadelphia, 2010). In January 2014, the Australia-based Ecosave international company which is active on energy efficiency services (i.e. energy financing, auditing, implementation) made also the decision to have its headquarters at the Navy Yard (philly.com, 2014).

7.2. The Hub's Mission within the Greater Philadelphia Region's Context for Commercial Energy Efficiency Innovation

Global energy demand rising at accelerating rates over the last decade, and fossil fuel depletion fueling soaring energy prices, have been key motivating factors in developed countries behind policies to reduce building energy consumption. For instance, in the U.S. commercial buildings energy consumption reached over 19% of national energy consumption in 2013, and grows at a higher rate than any other sector of the economy. Similarly, the European Union has identified buildings as the most promising sites to improve the energy intensity of national economies, with commercial sites providing a high potential for energy use reductions (Azar and Menassa, 2014).

In addition to public policy rationale for commercial energy efficiency, businesses are increasingly acknowledging the importance of energy efficiency for reducing energy costs[129], promoting Corporate Social Responsibility, and managing market risks linked to energy regulation (Center for Energy Efficiency and Sustainability, 2012).

In the U.S., historically the building sector achieves significantly lower energy efficiency improvements compared to other sectors of the economy. This is evident in Figure 13 that presents the level of energy reductions in various systems of the U.S. economy over the last decades:

[129]Energy costs associated with building operation can be significant. For example, it is estimated that HVAC systems account, on average, for over 67% of a building's total energy consumption in the education sector in the U.S. (Center for Energy Efficiency and Sustainability, 2012).

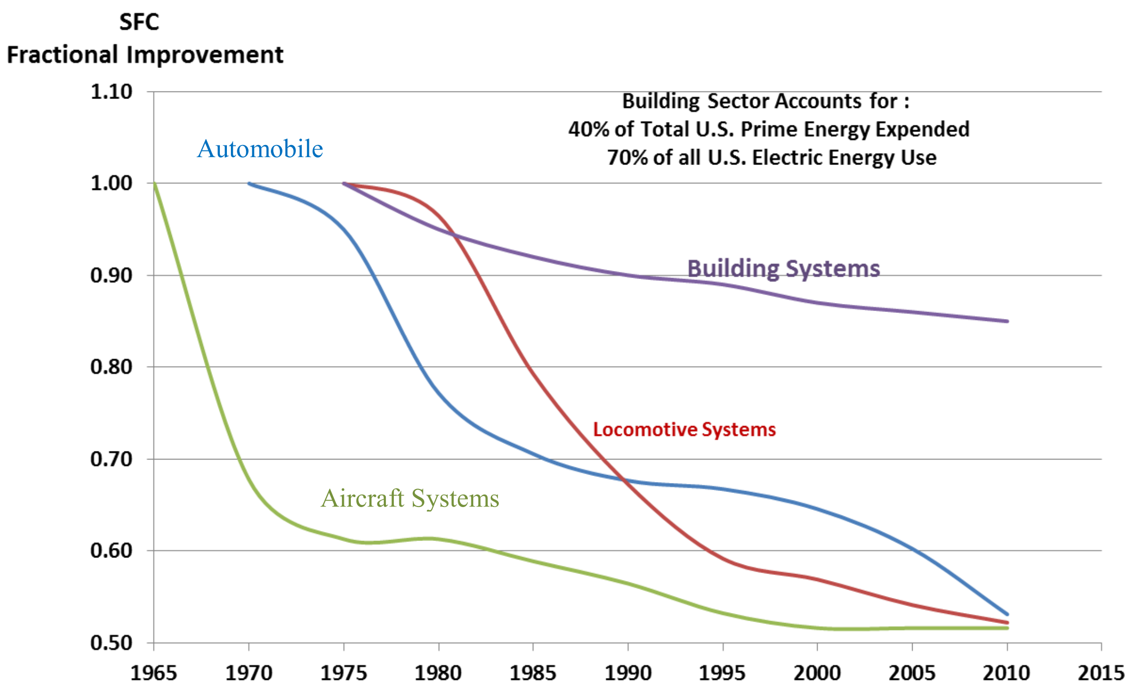

Figure 13: Improvements in the energy consumption per output for various systems of the U.S. economy, 1965-2010

Source: (EEB Hub, 2012a)

As Figure 13 suggests, over the period 1975-2010, improvements in energy consumption per output in the U.S. have been greater for sectors such as automobiles, aircrafts or locomotive systems compared to the building sector[130]. At present, new commercial buildings in the U.S. are performing at 257 kWh/m^2 which is about similar compared to commercial sites built before 1960 (Andrews & Krogmann, 2009).

The U.S. Energy Information Administration (EIA) estimates that the primary energy consumption of the U.S. commercial sector reached 17930.385 trillion BTUs in 2013. This is over 18.4% of that year's total U.S. primary energy consumption.

[130]However, these higher energy efficiency improvements have been achieved within vertically integrated industries where large-scale adoption of new systems and practices is easier compared to the case of the fragmented and diffused building and construction sector (GPIC, 2010).

Office space, retail space, and educational facilities represented around half of the total commercial energy consumption in that year. The top three end-uses of the sector were space heating, lighting, and space cooling, representing nearly half of its total energy consumption (EIA, 2014).

In addition, data analysis suggests that between 1980 and 2009, U.S. commercial floor space and primary energy consumption grew by 58% and 69% respectively. EIA projects that both these metrics will continue to grow until 2035, although at slower rates (estimated at 28% and 22% respectively) (D.O.E.EERE, 2012).

Despite the fact that buildings are key sites for addressing energy problems, since they are large energy users, a large untapped potential to increase their energy performance exist, and various policy instruments have been traditionally implemented to promote their energy efficiency, overall the pace of innovation that has been achieved in this area can be characterized as limited (Altwies & Nemet, 2013).

Explanations for this outcome include aspects ranging from fragmented decision-making structures and principal-agent problems to inadequate information and limited learning taking place across the implementation of heterogeneous projects. In addition, although innovation in end-use energy technologies has achieved substantial impacts, it has received relatively less support in research priority and funding. This suggests that there is a need for a more focused research approach in this area (Altwies & Nemet, 2013).

With respect to the Philadelphia region, the Hub expressed the view that there is a large potential for improvements in commercial energy efficiency, but also market and organizational barriers that require targeted policies to be overcome (Actman, 2012).

In Fall 2012, the Hub commissioned a scoping study for the region's commercial real estate market of small to medium-sized buildings, between 20,000 and 100,000 sq. feet, which found that nearly half of these sites are good candidates for energy efficiency retrofits. In addition, the study found that undertaking such work could spur $618 million in local spending, and support 23,500 jobs (Actman, 2012).

Furthermore, the average commercial property owner in Philadelphia spends approximately $2.84/sq. foot/year on energy costs, which is significantly higher than the average estimate of $2.21/sq. foot/year for U.S. commercial properties. As a result, Philadelphia's commercial energy expenditures are nearly 29% higher than the national average, and the fourth highest among major U.S. cities (Actman, 2012).

What is more, the study found that the top-twenty property owners in the region own just 10% of all commercial buildings, an indication of the diffuse ownership of mid-sized commercial properties in the Philadelphia area. For instance, even the two largest and most recognized commercial landlords in the area, Brandywine Realty and Liberty Property, account for only 3% of all commercial space whether measured by number of properties or total square footage (Actman, 2012).

What these findings overall, thus, suggest is that the regional market for commercial energy efficiency offers large opportunities in terms of retrofit activity. However, in order to exploit such potential, new tools would be required in order to develop education and interest in energy efficient among owners and tenants of commercial buildings. This is particularly the case since the majority of the commercial stock in the area is not owned by larger and well-resourced companies that may have the ability to invest in understanding and improving their building energy use, as well as leveraging existing incentives or programs in this field (Actman, 2012).

In addition to focusing on small and medium-sized businesses as potential receivers of energy efficiency, such entities were seen by the Hub as having a key role to play for market transformation and the development of a more integrated approach in commercial energy retrofitting in the region (GPIC, 2010).

The Hub, hence, aimed to engage in education and training, and technology development and deployment activities small and medium-size enterprises from industry sectors that produce energy efficient building components with the goal to position them as preferred suppliers to original equipment manufacturers in building energy efficiency sectors (GPIC, 2010).

In order to address technical, financial and organizational barriers, such as those described above, in a systemic way, the EEB Hub adopted an integrated approach in energy innovation with the goal to achieve industry and market transformation that will lead to 20% energy use reductions in the commercial sector by 2020 (EEB Hub, 2012a).

In meeting the 20% reduction goal, the approach of the Hub was to scale-up energy efficiency solutions by addressing diverse aspects in energy retrofitting, including cost-effectiveness, skills and technical tools, job training, market creation, knowledge spill-over, and policy effectiveness (EEB Hub, 2012a).

In this context, the aspects of 'proven technologies', 'informed people' and 'validated information' were considered as key for developing a 'whole building' approach for Advanced Energy Retrofits (AER) through existing and new technologies (EEB Hub, 2012a).

The promotion of AERs was the overarching goal of the Hub's agenda. An AER is a method that seeks to optimize energy efficiency by combining multiple systems in an integrated design approach. An integrated design is a design and implementation methodology that gathers clients, architects, builders, systems auditors and engineers, and sometimes building occupants, early in the process to act as co-collaborators in the design and construction of the site. AERs see a building as a complete unit rather than as an accumulation of separate parts and systems. For example, if a building owner plans to improve the insulation of the building envelope it may be advantageous to also install triple glazed windows (EEB Hub, 2013a). Section 7.3 presents that Hub's innovation agenda, and the type of activities that it pursued in this context.

7.3. The Hub's Innovation Agenda

7.3.1. Overview

The EEB Hub organized its innovation agenda around eight tasks split by the 'Technical' and 'Market and Commercialization Engagement' categories aiming to develop an integrated approach in the demonstration, deployment and market adoption of commercial energy efficiency technology and practices (EEB Hub 2012a, DVIRC, 2012). The Hub's leading partner and overall goals for each of these tasks are summarized in Table 15:

Table 15: Leading partners and overall goals of the EEB Hub Tasks

Task	**Leading partner**	**Overall goals**
Technical		
Modeling and Simulation Task	Penn State University	Suite of simulation tools for predicting energy use in buildings. Supporting early design, investment and critical decisions in building energy retrofitting, maintenance and renovation
Building Energy Informatics Task	Penn State University	Demonstration of integrated technologies and building solutions that reduce building energy use through energy information modeling and management
Intelligent Building Operations Task	Purdue University	Integrate and demonstrate scalable and low-cost technologies to optimize building operations
Building Energy Systems Task	Bayer MaterialScience	Demonstration of integrated technologies and building solutions that reduce building energy use through energy systems integration
Market and Commercialization Engagement		
Markets and	United Technologies	Examining features of the advanced

Behavior	Corporation	energy retrofit marketplace (i.e. standards, tax policies, utility regulation) and occupant behavior that can influence adoption of energy saving solutions in commercial buildings
Education and Training	Penn State University	Identify skill gaps and developing and piloting new programs and credentials needed to support the advanced energy retrofit sector
Catalyzing the Advanced Energy Retrofit Sector	Wharton Small Business Development Center - University of Pennsylvania	Catalyzing the advanced energy retrofit market in the Greater Philadelphia area in a manner replicable in other regions of the country (financial analysis, technical assistance, business positioning)
Stakeholder Engagement	Penn State University	Connect regional, national, and international audiences to the key research activities of the EEB Hub (understand market needs, guidance, networking, information sharing and knowledge dissemination)

Source: (EEB Hub, 2013a)

In addition, three energy-related D.O.E. research and education centers, located in the Navy Yard and managed by Penn State University, acted as a source of expertise and collaboration for the Hub. One of them is the Mid-Atlantic Clean Energy Applications Center which promotes clean energy technology by the industry and government. The Center promotes the adoption of CHP, district heating and waste to power energy technologies and applications through three activities: market opportunity analysis for CHP in diverse sectors such as industrial, federal, institutional, and commercial; education and outreach by providing information on the energy and non-energy benefits and applications of CHP to diverse audiences ranging from state and local policy makers to regulators, energy end-users, and trade associations; and technical assistance to end-users and stakeholders to help them consider the adoption of CHP, waste heat to power, and/or district energy in their facilities and to help them throughout the project development process (D.O.E. EERE, 2014).

The second is the Northern Mid-Atlantic Solar Education and Resource Center which offers education and workforce development in Pennsylvania, Delaware, New Jersey and West Virginia. The Center's mission is to provide education and training programs on solar technology, and to develop partnerships that link research, commercialization, and workforce development in relation to solar technology (Penn State, 2014).

The Center focuses on three areas of work, that is technology transfer, systems research to advance the performance of solar energy systems, and education provision to architecture, engineering, and construction professionals. The Center belongs to a national consortium of solar energy training centers formed by the Solar Market

Transformation program of the D.O.E. The goal of this consortium is to create a national Solar Instructor Training Network and a national curriculum for solar photovoltaic, heating and cooling technologies (Penn State, 2014).

The third is the GridSTAR Smart Grid Training Center which promotes education and training in smart grid integrated clean power production in the Mid-Atlantic region (GPIC 2010). The Center was formed through a three-year period award of $5 million by D.O.E. to Penn State University plus $5 million of match-funding by Penn State University (GridSTAR Center, 2014a).

The objective of the Center is to foster regional partnerships where diverse stakeholders such as utilities, grid operators, manufacturers, policy makers, & builders collaborate to acquire learning and leverage expertise to design and build a more efficient, cost effective, and resilient low carbon electric grid (GridSTAR Center, 2014b).

The Center aims to serve as an education and research resource for smart grid technologies, policy and business practices. Towards this end, the Center offers education and research programs in Philadelphia, University Park campus of Penn State University, and Pittsburgh, in addition to several online educational formats. Target audiences for these programs include persons who seek entry-level training, college and graduate students, advanced researchers, practicing engineers, and the general public (GridSTAR Center, 2014a).

The Hub collaborated with various entities in Philadelphia for its activities, including the city government. For example, it interacted with MOS and the City's Law Department on the development and adoption of the City's Energy Benchmarking Ordinance, while it assisted with its implementation, for instance by analyzing energy consumption data through the ENERGY STAR Portfolio Manager software to determine the energy efficiency rating of sites (EEB Hub, 2013b).

In 2013, the Hub commissioned the Institute for Market Transformation (Hub partner) to produce a report that offers guidelines to utilities on the establishment of data access procedures for building benchmarking programs. This material will inform the work that the City currently undertakes with PECO on the development of systematic data access procedures for building owners that need to comply with the Ordinance[131] (EEB Hub, 2013a).

Sections 7.2.2 and 7.2.3 review key activities undertaken by the Hub along the 'Technical' and 'Market and Commercialization Engagement' Hub task categories.

7.3.2. EEB Hub Technical Activities

The EEB Hub performed various technical activities in the areas of building energy efficiency innovation through the use of new and existing technologies, methodologies and tools. A key objective of this work was to develop successful demonstrations of integrated building design methods that would lead to large reductions in energy use while improving the asset value of sites (EEB Hub, 2012b).

The Hub undertook building demonstration projects to test and showcase technical innovation on energy efficiency. A flagship one is 'Building 661' which involved the renovation of a 38,000-square-foot site located at the Navy Yard to host the Center for Building Energy Science and Engineering (CBESE), and the

[131]For example, data availability in a form that is easy for use in EPA's Portfolio Manager tool is considered important for the effective implementation of the Ordinance. Part of this would likely involve supplying building owners with utility data on aggregated building energy use. Utilities would typically send out building energy use information for single customers upon request; however, a building may include more than one utility customer (EEB Hub, 2013b).

construction of a 25,200-square-foot facility to host the Center for Building Energy Education and Innovation (CBEEI) (EEB Hub, 2012b).

CBEEI will include research laboratories and technology demonstration spaces, as well as offices and state-of-the-art teaching facilities. Both buildings are part of the Hub's facilities and will be LEED-certified. The project, which was initiated in 2011 with the support of the $30 million fund allocated by the Commonwealth Pennsylvania, is expected to complete by Fall 2014 (Azobuild, 2014).

The CBESE project offered opportunities for collaboration across task areas of the Hub (EEB Hub, 2012b). For example, the Hub Integrated Modeling and Design Task team produced a report that identified strategies of design process management to advanced energy retrofit projects, including CBESE. The report was shared with the 'Building 661' project development team that implemented several of these recommendations (EEB Hub, 2012b).

In addition, the Hub Integrated Technologies and Systems Task team collected and evaluated a state-of-the-art technology portfolio that could be adopted in the CBESE site. In addition, the Hub Policy, Markets, and Behavior Task team tracked the project to assess how such activities can influence the AER industry (EEB Hub, 2012b).

In 2012, the Hub was awarded a grant by the National Institute of Standards and Technology (NIST) to support training of building operators in the commercial sector to assist them operate their facilities more energy efficiently. Through this grant, the Hub established the Center for Building Operations Excellence to provide information, training and education to building operators about proven energy-saving strategies and technologies towards commercial buildings energy consumption reductions (EEB Hub, 2012c).

The pilot program consisted part of the Hub's Building Construction Technology Extension Program that was focused on the 're-tuning' method for energy efficiency, a process which helps existing buildings to quickly and affordably identify and pursue energy efficiency. In this method, data is collected from the site's automation system that are used to identify opportunities to improve the operation of the building, while guidance is also provided on how to implement identified low or no cost measures that reduce overall energy consumption (EEB Hub, 2012c).

The pilot program, which will continue under CBEI, has four objectives: to develop a High Performance Building Operator Competency Map that defines operation, auditing and energy management skills in operating high performance buildings; to develop a curriculum on energy efficient operation of commercial buildings; to conduct professional development of instructors that will assist with the implementation of the curriculum; to undertake re-tuning projects to demonstrate and evaluate the produced energy curriculum and competency map (EEB Hub, 2012c; CBEI, 2014b).

The Hub was also active in the development of tools that facilitate access to energy modeling techniques and communication between stakeholders that could promote improvements in the energy performance of buildings through their operation. Towards this goal, the Hub created a Simulation Platform to circumvent much of a need for a technical background when undertaking basic building energy simulations so that a relative layperson can begin to be involved with issues of building energy design, while also simplifying more complicated simulations in order to reduce input and processing time by professionals (EEB Hub, 2014b). This work is continued by CBEI (CBEI, 2014b).

The Simulation Platform offers a menu of web simulation tools which process models on a remote server given a set of user inputs. Depending on the audience of the application, simulation tools of differing detail have been developed ranging from 'basic' (targeting building owners) to 'partial' (targeting building designers), 'substantial' (targeting building auditors) or 'comprehensive' (targeting building analysts) (EEB Hub, 2014b).

Advances to specific building energy techniques or systems have been worked on by the Hub. For example, significant amount of energy is consumed by the HVAC system in commercial buildings. Hence, the optimization of such systems through control techniques holds promise for reducing their energy consumption. The Hub developed a theoretical model on control optimization of HVAC systems by using 'Building 14' of the Navy Yard as a site for modeling analysis (EEB Hub, 2012d).

Furthermore, Carnegie Mellon University's Center for Building Performance and Diagnostics (CBPD), a Hub member, undertook work on different lighting retrofit options by applying a 'triple bottom line' methodology which links economic, environmental, and human health and productivity costs to improved lighting quality. Practices tested include occupancy/vacancy sensors for closed spaces, maximization of daylight use through sensors for dimming perimeter lights, or more comprehensive interventions that integrate low-energy light fixtures with lighting automation on daylight harvesting, dimming and control (EEB Hub, 2013c).

Furthermore, 'Building 669' of the Navy Yard has been used as a test-site for demonstrating the benefits of more efficient window systems in building energy load reduction. In addition to energy savings, installation of high-performance glass reduces HVAC capital and operation costs for the site contributing to finance savings for potential developers (EEB Hub, 2013d).

The Hub undertook also research on 'energy flow' mapping and measurement, a type of analysis that can assist with energy management at multiple scales (from the building to the city and regional level). This work involves the development of techniques to better understand patterns of energy use in buildings. A relevant method, originally developed by the Lawrence Livermore National Laboratory (LLNL), is the so-called Sankey diagrams that visualize energy flows and help identifying opportunities to deploy energy saving technologies (Singer et al., 2013).

Using 2010-2011 data for over hundred metered buildings, a Navy Yard campus-level Sankey diagram was generated by LLNL that quantifies natural gas and electricity usage by main building activity. In addition, the lab has generated Sankey diagrams for ten building use types of sites that are part of the Navy Yard's Master Energy Plan forecasting their annual energy use changes over the period 2011-2022 (Singer et al., 2013).

An unregulated site for smart grid research and application

As part of the Navy Yard's Master Redevelopment Plan formed in 2004, the site hosts an un-regulated electric distribution grid that accommodates a micro-grid system. This regulatory provision and technical infrastructure offered a unique opportunity for the testing of innovative policy provisions in relation to technology development activities undertaken by the Hub (GridSTAR Center, 2014).

A relevant project involved the research, deployment, development and application of smart grid systems[132] by using the Navy Yard's micro-grid system as a technical basis. This project is led by the GridSTAR Smart Grid Experience Center and involves the development of a highly monitored sub-grid energy system through a combination of 'plug and play' test opportunities, development of prototypes, and evaluation of ancillary services offered to PJM's grid system (GridSTAR Center, 2014).

The GridSTAR Center will be used as a test-bed in this effort by being turned into an ultra-energy efficient and instrumented site which will be connected to a micro-grid test loop that is located in the Navy Yard where modular components of the building will be easily installed and removed by using 'plug and plan' adaptations. These technical adaptations will be connected to the PJM electricity market and operate in response to real-time price signals to evaluate the technical and economic performance of the ancillary services offered to the grid (GridSTAR Center, 2014).

The idea is that the smart-grid systems and techniques developed and successful in this initial project will be widely installed across the Navy Yard, as part of its Master Development Plan, through an integrated energy resource management

[132]'Smart grid' as defined by D.O.E. is a fully automated power delivery network that monitors and controls all energy users and nodes, ensuring a two-way flow of electricity and information between power plants and energy consumption devices, and all points in between them. This 'distributed intelligence' is coupled with broadband communications and automated control systems to enable real-time market transactions and seamless interfaces among people, buildings, industrial plants, generation facilities, and the electric network to take place (Portland Sustainability Institute, 2012).

technical approach[133]. In this way, it is envisaged that the Yard will act as a showcase of how to successfully deploy such type of technologies within a mixed-use urban development setting (Dobbs & Riley, 2013).

Adopting such an integrated approach would involve the development and implementation of a comprehensive technical plan[134] that combines diverse aspects including demand-side energy management, distributed energy resource management and deployment of smart-grid technologies[135]. In addition, a business model will be developed that incorporates aspects such as energy tariffs, or procurement and system revenues, in order to document the value of ancillary energy services and revenues gained through the experiment (Dobbs & Riley, 2013).

On May 7, 2012, PIDC and Viridity Energy launched the Navy Yard's Network Operations Center (NOC). This is an on-site energy research, education and training platform and was one of the first steps that the Hub took towards the establishment of electric distribution control and monitoring network in the existing smart-grid infrastructure (EEB Hub, 2012e).

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[133]Developing such an approach in the Yard is facilitated by the existence of different tenant load profiles (i.e. existing industrial, offices research and development sites; future residential/hotels sites) (Dobbs and Riley 2013).

[134]Two key aspects of the technical plan involve testing how to achieve high penetration of renewable energy through load adjustment, and energy storage (Dobbs & Riley, 2013).

[135]For example, zero-energy sites that incorporate building energy management systems and smart meters, electric vehicle charging stations with associated storage battery and vehicle-to-grid capability, grid-scale energy storage, smart distribution infrastructure such as power quality meters and remote switching and communication, sub-microgrids for managing critical circuits (Dobbs & Riley, 2013).

The NOC project plan which has been developed by Viridity Energy, a smart-grid technology company with headquarters in Philadelphia, aims to create a research, education and training platform based on load management technology and energy demand response markets operated by PJM. The platform is expected to improve both software tools and pricing mechanisms in relation to grid-based load management, and to contribute to overall energy efficiency improvements in the site[136]. NOC will also work to support integrated models of energy management planned to be developed in the Navy Yard that include distributed energy components such as solar electric vehicle charging stations and grid-scale electricity storage[137] (EEB Hub, 2012e).

7.3.3. EEB Hub Policy and Market Engagement Activities

EEB Hub's input in energy policy initiatives in the Philadelphia area

The Hub provided technical advice during for the drafting of the City's Energy Benchmarking Ordinance and supported the bill proposal with a testimony before the city government's Committee on the Environment (Actman, 2012).

In the testimony, part of Hub's input argued that understanding building energy use is a critical step for engaging building owners in energy efficiency and

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[136] In highlighting a broad model for enhancing smart-grid development in the center-city area of Philadelphia, Viridity Energy points out four aspects: a computerized information network to connect buildings with smart-grid and energy services; aggregation of large energy users to support system reliability improvements through demand reduction; public-private partnership mechanisms to harness resources and stakeholder relationships for scaling-up projects; coordination of pilot projects and technology applications to maximize impacts (Zibelman, 2013).

[137]These two aspects are part of the Navy Yard's Master Energy Plan (Dobbs & Riley, 2013).

retrofit strategies in the sense that if owners disclose the energy performance of the site that they sell or rent, this information could contribute to more appropriate pricing of space based on their energy costs and more informed market decisions by tenants. In this regard, benchmarking and disclosure of building energy use could accelerate the adoption of energy retrofits by generating interest and demand among owners and tenants in more energy efficient space[138] (Actman, 2012).

Following-up on its advisory role for the drafting of the Ordinance, the Hub was involved with education activities about the importance of energy benchmarking, and necessary steps that stakeholders need to take to comply with the ordinance. For instance, the Hub convened in May 2013, in partnership with the Institute for Market Transformation and the National Resource Defense Council, a meeting on the topic of Urban Energy and Benchmarking where representatives from three U.S. cities with benchmarking legislation (Seattle, Washington, D.C., and Boston) were brought together with governmental officials from over twenty other cities of the country that were considering the adoption of this type of measure (EEB Hub, 2013e).

In addition, starting in July 2013, the Hub offered to the local business and building community five monthly sessions on strategies and resources that could improve energy performance of commercial buildings. This series complemented a two-day seminar that took place in September 2013, in partnership with EPA and the Philadelphia Building Managers and Owners Association, that offered training to

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[138]According to a study conducted by Eco on behalf of the Hub, energy efficiency improvements envisaged to be undertaken as a result of the Ordinance would amount to energy retrofitting of approximately 5.3 million sq. ft. of office space for a total cost of $1.9 million and would create 157 direct jobs. The ripple effects of the investments would generate an additional $1.6 million in activity, adding-up the economic value to the Philadelphia economy to over $3.5 million (Actman, 2012).

building operators on how to reduce energy use in their sites through ongoing refinements (Actman, 2012).

The Hub offered also in partnership with the City of Philadelphia regular educational sessions for building owners and service providers about compliance with the benchmarking ordinance and the use of the ENERGY STAR Portfolio Manager tool for energy use assessment and reporting (EEB Hub, 2013f).

In addition, in collaboration with PUC, the Hub convened a Regional Data Management Working Group to offer guidance to utilities on the provision of automated access to whole-building energy consumption data to building operators in relation to compliance with the ordinance, while maintaining confidentiality on customer data. The Working Group held a series of meetings in 2012 and 2013 to explore the benefits and challenges of implementing data accessibility programs. These included local utilities, utility regulators, building owners and experts from the real estate, academic, and energy efficiency fields (EEB Hub, 2013g).

The Hub also partnered with Honest Buildings and the City of Philadelphia to create an interactive network where building owners, contractors and tenants would showcase their sites online by making profiles that feature photographs, building descriptions and energy use. Individual retrofit projects can be highlighted for each building, giving to potential tenants more information about the building's energy characteristics (EEB Hub, 2013h).

As noted, CBEI, the new structure that has succeeded the Hub, focuses on the demonstration and deployment of technical and market solutions for commercial energy efficiency retrofitting in the Philadelphia region, aiming to also instigate spill-over effects at the national level. CBEI will continue part of the Hub’s policy and market agenda but with a narrower focus than its predecessor.

An intermediate space for stakeholder engagement to drive market adoption of commercial energy efficiency

A key aspect of the Hub’s approach in transforming the regional market involved the identification of stakeholder needs on energy efficiency, the development of technical and financial tools and guidance to address such needs, and the fostering of networking relationships between actors to facilitate information exchange and foster opportunities for joint action. To address such aspects, the Stakeholder Engagement Platform (SEP) Task was established to serve as a communication mechanism between the Hub and the regional energy efficiency market. The Platforms, hence, formed a dialogue forum that was created to bring together the Hub and regional stakeholders for the exchange of information, ideas and expertise (J. Jenkins, personal communication, April 25, 2013).

In this context, the main goal of the SEPs was to elicit feedback from a diverse body of stakeholders on the Hub’s technical solutions and market initiatives for commercial energy efficiency in order to better understand their needs in this area, and how the Hub’s tools and products could better meet them. Each Platform was led by a designated Hub leader and co-chaired by individuals from companies and organizations active on energy efficiency in the region (EEB Hub, 2013a).

The next section discusses challenges and opportunities for the wider adoption of energy retrofits in the commercial sector of the Philadelphia area identified in meetings of the Stakeholder Engagement Platforms.

The Hub's Stakeholder Engagement Platforms for commercial energy efficiency development in Philadelphia

The Hub's SEP Task started-off in May 2012 and initially included four Platforms: Building Owners, Operators, and Occupants; Architects, Engineers, and Construction Managers; Retrofit Suppliers; and Retrofit Workforce Educators and Trainers. In June 2013, the Platforms of Banking, Finance and Real Estate, and Utilities and Policy Stakeholders were added (EEB Hub, 2013a).

Although the formal plan called for quarterly Platform meetings, this was the case for certain Platforms (Retrofit Suppliers; Building Owners, Operators, and Occupants; Banking, Finance and Real Estate) while others used to meet less frequently (i.e. Architects, Engineers, and Construction Managers; Retrofit Workforce Educators and Trainers; Utilities and Policy Stakeholders) (EEB Hub, 2013e).

In each meeting, the audience was giving feedback on the Hub tools and resources for AERs. In this regard, it was acting as a reviewer on the Hub's work, but also as a receiver of the Hub's research and policy work (J. Jenkins, personal communication, April 25, 2013).

In addition, the Retrofit Workforce Educators and Trainers Platform brought in the discussions community technical colleges and stakeholders who were interested in updating their curriculum with energy education topics. The work of this Platform involved diverse aspects including development of training certificates and career mapping in the AER marketplace (i.e. the Hub launched a training and certification program for building operators in partnership with D.O.E); alignment of the Hub's approach with D.O.E policies on energy efficiency credentials (i.e. standardization of workforce certifications for the AER market has been completed in cooperation with

D.O.E.); fostering integrated design competencies for industry professionals; and exploring the role of schools as leverage points for developing a building energy efficiency vocational base at the regional level (EEB Hub, 2013i).

MOS and PECO were members of the Hub's Utilities and Policy Stakeholders Platform whose meetings included mostly the work of the Regional Data Management Working Group on technical data requirements and guidelines for the implementation of the Benchmarking Ordinance (EEB Hub, 2013a).

The SEP meetings involved several entities and individuals that were either formal Hub partners or external actors[139]. The meetings had twenty to thirty people attending to allow for focused interaction. The discussions were centered on how workable the Hub's tools to market practitioners were, and how they could be modified to better serve their needs. This material was, then, worked-out by Hub investigators to create better resources for the energy efficiency retrofit market (L. Billhymer, personal communication, April 25, 2013).

A particular point that the meetings revealed is the importance of having a collaborative and integrated approach in AER as a way of tackling barriers that small and medium-size businesses face in market integration such as the existence of a relatively young AER market with few contracts and a lack of verifiable results and standardized knowledge. These conditions bring market uncertainty and financing and contracting complexities, especially for small commercial projects with lower profit margins and longer payback periods, that create difficulties for designers, contractors,

[139]For example, the New York City Energy Efficiency Corporation, a quasi-public independent financing entity that develops and distributes financial products for energy efficiency development, took part in the Finance and Real Estate meeting that was held on December 2013 (EEB Hub, 2013j).

owners and tenants who seek to share risks and rewards of AER projects in order to get involved in such activities. Further problems involve fluctuating energy prices and a piecemeal policy approach in crafting financial incentives for energy efficiency development, both of which factors work against market demand for energy efficiency (EEB Hub, 2013j).

The benefits, hence, associated with an integrated AER approach are diverse and extend across the energy efficiency value chain. For example, from the view of providers, collaboration and integrated design enables access to an otherwise closed market in difficult economic times. From the view of expanding a valuable component of economic development and creating a source of energy efficiency innovation, integrated design enables small, flexible, asset-light business collaborations to become incubators of innovation, while it also facilitates their integration into AER market structures. In addition, from the view of building owners, a collaborative and integrated approach would likely develop a higher quality product and lead to larger energy savings (EEB Hub, 2013k).

Promoting an integrated AER approach, thus, requires that various stakeholders take into consideration energy consumption goals in their work. Here, the early involvement of the building design and construction professionals with energy efficiency appears critical as well as ensuring that all other project participants (i.e. engineers, financers, building owners or occupants) understand the energy goals and operation of the site. In this way, the participants are offered a structured way and a set of targets for the retrofit and operation of the building according to energy efficiency criteria and practices (L. Billhymer, personal communication, April 25, 2013).

Developing an integrated design approach between stakeholders will require, however, the adoption of new ways of doing things, and this can be challenging. As the Navy Yard's project manager stated with reference to the BERSE showcase project ('Building 661'), the adoption of an integrated approach involves a 'big cultural shift' for clients in terms of bringing in contractors early on at the design stage (Philly.com, 2013d).

The SEP meetings allowed also learning to take place regarding the needs of different segments of the AER chain. For example, a Retrofits Suppliers meeting that was held in September 2013 discussed processes and steps for realizing AERs from the perspective of building owners by assessing issues such as the benefits that retrofits can offer to this group, why building owners are or are not pro-actively adopting energy retrofits, or why in cases where owners need to replace at least one component of the site an integrated solution that includes AER is not typically followed (EEB Hub, 2013l).

In addition, this meeting identified six action items for further consideration by the SEPs: the need for suppliers (i.e. contractors, installers) to understand the market characteristics of private building owners (i.e. number of buildings owned, size of buildings, and ownership structure); the need to educate building owners and operators about proven methods for AERs; the need to make available to owners and operators a list of possible sources of financial support for AERs (utility rebate programs; government grants and tax incentives); the importance of educating the local financial community on the benefits of AERs as a value enhancement for buildings, and the need to develop lending packages for such investments that are easy and quick to use; the need to inform suppliers on credibility issues related to

AERs, and educate them on how to better talk the language of owners; the need to develop a list of existing buildings that have successfully completed partial or substantial AERs for owner to owner sharing. These six points were viewed as important for the creation of market-pull demand for AERs from the perspective of the building owners (EEB Hub, 2013l).

These points were used as an input material in the Retrofit Supplier meeting that was held in December 2013 where building owners also participated to offer their perspective on the areas for improvement that were suggested by suppliers and how their recommendations can become more compelling and focused. DVIRC, that led the meeting, aimed to develop out of the discussion guidelines that would facilitate the effective engagement of both suppliers and owners in AERs[140] (EEB Hub, 2013m).

The SEP discussions pointed out also the significance of developing stable finance streams for AER projects. This requires the active involvement of entities and individuals that could lend finance and manage transactions for such type of projects (i.e. lease or negotiation) in order to explore strategic ways of unlocking and securing capital resources. In addition, the meetings revealed the importance of building owners having confidence in the financial return of the retrofit investment. In practice, this implies that building owners need to have a viable business plans for the energy retrofit project, and that the market needs to support these plans (L. Billhymer, personal communication, April 25, 2013).

[140]The record of the event does not include any information regarding what the owners' feedback on the proposals was.

These SEP findings on the financial aspects of AERs were anticipated by discussions at a workshop organized in January 2013 by the EEB Hub and the Penn Institute for Urban Research that hosted a group of financial experts to review current trends and future opportunities for AERs in the commercial real estate sector. The participants identified key aspects on commercial energy retrofit financing such as the need to have tailored responses that take into account the particular profiles of the site (i.e. service provision, tenant, owner etc.), and the need to develop appropriate lending tools for interventions in small-scale commercial sites[141] (i.e. 'loan bundling') and financial risk assessment metrics that capture the benefits of energy efficiency investments (i.e. net present value cash flows versus simple payback period) (EEB Hub, 2013n).

This kind of analysis is envisaged to enhance the perception of the local financial community on the financial value of energy efficiency investments and make a firm case that AERs can constitute tangible quantities for private capital investments. The Hub has argued that once the financial potential of energy efficiency becomes more visible, then the financial community will likely be more interested in

[141]For example, participants suggested that while financing AERs for industrial and larger commercial spaces is common, the banking industry remains hesitant of making loans available for smaller buildings. This is because lending for such projects is currently based on a company's existing credit, leaving outside any potential profitability due to the AERs. Hence, loan allocation tends to favor larger industrial or commercial entities with existing corporate credit. In particular, there is a lack of standardized methods for verifying the potential energy savings of an AER project, and for measuring the effect that energy savings would have on debt service and repayment. For such reasons, providing energy efficiency loans for small and diverse properties requires credit overlay or support from a municipality, energy utility or some other entity with a vested interest in the AER project. In this regard, energy efficiency financing measures for smaller buildings will need to be included under the umbrella of a larger organization with the necessary access to credit, at least until a sufficient record of performance for smaller loans becomes available (EEB Hub, 2013n).

pursuing such type of investments (J. Jenkins, personal communication, April 25, 2013).

Using these initial discussions and findings as a basis, the Hub launched in June 2013 its first Finance and Real Estate Platform meeting which discussed barriers for retrofit uptake and assessed ways to accelerate investments in AER projects through different public, private or civil-led financial models, such as Property Assessed Clean Energy finance, Energy Service Companies arrangements, public-private partnerships, and non-profit financing organizations that work with investors and businesses (EEB Hub, 2013j).

The participants of the meeting identified potential barriers for AERs in the Philadelphia area and categorized them according to whether or not the Hub could directly influence them. Overall, participants suggested that the Hub should put attention on aspects like fostering stakeholder engagement, reducing the complexity of the AER process by outlining clear decision making procedures, reducing the uncertainty around the financial benefits of AERs, and addressing information and knowledge gaps across stakeholders (EEB Hub, 2013j).

In contrast, the participants recommended that the Hub should not put much effort on issues like securing transaction and up-front costs for AERs in small commercial buildings, transitioning the industry away from first costs to life-cycle cost assessments, or clarifying the short-term benefits of AER projects (EEB Hub, 2013j).

The second meeting of the Finance and Real Estate Platform took place in December 2013 and it focused on the effect of energy benchmarking legislation in the AER market and the role of existing financial tools in promoting AERs. An overall point offered in the meeting was that funding availability for energy efficiency is practically at the same levels over the last years. However, more financial options for AERs are currently developing and becoming available in the market (EEB Hub, 2013o).

Furthermore, in the face of governmental programs that do not reveal full effectiveness on energy efficiency (i.e. a federal program known by its tax line 179(d) which offers tax-rebate based incentives has not been fully absorbed yet), there is an increasing rationale for local action and locally available resources that could reach building owners more easily[142]. Participants, finally, underscored the potential of ESCO models to drive AERs in the commercial sector (EEB Hub, 2013o).

In addition to discussions on appropriate finance mechanisms for AERs, the Hub produced guidelines to assist potential lenders in the evaluation of energy retrofit projects. The guidance consists of a list of requirements that lenders can refer to when deciding to underwrite or not AER investments. The Hub has suggested that energy data reported to comply with the benchmarking ordinance can assist the financial

[142]A similar point was noted in the study's discussion with ECA SES which suggested that a key challenge for commercial energy efficiency development in Philadelphia is the lack of effective financial instruments to unlock private capital for energy efficiency retrofits, rather than necessarily lack of finance to realize such project. One of the key obstacles that ECA SES team faces in its work on commercial energy efficiency is to convince institutional investors to fund the team's business proposals. The team suggests that energy efficiency upgrades in local small and medium commercial entities can produce a 10% Return on Investment over a five to ten year period. In addition, the team says that an effective approach to unlock this market potential would be to apply ESCO models to aggregate energy efficiency demand for a pool of minimum twenty to thirty entities. ECA SES plans to put together a fund of $10 million for commercial energy efficiency development through institutional investors and high-networked individuals (A. Kleeman, personal communication, April, 20, 2013).

entities to better evaluate the financial performance of commercial energy efficiency proposals (Actman, 2012).

The Hub, finally, has argued that the issues of project finance and integrated approach in building energy retrofits are interlinked. Hence, it created, as part of the Architects, Engineers, and Construction Managers (AEC) Platform work, a roadmap that offers guidance on steps that could be taken towards an integrated approach for energy retrofits, and information about financial aspects and benefits of such an approach (L. Billhymer, personal communication, April 25, 2013).

7.4. Scaling-Up Commercial Energy Efficiency Development in Philadelphia and Beyond

As noted, the work of the EEB Hub involved the development of replicable and scalable energy efficiency interventions for the commercial building sector that would contribute to energy and economic outcomes at the regional level in terms of energy use reductions, energy-related business development, and jobs creation. In addition, the Hub had the objective to catalyze energy market transformation and technology adoption at the national level (GPIC, 2010; EEB Hub, 2012a)

This raises the point of assessing the extent to which the Hub managed to achieve its goals. In doing so, the study undertakes a mixed-type assessment. First, it evaluates the extent to which the Hub made progress on key performance metrics.

Second, it assesses the extent to which the Hub has acted as a space that promoted interactions and arrangements for the adoption of AER technology and practices at the regional to national level.

Metric-based evaluation of the EEB Hub initiative

The EEB Hub's strategic plan and programmatic objectives included the achievement of specific targets within a five-year timeframe, from 2012 to 2017. Some of these were expressed in specific metrics, while others formed wider policy objectives rather than explicit deliverables.

The study evaluates the EEB Hub based on performance goals that are considered as central in relation to the mission and objectives of the initiative. The performance goals, and their relevant metrics wherever available, are summarized in Table 16[143]:

Table 16: Performance goals related to the mission and objectives of the EEB Hub

Performance goal	**Metric**
1. Energy use reduction in the commercial sector of the Greater Philadelphia Area	Reduce by 20% by 2020
2. Philadelphia's commercial energy expenditures per square foot	Contribute to reductions as this cost is currently over 29% above national average
3. Volume of investments of energy efficiency retrofits in the regional commercial small and medium-size market (20,000 to 100,000 sq.ft)	Investments could spur $618 million in local spending

[143]The main source used to select the performance goals is the proposal document for the establishment of the EEB Hub submitted to the U.S. Department of Commerce, U.S. Department of Energy and U.S. Small Business Administration which includes proposed areas of work, evaluation metrics etc. (GRIP, 2010).

4. Energy efficiency related job creation in the small to medium size commercial market of the region	Potential for 23,500 direct jobs through AERs in the region
5. Launch new business ventures in the advanced energy retrofit marketplace	No specific goal
6. Develop new business models to unlock the investment value of AERs	No specific goal
7. Degree or professional programs developed to promote AERs	No specific goal
8. Joint research, development, demonstration and deployment (RDD&D) projects developed to promote AERs	No specific goal
9. Identify and overcome market barriers in implementing energy efficiency in existing commercial buildings	Implement market-based solutions in twenty regions of the country through national partnerships
10. Accelerate adoption of energy efficient retrofit solutions at local and national scales	Ten states/regions to implement a structured set of technology and market-based solutions developed by the Hub in collaboration with key stakeholders (e.g., D.O.E., NGOs)

Source: (GPIC, 2010; EEB Hub, 2012a; 2013a)

The study found no systematic reports on any of the above performance goals. Various Hub sources were accessed to find relevant information ranging from ‘reports’ and ‘event presentations’ to ‘success stories’, ‘background information’ and ‘newsletter archives’.

Given the importance of these performance goals for the accomplishment of key Hub objectives, it can be assumed that had any of them been achieved they would have likely been officially reported.

It should be noted, however, that, in general, tracing the direct impact of Hub activities on performance goals appears to be a challenging task given the several actors, policies and processes relevant to them. This point raises the issue of the extent to which the Hub managed to act as a contextual site for achieving the impact that it aspired to, at the regional and national level. This is discussed below through a more contextual assessment of the initiative.

Assessing the EEB Hub impact towards the adoption of technical, policy and market innovation for Advanced Energy Retrofits at the regional level

Living laboratories, like the EEB Hub, have been presented as a type of experiment that hold potential seeds of transformation and innovation for sustainable development. This point is underpinned by two assumptions: first, that they form real-life experiments with the potential to produce useful knowledge; and second, that they constitute highly visible interventions with the ability to foster rapid social and technical change. Central to the transformative nature of the living laboratories concept lays the idea of creation of contextual knowledge and its subsequent packaging and dissemination to other localities (Evans & Carvonen, 2011).

In the case of the EEB Hub, such an aspiration was expressed in its ambitiousness to drive large-scale transformation of energy efficiency at the regional level, with potential repercussions at the national level. As described previously, the

Hub adopted a multi-faceted approach on technical and market innovation which brought together several public and private entities.

Regarding the development, deployment and transfer of knowledge and innovation, the Hub followed a four-stage approach as shown in Figure 14:

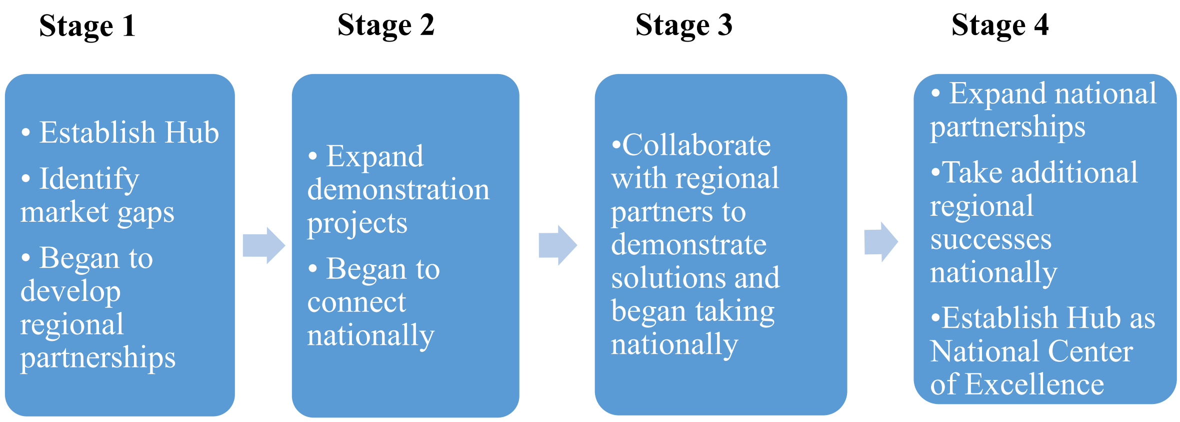

Figure 14: The stages of the innovation process of the EEB Hub

Source: (EEB Hub, 2013a)

In order, hence, to evaluate the impacts of the Hub on wider policy and market transformation, the study discusses key activities, initiatives and outcomes in relation to the Hub's framework of innovation. In that way, an overall idea can be gained regarding the distance that the Hub has travelled in relation to its innovation framework.

As described previously, most of the Hub activities involved the testing, demonstration and development of technical tools, systems and components for energy efficiency interventions that address the needs of a diverse audience. In addition, barriers that limit the integration of small businesses into AERs were identified, policy responses discussed (i.e. financial mechanisms to unlock capital resources for AERs), and guidance produced and disseminated to stakeholders (i.e.

integrated design roadmap for AERs). The Hub was also involved in local energy policymaking and implementation, while workshops and events have drawn on the expertise of actors from outside the region.

Overall, thus, the Hub has acted as a medium that mobilized and promoted resources, expertise and collaborations towards the wider adoption of technical solutions, business models, financial mechanisms and user practices for AERs. In this regard, it appears that the Hub managed to foster technical, market and policy interactions such as those mapped in its organizational context (Figure 12, p.270) by addressing stages 1 & 2 of the innovation pathway (Figure 14, p.306).

But what is the Hub's impact on AERs at the regional and national level? First, as noted there is no data available to monitor the Hub's progress over key performance metrics, with most likely that there is a significant gap between targets and actual achievements. For instance, *Greenworks Philadelphia* data suggest that citywide building energy consumption has increased in Philadelphia since 2009. Although this refers to all types of buildings in the city, it may be reasonable to assume that this applies to commercial buildings.

Second, while obstacles, and solutions, for the greater adoption of AERs have been discussed through the Hub, there was not much progress on the actual adoption of policies or mechanisms to address such barriers (i.e. financial tools to facilitate funding of AERs in small businesses).

Third, the level of market transformation that would be required to mainstream AERs in the region appears large. For example, the Hub suggested that SEP meetings were important to provide effective information, guidance and tools for AERs, and to contribute to having a more accurate profile of the regional energy retrofit market.

The SEP meetings focused on small to medium commercial buildings, between 20,000 to 250,000 sq. feet, as many of these lack organizational resources and expertise to adopt energy efficiency, and were hosting between twenty to thirty individuals each time (L. Billhymer, personal communication, April 25, 2013).

At the regional level, however, the number of such stakeholders is placed in the order of thousands. For example, PECO suggests that the various types of contractors or trade allies that could have an active role on energy efficiency development in the Philadelphia area are estimated in the order of 2,000[144] (F. Jiruska, personal communication, June 06, 2013).

Furthermore, the links between the role of the Hub and certain key factors relevant to AERs at the regional level was limited. For instance, in the starting SEP meeting that took place in May 2012, participants were asked to identify from a list of incentives those that would likely be effective to encourage investments in AERs. In the ranking exercise, 'higher energy prices' received the highest score, but this factor was also identified as being out of the direct influence of the Hub (EEB Hub, 2012f).

Regarding the issue of knowledge transfer, the main ways that the Hub used to share lessons were through D.O.E. (for the national level) and interactions with partners such as the Institute of Market Transformation, the New Buildings Institute, the Natural Resources Council, the Environmental Defense Fund, and the Natural

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[144]Regarding the region's level of green-related businesses, based on a 2010 Philadelphia Workforce Investment Board Study which uses the definition of a green job included in the Green Jobs Act 2007, it is estimated that Southwestern Pennsylvania has over 88,000 workers engaged in fields such as energy efficiency design, construction and retrofitting; renewable and sustainable energy; green property and facility management; energy auditing; and deconstruction and material use recycling (GPIC, 2010).

Resources Defense Council. These were considered by the Hub as innovative organizations that could contribute resources in alignment with Hub activities (EEB Hub, 2013e).

In addition, the Ben Franklin Technology Partners of Southwestern Pennsylvania entity, a Hub member with the remit to promote the diffusion of Hub innovation, was in charge of the operation of the EEB Hub Commercialization Center established to support start-up and existing businesses that focus on energy efficiency improvements in new and existing commercial buildings[145] (Ben Franklin Technology Partners, 2014).

The Hub also hosted workshops and participated in events and conferences nationally and internationally in themes related to its work (i.e. Urban Energy and Benchmarking convention held in May 2013) (EEB Hub, 2013e).

As mentioned in the beginning of the Chapter, the effectiveness of the Hub to accomplish its programmatic responsibilities as a designated national center for energy innovation became a highly politicized issue. In July 2013, the U.S. Senate Appropriations Committee claimed in its Energy and Water Development Appropriations Bill for FY 2013-14 that the Hub has not manage to achieve any measurable goals over the whole course of its operation, and for this reason its original five-year plan should be cut short (U.S. Senate Appropriations Committee, 2013):

The Committee recommends no funding for the Energy Efficient

[145]For example, the Center offers relevant virtual programs and services through the Ben Franklin Navigation program to create links at the regional, national and international level for businesses interested in exploring opportunities on energy efficiency or collaborate with the Hub (Ben Franklin Technology Partners, 2014).

> Buildings Hub and directs the (D.O.E.) Department to terminate the Hub.

According to the U.S. Senate Appropriations Committee, after $80,000,000 in appropriations and spending $55,000,000 since 2011, it has seen no measurable benefits from this investment. As such, the Committee proposed that the $25 million appropriation fund for 2013-14 is not allocated, and the Hub terminate its operation (U.S. Senate Appropriations Committee, 2013).

The report charged that unlike the other four National Energy Innovation Hubs[146] set-up by the federal government since 2010 to drive the discovery and commercialization of transformational energy technologies which have clear goals and timeframes, the EEB Hub never managed to establish key deliverables throughout its operation. It continues by saying that the Hub was more focused on achieving impacts in the Philadelphia area rather than developing a national program to improve building energy efficiency across the country (U.S. Senate Appropriations Committee, 2013).

It also suggests that most of the Hub activities were already being addressed by core D.O.E. Office of Energy Efficiency and Renewable Energy programs. In addition, it argues that an independent review that was conducted in 2013 found that

[146] These are the Fuels from Sunlight Hub, the Batteries and Energy Storage Hub, the Nuclear Modeling and Simulation Energy Innovation Hub, and the Critical Materials Hub which undertake research on various themes ranging from production of fuels directly from the sunlight, to improvements in the battery technology for transportation and the grid, modeling and simulation to increase the efficiency of nuclear reactors, and the development of solutions for rare earth other materials that are important to a growing number of clean energy technologies (D.O.E., 2014b).

the Hub was poorly managed[147], and that it lacked measurable goals. Furthermore, despite efforts taken by D.O.E. to improve the management practice of the Hub and establish key deliverables, the Committee saw no progress on these issues (U.S. Senate Appropriations Committee, 2013).

The Committee also argued that D.O.E. did not exercise effective oversight and control on the operation of the Hub, partly because of a Hub organizational structure that involved a large number of federal agencies and non-governmental partners[148](U.S. Senate Appropriations Committee, 2013).

In July 2013, the Hub responded to the criticism of the federal Appropriations Committee by sending out the 'Energy Efficient Buildings Hub Activities and Accomplishments Brief' describing the technical and management performance of the Hub, and highlighting selected accomplishments achieved since its establishment. These included aspects such as improving data access services for building tenants from energy utilities; demonstration of energy retrofit projects; technical advice to the City of Philadelphia on the Energy Benchmarking Ordinance; and a roadmap of

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[147]On this point, the University of Pennsylvania (Hub Member) lead investigator for the University's faculty and staff members that participate in the Hub, and the Executive Director of the Delaware Valley Green Building Council (Hub Partner), expressed the view that the originally appointed Hub Director and Executive Director from Penn State University (the leading Hub Member) could not exert full attention to the tasks of the Hub due to their existing commitments in place. This, in combination with their lack of proximity to Philadelphia, resulted in more attention given to the management of bureaucratic details rather than developing a leadership vision for the Hub (Axisphilly, 2013).

[148] As reported in the local news, Philadelphia political leaders remained unalarmed about the potential Hub's rebuke, despite the Committee's recommendations, expecting a gridlocked Congress to be unable to pass a budget for the 2013-14 year and the Hub to receive funding under continuing resolutions (Philly.com, 2013e).

working credentials in the energy efficiency building sector (Axphilly, 2013; EEB Hub, 2013p).

The brief supported that the EEB Hub was preparing each year a scope of work and budget report that included annual deliverables and quarterly milestones for each project approved by D.O.E., and that since the establishment of the Hub all quarterly milestones and annual deliverables were completed on time and within budget. In addition, the brief noted that four internal annual reviews on the Hub's performance and two external D.O.E. annual reviews took place that did not raise any major points regarding the performance (Axphilly, 2013; EEB Hub, 2013p).

According to the Hub, these reviews for year 2012-13 identified no major management deficiencies, while the Hub management team incorporated many of their suggestions. Furthermore, the Hub suggested that improved communication and feedback between D.O.E. and the leadership of the Hub was effective to advance its management operation (Axphilly, 2013; EEB Hub, 2013p).

Political leadership at the state level was also involved in the debate over the effectiveness of the Hub. When the Appropriations Committee report went public, U.S. Senator Bob Casey (D, PA), and U.S. House Representatives Chaka Fattah (D, PA) and Allyson Schwartz (D, PA) took the position that the Committee's recommendation is flawed and that the Hub should continue its operation (Axphilly, 2013).

The evaluation process of the EEB Hub, finally, led to a new organizational structure and agenda, under the new name Consortium for Building Energy Innovation, which is more focused on demonstrating and promoting technical and market solution for AERs rather than promoting regional clustering innovation, and a funding cut down from 25 million per year to 10 million per year (CBEI, 2014a; c). In April 2014, shortly after the transition, the former CBEI Deputy Director stated that the main reason for the change that took place was a lack of alignment between the EEB Hub leadership, D.O.E. and the Congress (Technically Philly, 2014).

As a result of the transition, the CBEI is comprised of fewer partners than its predecessor. Instead of the previous two blocks of 'core' and 'partner' Hub groups that were adding up to over seventy stakeholders, CBEI includes fourteen partner organizations, all of which were core members of the EEB Hub[149], while Penn State has remained the leading partner. The shift from the EEB Hub to the CBEI involved a number of key changes, other than the composition of partners, which are summarized in Table 17:

Table 17: Key changes in the EEB Hub's transition to CBEI

Key aspects	**EEB Hub**	**CBEI**
Scope	Regional clustering innovation	Consortium to demonstrate and diffuse technical and market solutions
Overall goal	20% energy use reduction in the building sector of the Greater Philadelphia region by 2020	50% energy use reduction in the building sector nationwide by 2050

[149] The core members of the EEB Hub partnership that are not included in CBEI are IBM Corporation, Princeton University, Lawrence Livermore National Laboratory, PPG Industries, Turner Construction, University of Pittsburgh, Wharton Small Business Development Center, and the Collegiate Consortium for Workforce and Economic Development (CBEI, 2014d).

Federal funding	25 million/year	10 million/year
Partner organizations	Over 100 partners	14 partners
Role of D.O.E.	Little oversight and control exercise	Close interaction between CBEI and D.O.E. Building Technologies Office; CBEI work builds on D.O.E. innovation work
Operational agenda	Eight technical and market engagement tasks	Re-organization to new tasks with altered focus to reflect the new scope

Source: (GPIC, 2010; CBEI , 2014a; c; EEB Hub, 2013a; Technically Philly, 2014)

On the other hand, CBEI has kept the innovation framework of the EEB Hub (Figure 12, p.260) to address the technical and market components of its agenda (CBEI, 2014d). The operational tasks of the CBEI are summarized in Table 18:

Table 18: The operational tasks of the CBEI

Task	**Scope**
Integrated Technologies	Optimization and demonstration of approaches that move the market to 50% energy reductions through combined packages of technologies
Building Operations	Development of low-cost solutions to improve building operations with little or no additional investment in equipment

Retrofit Tools	Development of guidance and tools for small and medium-sized business owners and retrofit providers that demonstrate the business case for an energy efficiency retrofit, and ways to plan and execute them. The work will be based on real world demonstration projects.
Market Development Strategies	Engagement of stakeholders through project demonstrations to compile case studies, best practices and tools that support energy retrofit implementation at the city and regional level.
Capacity Improvements	Design business models and use of information that address the varying drivers of market actors and better align them at the local level.
Building Benchmarking and Data Access	Use of best practices and tools learned from prior and ongoing projects in the Mid-Atlantic region related to energy benchmarking and data access, as well as other D.O.E. regional efforts, and package them for national implementation.

Project Management	Oversight and coordination of programs and activities.

Source: (CBEI, 2014 c: d)

The objectives of CBEI for its first year of operation involve the development and demonstration of packages of integrated technological solutions for AERs, particularly low-cost building operations solutions (sensors, controls, and diagnostics); the development of tools and strategies for AERs tailored to the needs of small and medium-sized businesses; the demonstration of AER strategies at the regional level in collaboration with relevant stakeholders (i.e. regulators, the financial sector, energy program administrators, manufacturers, engineering firms, building owners and operators); and the packaging of regional successes for application at the national level (CBEI, 2014c).

What can then be concluded about the effectiveness of the EEB Hub to fulfill its transformative role in energy efficiency development?

On the one hand, the discussion suggests that the Hub managed to act as a site where various entities across the AERs value chain shared ideas, information and knowledge for the development of technical and policy tools towards the wider adoption of energy efficiency, as well as to foster networking opportunities for joint action in this area. In this regard, the Hub performed a critical function in the regional energy retrofit market by forming a venue where dispersed agencies communicated and coordinated (Hodson & Marvin, 2011).

The Hub, hence, revealed the potential to act, at least in certain aspects, as an intermediary space positioned between technological possibilities and local contexts to drive processes of energy change at the urban level (Evans & Karvonen, 2011).

On the other hand, the discussion suggests that there is little evidence that the Hub managed to develop, or set in motion, wider interactions and impacts for AERs at the regional and national level. In addition, the exact strategies or mechanisms that would guide this transformative role of the Hub were not defined explicitly or in detail. In this respect, the Hub seems to confirm the typical approach adopted by living laboratories on knowledge packaging and transfer where while they express a desire to influence the wider world, the specific strategy or ways of achieving this is rarely outlined in detail. Rather, it is assumed that their innovative practices will somehow find the way to infiltrate and become the norm (Evans & Karvonen, 2011). The new form of the partnership which aims, too, to catalyze wide changes in the commercial energy efficiency market at the regional and national level does not define, as well, how this goal will be achieved.

7.5. Conclusion

This chapter assessed the role of the former Energy Efficiency Buildings Hub in catalyzing technical innovation and market deployment of energy efficiency in the commercial sector by using the Philadelphia region as a test-bed. While lack of data and detailed assessments regarding undertaken activities and achieved outcomes create challenges for a comprehensive evaluation of the Hub's performance, the discussion suggests that wider energy, economic and market impacts and practices, through Hub activities, were not fostered at the regional level, or diffused at a higher scale, i.e. the national level, as envisaged. Nevertheless, the discussion revealed that the Hub managed to act as a space were diverse local and regional actors came together and discussed policies that could address technical and financial barriers on commercial energy efficiency, as well offered an 'insider' view on how to improve tools and products that could better suit the needs of the market.

In the end, the federal administration's evaluation of the Hub's performance led to the downscaling of its agenda and resources on the basis that measurable outcomes were not achieved over its operation. This example, hence, indicates the likely political nature of innovation activities aiming to transform the urban energy system, and the need for applying in their evaluation specific frameworks that incorporate both indicator and contextual-based factors in order to assess more comprehensively the effectiveness of such type of activities.

Chapter 8

THE FINDINGS OF THE STUDY

8.1. The Focus of the Study

Urban sustainable energy development is largely a context-specific phenomenon. The capacity and ability of cities to develop and implement energy sustainability is influenced by factors such as the wider energy-related politico-economic environment within which they are situated, the characteristics of their physical environment and energy infrastructure, and the nature of relevant policy and social dynamics. As such, different urban areas face different challenges and opportunities with respect to sustainable energy development.

Within this context for urban energy, the presence of particular political, economic and cultural conditions may create favorable circumstances for local energy sustainability action, i.e. level of resources, local political leadership, control over energy-related planning decisions and an environmentally-aware citizenry have been documented as drivers of action in urban energy sustainability (Newman et al., 2011; Coutard & Rutherford, 2011).

At the same time, there is an increasing body of large metropolitan cities worldwide whose focus and capacities concerning sustainability are increasingly significant, particularly with respect to the energy-related dimensions of the high energy consumption of the urban built environment. In order, then, to better understand more generally the ways in which major cities in large metropolitan regions develop energy sustainability-related policies and how these efforts might be enhanced, research needs to look at cities beyond the usually mentioned ''sustainable-oriented leaders'' like Seattle, San Francisco, London, New York, Freiburg, Germany, or Copenhagen, Denmark.

In contributing to this discourse, this study examined how sustainable energy is developed in the city of Philadelphia which adopts important energy sustainability initiatives but it's been only recently that its role as a leading example on sustainable energy development is discussed at the national and international level.

In this context, the aim of the study was twofold. The first was to gain insight on how energy sustainability is developed in Philadelphia. This was elaborated by assessing key factors that influence the city's capacity and ability for sustainable energy, and the type of actor interactions that are central for energy development in the city. The second was to identify policy directions that can enhance the city's current efforts on sustainable energy development. Given the broader body of major metropolitan cities pursuing energy sustainability, the basic issues, problems and future policy directions identified in Philadelphia's case can contribute to the broader discourse of urban sustainable energy development.

As a way of addressing the above issues, the study examined the overall governance environment for energy sustainability in Philadelphia, and four key local energy sustainability initiatives pursued in this environment. Within this evaluation framework, the findings of the study are structured on three aspects. The first is the city's overall policies and performance in energy sustainability to get a broad idea about the extent to which the city formally and informally moves towards sustainable energy-based systems of service provision. The second is the particular aspects that shape the city's overall performance to gain insight on the type of factors that influence the city's ability to make progress on its energy sustainability targets. The third involves what kind of policy directions can further promote energy sustainability in Philadelphia.

8.2. The Overall Policy Context for Energy Sustainability in Philadelphia

Philadelphia is a major U.S. city with a large population and central location within a three-state (Pennsylvania, New Jersey, and Delaware) and 11-county metropolitan region. The city is a diverse urban area that blends manufacturing industries, service-based economic activities and neighborhood economic development. The city has a county status and a strong mayoral type of government. The main energy sources consumed in the city is natural gas supplied by Philadelphia Gas Works (PGW), the city-owned gas utility, and electricity whose supply is monopolized by a large regional private utility, Philadelphia Electric Company (PECO). In addition, a number of energy policies and legislation at the state and federal level structure a multi-level policy environment within which Philadelphia pursues its energy sustainability activities.

The city of Philadelphia has not been a major urban leader in sustainable energy development in the U.S or internationally, unlike like Seattle, San Francisco, New York, and London, as noted above. Until the middle to late 2000s, the city of Philadelphia was undertaking energy sustainability initiatives sparsely and in an ad-hoc manner. However, in the context of the 2008 mayoral race, advocacy group demand led by the local civic coalition Next Great City successfully advocated for the incorporation of the issue of sustainability in the candidate's political agenda. This created incentives for the adoption of a more structured municipal policy approach on sustainability, including the area of energy. As a response to this advocacy demand, and motivated by the socio-economic and environmental benefits that sustainability activities can bring into the city, the newly elected mayor of Philadelphia formally developed an ambitious municipal sustainability plan, *Greenworks Philadelphia*. The plan was modeled after a ten-point sustainability agenda suggested by Next Great City and a special city government unit, the Mayor's Office of Sustainability, was established to manage it and coordinate action by a diverse set of market and non-market actors.

Greenworks Philadelphia adopted ambitious energy sustainability targets both for the formal governmental structure and overall citywide level. As a way to foster progress on these energy sustainability targets, the plan proposes a range of policy measures across urban sectors (i.e. municipal, residential, and commercial) and calls for the development of policy collaborations between public, private and civic stakeholders.

As a result of the policy approach on energy sustainability formally adopted in the context of the city's sustainability plan, Philadelphia is undertaking more systematic sustainable energy initiatives both at the municipal government and citywide level since 2009. Despite the range of these initiatives, the city has not been recognized as a major urban energy sustainability leader in the U.S. or internationally, unlike a number of ''sustainable-oriented'' city leaders such as those mentioned above.

In addition, the city's policy efforts on sustainable energy development have received little attention in the literature. Hence, this study is using Philadelphia as a case of study on energy sustainability aiming to gain understanding on how the city develops its energy sustainability initiatives, what factors have influenced the performance of these initiatives, and how prospects for further action can be fostered.

In the overall context for sustainable development in Philadelphia, a key concept that has been adopted by the city government political leadership is that Philadelphia becomes the greenest city in the U.S by 2015. In this respect, *Greenworks Philadelphia* is portrayed by the city government as the vehicle that will enable Philadelphia to reach this goal and to foster socio-economic benefits for local residents and businesses, including reduced energy costs, sustainable economic development, business competitiveness, and social equity. The energy sustainability targets of the plan are part of this broader sustainable vision for the city. These energy targets involve ambitious goals one of which relates to policy issues that the city government has relative control upon (i.e. municipal government energy management and policy) and others (three) which significantly relate to decisions and action by the private and civic sector.

As noted above, the city government has adopted the sustainability policy goal of Philadelphia becoming the greenest U.S. city by 2015, which is the final year of *Greenworks Philadelphia*. Meeting this goal is, among others, dependent on progress in meeting the energy sustainability targets of the plan. *Greenworks Philadelphia* contains four energy sustainability targets. Its first energy target (Target 1) calls for a 30% reduction in municipal energy use by 2015. This involves the energy that is consumed in municipal sites and fuel consumption in the municipal vehicle fleet. Its second energy target (Target 2) refers to the overall city level and calls for a 10% reduction in citywide building energy use by 2015. The third energy target (Target 3) refers to the energy retrofitting of 15% of the citywide housing stock with insulation air sealing and cool roofs by 2015. The fourth energy target (Target 4) calls for the procurement and generation of 20% of citywide electricity use through renewable energy sources. Local solar electricity generation is considered as one measure for making progress on this target.

How well then Philadelphia progress on meeting its *Greenworks Philadelphia* energy sustainability targets? Section 8.3 summarizes the city's performance in the four energy sustainability targets of the plan and what can be expected in terms of the city's progress in energy sustainability in the future given of the record of achievements that Philadelphia has accomplished so far in the context of *Greenworks Philadelphia* plan.

8.3. Philadelphia's Performance in Meeting the Greenworks Philadelphia Energy Sustainability Targets

Based on the data that are reported in the annual progress reports of *Greenworks Philadelphia*, the city is lagging significantly behind meeting its municipal and citywide energy efficiency targets (Targets 1-3). This is despite the fact that energy efficiency is the area in which most of the city's energy sustainability initiatives take place. With respect to Target 1, although a trend of municipal energy use reductions is observed over the period 2008-2013, the municipal government energy use in 2014 reached 2% above the *Greenworks Philadelphia* energy consumption baseline. This outcome was largely the result of higher energy demand driven by weather conditions.

With respect to the citywide level, building energy consumption in 2014 (Target 2) reached 12% above the baseline. Additionally, although a range of affordable energy initiatives are taken in the city, the number of housing energy retrofits that has been developed in the city since 2008 (baseline year of the *Greenworks Philadelphia* target) through government, utility and non-profit programs has reached 11,669 as of 2014. These retrofits which are the bulk of the total retrofits developed in the city (there is also small private activity in this area) account for only 14% of the total number of retrofits required to meet the *Greenworks Philadelphia* target.

Regarding the renewable electricity use target (Target 4), substantial progress has been made so far and 14.8% of total electricity use in the city is renewable energy-based, with the *Greenworks Philadelphia* target set at 20% for 2015. However, there is minimum contribution by local renewable electricity generation, including solar in this outcome.

In addition to the four energy sustainability targets of *Greenworks Philadelphia*, the achievement of sustainability outcomes in the Greater Philadelphia Region through the city-supported agenda of the Energy Efficient Buildings Hub[150] in terms of retrofits, energy use reduction, green jobs, and knowledge spill-over proved challenging. In the context of U.S. Congressional questioning over the ability of the Energy Efficient Buildings Hub to produce measurable impacts, the partnership transitioned to a new organizational structure whose impact remains to be seen given the short time-period of its operation until present (April-December 2014).

[150] For example, the Energy Efficient Buildings Hub was hosted in the Philadelphia Navy Yard site which is owned by the Philadelphia Industrial Development Corporation, while policy interactions on energy were developed between the city government of Philadelphia and local actors, and the Energy Efficient Buildings Hub.

Overall, hence, five years after the introduction of *Greenworks Philadelphia*, the patters of energy supply and demand for the city Philadelphia remain fossil fuel-based. In addition, given the city's ambitious energy sustainability targets and its low actual performance in meeting them, questions arise whether the adopted targets reflect the city's actual capacity for sustainable energy development.

As evident above, the progress that the city has achieved so far in meeting its energy efficiency targets can at best be associated with reductions in the growth of energy use at the municipal and citywide level, through the adopted energy efficiency interventions, rather than with reductions in absolute energy use as the targets call for. Hence, based on the city's performance so far, it can be expected that in the near future Philadelphia will face challenges in making substantial progress over the *Greenworks Philadelphia* energy efficiency targets, or any new targets extended after 2015 that will involve energy use reductions.

In addition, based on accomplishments up to date, challenges are also expected in terms of scaling-up residential energy retrofit activity in the city. Furthermore, while the prospects seem better for making further progress on the renewable electricity use target, it seems challenging that this can be based mostly on new local renewable electricity systems rather than procurement of electricity that is produced outside the city boundaries.

Additionally, given the difficulties that the Energy Efficient Buildings Hub encountered in transforming the regional commercial energy efficiency market, and the narrower agenda and resources of the Consortium for Building Energy Innovation (CBEI), the partnership that has succeeded the Energy Efficient Buildings Hub, it is expected that progress over the next years in the market adoption of commercial energy efficiency in the Greater Philadelphia Regional through the CBEI agenda will be challenging.

Despite the low progress in meeting the energy efficiency targets of *Greenworks Philadelphia*, and the fact that the city's large share of renewable-based electricity use does not reflect a move towards locally-based renewable electricity generation systems, the city government of Philadelphia has been involved with, or facilitating, a range of initiatives for energy efficiency and solar electricity development that are directly, or indirectly, related to the plan's four energy sustainability targets. Four key such initiatives are the Mayor's Office of Sustainability (MOS) energy policy role and Philadelphia Solar City Partnership (SCP) both led by the city government of Philadelphia, and residential affordable energy development in local neighborhoods, and the Energy Efficient Buildings Hub (EEB Hub) agenda in commercial energy efficiency development both which largely involve the private and civic sector.

In the context of *Greenworks Philadelphia*, the Mayor's Office of Sustainability has taken various activities to address technical, market and policy aspects in relation to energy efficiency development at the municipal and overall city level. Key such activities include a utility database system on municipal energy use that traces consumption at the facility level; municipal relevant planning and legislative provisions (City of Philadelphia Benchmarking Ordinance, zoning system); market incentives through the multi-county *EnergyWorks* energy efficiency program developed in partnership between the City of Philadelphia and the surrounding Southeast Pennsylvania counties of Chester, Delaware County, Montgomery through federal stimulus funding from the American Reinvestment and Recovery Act 2009;

policy coordination between stakeholders in the context of *Greenworks Philadelphia*; and monitoring of performance over the plan's energy sustainability targets.

These activities have resulted into increased awareness for the issue of energy efficiency within the city government of Philadelphia, project development in municipal facilities, and supportive policy infrastructure to enable local energy efficiency action by the private and civic sector.

Similarly, policy activities have been taken by the city government in the context of the Philadelphia Solar City Partnership aiming to make Philadelphia a friendlier site for solar power development. These activities involve guidelines and information provision to the private sector (households and businesses) on solar power, development of technical capacity (i.e. solar mapping of the city's built environment), and municipal planning provisions to facilitate the installation of renewable energy systems in the city's built environment.

With respect to residential energy affordability, local actors (city government, energy utilities, civic sector) offer technical support, financial assistance and educational services to local neighborhoods that aim to facilitate the adoption of energy efficiency systems and to foster energy savings through behavioral changes. In regards to the Energy Efficient Buildings Hub, a range of research, market and policy issues were worked out through its working agenda. This included the development and demonstration of tools, data and integrated technical interventions for advanced energy retrofitting in building sites; analysis of market barriers that constrain adoption of energy retrofitting by the commercial sector in the Greater Philadelphia region; gaining understanding of what type of products can meet the needs of market stakeholders on energy efficiency; and technical support to local stakeholders, i.e. the city government and PECO on the Energy Benchmarking and Disclosure Ordinance implementation and energy data requirements.

What is then the impact of these four energy sustainability initiatives, and *Greenworks Philadelphia* plan, regarding the overall possibilities of Philadelphia on sustainable energy development? Although, as noted above, the city has made little progress in meeting the *Greenworks Philadelphia* energy sustainability targets, the activities that have been taken so far in the context of the MOS, SCP, residential energy affordability, and EEB Hub initiatives suggest that there is a general city government direction towards energy sustainability. This is particularly the case with building energy efficiency where most of Philadelphia's policy efforts concentrate, whereas systemic policy and market barriers are found to considerably limit the city's prospects with respect to local solar power development.

Additionally, the four energy sustainability initiatives have developed a policy and market basis that can facilitate the adoption of further policy and market action for local sustainable energy development. For example, the new initiatives of City Energy Project and municipal solar power resolution build on the City's Benchmarking and Disclosure Ordinance and SCP respectively. Furthermore, a number of private and civic-led initiatives such as PECO's energy efficiency programs, Energy Coordinating Agency's portfolio, Philadelphia Housing Agency's energy programs, and private initiatives on solar electricity (i.e. The Energy Co-op) more or less closely relate to the four energy initiatives examined in this study, as well as the *Greenworks Philadelphia* energy targets.

Overall, hence, the policy field for sustainable energy development in Philadelphia is multi-level, dynamic, and in flux. As Table 19 suggests, the study identifies a wide-range of market and non-market actors across policy scales to influence the city's ability and achievements on energy sustainability:

Table 19: Key actors for sustainable energy development in Philadelphia, split by government, private and civic sector

Government Sector	Private Sector	Civic Sector
City Government -City government departments -City government agencies and commissions -Municipal gas utility **State Government** -Public Utility Commission -Department of Environmental Protection's Office of Technology Innovation and Energy Assistance -Department of Community and Economic Development -Department of Welfare **Federal Government** -Department of Energy -Department of Housing and Urban Development	-Energy utilities -Energy companies -Energy consultants -Land developers -Building industry professionals -Small and medium sized businesses -Housing associations -Financial institutions -Academic institutions	-Non-profit community development corporations -Quasi-public agencies -Policy advocacy organizations -Charities -Foundations -Non-profit membership-owned energy supply entities

Based, then, on the evaluation of the four energy sustainability initiatives undertaken in this study, Philadelphia's current performance on energy sustainability within this multi-actor policy system, as well as its future possibilities on energy sustainability, appear closely related to three ''policy aspects'' in broad terms: the contextual policy and political circumstances relevant to sustainable energy development in Philadelphia; the multi-actor characteristics of the energy governance system for Philadelphia; and the role of the state and federal government in relation to the city's possibilities on energy sustainability. These aspects are further elaborated in

Section 8.4 which looks into more detail at the factors identified in this study influencing the development and implementation of the Mayor's Office of Sustainability, Solar City Partnership, residential energy affordability and Energy Efficient Building Hub initiatives.

8.4. Key Factors Influencing the Development of Energy Sustainability in Philadelphia

8.4.1. The Mayor's Office of Sustainability

Municipal government energy efficiency development

The Mayor's Office of Sustainability leads the municipal energy efficiency portfolio of the city government of Philadelphia. This involves several types of activities that address relevant technical, economic, and organizational aspects. Progress in municipal government energy efficiency development is also seen by the city government as a necessary element of its policy role on promoting energy sustainability at the overall city level through ''leading by example''.

The study's evaluation of the MOS initiative identified the following key factors influencing municipal government energy efficiency development in Philadelphia:

- Development of supportive policy and technical infrastructure
- Project implementation
- Resource availability
- Training and skills
- Bureaucratic structures and practices

To begin with, the developed municipal energy database system is an important tool for tracking municipal energy use, identifying opportunities for energy efficiency upgrades in municipal sites, and monitoring the energy and financial performance of energy efficiency interventions. With over 600 sites in its municipal portfolio, MOS spent almost two years to develop a robust database system that monitors energy consumption at the facility level.

In addition, good quality energy use data are instrumental in terms of putting forward a more valid preposition for new energy efficiency projects by enabling the calculation of financial metrics like the payback period of investments. Furthermore, MOS argues that a proven record of success in managing smaller municipal energy efficiency projects needs to be build-up before proposals for larger interventions are put forward to the administration.

Initiatives for the greater incorporation of energy efficiency considerations within the management and operation of city-owned sites are also taken. For example, municipal legislation requires LEED certification for all new city-owned buildings over 10,000 square feet. Furthermore, MOS provides energy conservation education to municipal staff and pilot projects that have been developed recently assess the impact of remote control systems in the energy performance of municipal sites. Additionally, the feasibility of deploying an inter-departmental energy efficiency incentives program has been tested through a pilot program. Also, Philadelphia Energy Authority's Work Plan 2014-15 aims to create a dialogue forum between city agencies on energy issues such as energy procurement and strategic energy planning, as well as to document municipal energy activities that will serve as a reference basis for future municipal energy action (PEA, 2014b).

Despite such initiatives, various factors including resource availability, competing priorities, framework policy conditions and established organizational practices were found to constrain the city government's ability to make progress over the *Greenworks Philadelphia* target of 30% reduction in municipal energy use by 2015.

For example, MOS suggests that scaling-up energy efficiency at the municipal government level will require the availability of large financial resources. In this respect, a mechanism that couples bond financing and an Energy Service Company project development model can be an effective way to address the necessary up-front costs and technical expertise for energy efficiency interventions across the municipal government site portfolio. However, what it could be achieved out of this mechanism is dependent on aspects such as competing bureaucratic priorities or the level of debt that the city government can absorb. This means that decisions which are made by several key individuals within the city administration, i.e. the Budget Director and the Finance Director, influence the level of financial resources that may be available for municipal government energy efficiency development.

In addition, given that the size of the municipal government infrastructure consists of over 600 buildings and 22,000 employees fostering wider municipal energy efficiency requires that interventions are taken across a large portfolio of sites and that the everyday energy-related practices of a large number of individuals is taken into account. Nevertheless, this is far from straightforward as the initial findings from the interdepartmental energy incentives pilot program indicate. More specifically, establishing the technical foundation of the program proved to be a complicated process while issues of data quality appear important for its success.

With a diverse set of facilities, many of which consume energy in different patterns, comprehensive data and technical analysis for this program become challenging. In addition, the technical specifications of the program were essentially defined politically. For example, what is reasonable and fair to include in the benchmarking energy analysis of the participating sites was defined at the political and departmental level. Furthermore, the program was presented to participating departments mostly as an opportunity for gaining financial rewards and less focus was given to the potential financial penalties that departments may encounter. If such an approach is followed in the case that the program is fully deployed, this may reduce the ambitiousness of the program and the level of inclination by departments to implement it.

Additionally, managing such a program at a full-scale will likely burden the institutional resources of the city administration. Furthermore, penalties for wasteful energy behavior will have to be imposed on departments when they exceed certain energy consumption thresholds. In this regard, tying energy costs to the operations of departments could be a controversial arrangement. For example, it would be challenging to modify, or cancel, public service programs and functions based solely on energy cost considerations. The findings of the pilot program also indicate that its successful full deployment appears dependent on having in place an operational framework that pulls together the technical, financial, institutional and behavioral aspects of the program which is currently lacking.

The evaluation of the MOS initiative found also that contradictions may arise between established organizational practices and greater municipal government energy efficiency development. For example, centralized procurement of municipal energy saves costs to the city government but it conflicts with the adoption of a decentralized energy management system where departments would be held accountable on their energy costs. In addition, these achieved energy cost savings work against the financial viability of prospective municipal energy efficiency projects.

Citywide building energy efficiency development

As noted, the Mayor's Office of Sustainability is coordinating through *Greenworks Philadelphia* policy and market activities for citywide building energy efficiency development in Philadelphia. The study's evaluation of this policy field found that three key factors influence Philadelphia's ability in buildings energy efficiency across the city. These are the role of the city government in developing an enabling context for action by the private sector, the need for stable financial resources, and the role of a range of market and non-market actors across the energy efficiency value chain.

More specifically, the city government takes various initiatives to create a facilitative market context for building energy efficiency development in Philadelphia, including funding development, supportive legislative provisions, and provision of information to local residents and businesses. These initiatives target primarily the city's commercial sector with MOS aiming to understand the barriers that that local businesses face in the adoption of energy efficiency and accordingly establish an easy pathway for uptake. For example, based on findings from the *EnergyWorks* program and the City's Energy Benchmarking Ordinance, MOS suggests that many building owners of commercial sites in the city lack a clear idea of whom to contact to get information about financial assistance or project development issues regarding energy efficiency. In addition, it appears that at present there is effective political opposition for the introduction of mandates to increase energy performance of new commercial sites as such a provision will likely increase the cost of site development considerably.

Based on these initial policy activities, the city government of Philadelphia promotes more targeted initiatives for commercial energy efficiency development. For example, in Spring 2014 Philadelphia joined the nationwide City Energy Project initiative which aims to promote energy efficiency in large commercial buildings in ten U.S. cities. The initiative in Philadelphia seeks the active involvement of the private sector (i.e. real estate sector, external consultants) and aims to assess whether regulatory measures (i.e. energy efficiency performance mandates) could be considered for the commercial sector.

The city government takes also initiatives to foster wider policy discussions on the topic of building energy efficiency development. For example, Philadelphia Energy Authority's Work Plan 2014-2015 aims to develop a dialogue venue between City agencies and external actors, such as local universities and the Southeastern Pennsylvania Transportation Authority, where ideas and suggestions on energy sustainability will be shared (PEA, 2014b). In addition, PEA's Work Plan involves the production of an Energy Plan that will undertake a comprehensive review of the energy use, production and delivery within Philadelphia that will serve as reference information for future energy planning; for example, by coordinating energy initiatives undertaken separately by the city government and local entities, and by identifying opportunities for integrated development of the city's energy infrastructure (PEA, 2014b).

Furthermore, the evaluation found that stable financial resources are required to further support cost-effective energy efficiency interventions in the city's building sector. An option currently under consideration that could address this issue involves the development of private capital for commercial energy efficiency projects (i.e. Energy Coordinating Agency's Smart Energy Solutions interaction with institutional investors). In addition, overall, an Energy Service Company project development model that aggregates demand across commercial sites appears to be a promising mechanism for further promoting energy efficiency in local small and medium-sized businesses in Philadelphia. A second option to ameliorate the constraint of finance availability for building energy efficiency development in Philadelphia is the 'on-bill financing' mechanism that is currently considered for approval by the Pennsylvania Utility Commission. In this model, a monthly surcharge placed on a utility customer's bill is used to pay back the finance of an energy efficiency intervention installed in the site of the customer. The finance of the intervention is typically raised through bond financing and it is executed either through the energy utility or a third party.

Moreover, the evaluation suggests that a diverse set of actors is involved in a range of policy and market activities for building energy efficiency development in the city. To offer an indicative example, Figure 15 presents an overview of key governance functions, and who is undertaking them, in relation to the development and implementation of Pennsylvania Act 129 in Philadelphia, the state legislative provision that mandates investor-owned utilities in Pennsylvania to design and implement energy efficiency programs that will result into specific reductions in their retail electricity sales:

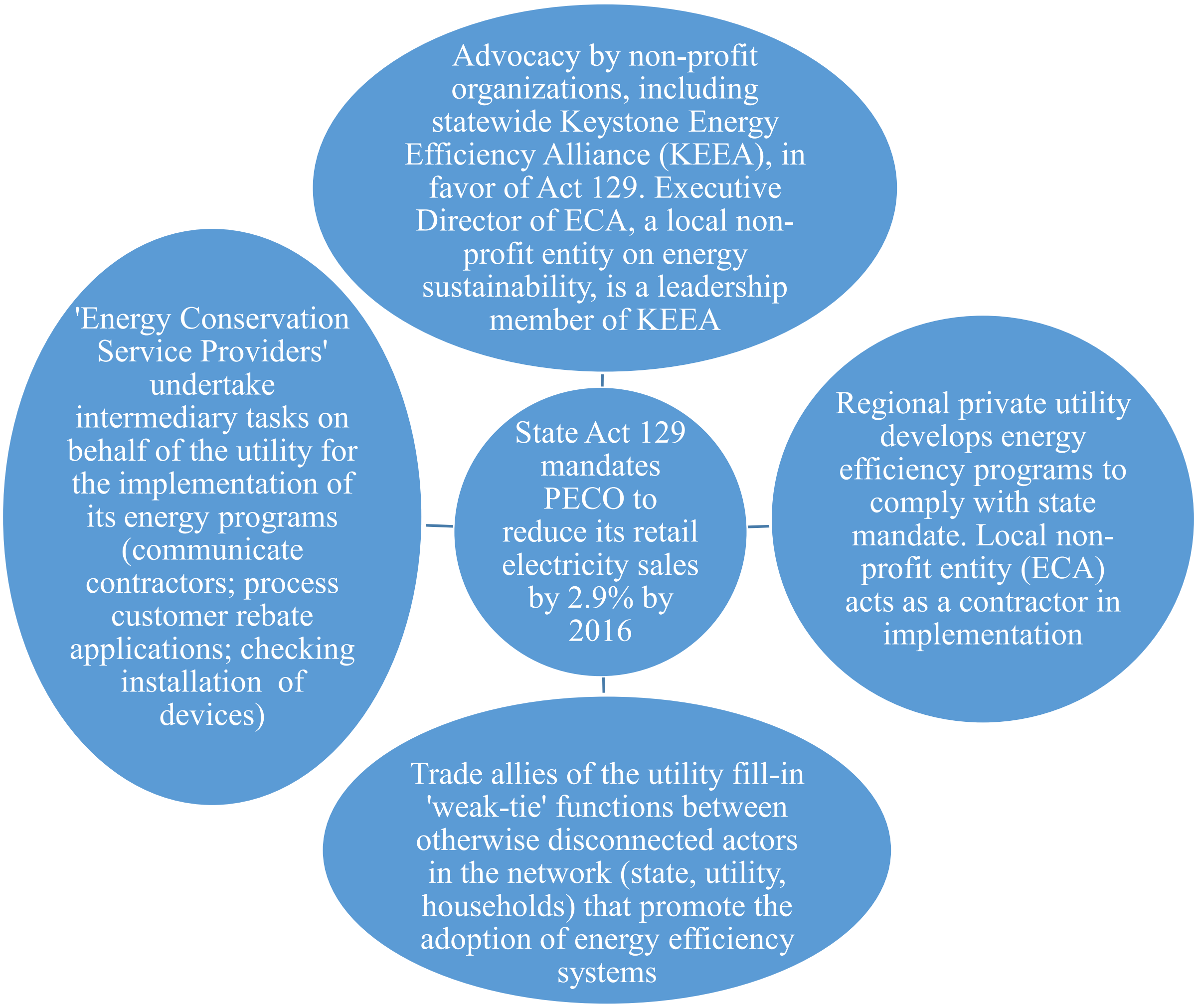

Figure 15: Key policy and networking functions in relation to the development and implementation of PECO's state Act 129 energy efficiency programs in Philadelphia

Source: (PUC, 2013; KEEA, 2012; Jiruska, 2012; PECO, 2014a)

Figure 15 points to two issues. The first is the role of governance interactions across policy scales with respect to energy efficiency development in Philadelphia, as evident by the advocacy action of a statewide entity (Keystone Energy Efficiency Alliance) whose leadership includes the Executive Director of a local non-profit energy entity (Energy Coordinating Agency) in favor of state regulation for energy efficiency.

The second is the importance of networking relationships between ‘‘intermediary entities’’ regarding building energy efficiency development in Philadelphia, and the various tasks that these entities perform including policymaking (KEEA); program design and implementation (utilities, ECA, contractors); program promotion (trade allies); and program administration and monitoring (Energy Service Conservation Providers). In particular with respect to PECO’s Act 129 energy efficiency portfolio, the utility suggests that the role of contractors is important for the successful implementation of these programs. As Figure 15 suggests, in this regard contractors fill in a ‘‘weak tie’’ function in the system by facilitating the connection of otherwise disconnected actors in the network (i.e. state, utility, households).

8.4.2. Philadelphia Solar City Partnership

The city government of Philadelphia has taken policy initiatives to support solar power development in the city. These initiatives have been supported with technical and financial assistance by the federal government in the context of Philadelphia’s designation as a Solar America City which led to the development of the Philadelphia Solar City Partnership initiative led by the city government.

The study’s evaluation of the Philadelphia Solar City Partnership revealed the importance of developing supportive policy infrastructure to facilitate solar power investments by local residents and businesses in the city. For example, in the context of SCP, the city government developed guidelines on the process of solar power development in the city, introduced reductions in the cost of permit fees for solar photovoltaic systems, made available public information on what steps do local residents and businesses need to follow if they want to install renewable energy systems, and passed municipal zoning provisions that facilitate the installation of such systems in the city's built environment.

At the municipal government level, the study found that the technical and financial viability of solar photovoltaic projects are important factors for raising the profile of this type of technology within the city administration, and make departments more open to consider the adoption of renewable energy systems.

Regarding the overall city level, the city government of Philadelphia was found to have a low interest in direct electricity generation and supply, for example by functioning as a broker that would aggregate electricity demand and delivery on behalf of local residents and businesses. This approach could then be used to promote wider solar electricity generation or use in the city. Instead, the city government of Philadelphia sees the deregulated electricity market in Pennsylvania solely as an opportunity to achieve municipal energy costs reductions. For instance, the Mayor's Office of Transportation and Utilities perceives the business of electricity generation as a complex and risky task for the city government to get involved with. Additionally, the city government sees the ownership of energy generation assets as a factor that would increase its ecological footprint, an outcome which would not be desirable. On the contrary, the city government would like to see its energy and greenhouse gas footprint shrinking over time.

Furthermore, the evaluation suggests that solar electricity has not still received large attention as a policy issue within the city government. For example, the dialogue for solar electricity that takes place within the city government is fragmented and non-systematic. In addition, it does not necessarily focus on the overall city level.

Yet, Philadelphia has a high share of renewable electricity use at the citywide level which reaches nearly 15% of the city's total annual electricity consumption. However, this outcome is primarily the result of the procurement of renewable energy credits in the market, partly for compliance with the requirements of the state's Alternative Energy Portfolio Standard, rather than due to renewable electricity generation, including solar power, within the jurisdictional boundaries of the city.

In this context, the study found that systemic market and policy barriers, including persistently low Solar Renewable Energy Credit market prices and the ''non-facilitative'' policy position of Pennsylvania Public Utility Commission and PECO on solar power to strongly limit Philadelphia's possibilities for local solar power development.

Furthermore, as noted a large portion of the Renewable Energy Credits that are procured by the city government of Philadelphia, and local actors like PECO and the private sector, partly for the requirements of the state's Alternative Energy Portfolio Standard, derive through electricity systems that are located outside the state of Pennsylvania, in some cases located at the nationwide level. Thus, at present it is not clear the extent to which Solar Renewable Electricity Credits procured by Philadelphia-based entities drive solar electricity development that is additional to business as usual.

Despite these constraining policy and market conditions for solar power development in Philadelphia, a non-legally binding municipal resolution for the development of 20,000 solar roofs in Philadelphia by 2025 was recently passed by the city government. This initiative has been driven by the civic sector and aims to foster a broad vision for solar power development in Philadelphia. The goal of the resolution translates into an installed solar photovoltaic capacity of 120MW by 2025, while at present the installed citywide capacity accounts for over 9MW.

The evaluation of the SCP initiative raises, hence, two broader points with respect to solar electricity development in Philadelphia. The first is that the relatively large share of local renewable electricity use does not reflect a move away from a fossil fuel-based local electricity system. The second is the extent to which changes in the state regulatory and market context, as well as in PECO's policy position, appear to be pre-conditions for further possibilities on solar electricity development in the context of policy initiatives such as the Solar City Partnership or the Philadelphia Municipal Resolution on solar power development.

8.4.3. Residential Affordable Energy Development

Residential energy affordability is a major social issue for the city of Philadelphia. Activities to improve the energy performance of the housing stock in low-income neighborhoods of the city, as well as to foster energy savings through behavioral changes, have been pursued for long time in Philadelphia. Key actors in these activities are civic entities and the two incumbent energy utilities, PGW and PECO. For example, ECA leads residential energy affordability in collaboration with local Neighborhood Energy Centers for over thirty years now. The agency is also active on energy policymaking, administration and advocacy, while it is an approved contractor for PECO's state Act 129 mandated energy efficiency programs and Philadelphia Gas Works *EnergySense* voluntary energy efficiency programs, both of which support residential energy affordability. Hence, the experience, expertise and network relationships of ECA, the NECs, PECO and PGW are valuable assets for residential energy affordability in Philadelphia.

Furthermore, the study suggests that lack of stable financing challenges the scaling-up of residential affordable energy development in the city. This is even more the case as part of the city's population that is not classified as 'low income' are in need for affordable energy services. Alternative financial mechanisms such as the 'on-bill financing' that is currently discussed at the state level could partly ameliorate existing restrictions on funding availability for residential affordable energy development in Philadelphia.

The study found also that information and education are key aspects for fostering longer-term energy savings in low-income households. As the discussion with Southwest Neighborhood Energy Center suggests, when residents in the neighborhood are aware of how much energy they consume, how this energy is spent, and how it can be saved, they are more likely inclined to conserve energy. Without this knowledge in place, even if people adopt energy efficiency devises in their households it is not certain that they will necessary make changes in their daily habits that are needed to save energy, or they may not be interested at first place to hear about how they can reduce their energy consumption. In addition, the provision of simple steps and guidance to local residents seems to facilitate the adoption of energy conservation devices and practices. Furthermore, it appears that there is a link in the Southwest Neighborhood between availability of energy bill assistance and households' inclination for receiving energy conservation education, where lack of bill assistance reduces motivation for education.

On the other hand, no such link between energy bill assistance and inclination for education was found in the case of the New Kensington neighborhood. Examining this issue in other neighborhoods of the city would be helpful to have a more accurate picture on the extent to which households' inclination for energy education is influenced by the availability of energy bill assistance, a policy aspect which is mostly defined at the state and federal level (i.e. in terms of level of financial resources).

Additionally, the study suggests two interrelated issues regarding the policymaking for greater affordable energy development in Philadelphia. The first is that local civic-sector entities active in residential energy affordability are not adequately represented in relevant policymaking processes and interactions. For example, there is no direct interaction between NECs and the city government, or any such plans in the context of Philadelphia Energy Authority's Work Plan 2014-15.

The second is that despite a few wider interactions that have taken, or take place, recently in the city, i.e. between *EnergyWorks* and PECO with civic organizations (Shulock 2012), it appears that there is space for a more networked approach on residential energy affordability in Philadelphia that cuts across public, private and civic entities and the local neighborhoods. For example, as evident in past policy efforts in this area, the state (i.e. PUC) and private sector (i.e. PECO) were key partners in the more proactive approach for affordable energy development that was then followed in Philadelphia. In addition, aspects like public communication and outreach, energy conservation education, provision of tailored support, and higher accountability by households on the management of their energy consumption and costs were found to be success policy factors in these past initiatives for energy affordability in the city.

8.4.4. The Energy Efficient Buildings Hub

The Energy Efficient Buildings Hub was set-up in February 2011 through federal funding as a five-year public-private partnership, led by Penn State University, to catalyze the transformation of the market for energy efficiency development in the commercial sector at the nationwide level by using the Greater Philadelphia Region as a test-bed.

The key concept to achieve this objective involved the production of replicable and scalable integrated energy efficiency solutions for existing small and medium sized businesses. Two years after the launching of the Hub, the U.S. Senate Appropriations Committee developed concerns over its effectiveness and potential to achieve desired outcomes (i.e. market transformation at the national level, or key technical milestones). In addition, the Committee expressed the critique that the EEB Hub was primarily focusing its activities on the Philadelphia region rather than the national level. Based on such objections, in July 2013 the U.S. Senate Appropriations Committee recommended that no federal funding is further allocated to the Hub, and that the latter terminates its operation. This position was successfully confronted by Pennsylvania State Representatives but the nature of the organization changed from a regional cluster to foster technical and market innovation towards a partnership that focuses on technology demonstration and development, and its funding reduced. This study focused on the activities of this initiative under the Energy Efficient Buildings Hub status.

The evaluation of the EEB Hub initiative revealed the following key points in relation to energy efficiency innovation and diffusion in the commercial sector of the Greater Philadelphia region. The first is the importance of having an integrated approach in energy retrofitting that brings on board various segments of the energy efficiency chain. In this regard, the early involvement of building design and construction professionals in project development is critical. Furthermore, building owners and operators need to understand the benefits that advanced energy retrofits bring on the energy performance of the building and the importance of an effective building energy operation to maximize energy savings.

Additionally, the analysis finds that the financial value of energy efficiency investments is not fully recognized by stakeholders in the Philadelphia area at present. Therefore, the development of strategic funding for advanced energy retrofits (AERs) requires that financial entities that can have a stake in AER financing (i.e. with respect to lending and leasing) are engaged in this task. This calls for the development of tools and data analyses to assess and reveal the financial viability and business case of AERs.

With regards to the performance of the EEB Hub to achieve wide impacts the evaluation identified a number of challenges that constrained its ability to catalyze the diffusion of AERs in the Greater Philadelphia region. These include the complexity of such a task which involves addressing technical, policy, market and behavioral aspects related to AERs; the need to involve and sustain interest by stakeholders across the energy efficiency chain; the need for these stakeholders to adopt new practices; and the ambitiousness of the Hub's adopted goal of 20% reduction in commercial energy use in the Philadelphia region by 2020.

The above discussion raises the question of the extent to which the EEB Hub was successful in meeting its objectives, and to catalyze technical and market development for AERs in the Philadelphia region and nationwide as envisaged in its programmatic goals. On this issue, the discussion revealed that assessment views regarding the EEB Hub's performance and ability to achieve energy change varied. On the one hand, the U.S. Senate Appropriations Committee questioned the ability of the Hub to achieve measurable impacts, particularly at the national level, and suggested the termination of its operation. On the other hand, the Hub leadership argued that agreed technical milestones were always achieved within schedule and budget, and that the Hub had the potential to fulfill its objectives.

It appears that these divergent views reflect different evaluation perspectives, with a more contextual assessment adopted by the leadership of the Hub, and a more indicator-type of assessment undertaken by the U.S. Senate Appropriations Committee.

While a more rigorous assessment in terms of progress achieved on key performance indicators would offer a clearer picture on the effectiveness of the Hub to meet its programmatic goals, the analysis suggests that in certain aspect the Hub managed to act as an area-based space that mediated between possibilities and local contexts to promote technological innovation and policy interactions for energy efficiency development.

At the same time, however, the discussion revealed the controversies and political dimensions in relation to the evaluation of the Hub's performance, and the debatable character of the main premise that characterizes such initiatives, namely that they can achieve the level of change that they aspire to. Thus, the development of specific evaluation frameworks of performance can assist with assessing more accurately the real impact of initiatives like the EEB Hub, as well as informing the political process of their appraisal.

8.5. Policy Recommendations for Sustainable Energy Development in Philadelphia

Based on the evaluation of the examined four local energy initiatives (MOS, SCP, residential energy affordability, EEB Hub), this section summarizes key issues and problems that can be identified from this study in relation to Philadelphia's sustainable energy efforts and what type of policy actions can be taken to enhance them. Given the large number of major metropolitan municipalities worldwide that have high energy consumption but are not part of the leadership group of global cities in sustainable energy policies for the urban built environment, the extent to which the problems and possible ways to improve the policies found in the Philadelphia case study can contribute to the broader discourse of urban sustainable energy development.

8.5.1. Baseline Evaluation of Policy Activities

Various programs and initiatives are in place in relation to sustainable energy development in Philadelphia. A closer evaluation of their performance could offer baseline information upon which to consider modifications to enhance their effectiveness, or inform the design of new energy sustainability activities. For instance, this task could include assessing what type of factors constrain or facilitate action, or how the existing distribution of energy-related policy responsibilities and resources between relevant actors can be modified to better support energy sustainability in the city.

In this respect, it is suggested that a more detailed evaluation and public documentation of lessons and outcomes of completed and under progress local energy-sustainability activities is undertaken. For example, no assessment was available regarding the impact of Southwest NEC's energy conservation services on the energy consumption of households, nor any formal assessment of the role of the various municipal government departments that have been identified as Lead and Partner entities for driving forward the *Greenworks Philadelphia* energy sustainability initiatives has been made publicly available, if undertaken at all.

In addition, limited information is publicly available on the technical and policy assumptions behind the selection of the *Greenworks Philadelphia* energy sustainability targets, and the actual (estimated) contribution of undertaken (planned) initiatives to make progress on meeting the targets.

This kind of baseline evaluation task could also add understanding regarding the city's actual capacity for sustainable energy development and inform policy discussions over future directions of local energy sustainability initiatives. As *Greenworks Philadelphia* is the core policy framework within which the city pursues energy sustainability, it is proposed that such type of analysis becomes part of any successor to the sustainability plan.

8.5.2. Municipal Energy Policymaking

The city government of Philadelphia is a key policy actor that undertakes a range of activities for sustainable energy development at the municipal government and overall city level. This includes development of technical systems and data, municipal planning and legislative provisions, conductive institutional structures, financial mechanisms to facilitate project development (i.e. Energy Efficiency Fund, Guaranteed Energy Savings Act/Energy Service Company mechanism), and education and professional training of municipal employees and staff on energy efficiency. In addition, energy-sustainability related inter-municipal government dialogue and interactions, as well as wider policy collaborations that involve the city government (i.e. *EnergyWorks* program, City Energy project), are pursued.

As a result of such activities, outcomes like awareness raising for energy issues, reductions in municipal energy use (between 2007-2013) and costs, a record of successful municipal energy efficiency projects, and facilitative provisions for solar power development in the city have been achieved so far.

At the same time, however, a variety of bureaucratic factors were found to have prevented aspects of the city government's policy approach on energy sustainability from being achieved or fully achieved. These include limitations in institutional resources, lack of wider integration of energy sustainability considerations within municipal planning policies and development plans, and conflicts with established organizational practices (i.e. departmental accountability on energy and centralized energy procurement).

In this regard, several further suggestions can be offered to enhance the city government's current approach on energy sustainability. The first is the greater incorporation of energy sustainability considerations in municipal planning policies and decision-making procedures. With respect to energy efficiency this could involve aligning administrative arrangements (i.e. budget allocation for capital projects) with energy criteria (i.e. energy efficiency thresholds). In addition, one of the Local District Plans that are currently under progress could be used as a pilot-case for community energy sustainability planning to draw broad lessons on how the city could move forward with larger scale sustainable energy development.

Regarding solar electricity development, steps to improve the current city government policy approach could involve the greater incorporation of solar electricity considerations into municipal codes and guidelines, taking into account solar energy at the early stages of building design and construction, and fostering market incentives which, at the very least, will motivate the construction of ‘‘solar ready’’ sites, and, at best, will lead to installation of solar systems. Such policy aspects for solar power could be considered in the context of the recently adopted municipal resolution for the development of 20,000 solar roofs in the city by 2025. They will also likely require more municipal institutional resources. As the Mayor’s Office of Transportation and Utilities suggests, having the City’s Energy Manager as the only municipal staff to work-out all the communication and interactions for the Solar City Partnership initiative is challenging.

Additionally, the city government can consider enhancing its policy interactions with energy sustainability-related local entities. An example on this would be to have Philadelphia Energy Authority Board members sitting in key local institutions which are relevant to the *Greenworks Philadelphia* energy targets and which possess capacity to support the City’s energy sustainability agenda; for instance, by offering technical expertise on energy efficiency contracting or suggesting recommendations for effective functioning of the Pennsylvania Solar Renewable Energy Credit market (Hughes, M. 2012). The city government could also consider interacting regularly with local public groups and neighborhoods on energy sustainability as currently few such initiatives take place.

One issue that may have an impact on the city government’s future approach in energy sustainability is the status of institutional permanency that was recently granted to the Mayor’s Office of Sustainability. However, at this stage it is still not clear what the new role of MOS will involve under this status and whether the Office will be equipped with greater resources and responsibilities on energy policy. With local government elections taking place in 2015, MOS suggests that any changes in its policy role will be largely determined by how the new city administration will perceive and prioritize the issue of sustainability. This aspect itself is related to the level of public and advocacy group demand for city government action in the area of sustainability.

8.5.3. Stable Financing for Market Development

The analysis of the MOS and EEB Hub initiatives suggest that progress on the citywide building energy reduction goal of *Greenworks Philadelphia* is dependent on the creation of a viable local energy efficiency market, including residential energy affordability. In this regard, several aspects need to be addressed such as data availability and assessment tools to undertake technical and economic analysis of energy efficiency project development (energy data, building stock data, financial metrics etc.); options for cost-effective energy efficiency interventions; and greater involvement of those stakeholders across the energy efficiency chain (i.e. building industry, financial community) who are deemed necessary to address market barriers such as awareness raising regarding the economic and social benefits of energy efficiency, and strategic funding for project development.

In particular, the study found that availability of stable financing is key to further promote building energy efficiency. In this respect, three issues can be proposed regarding fostering stable investment environments to catalyze energy efficiency adoption in Philadelphia. The first is financial mechanisms that offer cost-effective interventions to a broader customer basis. The 'on-bill financing' mechanism currently considered at the state level by PUC is one such option. In addition, the greater involvement of the private sector in strategic energy financing (i.e. banks, financial intermediaries, foundations) should be facilitated. In this regard, policy and research analysis on appropriate financial tools and methodologies that assess, and reveal, the financial value of energy efficiency would be helpful for creating a stronger business case for such type of investments. Bundling financing mechanism (i.e. rebates, loans) can be also considered as a way of increasing the cost-effectiveness of energy efficiency in the building sector.

Furthermore, it is recommended that regular sharing of lessons between energy programs take place. For instance, experience with the *EnergyWorks* suggests that residential customers' interest for energy efficiency increased substantially once large discounts for the cost of the energy audit were offered. This point was incorporated in PGW's *EnergySense* program that was developed subsequently (D.O.E. EERE, 2013d).

An overarching principle to increase the cost-effectiveness of building energy efficiency in Philadelphia should be that any programs or financial options on energy efficiency that are offered to customers create a positive financial cash-flow from the beginning of the adoption of the intervention. In the case of the 'on-bill financing' mechanism this would mean that the monthly energy cost savings as a result of the energy efficiency intervention are equal, or greater, than the monthly payment for the intervention through the surcharge that is placed on the customer's utility bill.

Additionally, given that part of the city's housing stock requires basic upgrade work before energy efficiency can be implemented, arrangements that address financial and project development aspects of this would be helpful. This could take the form of a mechanism that promotes data-sharing between stakeholders, partnerships between housing programs, and inter-agency collaborations, in order to foster a streamlined and integrated process for cost-effective housing interventions in which energy efficiency considerations are incorporated (Shulock, 2012). The Green and Healthy Homes Initiative could offer a platform for such an approach in Philadelphia. This is a nationwide initiative where federal and philanthropic investments for health and safety, weatherization and energy efficiency are bundled together (Green and Healthy Homes Initiative, 2013).

Finance availability and cost-effectiveness were also found in the study to be key factors regarding local solar power development. In this regard, the re-establishment of the state's Pennsylvania Sunshine Solar program through a dedicated long-term funding stream could assist the growth of the solar industry and add certainty in the solar market statewide in Pennsylvania (Clean Energy Wins, 2014). In addition, the adoption of state policies that promote long-term contracting for Renewable Energy Credits could reduce the cost of solar electricity generation throughout Pennsylvania by contributing to reductions in the cost of project development (Clean Energy Wins, 2014). Such aspects, in combination with policy reforms that extend the share of state's Alternative Energy Portfolio Standard, and its solar carve-out that is currently set at 0.5% for 2021, could, in turn, enhance prospects for solar power development in Philadelphia.

8.5.4. Deepening Policy and Networking Interactions

The study suggests the need for actors, other than the city government, to assume a more active role on sustainable energy development in Philadelphia. Key such actors range from non-profit environmental organizations (Energy Coordinating Agency) and quasi-public agencies (Philadelphia Energy Agency) to neighborhood energy centers, the two incumbent utilities, the local building community, financial intermediaries (The Reinvestment Fund) and the academic community (in case of EEB Hub).

From this range of actors, the study finds that three actors, other than the city government, have in particular an important role for energy sustainability in Philadelphia. These are the two incumbent energy utilities, PECO and PGW, and ECA. More specifically, PECO was found to adopt a 'non-facilitative' position when core interests of the utility are at stake. For example, PECO strongly opposed the bill proposal for the establishment of the Philadelphia Energy Authority by suggesting that if a municipal agency like PEA facilitates citywide electricity development this could hurt the bond rating of the utility, which itself will increase its cost of borrowing and as a result lead into increased electricity prices for local residents and businesses.

In addition, the utility does not fully acknowledge the system benefits that renewable electricity devices bring into the operation of the grid but rather perceives solar photovoltaics as components that mostly take advantage of the grid. On the other hand, the utility appears more willing to participate in more peripheral activities for solar power development like the technical work on the solar resource mapping of Philadelphia's grid infrastructure and built environment jointly undertaken with the city government.

Regarding energy efficiency, PECO's role is found multi-faceted. The utility performs several energy efficiency-related activities including the design and implementation of programs for various types of users (residential, commercial, industrial), the development of technical infrastructure (i.e. smart meters) in the context of state Act 129, the provision of technical advice to the city government (i.e. data requirements for the energy benchmarking legislation), and interaction with local actors for the effective promotion and implementation of its Act 129 programs (i.e. information and education to trade allies; public outreach). In this regard, the utility is a key actor for energy efficiency development in Philadelphia.

Similarly, PGW, the municipally-owned gas utility, is found to be a key actor on energy efficiency development in the city through the range of energy programs that it offers to various end-users, including assistance and services to low-income households such as energy bill subsidies, emergency bill assistance, weatherization and education.

With respect to ECA, the agency is active on energy efficiency and affordable energy development through a wide range of functions on policymaking and implementation (policy advocacy and input for *Greenworks Philadelphia*), market development (contractor, Knights Green Energy Center, *EnergyWorks* program administration), and community energy (weatherization, coordination of NECs).

Overall, then, three issues were found in the study as key with respect to the diversified body of actors relevant to local energy development in Philadelphia. The first is that these actors use both formal and informal policy and networking mechanism to act. The second is that they undertake multiple policy and market functions for energy sustainability. The third is that there is an untapped potential for deeper collaborations between actors in relation to sustainable energy development in Philadelphia. Deepening such interactions then could enhance the city's existing efforts on energy sustainability. This can be considered in terms of strengthening existing interactions or creating new partnerships between actors already active in local energy sustainability. For example, EEB Hub identified energy utilities as key partners for the diffusion of AERs in the Greater Philadelphia region, but regular interactions between the Hub and PECO or PGW never took place. In the broader level, several actors pursue their own initiatives on energy efficiency (i.e. utilities, ECA, City agencies, quasi-public agencies). While dialogue and informal communication between such actors do take place, exchanging information and ideas on a more structured basis would be helpful to share lessons across a wider body of relevant actors regarding what works well and what not, and to foster opportunities for collaboration on energy sustainability. In addition to the role of existing actors, it could involve assessing ways to foster the involvement of actors that currently do not participate in energy sustainability-related activities yet their input can promote sustainable energy development in the city.

In either case, mapping the type of exchanges that do, or do not, take place between them (i.e. in terms of information, financial assistance, etc.), and assessing what type of support, and by whom, is needed to broaden the ‘‘constituency’’ for local energy sustainability are tasks that can inform the design of policies aiming to foster greater actor participation and mobilization of diverse resources and expertise for sustainable energy development in Philadelphia.

The study also found that local public and civic entities assume a central role for residential energy efficiency development in Philadelphia. In addition, civic entities like the Neighborhood Energy Centers are perceived by local residents as trustworthy partners with respect to energy issues (Shulock, 2012). Hence, local public and civic entities in Philadelphia can act as intermediate partners towards fostering a more active involvement by local residents and civic associations in energy policymaking (Portney, 2012; Späth & Rohracher, 2012). However, this requires that participatory policy mechanisms which offer such an opportunity are in place which is not the case in Philadelphia at present. Such option, for example, could be considered in the context of PEA's Work Plan 2014-15 which calls for the development of a dialogue forum on energy issues including city agencies like the Philadelphia School District and the Philadelphia Airport, and external actors like the University of Pennsylvania and SEPTA (PEA, 2014b). In broadening this forum, organizations that represent local residents and neighborhoods could be considered for participation.

Additionally, there are suggestions that can be made for developing a more inclusive policy approach on residential energy affordability in the city. First, community outreach strategies would be required to inform the neighborhood directly about available energy programs and assistance. Furthermore, greater adoption of energy efficiency in the neighborhood could be facilitated through simple energy efficiency devices that do not require much finance or effort by households. In addition, energy education programs offered to households should reduce the 'hassle factor 'of participation. They should also target the neighborhood at large, as 'non-low income' households need assistance too on ways to reduce their energy consumption. However, once resources and support are offered to local residents, the latter should be held accountable for the energy performance of their household.

8.5.5. Multi-Level Policymaking

Philadelphia's sustainable energy initiatives are structured within a multi-level policy environment. In particular, the study suggests that the federal and state government levels play an important role regarding Philadelphia's possibilities for sustainable energy development. This is manifested in various ways. The first is the availability of technical and financial support for local sustainable energy. For instance, a series of funding streams (American Recovery and Reinvestment Act 2009, Pennsylvania Act 129, Weatherization Assistance Program, Low Income Usage Reduction Program) and technical assistance (Solar City Partnership) have supported energy efficiency and renewable energy development in Philadelphia. This external financial support is important in terms of size. For example, the Energy Manager of the City of Philadelphia who is also in charge of the SCP initiative was hired with federal funding as part of Philadelphia's participation in the initiative. In addition, leading local entities on energy efficiency like ECA are largely dependent on state funding. For instance, in 2010 the agency's total revenues reached $14,437,958, 61% of which came from the state, 14% from the City of Philadelphia, 11% from utilities, 9% from foundations, corporations and individuals, and 5% from service fees (ECA, 2010). Furthermore, the state Act 129 through which PECO develops its energy efficiency programs is considered as a key mechanism, along with PGW's voluntary energy programs, for the promotion of energy efficiency at the overall city level in Philadelphia.

Besides the state and federal level financial and technical support, the study finds that systemic market and regulatory factors which are largely defined at these policy levels strongly influence Philadelphia's possibilities on energy efficiency and solar electricity development. This is evident in structural policy aspects like the currently weak SREC market performance in Pennsylvania, as well as in PUC's and PECO's position on solar power, both factor of which were found to constrain the city's capacity for solar electricity development. As MOTU suggests, state regulatory provisions appear necessary for creating a more favorable context for solar electricity development in Philadelphia, for example in terms of optimizing the operation of the SREC market or legislation that will push the utility to be more responsive on solar electricity development.

In addition, shifting state and federal government financial input was found to create inconsistencies with respect to sustainable energy development in Philadelphia. For example, sizeable state funding for energy efficiency was available under the state administration of Edward Rendell (2003-2011), whereas the succeeding state administration under Governor Tom Corbett (2011-2013) was more focused on financially supporting existing energy sources such as natural gas and liquefied natural gas. The new state Governor Tom Wolf, whose administration takes office in January 2015, appears more inclined to support energy sustainability in Pennsylvania (DVGBC, 2014a) but at this stage it is unclear what would this mean in practice for Philadelphia's possibilities on sustainable energy.

At the same time, current policy workings at the federal level may create opportunities for greater local sustainable energy action in the U.S, for example through state energy plans for compliance with the U.S. Environmental Protection Agency's proposed Clean Power Plan Rule that mandates reductions in carbon emissions from existing fossil fuel power plants. These plans have to be developed and put in practice by June 2016.

Furthermore, two wider energy issues that involve state and federal energy policymaking, that of natural gas development in the Greater Philadelphia region and the role of nuclear power which currently accounts for around 20% of the statewide electricity mix, may influence the city's prospects on sustainable energy development, particularly in the medium to longer term. Until present, both topics have not been largely discussed, or assessed, in local energy policymaking. For example, *Greenworks Philadelphia* does not contain any discussion on the role of these two energy sources in relation to the city's efforts for making progress on its energy sustainability targets. Also, the city government political leadership, or agencies like the Mayor's Office of Sustainability and Philadelphia Energy Authority, have not adopted any clear position either in favor or against existing plans, and broader goals, with respect to natural gas development in the Philadelphia region that are promoted through business interests and state agencies like PCU and the Philadelphia River Port Authority largely in connection to natural gas production in the Marcellus Shale field.

Overall, hence, the study finds that the state and federal government level are important policy sites regarding the type and scale of sustainable energy action that Philadelphia pursues, or can pursue. In this respect, wider development of energy sustainability in the city is currently partly dependent on enhanced cooperation and supportive arrangements (i.e. market, regulatory) from higher levels of government.

Mapping, then, key aspects of this multi-level policy environment, i.e. the existing allocation of responsibilities and resources, and the type of interactions taking place between stakeholders, can be helpful to better understand how its structure and functioning overall constrains and enables energy sustainability action in Philadelphia. This information can, in turn, offer guidance to sustainable energy policymaking for Philadelphia in terms of the type of arrangements and mechanisms (i.e. re-distribution of responsibilities, policy responses to market failures, policy coordination etc.) that could address identified barriers for local sustainable energy development.

This task of analysis can encompass assessing the extent to which energy-related municipal powers and competences promote the type of action required to make progress in relation to the *Greenworks Philadelphia* energy sustainability targets. In addition, it can involve the identification of policy areas relevant to local sustainable energy development that are mostly the remit of external policy scales and, as such, indicating opportunities for policy collaboration and advocacy that the city government could pursue to promote its energy sustainability interests.

In this regard, two indicative examples in relation to energy efficiency development in Philadelphia can be offered. The first is EPA's proposed Clean Power Plan Rule for which the city government can advocate that energy efficiency development takes priority in any state compliance energy plan, and that this condition is accompanied with facilitative arrangements for local implementation (i.e. in terms of financial resources, technical support etc.). The second is the review process at the state level, that started in summer 2014, regarding whether Pennsylvania will adopt the 2015 International Conservation Building Code which specifies building energy efficiency standards that are 15% higher compared to those currently in effect statewide (DVGBC, 2014b).

With respect to solar power, Philadelphia could consider advocating in favor of increases in the overall renewable energy requirements of the AEPS, and the corresponding solar carve-out, as a way of enhancing market demand for solar power at the statewide level, as well as partly addressing low SREC prices. In addition, a policy provision that mandates electric distribution companies in the state to meet a portion of their AEPS share with SRECs that are generated within the boundaries of the state of Pennsylvania could be considered as a way to limit the overflow of out-of state RECs that take place currently. Furthermore, provisions such as long-term state funding streams and contracting arrangements for SRECs could be considered for fostering market certainty for solar power development throughout Pennsylvania, hence at the local level. Furthermore, the city government of Philadelphia can consider lobbying local actors that procure RECs, which account for the bulk of RECs consumed in Philadelphia, to follow its approach and shift to credits that are generated at the local to Greater Philadelphia regional level.

8.6. Future Research

The study proposes three areas for further research regarding the topic of cities and sustainable energy development:

1. The city government of Philadelphia faces diverse types of barriers in energy sustainability; for example, contextual (wider energy policy environment and conditions; competing policy priorities; older city building infrastructure); organizational (i.e. administrative arrangements and procedures; resources); and regulatory (i.e. nature of policy tools at the disposal of city government; energy-related power distribution between levels of government). Understanding better the nature of such barriers, their interrelated functions, and how they can be translated into action, could constructively inform municipal energy sustainability policies.

2. The study identified the importance of long-term fiscal resources and networking relationships for local sustainable energy development. Exploring how stable financial resources for local action can be developed, and how a variety of actors can be better incorporated in local energy governance structures (i.e. what type of support actors need and what mechanisms could provide them), could inform the crafting of local energy sustainability responses.

3. The analysis suggests that Philadelphia is dependent on external levels of government for wider sustainable energy development. Therefore, assessing how integrated planning and action frameworks for local sustainable energy development can be fostered within a multi-level policy context for urban energy is a topic that can be considered for further research.

Finally, other metropolitan areas can be the focus of similar case study analysis so that a comparative body of research on urban sustainable energy development can start to be built.

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APPENDIX A

LIST OF INTERVIEWEES

Katherine Gajewski	Director of City of Philadelphia Mayor's Office of Sustainability
Kristin Sullivan	Energy Manager of City of Philadelphia, Mayor's Office of Transportation and Utilities
Adam Agalloco	Energy Officer, City of Philadelphia Mayor's Office of Sustainability
Mardi Dietze	Energy Analyst, City of Philadelphia Mayor's Office of Transportation and Utilities
Eva Gladstein	Former Executive Director of City of Philadelphia Zoning Planning Commission
Alan Urek	Director of Strategic Planning and Policy Division, Philadelphia City Planning Commission
John Haak	Planner, Philadelphia City Planning Commission
Michael Flink	Deputy Commissioner for Development, City of Philadelphia Department of Licenses & Inspections
Liz Robinson	Executive Director, Energy Coordinating Agency
Andrew Kleeman	Director of Smart Energy Solutions Team, Energy Coordinating Agency
Donna Henry	Executive Director of Southwest Community Development Corporation
Anne Czajka	Energy Manager of New Kensington Community Development Corporation Neighborhood Energy Center
Jackie Jenkins	Energy Efficient Buildings Hub Task Leader: Catalyzing the Advanced Energy Retrofit Sector, Wharton Small Business Development Center
Leslie Billhymer	Energy Efficient Buildings Hub Task Leader: Stakeholder Engagement, University of Pennsylvania
Frank Jiruska	Director of Energy and Marketing Services, PECO Energy Company
Alex Waegel	Research Associate, T. C. Chan Center for Building Energy Studies, University of Pennsylvania
Elise Harrington	Research Associate, T. C. Chan Center for Building Energy Studies, University of Pennsylvania

APPENDIX B

TEMPLATE QUESTIONNAIRE OF THE INTERVIEWS

1. Origins of the initiative
2. Overview of the initiative
3. What progress has been made so far in the initiative?
4. What are the key lessons that can be taken so far from the initiative?
5. What challenges has the initiative faced on its implementation?
6. How were the challenges overcome?
7. What challenges faces the initiative to further progress?
8. How could such challenges be overcome?
9. Interdepartmental collaboration on the initiative?
10. Collaboration with city actors on the initiative?
11. Collaboration with actors situated outside the city on the initiative?
12. Future directions of the initiative

This is the template for the interviews with the city government of Philadelphia. The interview questionnaires for the public sector, business sector and civic sector groups are the same as above, including a question regarding collaboration with the city government of Philadelphia on the examined initiative.

APPENDIX C

IRB APPROVAL FOR THE INTERVIEWS

UNIVERSITY OF DELAWARE

RESEARCH OFFICE

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DATE:	April 26, 2013
TO:	Iraklis Argyriou
FROM:	University of Delaware IRB
STUDY TITLE:	[337164-1] Urban Sustainable Energy Development: A Case Study of the City of Philadelphia, PA.
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	April 26, 2013
REVIEW CATEGORY:	Exemption category # 2

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will put a copy of this correspondence on file in our office. Please remember to notify us if you make any substantial changes to the project.

If you have any questions, please contact Jody-Lynn Berg at (302) 831-1119 or jlberg@udel.edu. Please include your study title and reference number in all correspondence with this office.