INVESTIGATING THE GAP BETWEEN ESTIMATED AND ACTUAL ENERGY EFFICIENCY AND CONSERVATION SAVINGS FOR PUBLIC BUILDINGS PROJECTS & PROGRAMS IN UNITED STATES

by

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Hazrat Ali (R.A) had stated: “I am a slave to anyone who ever taught me even a single word”. All the acknowledgements are for my teachers which include my parents, professors, external reviewers, friends and last but certainly not the least “my near and dear ones”

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ABSTRACT

The gap between estimated and actual savings in energy efficiency and conservation (EE&C) projects or programs forms the problem statement for the scope of public and government buildings. This gap has been analyzed first on impact and then on process-level. On the impact-level, the methodology leads to categorization of the gap as 'Realization Gap'. It then views the categorization of gap within the context of past and current narratives linked to realization gap. On process-level, the methodology leads to further analysis of realization gap on process evaluation basis. The process evaluation criterion, a product of this basis is then applied to two different programs (DESEU and NYC ACE) linked to the scope of this thesis.

Utilizing the synergies of impact and process level analysis, it offers proposals on program development and its structure using our process evaluation criterion. Innovative financing and benefits distribution structure is thus developed and will remain part of the proposal. Restricted Stakeholder Crowd Financing and Risk-Free Incentivized return are the products of proposed financing and benefit distribution structure respectively. These products are then complimented by proposing an alternative approach in estimating EE&C savings. The approach advocates estimation based on range-allocation rather than currently utilized unique estimated savings approach. The Way Ahead section thus explores synergy between financial and engineering ranges of energy savings as a multi-discipline approach for future research. Moreover, it provides the proposed program structure with risk aversion and incentive allocation while dealing with uncertainty. This set of new approaches are believed to better fill the realization gap between estimated and actual energy efficiency savings

CHAPTER 1

INTRODUCTION

1.1 Energy Efficiency & Conservation in the Context of Climate Actions

Globally, natural disasters have steadily increased since 1970's with various studies establishing the link between natural disasters and climate change (Leaning and Guha-Sapir 2013, 1836–37; Anderson and Bausch 2006; Anderson, Jason and Bausch, Camilla 2007). Even with this established link social scientists and ecologists have long struggled in convincing the world and its incumbent authority to change their direction away from business as usual and towards climate actions (Carson 2002, 1–3, 15–37, 277–97; Mumford 2010, 151–211). An economic rationale has proven to be a convincing rationale while triggering climate actions (OECD and IEA 1994; Nordhaus 1994; Fankhauser 1995; Sanderson and Islam 2007). Energy Efficiency and Conservation (EE&C) due to its economic foundation and other diverse benefits has become one of the cost-effective ways of attaining climate action goals (B. Prindle 2009; Kerr, Gouldson, and Barrett 2017). Therefore, EE&C has become integral to the climate actions.

Although a global perspective of Climate Change is used to understand its effects, yet, local actions and bottom-up approaches with respect to Climate Change are at forefront (Lutsey and Sperling 2008). On the lines of local climate actions, the State of Delaware aims to reduce greenhouse gases (GHGs) by 30 % from a 2008 baseline by 2030 (Cabinet Committee on Climate and Resiliency 2016). Other states and cities

(New York City, Seoul, California) are pursuing much aggressive climate action goals. The 80 X 50 goal of New York City aims at reducing 80 % of GHGs emission by 2050. Similarly, South Korea capital; Seoul, aims at reducing 25 % reduction in GHG emissions by 2020. Likewise, California aims to reduce GHGs emission to 80 percent from a 1990 baseline by 2050. Reducing GHG emissions while utilizing Energy Efficiency and Conservation (EE&C) is envisioned to play a substantial role ("Office of Governor Edmund G. Brown Jr. - Newsroom" 2017). Not only it plays an integral role, it is regarded as an essential element for the realization of cost-effective climate actions (Grueneich 2015, 47).

Cities' and States' climate actions focus on EE&C within buildings as it constitute a major source of GHG emissions (Satterthwaite 2008). More than 68 percent (68 %) of New York City wide GHGs emission can be attributed to the buildings sector whereas 72 percent (72 %) of citywide emissions of Seoul, South Korea can be credited to the buildings[1] [2]. Consequently, EE&C plays a vital role for cities and their buildings sector (Hoornweg, Sugar, and Trejos Gómez 2011). Therefore, it is logical to infer that for realizing climate actions within cities and state, EE&C within buildings need to perform as estimated, since announced climate actions are based on these estimated EE&C savings (Executive Office of the President 2013, 6,8-10).

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[1] New York City's Roadmap to 80 X 50, 2015 by New York City Mayor's Office of Sustainability:

http://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/New%20York%20City's%20Roadmap%20to%2080%20x%2050_Final.pdf

[2] Seoul Climate Data:

https://www.compactofmayors.org/cities/seoul/

1.2 Energy Efficiency & Conservation in Buildings

Energy Efficiency and Conservation efforts within buildings can be segregated into three segments; Residential, Commercial and Public buildings. Each market segment has its own market-driven solutions as well as policy interventions for accelerating climate actions or reducing GHG emissions (Nadel, Steven 2015). However, this paper focuses on the energy efficiency and conservation projects and programs in Public Buildings while briefly discussing the potential in residential and commercial buildings.

1.2.1 Energy Efficiency & Conservation in Residential & Commercial Buildings

Residential buildings account for 25 % of the total energy consumed in the United States. About 80 % of this energy is used in single-family homes, 15 % in multi-family homes (such as apartments and condos), and 5 % in mobile homes. Similarly, commercial buildings account for 19 % of the energy consumed in the United States ("Residential Sector: Homes & Appliances" 2017).

Residential buildings sector is projected to account for 29 % of 2020 Business As Usual (BAU) end-use consumption while commercial buildings sector is projected to account for 20% of 2020 BAU end-use consumption. Residential energy efficiency end-use potential is estimated at 35% across 120 million households. Similarly, commercial energy efficiency end-use potential is estimated at 25% across 87 billion square feet of floor space (Granade et al. 2009, 10–11).

Table 1: Energy Efficiency Market and End-use potential within Buildings of USA[3]

Year	**Residential Buildings** (% of total energy consumed)	**Commercial Buildings** (% of total energy consumed)
2017	25	19
2020	29	20
End Use Efficiency Potential by 2020 (% of total energy)	35	25

It is to be noted that the comparison along the same lines with 2020 projected consumption and end use potential for Public buildings would have been valuable, however, research in the literature is very rarely able to segregate the public buildings from the commercial buildings sector. This has been further explained in the following heading.

1.2.2 Energy Efficiency & Conservation Market Potential in the Literature for Public Buildings

Though less, yet quality literature is present for the analysis of EE&C efforts in Public buildings market segment (Parejo-Navajas 2015; National Academy of Sciences (U.S.) 2010). However, typical EE&C market evaluation studies focus on the residential and commercial sectors while including and sometime discounting public buildings as a distinctive market segment.

[3] Data along these lines not present for Public Buildings

1.2.2.1 Pre-Requisite for Understanding Market Potential within EE&C in buildings

It is particularly noteworthy for policy advocates, energy policy students and analysts that the potential for energy efficiency and conservation efforts differs, not only on the basis of reporting requirements (Eldridge, Elliot, and Neubauer 2008), but also on the approaches used while projecting its potentials. It may change for individual state reporting requirement from projecting potential from EE&C technologies approach, like lighting, cooling/heating, ventilation etc. to applying a whole building/facility approach. Likewise, the output potential also ranges from technical, economical and achievable potential where achievable potential will always be the lowest amongst all defined potentials (Nadal, Shipley, and Elliot 2004).

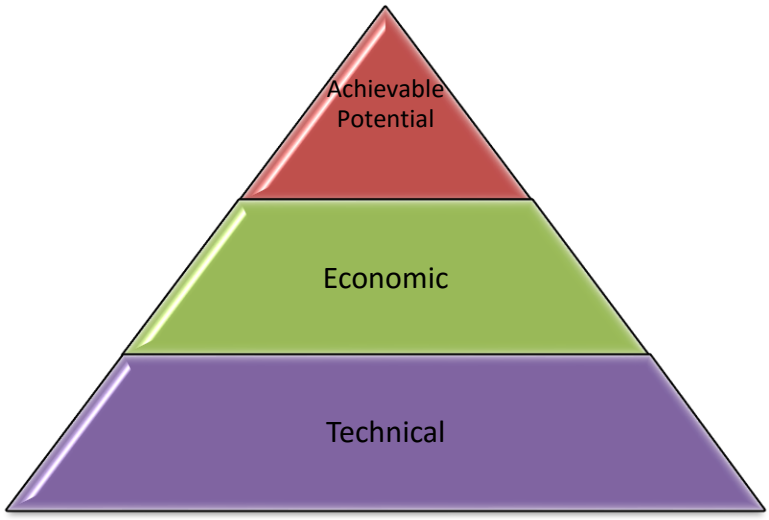

Figure 1: Energy Efficiency and Conservation Potentials based on different approach

1.2.2.2 Public Buildings Market Segment

The portfolio of public buildings for this paper remains inclusive of governmental and non-profit buildings. EE&C efforts with respect to Public buildings are thus segregated here into federal, state and city government buildings. Furthermore, this

segment being categorized as municipalities, universities, schools and hospitals in the literature, has been specified as MUSH market. It generally refers to properties that are owned and operated by government entities as well as by nonprofit institutions (Kim et al. 2012).

Federal buildings yield annual operating costs of $30 billion to $28 billion across 3 to 2.5 billion square feet of floor space[4] (Drain 2015). Recent legislations for enhanced public-private partnerships (Kinzinger et al. 2017) depict that the federal government is missing out on an estimated $20 billion in savings by continuing to run outdated, and energy inefficient federal facilities (Coit 2017).

Government or public buildings represent a much larger economic chunk. McKinsey claims "21.2 billion square feet of floor space; where only the office and the educational buildings make up to 63 % of space and 53 % of energy consumption in this cluster". Equivalently, the incremental efficiency potential is greatest in the local government buildings as it constitutes 62 % of the cluster's floor space. Unlocking the potential in local buildings would require $19 billion of upfront investments and provide $36 billion of present value savings. While unlocking the potential in state buildings would require $7 billion of upfront investments and provide $13 billion of present value savings (Granade et al. 2009, 60–61).

Not many studies have linked the public buildings market segment with the commercial buildings sector (Kim et al. 2012) while fewer have analyzed the potential of segments as office (Building Technology Office 2014; Zografakis, Karyotakis, and

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[4] The Federal Real Property Council's FY 2010 Federal Real Property Report an Overview of the U.S. Federal Government's Real Property Assets

https://www.gsa.gov/graphics/ogp/FY_2010_FRPP_Report_Final.pdf

Tsagarakis 2012) or educational buildings (Roslizar et al. 2014; Magrini, Gobbi, and d'Ambrosio 2016) which shares and intersects the market segment of government and commercial buildings. The potential within office buildings is estimated to be up to 50 % of the energy savings (Building Technology Office 2014). Hardly anyone can be credited with analyzing this public-buildings market segment to create innovative policy instruments for actionable climate goals achievement.

In nutshell, EE&C opportunities are scattered across a range of climate, users, end-uses, fuels, and type of technology and buildings (Granade et al. 2009, 10). Therefore, the aim of including the above-mentioned market segments is to provide the reader with the context of different market segments of EE&C in buildings. Similarly, it aims to establish scattered yet wide ranging opportunities within public buildings segment. Additionally, it prepares the stage to discuss policy issues within buildings generally and public buildings particularly.

1.3 Realization of Estimated Energy Efficiency and Conservation Efforts into Actual Savings

The scattered and diverse nature of EE&C efforts hamper its estimation from macro level in programs of state, cities, municipalities and utilities to micro level of individual project estimated savings. The difference in the estimation of actual savings has thus been widely accepted as a gap in the research and widely studied in EE&C efforts.

On a micro level, the difference between estimated and actual EE&C savings for projects, can be defined through realization rates by matching the predicted results to expected ones. The realization rates are therefore the ratio of measured savings to audit-predicted savings. If the predicted and measured savings match exactly the realization

rate would be equal to 100 %. When the measured savings exceed the predicted savings, the realization rate is greater than 100 %. When the measured savings are less than the predicted savings the realization rate is less than 100%.

On macro level, the said difference in programs is studied from the perspective of buildings life cycle from its designed to operation stage. Predicting energy during design phase is synergized with measuring and evaluating energy savings within operation stage of the building life cycle. This difference is termed as a performance gap which includes technical and behavioral elements of buildings in the literature reviewed (Kampelis et al. 2017; Menezes et al. 2012; Cohen and Bordass 2015; Burmand, Mumovic, and Kimpian 2011).

On a policy level, this difference and the gap associated with it have been acknowledged as a social structuring of technical innovation and its diffusion within society as an "Energy Efficiency Gap" (Shove 1998; K. Palmer and Walls 2016). This gap has been dealt as a heterogeneity of consumer problem and analyzed through a wider lens with consideration of non-coherence among approaches of economics, technology and society while utilizing such technologies and behaviors (Allcott and Greenstone 2012).

For this paper, the terminology of realization gap has been used extensively. Drawing parallel between the two gaps, one may view the realization gap as a subset of Energy Efficiency gap while sharing certain traits with Energy Efficiency gap in terms of behavioral element of the gap (Gerarden, Newell, and Stavins 2015).

It is to be noted that the realization gap is not only dynamic because of difference in the estimation approaches but also due to the differences in verification approaches for evaluating actual or measured energy savings. These differences have

been further explained in the literature review section for evaluation of EE&C projects and programs.

1.4 Policy Issue

Current and future policy issues within the market segment of buildings energy efficiency projects are diverse, complex and entangled ranging from cultural, behavior and political elements to organizational and capital availability (Sovacool 2009). Using our previously established link of attaining climate action goals and EE&C being integral for achieving the goals, we will be restricting our discussion to following policy issues:

1- Policy issues for realizing at the minimum, the estimated EE&C savings with BAU investments.

2- Policy issues for increasing the investments in EE&C efforts to accelerate climate actions.

The reason for choosing the first policy issue is due to its clarity of affecting 'estimated savings'(Kaufman and Palmer 2012) as well as its established link with Measurement & Verification (M&V) and impact evaluations of EE&C efforts (EM&V Working Group 2012, 7–5). The second policy issue however, relates directly with the financing/capital availability(Parker and Guthrie 2016, 15–37) as well as its linkage with process evaluation (Dunsky et al. 2016, 6–8, 19; G. Kats et al. 2011). It also explicitly relates with the first issue as achieving estimated savings is necessary and sometimes pre-requisite for luring financing in this market segment since investor confidence remain a pre-requisite for capital investment (Energy Efficiency Financial Institution Group 2015, 69, 74; Taminiau et al. 2017, 1–2).

1.5 Problem Statement

The thesis problem statement investigates the variance in realization rates of 'estimated to actual' energy efficiency and conservation savings as a realization gap. This variability reduces the effectiveness of EE&C projects and programs and thus hampers in attaining estimated and celebrated climate actions.

1.6 Scope of the Thesis Paper

The scope involves the portfolio of public buildings which broadly includes governmental and non-profit buildings for this thesis. Public buildings have been used extensively to represent the governmental buildings at federal, state and city level but also non-profit buildings including municipalities, universities, schools and hospitals often represented as MUSH buildings segment.

EE&C efforts at federal, state and city level are typically program based where diverse programs are deployed to attain respective climate actions. On the contrary, EE&C in the MUSH sector is typically project based where ESCOs (Energy Service Companies) have created a business model around this market. Therefore, the scope of the thesis paper thus aims at investigating the realization gap within individual projects on a microscopic level and then within programs on a macroscopic level.

1.7 Research Questions

The core of the problem statement as a realization gap formulates the first research question of how this gap has been researched and analyzed within literature. Where do the previous and current approaches as well as solutions within EE&C industry lead to and which technological, economic or social narrative is followed for such a diverse interdisciplinary problem? This forms the literature review section of this thesis.

The second research question originated from the investigation of this gap with the objective of critiquing prevalent approaches in the context of filling the realization gap. This was done by critiquing the current approaches of 'estimating, implementing, evaluating and financing' EE&C within projects and programs. The answer of this question constitutes the analysis part of the thesis.

Furthermore, within the current approaches of 'estimation, implementation, evaluation and financing' of EE&C projects and programs, what must change to realize climate action efforts? What are those alternative set of approaches that should be followed? Discussion part of the thesis highlights these aspects.

Similarly, how do the proposed alternative set of approaches help in filling the realization gap, became the 3rd important question which forms the response section of this thesis. This section further investigates the gap by identifying and utilizing synergies among approaches of 'estimating, implementing, evaluating and financing' EE&C efforts.

Program and Policy proposal chapter provides with an actionable proposal that can utilize synergies to fill the realization gap.

Finally, the 'Way Ahead' chapter develops on how the proposed approaches can synthesize synergies and form a counter narrative to individual technological, economic and social narratives prevalent within current approaches.

CHAPTER 2

REVIEW OF LITERATURE

This chapter focuses on the first research question out of the total three mentioned in the last section of our previous chapter. This section, thus investigates the current approaches and solutions within literature with respect to our defined realization gap. Additionally, which narratives do prevalent approaches follow and how does/do the/these narrative/s affect our realization gap. This section also provides the reader with enough background information to understand and appreciate analysis of prevalent approaches of 'estimating, financing, implementing and evaluating' EE&C efforts.

The research design and methodology which was opted for investigation in this regard was to first construct a brief evaluation, measurement and verification timeline to discover the previous and most prevailing narratives within EE&C industry and establish a connection with how they affect the realization gap in our problem statement. Next, the analysis of the prevalent approaches for implementing, evaluating and financing EE&C efforts with the focus on diverse evaluation mechanism to evaluate these efforts was done.

The primary objective of this thesis remains to investigate the gap from a systems' perspective, to explore synergies in the lifecycle of estimating, funding, implementation and evaluation within EE&C projects and programs of our scope [5] (Paul A. et al. 2002; Brown et al. 2005). Systems' perspective help us in exploring

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5 http://www.sqconsult.com/content/newsletter_html/SQ_Towards_effective_NAMAs_tapping_knowledge_from_policy_evaluation.html

synergies with approaches of 'estimating, financing, implementing and evaluating' EE&C efforts. Stakeholder engagement has been added within the systems approach for literature review as well as for the other parts of this thesis to be more inclusive in nature. This systems' perspective also helps in viewing the problem statement within the project management lifecycle while proposing actionable Program and Policy Proposal.

The research design and methodology for other research questions and sections of this thesis has been discussed later in detail in the research design and methodology section as it was developed with the help of reviewing literature.

2.1 Evaluation Measurement & Verification Timeline

A large portion of literature has been dedicated to the Measurement & Verification (M&V) segment which is the foundation of Evaluation, Measurement, and Verification (EM&V) in current EE&C efforts. Consequently, the EM&V can trace back its roots in the evolution of M&V as a system/approach. An innovative approach towards broadly and briefly introducing the reader with the M&V of the EE&C projects in buildings has been developed in the form of a timeline in Table 2 (Kummer, Nix, and Drees 2011, 9; Herriges et al. 1985; Train 1992; Parti et al. 1994; Goldman et al. 2000).

This timeline includes the early 1960's to 1975 period while the EE&C industry was still at its nascent stage. Utility bills' comparison remained the only method to compare and contrast between estimated and actual energy savings. Till 1990's, though the industry was using inaccurate approach of utility bills' comparison, it reacted to changing dynamics of EE&C efforts from whole buildings to specific technology such

as lighting, cooling/heating etc. Retrofit isolation methods may be regarded as a reactionary approach to inaccurate utility bills comparison method. The third time-period from 1990 to 2010 remained the focal push in forming recent trends. However, the establishment and acceptance of International Performance Measurement & Verification Protocol (IPMVP) as a standard within the EE&C efforts worldwide, is a primary milestone within this period. The solutions leaning towards technology, performance enhancement to Energy Services Performance Contracting (ESPC), and cost effectiveness remained the major driving force during this period. However, recent trends include only the Information and Communication technologies (ICT) application to make this field more data driven and hence more technology driven.

The formulated timeline tries to sort out the milestones from within research, academia, industry and policy spheres chronologically, for analyzing how narratives formed and evolved over a time-period. It aims at answering the question about where the current solutions for filling the realization gap lead to. Moreover, it is also an attempt to understand why certain different approaches are prevalent within the industry as well as how the industry has reacted towards realization and building performance gap.

Table 2: Timeline of evolution of EM&V and subsequent Narrative development

Timeline	Market Characteristics: Energy Efficiency in Buildings (Projects/Programs)
1960-1975	• A formal energy efficiency industry was just starting to emerge with no standard methods for M&V • The first attempts for verifying savings were simply to compare utility bills before and after an energy efficiency project is done at the facility/meter level.
1975-1990's	• 'Utility Bills difference approach' proved highly inaccurate. It is partially due to the diversity of inherent variability (occupancy, weather etc.) as well as the meter-noise. • Industry at that time, answered with developing retrofit isolation methods for breaking down the complexity and diversity of EE&C projects in buildings. • Social Scientists answered by regression methods for billing analysis utilizing statistically adjusted engineering model approach.
1990's -2010	The period from 1990-1997 and then from 1997-2010's is the period which led to establishment of recent trends in M&V world.
	1990-1997 (Performance gap narrative) • M&V market direction towards data/technology for enhanced improvement. • Performance enhancements to Energy Savings Performance Contracting • IPMVP: Established and formalized the existing methodologies (retrofit/regression)
	1997-2010 (Technology solution narrative) • Transition from Short-term M&V to Long Term M&V • Guaranteed savings as a market solution • Post 2003 expansion of EE&C projects • IPMVP: A widely accepted standard throughout the world!
Recent trends	Major Interventions/forces currently leading the Market • Data Analytics/ICT • Standardization within building, & OpenSource Collaboration
2017 – onwards	Still Developing

Only widely accepted and best established practices are mentioned here to further develop our investigation of realization gap and how it has been researched in the literature. It includes the industry's primary M&V resource as IPMVP (Efficiency Valuation Organisation 2012), which is an international end-use, energy efficiency M&V guideline document. IPMVP provides a framework for conducting M&V, and most importantly, defines four M&V options that are used in the efficiency industry. The options however are not limited and include metering, regression, energy usage (billing) data regression analysis, and or computer simulations.

Complementing the IPMVP, Federal Energy Management Program (FEMP) M&V Guidelines 4.0 (Webster et al. 2015) remained the widely utilized program within our market segment. These guidelines, and accompanying technical notes, provide more details on M&V about specific measurement and technology applications. A third important M&V resource is ASHRAE Guideline[6] (EM&V Working Group 2012). It is to be noted here that literature provides necessary in-depth analysis of quantification of savings and assessment methods (S. Wang, Yan, and Xiao 2012), however, only IPMVP options are included in the appendix.

2.2 Prevalent Approaches within EE&C efforts

A review of literature reveals various approaches of financing, implementing and evaluating EE&C efforts. The Stakeholder engagement approach as an added item to systems' perspective, is separately included from prevalent approaches that shape the realization gap and narratives surrounding EE&C as an industry. This literature provides the necessary tools as well as depth for understanding the realization gap from

666 http://standards.globalspec.com/std/9892363/ashrae-guideline-14

another perspective of project life cycle as well as its evaluation diversity. Three types of prevalent and current approaches have been critiqued in this section:

1. Financing approaches for EE&C projects and programs (efforts)
2. Implementation approaches for EE&C efforts.
3. Evaluation approaches for EE&C efforts.

The assessment of these approaches helped us in the analysis and development of an alternative set of approach to fill the realization gap. The discussion about this will be presented in chapter 4.

2.2.1 Financing Mechanisms

Financing for public buildings' EE&C efforts mostly comprises of government sponsored or utility sponsor mechanisms. Additionally, government departments allot capital expenditure within the Operations or Maintenance budgets well before the listed specially aimed programs were designed for accelerating climate action efforts. It is also therefore a mixture of utility, government funds in the form of grants incentives or other measures.

Financing for such projects have been utilized from a recent study of Buildings Energy Efficiency and Retrofit (BEER) projects and programs done at Columbia Law School. BEER projects share the same market as that of MUSH sector. Moreover, it shares the same segregation of EE&C efforts to federal, state and city level that has been used in this thesis. The primary sources for BEER project financing include federal, state or local governmental entities or affiliated quasi-independent organizations; individual financial institutions; nonprofit organizations; and the capital markets. The main forms in which financing for BEER projects can be provided, include:

(i) equity financing, usually provided by the available cash reserves of the project sponsored by itself or by private equity sponsors

(ii) debt financing of a variety of different types [12]

(iii) grants, rebates or other "free money"

Other recent trends of acquiring financing for this scattered and vast EE&C sector include, but is not limited to:

a. Sustainable Energy Utilities (Houck, Walker, and Shreiber 2016)
b. Utility Financed Programs
c. Energy Services Performance Contracting (ESPC) [7]
d. Municipal Programs

Financing approaches for projects and programs within the scope of this thesis mainly represent a mix of government and utility funded EE&C efforts. Similarly, for residential and commercial sector the recent trend in financing is towards Property Accessed Clean Energy (PACE) with recent legislations and states accepting this financing instrument (Michael 2012).

It is considered prudent to mention that Energy Services Performance Contracting (ESPC) can not only serve as mechanism of filling this realization gap but also can be viewed as a financing tool. This financing tool in the context of federal programs has been further analyzed in the Analysis chapter of this thesis. However, 'guaranteed savings' as a concept is discouraged, since it represents the inherent credibility deficit of the investing party, either government or utility or ESCOs, in this case. In other cases, ESCOs arrange funds through private means for such projects to be

[7] https://energy.gov/eere/slsc/energy-savings-performance-contracting

undertaken, which need to be guaranteed either by ESCOs or by other implementing parties (Michael 2012). However, the noteworthy point is the inherent credibility gap due to difference between expected and actual energy efficiency savings which resulted in the need for "guaranteed savings" as a concept to be developed. It is deemed appropriate to note here that guaranteed savings in this perspective is viewed as a hurdle, a gap, or a pre-requisite for attaining financing which further leads to underestimating EE&C potential. Within the reviewed literature, however, the concept of guaranteed savings is either appreciated as a strategy [8] or regarded as boon for capital projects within energy efficiency & conservation efforts.[9]

The financing instrument establishes the structure of authority and leverage within the EE&C programs and projects. Different financing mechanisms along with different program objectives of EE&C efforts then result in different forms of implementation and evaluation approaches as will be explained in the forthcoming sections later.

2.2.2 Implementation Mechanisms

The implementation mechanisms here represent how the energy efficiency and conservation projects in public and government buildings are being implemented. Studies have generally categorized implementation mechanisms based on voluntary and mandatory programs. However, this paper only limits itself to the voluntary programs

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[8] J.P Morgan Study: https://www.jpmorgan.com/jpmpdf/1320603368599.pdf

[9] http://www.nytimes.com/2012/10/24/business/energy-environment/energy-service-contracts-a-boon-for-public-agencies.html

for the said categorization on the basis of their implementation mechanism (EM&V Working Group 2012, 2–1).

1- Deep Retrofit Projects (Al-Kodmany 2014)
2- Shallow Retrofits (Magrini, Gobbi, and d'Ambrosio 2016)
3- Single facility Multi-Energy Conservation Measure (ECM) Projects or Bundled ECMs[10].
4- Multi facility Single-Energy Conservation Measure (ECM) Projects or Separated ECMs ("Real Prospects for Energy Efficiency in the United States" at NAP.edu 2017, 61–67)
5- A cluster of the above

A Multi-facility single ECM may also be a shallow retrofits program. Similarly, a multi-facility multi ECM or single ECM may also be a deep retrofits project. The segregation in the implementation mechanisms is as varied as the project/program objectives and organizational capacity.

The above-mentioned implementation mechanisms are listed to show how the segregation of EE&C projects influence;

1- the delivery and/or service process of these projects,
2- behavioral risks associated with the cluster,
3- organizational structures and or program structures responsible for managing these projects

Examples of such implementation mechanisms include but are not limited to:

[10] https://www.energizedelaware.org/industrial-assessment-program/

1- New York City Accelerated Conservation and Efficiency Program (EDF Climate Corps 2016)
2- Delaware Sustainable Energy Utility Program [11]

The above two examples have been used throughout the paper as a reference case study since the author has personally worked within these programs.

2.2.3 Evaluation Mechanisms

EE&C evaluation mechanisms represent how the effect of energy efficiency projects based on program objectives are evaluated. Therefore, they may not be limited to energy savings only. To be inclusive, the government funded as well as the utility funded program and project evaluations have been discussed separately. All evaluations have been categorized as a form of impact, process or market evaluations. Evaluation mechanisms have also been segregated on various dimensions. Typically segregated as Formative or Summative, otherwise as impact, process and market evaluations for our scoped problem (EM&V Working Group 2012, 2–3).

Literature review is somewhat dominated by evaluation of programs undertaken by energy companies, usually as a result of regulatory requirements or incentives. (Wade and Ayre 2015). Fewer have established the linkages between impact and process evaluation and their complimenting nature for EE projects (SBW Consulting 2013). Department of Energy (DOE) guide for evaluation in EEE&C however include the impact, process and market characteristics evaluation (EM&V Working Group 2012, 2–1). However, using all the three towards reshaping the public

[11] https://www.energizedelaware.org/industrial-assessment-program/

discourse/dialogue and exploiting their synergies is yet to be researched. Therefore, this intent also forms the methodology basis for utilizing synergies for this market segment.

2.2.3.1 Evaluation Approaches for Government-funded Projects and Programs

For clarity, at first; process and impact evaluations have been studied for government funded and then for utility programs. Although the evaluation approaches include market, process and impact evaluations yet we have focused much on process and impact evaluations. The reason for not including market evaluations in detail is due to our scoped market of public and governmental buildings. As explained earlier the financing party has a leverage not only in deciding the implementation approach but the approaches of evaluation as well.

1) Market Evaluation

Market Evaluations are critical, but not exclusively used for, programs with market transformation elements and objectives. Examples of market evaluations are potential studies, baselines studies, and market effects studies (EM&V Working Group 2012, 2–1).

2) Process Evaluation:

Process evaluation techniques are systematic assessment tools that may include program delivery effectiveness, from design to implementation, then to identify current or potential gaps within, and finally to recommend potential improvements. Process evaluation is part of the process level analysis for next chapter and is viewed through the lens of organizational/management, and flow of capital etc.

3) Impact Evaluation:

Impact evaluations typically deal with Monitoring and Verification (M&V) of EE&C projects based on energy and non-energy benefits. These are the most common, while sometimes are the only evaluations done for EE&C programs and projects [12] (Dixon, Abdel-Salam, and Kauff mann 2010).

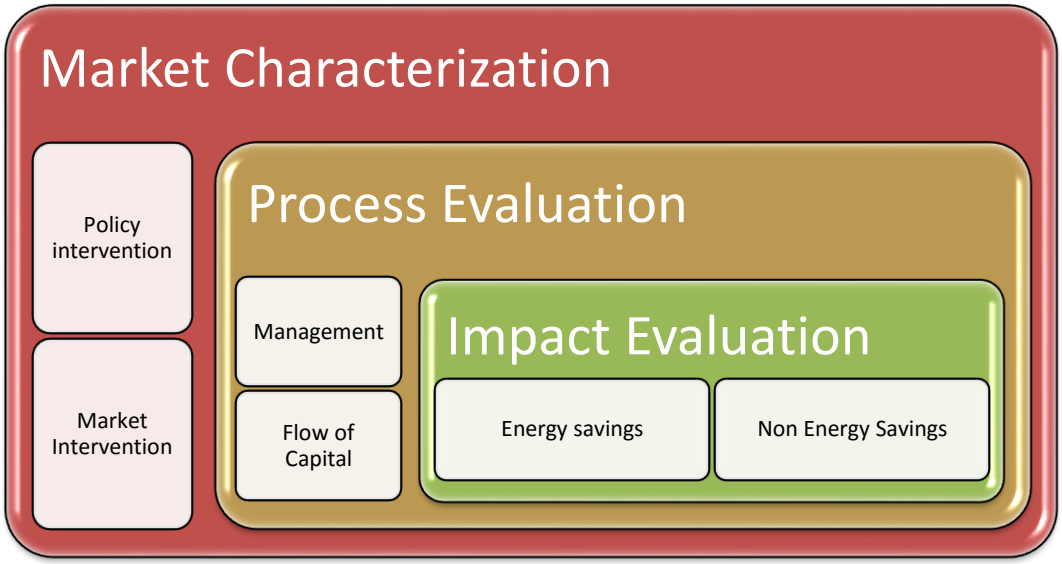

Figure 2: Theoretical illustration of proposed methodology

[12] CEE Guide to the Evaluation Guides
http://www.ieadsm.org/wp/files/Tasks/Task%2021%20-%20Standardisation%20of%20Energy%20Savings%20Calculations/M&V/CEEGuideToTheEvaluationGuides.pdf

2.2.3.2 Evaluation Approaches for Utility-funded Projects and Programs[13]

This section discusses the utility-type impact and process evaluations as a background material to establish the context of using utility or ESCOs as an institutional stakeholder for further analysis. This section views evaluation approaches as a means to fill the realization gap.

It is considered prudent to briefly explain utility based programs within performance contracting framework and how does it affect evaluation approaches. For projects, especially those done under performance contracts, M&V is a technical undertaking involving engineering estimates, baseline metering, and post-installation metering. The gap between engineering estimates and actual savings for a project is typically narrow when a performance contract is used to finance the project. This is because baseline metering includes the effects of occupancy, weather and other variables. Depending on the types of measurement procedure / tool installed, metering is typically used to measure post-installation savings. As noted before, contracts dictate the remedies if savings are below estimates. However, their limitations in terms of costs of M&V for conflict resolution has also been critiqued in the Analysis Chapter of this thesis. However, most performance contracts allow the customer to keep savings if actual savings come in excess of the estimates, and there is an incentive to operate a building efficiently after a project is completed.

Using the same structure as of government funded projects and programs, utility type projects and programs follow with the same impact and process evaluations but with different dynamics and objectives. Impact evaluation in the context of utility programs is very different. Utility programs apply to a broad range of customers, end-

[13] Reviewer Contribution: Ralph Nigro

users, and building types. There are two types of programs: prescriptive programs and custom programs. Prescriptive programs include the "menus" of efficiency measurement with the impacts of each measurement being estimated in advance during the market evaluation and program planning. During an impact evaluation, the goal is to determine whether the impact estimates are correct, within reasonable statistical margins of error or not. While the impacts of one measure on a certain occupant-set may vary considerably from the pre-determined impacts, it should be accurate on an average, and therefore the impacts for a program should be well known. Impact evaluations of utility programs necessarily take place only after the allocated time has elapsed after the launching of the program. A minimum of one year is typical. If the impact evaluation reveals that the original estimate was incorrect, it recommends changes to inputs, algorithms or other factors to make it more accurate. However, on the contrary, Custom programs evaluate the savings of specific projects using engineering estimation, but often require metering and other review during an evaluation to verify the savings. Additionally, some utility programs require customers to perform post-installation metering or billing analysis to verify the impacts even when an evaluation is not in progress.

Process evaluations of utility programs are done mainly for two reasons. The first reason is to discern if there are any problems in the delivery of a program to the utility's customers. These could include customer complaints about application processing, marketing deficiencies, information barriers, etc. The second reason is to determine net-to-gross ratios which determines the effects (primarily) of free-ridership and spillover on gross savings.

Impact and process evaluations are important for utility programs because they are funded by ratepayers, and regulators are responsible for ensuring that the ratepayer's money is spent prudently. However, utilizing evaluation protocols is not advocated or recommended since they are catered with a different set of financing and implementation objectives. Utility style evaluations do not apply to the individual building level and are mostly separated ECMs. They typically fall under the category of Multi facility single ECM, which may include lighting, upgraded boiler, HVAC system etc., therefore the nature of utility style evaluations may not be utilized as a standardized benchmark. Similarly, process evaluations, targeting net to gross ratios, do not apply to the building level.

In a nutshell, these types of evaluations are necessarily programmatic in scope with differences mainly in their diverse program objectives. These differences create non-coherence among impact and process evaluation approaches to complement each other while producing actionable policies. A summary of evaluation types and its application with project and program life cycle has been attached in Appendix B.

2.2.4 Stakeholder Approach within Projects and Programs

A lot of literature has already identified, established and advocated the stakeholder engagement in effectively managing EE&C projects and program for building segment (Becque et al. 2016; Bal et al. 2013). Although studies have identified and analyzed the importance of stakeholder engagement for public buildings yet it has not been analyzed as an integral part of the program structure and program theory (US DOE 2016). Similarly, studies have holistically establish the stakeholder engagement of local and

city government in the context of financial sustainability (X. Wang, Hawkins, and Berman 2014). [14]

For residential and commercial buildings, stakeholders are much larger in number than public buildings segment. These stakeholders are included within project lifecycle either through financing or accruing direct energy benefits from the project. Although for public-building market segment, stakeholders are less in number and easy to be used, yet utilizing direct stakeholder engagement is typically avoided. This is in part due to the reason that public employees, contractors, utilities or even government's core responsibility is not to manage energy savings and programs. Additionally, legal issues within conflict of interest may arise while engaging public employees who are getting personal benefits from such program structure. However, this argument has not been researched further.

To sum up, all the stakeholders mentioned above are considered necessary for the effectiveness of the EE projects, however, as per our focus on incentivizing stakeholder, their interests are not aligned and are not being incentivized by any policy instrument in current market segment of public buildings. Stakeholders as ESCOs, Utilities and Governments have been utilized as institutional stakeholders whereas building owners and occupants, contractors and communities have been categorized as individual stakeholders for Program & Policy Proposal Chapter.

2.3 Summarizing Remarks

This section tries to summarize the literature discussed and how does it affect our realization gap. It can be stated therefore, that there is a diversity within projects and

[14] http://eecoordinator.info/tag/stakeholder-engagement/

programs in filling this realization gap. Realization gap is different based on how the projects and programs are ‘estimated, financed, implemented and evaluated’. Two observations can be made from the literature reviewed in the context of our problem statement in this regard which is as follow:

- A lot of focus on filling the relevant gaps through Evaluation frameworks, typically for programs, is done, which is understandable & logical.
- Realizing the estimated savings into actual savings is an interdisciplinary problem which is being solved with individual discipline effort (engineering/social sciences/technology/contracting/financing).

Additionally, the literature reviewed in studying this gap asks the question of whether this is a Realization, Performance, M&V or EM&V Gap? Based on classical definition, realization or performance or M&V or EM&V, all can be regarded as the gap investigating the difference between estimated to actual savings. The defined realization gap is often referred in the literature as ‘building performance gap’ (Kampelis et al. 2017; van Dronkelaar et al. 2016). The relationship of defined realization gap with the literature reviewed ‘performance gap’ needs to be elaborated on why the same terminology (performance gap) was not used. It is primarily due to the reason that the terminology and narrative of performance gap is in practice, linked to Energy Performance Services Contracting EPSC. This in turn focuses on linking this gap with uncertainty and only utilizing the technological element for the whole realization gap. Currently used terminology of ‘realization gap’ itself tries to establish this difference of narrative.

Recently, integration of M&V into program evaluation has opened up new venues for research as well (NEEP 2016). This integration validates the use of

realization gap as the problem statement basis for this paper. Additionally, M&V is a subset of Impact evaluation, while building performance gap represent the pre-to-post building performance. Defining the realization gap with the only lens of M&V and building performance leans this towards construction and engineering solutions and thus a technology driven narrative.

Similarly, M&V and Performance gap itself represent the technological solution narrative and therefore utilize concepts of variance and uncertainty which is evident from solutions of modeling and sampling within this technology driven narrative. M&V or Performance gap both use technological and social sciences solutions respectively which may reduce the gap but also leaves us with the bi-product of only using individual discipline solutions for a diverse and interdisciplinary problem. Modeling errors, and sampling size issues are those bi-product which then demand more effort/struggle towards a single discipline narrative approach instead of an interdisciplinary approach towards exploring synergies.

For the use in this paper, 'Realization Gap' terminology has been used. The gap investigated by this paper mainly focus on evaluation, measurement and verification (EM&V), to find answers for the realization gap. It then tries to establish synergies between impact and process evaluations. These synergies are then taken forward to Analysis as well as the Response sections of the thesis at both impact and process level.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 Research Design Basis

3.1.1 Synergies in Evaluation Mechanisms

Literature review is somewhat dominated by the evaluation of programs being undertaken by government agencies and energy companies, usually as a result of regulatory requirements or incentives. (Wade and Ayre 2015). Some studies have established the linkages between impact and process evaluation and their complimenting nature for EE projects (SBW Consulting 2013). Though DOE guide for evaluation of EE&C efforts includes the impact, process and market characteristics evaluation (EM&V Working Group 2012, 2–1), nevertheless, using all the three towards reshaping the public discourse/dialogue and exploiting their synergies is yet to be researched.

Therefore, the first basis for research design is to explore synergies within the evaluation mechanisms that will enable us to connect to both impact and process evaluations.

3.1.2 Interdisciplinary Synergies

Exploring interdisciplinary synergies has its foundation on the following points:

1- It is based on how the programs and projects are ‘estimated, financed, implemented and evaluated’, within our scoped market segment. This approach from project to program also forms the basis to conduct process-level analysis on an apparently engineering and technological problem.

2- It is based on our defined Policy Issue of realization of the estimated climate action, which will in-turn help us in identifying our problem statement of realization gap and linking it with our scope.

3.2 Research Design

Research design follows the same approach as of initially discussed research question. It connects well with our research questions to guide the structure of the thesis. The question of 'what has already been done in the context of realization gap' has already been mentioned in the Literature Review section along with the research design and methodology. Here, with the help of the reviewed literature and basis established for our research design, the design of the research will be elaborated.

The second research question follows investigation of Realization gap with the objective of critiquing prevalent approaches in the context of filling this gap. This is done by critiquing the current approaches of 'estimating, financing, implementing and evaluating' EE&C within projects and programs. This at first done on an impact level by developing narratives within the M&V timeline and then analyzing policy interventions for 'estimating, implementing, financing and evaluating' approaches within EE&C efforts. The impact level of analysis section then summarizes the limitations of current approaches in filling the realization gap. Next, the analysis on process level tries to include process level evaluations in filling this gap and providing the strengths and challenges of process level evaluations in exploring synergies with the impact level analysis. Discussion section mainly deals with why is it must to change the direction of the current approaches.

Which alternative set of approaches will fill the realization gap on impact and process level? And how? The response section of the thesis answers this research

question by further investigating the gap in terms of identifying and utilizing synergies among approaches of 'estimating, implementing, evaluating and financing' EE&C efforts. This is done by categorization of the Realization Gap at Impact level and providing a Process Evaluation Criterion capable of utilizing synergies with the impact evaluations and our impact level analysis. For actionable research, the process evaluation criterion developed was applied to the two differently implemented programs within EE&C efforts in the public buildings sector.

Program and Policy proposal chapter tries to provide with an actionable proposal that can utilize synergies to fill the realization gap. This chapter incorporates the process evaluation criterion developed in response section to propose a program structure and its pilot project which tries to cover the thesis by establishing a case study where the proposal of alternative set of approaches can be applied in the Public buildings EE&C market. The proposal section is further strengthened by a critique and limitations sub-section, which supports the proposal using financial and economic cash flow analysis.

Finally, the 'Way Ahead' chapter develops on how the proposed set of approaches can synthesis to further synergize the existing estimation approach and financing mechanism. It briefly elaborates on how this could be done in future researches and which data is required for such analysis. This new set of approaches then form a counter narrative of 'exploring synergies' to individual technological, economic and social narratives prevalent within current approaches. The proposed set of approaches along with the counter narrative is considered the best mix to fill the realization gap under investigation.

Table 3: Research Design Questions

	Question	**Addressed within Thesis Chapter:**
1	Investigation of Realization gap with the objective of critiquing prevalent approaches in the context of filling this gap.	Analysis
2	Why is it must to change the direction of current approaches?	Discussion
3	What is the counter proposal and how does it change the direction on both process and impact level to fill our realization gap?	Response
4	How can the proposal be applied?	Response and Program and Policy Proposals
5	How does the new proposal change the direction of current approaches in filling the realization gap?	Way Ahead

3.3 Methodology

Qualitative data analysis of reports, standards, government regulations, interviews, academia, and industry published literature has been utilized. Furthermore, the related data and other specific information were obtained from program administrators and managers of the respective programs. All this was done for the case of Process Evaluation Criterion development.

On conceptual level, systems' approach was followed. Systems' perspective helped us in exploring synergies within approaches of 'estimation, financing, implementation and evaluation'. Stakeholder engagement has been added within the systems approach for all parts of this thesis to be more inclusive. The systems' perspective also helped us in viewing the problem statement within project management lifecycle. It helped bridging the gap between engineering, economic, financial, contracting disciplines for an interdisciplinary problem.

CHAPTER 4

ANALYSIS

Thesis has been analyzed in two dimensions; impact level analysis and process level analysis. The identified realization gap is an impact assessment output where the focus is mainly on Measurement and Verification (M&V), to establish whether the estimated savings have been realized or not. The investigation of the realization gap is done by reviewing prevalent 'estimation, financial, implementation and evaluation' approaches as mentioned in the research design.

As mentioned earlier, analysis section of this thesis treat the realization gap as an output of impact evaluation and then investigate in the context of policy interventions to analyze previous and current narratives in EE&C buildings' industry. Realization Gap is then investigated within process evaluation context to analyze synergies in between.

4.1 Impact Level Analysis

Impact level analysis attempts at answering the research question of where the current as well as previous solutions for filling the realization gap leads to?

The timeline method, utilized in literature review, helps in better understanding the EE&C market segment and analyzing future possible interventions. This timeline has been presented with the intention of readers able understand clearly, where we are today, and how have we gotten here in the M&V world of EE&C. Intentionally, the subjectivity of the timeline is broadened for the sole purpose of presenting the 'narratives' and its 'gap'. Furthermore, this timeline has been utilized in Table 6, at the end of this section.

Early 1970's to 1990's, the utility bill comparison approach was incorporated with statistical adjustment. Later on, it was referred to as the whole-facility approach, and IPMVP option C. The industry first answered by using evaluation methodologies of regression and then by developing retrofit isolation methods. These methods remain preferred as the industry pushed to reduce M&V costs.

1990's – 2010 subdivided into 2 periods, 1990-1997 and 1997-2010's, is the categorized period which led to the establishment of 'recent trends' in M&V world. The first period, 1990-1997, follows a more concentric and continuous approach within EE&C projects, and remained at the forefront throughout the establishing of IPMVP to include best practices available. This time-period also remains as the building performance gap narrative period. The next period of 1997-2010 remained at the forefront with respect to technology solution narrative. Technological interventions, evaluation methodologies (market, process and impact), and behavioral modifications remained at the center-stage in EE&C efforts. 2010 marks the milestone of translating IPMVP and the access to standardization in 12 languages. However, it only formalized the approach, but remained flexible and feeble in structure, to address the performance gap.

2010 - onwards remain the recent trend with data driven and technology centered solutions at forefront. It might be the time to revisit the whole performance gap narrative and its technologically driven solutions. Similarly, guaranteed savings approach to mitigate financier confidence gap also needs to be redesigned.

The narrative of this timeline is elaborated in the Appendix B.

4.1.1 Policy Interventions in the Context of Realization Gap

In order to show the trends forming into current and previous narratives linked with our defined realization gap, market and policy trends needed to be analyzed (Mills et al. 2006; "ICP" 2017; Aghemo et al. 2013; Grueneich 2015). While considering market trends, a broader approach towards the 'realization gap', independent of public, commercial and residential buildings, has been adopted. Whereas for considering policy trends, an even more focused approach was adopted for public building market segment. Moreover, the realization gap needs to be understood in the context of changing technology (Grueneich 2015; Kailas, Cecchi, and Mukherjee 2012) and particularly evolving grid (Gellings 2009; Coll-Mayor, Paget, and Lightner 2007).

This broader approach also helps in linking the current policy trends with our initially illustrated M&V Timeline in Table 2. Additionally, it helps us in understanding that M&V utilization and confidence is still growing. One can analyze from this timeline that it is still a newly accepted M&V mechanism and approach after decades of faltering confidence on energy efficiency itself.

4.1.1.1 Federal Approach in the Context of Realization Gap

It is to be noted here in the context of M&V utilization for public buildings segment that, FEMP does not require uncertainty calculations in estimating energy savings. Uncertainty is referred to as one of the major reasons for variation in EE&C projects in public buildings. However, M&V is required in phase 3, phase 4, and phase 5 of the ESPC procurement process as per the Office of Energy Efficiency & Renewable Energy (Webster et al. 2015). In the similar way, Realization gap can be viewed as a diagnostic/conflict resolution tool for this market segment. Another aspect to be noted is that even the utilization of EM&V as a diagnostic/conflict resolution tool

can be hampered if costs of M&V are higher than the non-compliance costs for federal buildings segment (Schiller, Goldman, and Galawish 2011, 26).

4.1.1.2 State-level Approach in the Context of Realization Gap

In the context of realization gap, a review of the literature on how different states in USA have approached in filling this gap, shows implicitly that different requirements of reporting hampers in filling the realization gap. It establishes that a great deal of diversity exists in how states are approaching this issue. At one end, nearly a quarter of states simply report gross savings. Another larger segment, probably the majority, nominally report net savings, but with a simplistic approach (often just using deemed net-to-gross ratios). Finally, a small number of states have pursued more complex approaches to measuring net savings, including spillover and in some cases, broader market effects (Kushler, Nowak, and Witte 2014).

4.1.2 Realization Gap in the Context of Financing

Continuing our discussion on the policy trends, M&V as a financing tool in the commercial and residential EE&C projects, serves two ways. It reduces the EM&V gap in a much better manner than public buildings market segment (Baden et al. 2006). Moreover, it accelerates the efforts towards attaining climate action goals by attracting financing and investment (G. H. Kats, Rosenfeld, and Mcgaraghan 1997). This concept as a financing tool is reflected in the current upgradations of EPS contracting [15] ("Energy Savings Performance Contracting, Department of Energy" 2017) from only

[15] US DOE Energy Savings Performance Contracting https://energy.gov/eere/slsc/energy-savings-performance-contracting

using the regulatory frameworks of ESCOs to directly attaining investments through public-private partnerships (Coit 2017). However, these interventions (legislations, contractual enforcement) ensure the utilization of M&V and also pose certain gaps. Guaranteed savings in this perspective is viewed as a hurdle, a gap, and a pre-requisite for attaining financing as explained earlier.

After elaborating various policy interventions in the context of realization gap, M&V and EM&V (Evaluation, Measurement and Verification) are the current solutions provided by the current approaches. M&V and EM&V is used as a Reporting/Disclosure Tool or as a Financing/Contractual Tool. On state-level, evaluation is done for programs rather than projects. Additionally, diversity in reporting requirements, as discussed earlier, acts as a challenge in determining the realization gap. On federal-level, although, reporting remains much more project oriented, yet, these reports are rarely with uncertainty calculations. This is complimented by the issue of M&V costs to non-compliance costs ratio which further discourages the effective evaluation for the ESCO or utility in EE&C projects.

Secondly M&V and EM&V is used as a financing and contracting tool with similar dynamics of ESPC at federal level. Within the context of ESPC, Guaranteed Savings is viewed as a hurdle, pre-requisite for attaining financing. It underestimates the EE&V potential as well as undermine confidence. Literature is filled with opposite perspective.

4.1.3 Reasons for the Realization Gap

Only the utilization of M&V and EM&V can be referred to as the utilization gap within our defined realization gap. This utilization gap can be reduced by

undertaking current evaluation approaches. However, based on the literature, market trends, and our defined realization gap, following are the general reasons identified:

1. Novelty/Little Knowledge
2. High Costs
3. Disincentive to use M&V

Newness and little knowledge as a reason is understandable but continues to erode its importance with time as a reason for filling this gap. This can also be established using the timeline provided in Table 1. For the cost element; market and policy trends continue to target this gap. However, the incentive or disincentive to use evaluation in the form of M&V or EM&V remains unaddressed and form the basis for next chapter.

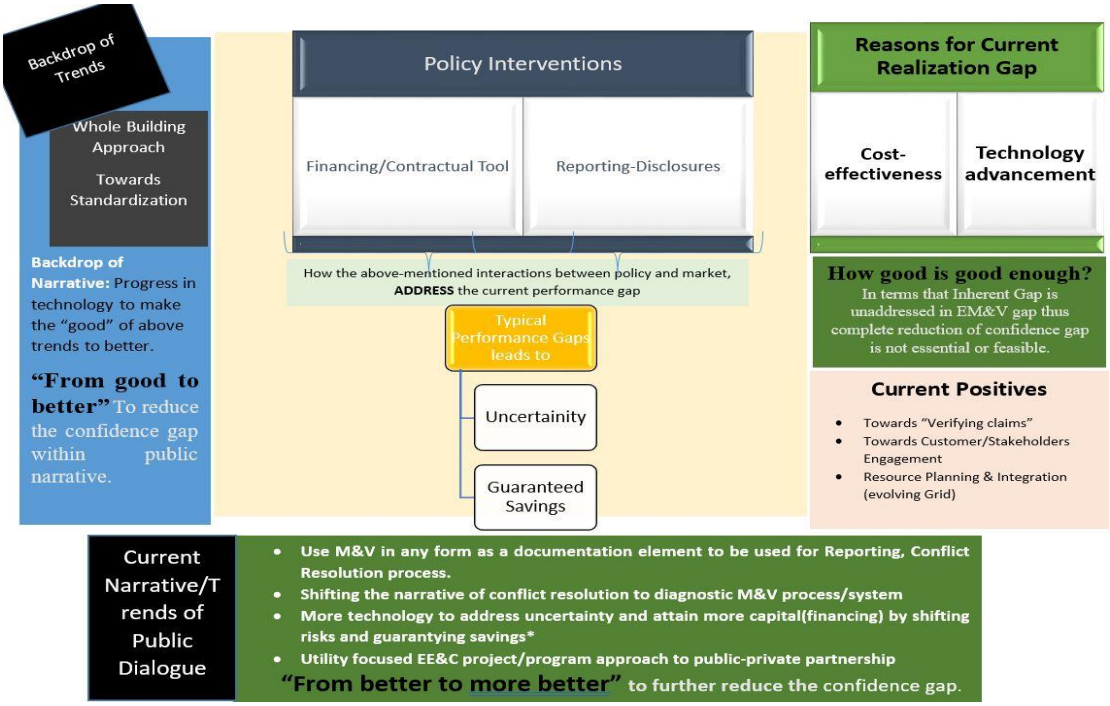

Figure 3: Previous & Current Narratives while filling the Realization Gap

4.1.4 Limitations of the Realization gap in the Context of Recent Trends

The question about incentive can be viewed in two different ways.

1- Using M&V as a requirement or a financing tool, or both;

2- Use direct incentive for conducting M&V or utilize M&V for incentive distribution

The utilization of M&V remains a requirement of 'verifying claims' as explained in the ACEEE report. It forms the basis of policy interventions by the government for EE&C projects to increase utilization (Kushler, Nowak, and Witte 2014, 29–30). However, the requirement of verifying claims does not translate into incentive for stakeholders involved in the process. Therefore, this 'incentive to use M&V' represents a growing gap between the advances that the evaluation industry has been making towards the more sophisticated methods for estimating factors such as spillover and market effects, and the actual approaches that state regulators are taking on this issue (Kushler, Nowak, and Witte 2014, 29). Hence, the utilization rate for even the cost-effective technology options for conducting EM&V, tends to be low, since it is not mandatory within public buildings.

For illustrative purposes, these recent trends (policy interventions) have been analyzed to see how they address the Realization or performance gaps. This 'disincentiveness' represents the reason of not filling the realization gap in spite of policy interventions. It will, therefore, remain at forefront in the Response section. After covering the various dimensions about the research question of how do the current approaches fill the realization gap, it is considered prudent to briefly mention why the direction opted by the current approaches do not solve the problem statement of

realization gap. Why the direction employed by prevalent approaches not able to fill this gap.

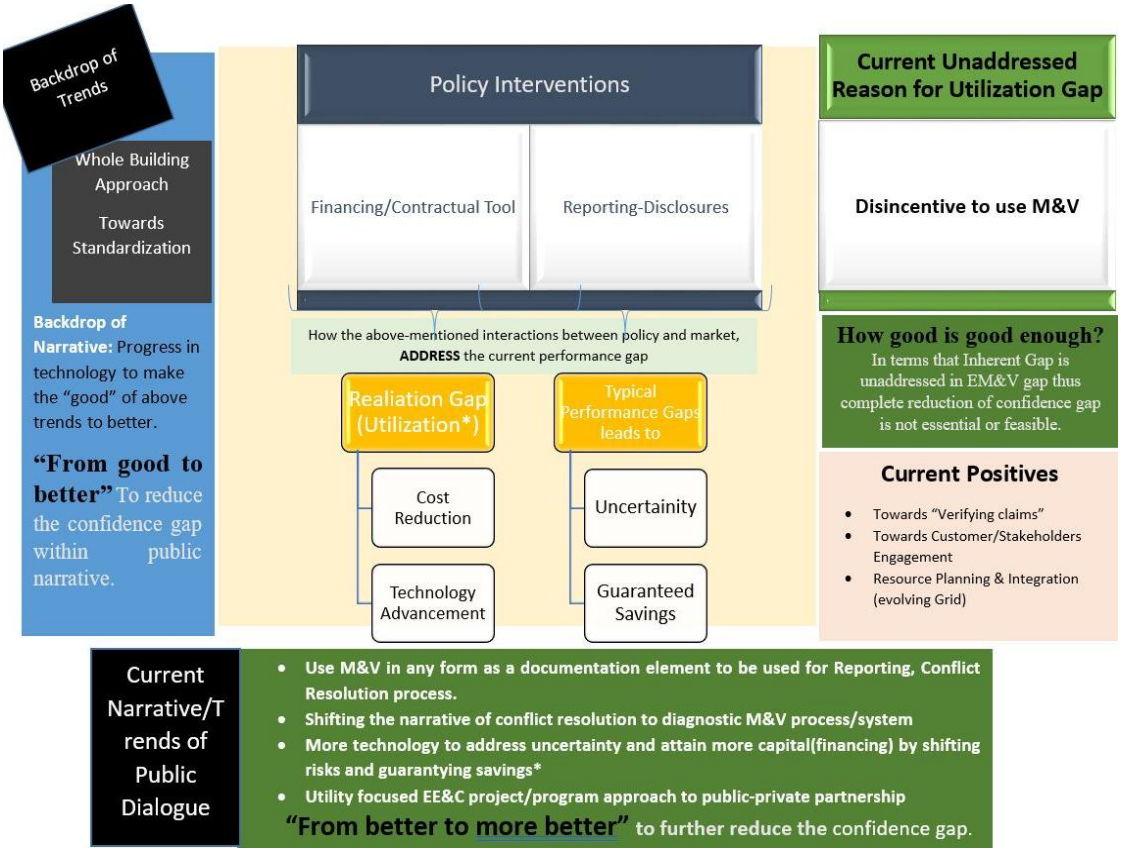

Figure 4: Previous & Current Narratives with unaddressed reason for Realization Gap

4.1.5 Why is the direction employed by prevalent approaches unable to fill the realization gap?

From our analysis of narrative solutions within the EE&C industry from previous to current trends; we are able to point out certain traits of the current narratives and approaches.

- Silver bullet solutions approach from the individual disciplines of evaluation, financial, contractual or data driven industries are technology centered solutions
- Inherent confidence gap due to established guaranteed savings approach within ESPC system.
- Risk shifting rather than opportunity creating approaches are employed to counter variance and variability within EE&C efforts.
- Less human involvement preferred within the measurement and verification system of the EE&C project.

4.1.6 Concluding Remarks

It is to be noted that far more literature available on advocating and using technology interventions for closing the Realization gap is present than on reducing or managing the cost. The same can be said for performance gap and its related uncertainty elements. Comparably, far less research has been conducted to qualitatively and quantitatively analyze the 'Inherent Realization Gap'. The 'Inherent Realization Gap' is the opposite of "Utilization Realization Gap" since it cannot be filled using current M&V and EM&V approaches, only. This concept has been further developed in the Impact-level Response. Only the utilization of M&V and EM&V is considered for our analysis of realization gap and therefore can be referred to as 'Utilization Gap' within defined realization gap.

The narrative perspective of M&V timeline is an attempt to view the engineering problem of Realization gap from a policy and narrative perspective. This summarizes the diverse and complicated elements related to our problem statement of Realization gap within Public Buildings.

Public Discourse/Public Dialogue needs to be understood in the backdrop of previous and current narratives/trends. The narratives of past and present provide the Launchpad for understanding the question of 'How good is good enough in the EM&V world?' They also provide the basis for our Summary Table.

Apart from this, these narratives have been used as a contextual background to understand the interactions between policy and market interventions. The policy interventions in the backdrop of these narratives interact with each other to answer or address the Realization or Performance gaps in different ways. The interactions between them are viewed as interdependent where one can incite the other element since only categorization is different. However, the categorization of Realization gap specifically will help us in establishing how differently it portrays the question than other typical gaps. It is to be noted again that only the utilization gap of realization gap has been used in the summary table for simplification. The categorization of Realization gap remains the objective of Impact-level Response section of the thesis.

4.2 Process Level Analysis

Previously, realization gap was considered as an output of impact evaluation and then was investigated within policy interventions and recent trends. Here, process level analysis tries to identify the reasons for realization gap from process evaluation perspective.

The primary objective of including process-level analysis is to explore synergies within prevalent evaluation approaches and linking with our impact-level analysis. Therefore, process level analysis tries to investigate a holistic and inclusive process evaluation criterion within prevalent process evaluation approaches that can be applied

to different process evaluations of the same or different market segments of EE&C efforts.

From the research design perspective, this section tries to answer the research question of what do the current approaches of process evaluation offer for filling this realization gap? This has been briefly discussed in the following heading.

4.2.1 Strengths & Challenges within the Literature

Studies (Pacific Corp 2011, 25; EverGreen Economics 2017; K. L. Palmer, Walls, and Hayes 2015) as well as evaluation frameworks and protocols (The TecMarket Works Team 2004; Peters and McRae 2009) on process evaluations should be praised for their thoroughness and applicability for their use by program administrators. Process evaluation have therefore been designed to primarily facilitate the program administrator from a project and program management perspective.

However, process-level evaluations, investigations and protocols tend to consider the flexibility and judgment in accommodating the prerogative of the program administrators as they typically decide on evaluation parameters as well as on the need of process level evaluation at the first place. Similarly, these evaluations are often unpublished or underreported in the literature and focused upon narrowly on program to program basis (Peters and McRae 2009, 1; Apmong and McDowell 2016).

One of the challenges of process-level analysis for general buildings as well as for public buildings market segment, is that primary methodology for process evaluations involves stakeholders' interviews. Utilizing interviews provides the best practices and approaches in steering the program to achieve its objectives (Peters and McRae 2009).

This methodology does helps in identifying the key stakeholders which is further utilized in Chapter 5 and 6. However, this current methodology does not help in using holistic parameters or process evaluation criterion for the same or different market segments within buildings portfolios. Therefore, the purpose of process level analysis is to propose a holistic and inclusive process evaluation criterion that can be applied to different process evaluations of the same or different market segments. This purpose has been translated into macroscopic analysis for this chapter and renders useful results.

4.2.2 Why the direction employed by prevalent approaches, unable to fill this gap?

Interviews of stakeholders and the current goals of process evaluations, in general, do not align with our process level analysis goals of exploring synergies. The current thesis systems' approach cannot be utilized directly since process evaluation differs enormously due to different program objectives of each program. Therefore, the direction is not catalytic for synergies due to following reasons:

- Unable to be inclusive for even process evaluations of same type of programs due to diversity among the interviews of the stakeholders.
- Unless the above pre-requisite is completed, it is unable to link the output of impact evaluation (realization gap) with process evaluation for a broader policy discussion.

4.3 Discussion

The discussion follows the research question of why is it needed to change the direction on impact and process level. On an impact-level, categorization of realization gap as utilization and inherent gap, calls for detailed categorization of the realization gap to understand it better and then fill it. Likewise, the unaddressed reason of

disincentive of using M&V needs to be incorporated in any set of proposed approaches. In other words, an incentive to utilize M&V must be in place for new set of approaches to be proposed.

On the process-level, to explore synergies with the impact evaluations while utilizing a systems' approach, the new direction calls for the need of a holistic and inclusive Process Evaluation Criterion (PEC). A PEC should be able to generate synergies with our categorization of realization gap. Therefore, Response section also elaborates on impact and process level, separately, following the scheme of Analysis section of this thesis. It appreciates synergies that can be explored within the impact and process level and its responses.

CHAPTER 5

RESPONSE

In the previous sections, the thesis investigates the realization gap however, in this section it proposes certain changes in the prevalent approaches on both impact and process level. The response section of the thesis answers the research questions of Which alternative set of approaches will fill the realization gap on impact and process level? And how? This is done by categorization of Realization Gap and proposing a holistic Process Evaluation Criterion (PEC). Impact level response and process level response has been segregated, following the same style as that of Analysis chapter.

5.1 Impact-Level Response

Impact level response of categorization of realization gap is an answer to how the solution narrative can be changed from impact level analysis? Ironically, the importance of energy-efficiency program evaluations is derived largely from the unfortunate reality that energy savings are extremely difficult to measure, since energy savings can never be observed directly, but only inferred (Eto et al. 1996; Kushler, Nowak, and Witte 2014). The diversity and variability of the nature of energy efficiency just adds cream to the flavor (Kaufman and Palmer 2012, 1). It can also be concurred that ‘Categorization of Realization Gap’ has remained diverse but non-holistic in nature. A holistic approach that directly establishes the original policy issues with the categorization, is not available for the public buildings segment. Correspondingly, a great deal of literature can be found in fixing this gap only on the program evaluation level with basic ingredients dependent for individual program structures (Blumstein 2003). Therefore, this chapter also adds to the growing literature for the categorization of Realization gap and how the it helps in closing this gap.

5.1.1 Categorization of Realization Gap

There are certain holistic categorization attempts in literature that typically lean towards economic, organizational, technological and behavioral categorizations of the Realization gap (Sorrell et al. 2000; Gerarden, Newell, and Stavins 2015). This categorization approach either focuses on the estimation element (Jing et al. 2017; Mihail–Bogdan, Constantin, and Horia 2016) or the verification element (Burman, Mumovic, and Kimpian 2014) of the realization gap. Thus, in application terms, it can be more categorized as a 'M&V gap' only due to the nature of it categorization.

On process evaluation parameters, studies have identified this realization gap based on variance in approaches of calculating EE&C savings, implementation mechanism variance (whole building or technology type) or/and as failure to account for market transformation (National Academy of Sciences (U.S.) 2010, 9).

A categorization analogous to our intention, includes 'deployment times approach'(National Academy of Sciences (U.S.) 2010) used by AEF Panel on Energy Efficient technologies. Others have used the 'barrier approach' while classifying the reasons (not the gap itself) as occupant behavior, uncertainty and poor operational practices etc. (van Dronkelaar et al. 2016). Similarly, categorization of proposals for reducing uncertainty with respect to what is easily quantifiable and what is much harder, has been established. For example, modeling inputs, may be more quantifiable, while other uncertainties related to occupancy or the cost of energy might be much harder to accurately quantify[16].

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[16] Uncertainty and Risk in Energy Efficiency

http://www.eeperformance.org/blog/uncertainty-and-risk-in-energy-efficiency

The Realization Gap has been segregated for this paper based on what is actionable currently and what can be actionable in future. This segregation is based on the intention to have an emphasis including each element of the Realization gap as well as its relationship with our initial policy actions. The basis for categorization are following two actionable items.

1. Actionable Currently:

   It represents the utilization gap of accepted and established best practices (IPMVP) with focus on cost and technology.

2. Actionable in Future:

   It represents the inherent gap that will remain for foreseeable future until a synergic approach towards technological, social, process, behavioral and organizational barriers of EM&V gap is synthesized. The gap may only be reduced and not eliminated.

a) Utilization Gap
   - Technology/Cost gap in utilization of current EM&V processes and approaches.
   - Other avoidable barriers (actionable) for a specific project also rests under the utilization gap for this paper.

b) Inherent gap
   - Occupant behavior
   - Estimator's assumptions including but not limited to weather related variance

Other unavoidable barriers for a specific project also rests under the inherent gap for this paper. See illustration in Figure 5: Conceptual Categorization of EM&V Gap.

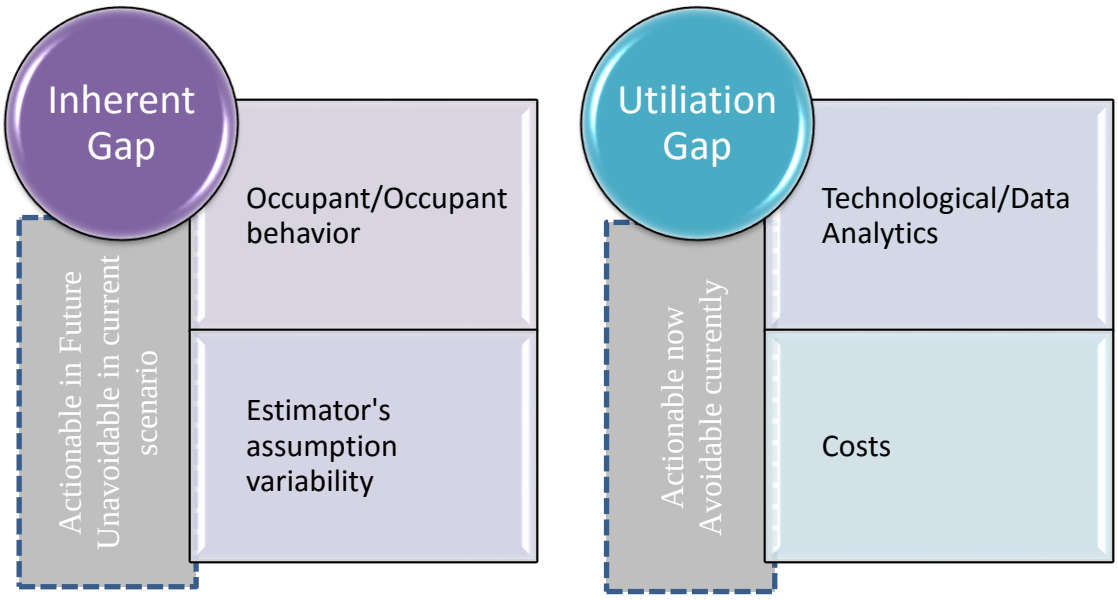

Figure 5: Conceptual Categorization of EM&V Gap

5.1.2 Inherent Gap

This heading provides one of the basis for the Chapter 7 'Way Ahead' and therefore is explained briefly to provide a Launchpad for Chapter 7.

All those gaps or risks or variances that are unavoidable within the accepted and established M&V (Efficiency Valuation Organisation 2012) frameworks fall under this category.

5.1.2.1 Behavioral Variability Gap / Barrier

It is logical to link any variability with uncertainty and then quantitatively propose solutions accordingly. Therefore, typically studies acknowledge behavior variability as a subset of uncertainty (Loper et al. 2010), and therefore, present technological or data solutions backed with empirical evidence (Mathew, Koehling, and

Kumar 2006). In this context, occupancy variability and occupant behavior needs to be defined separately. This may serve as a tool in analyzing and quantifying this behavioral variability element of realization gap for further research purposes.

1. Occupancy Variance

Typically, literature deals with this gap/variance by correlating occupancy patterns to energy use. Then predicting occupancy pattern for different type of buildings including but not limited to office, commercial and residential buildings etc. (Hong and Lin 2013; Branco et al. 2004; Stern 2007).

It is usually treated as a whole-building approach and pronounced as a collective phenomenon. It is established and defined through scheduling 'heating, cooling, lighting and other major equipment load' of the building, depending on occupancy levels. Variation of energy with respect to its inhabitants is the intersecting link between this occupancy-variability gap and Realization gap. It is to be noted that it does not fall under the behavior variability classification on a classical definition. However, the narrative presented here is that the occupancy variability also represents the behavior of the building under external and internal interventions.

This variability parameter helps in establishing certain occupancy characteristics to certain building types. Literature on correlating occupancy patterns to energy use and then predicting occupancy pattern, exists for different type of buildings, including but not limited to office (Hong and Lin 2013), commercial (Labeodan et al. 2015) and educational building types (Gul and Patidar 2015).

2. Occupant Behavior Variance:

Variability of energy use at individual or personal level (Kempton and Neiman 1987), as well as its heterogeneous combination at collective level (section of a building, floor etc.), can be regarded as occupant behavior variability gap.

Typically, studies have linked this gap with economics of choice (Santin 2013) and behavior and psychology/cognitive variables (Andersen et al. 2009; Schweiker and Shukuya 2009). However, this variance is the difficult and complex to understand and infer [17]. Additionally, studies have tried to reduce the inherent gap by using data analytics as it detects, analyzes, adjusts, evaluates and then readjusts again by continuously following the occupancy patterns and occupant's behavior (Virote and Neves-Silva 2012).

Although the case presented for inherent gap tries to establish that this inherent risk continues to exist for the EE&C programs, yet, the impact evaluation reports have tried to include behavioral benefits of EE&C with different methodologies (Chiodo 2012, 5–1; Gaffney et al. 2014; Dougherty et al. 2011). This shows how diversity in approaches of framing the question can help in identifying and initiating research to reduce this inherent gap element from evaluation perspective. Furthermore, this view raises optimism for the inclusion of the inherent risk of varied occupant behavior within the project/program parameters as well. Hence, manage that risk as an opportunity. The idea has further been developed and elaborated in Chapter 6 and 7.

In the light of the above definition, the heterogeneity of occupants in any space needs to be acknowledged as well (Oikonomou et al. 2009), which forms the basis in 'admitting' the inherent gap in general and occupancy gap in particular.

[1717] http://www.brightpower.com/occupant-behavior/

5.1.2.2 Estimator's Assumption Gap / Barrier

Any variance due to parameters incorporated for estimation or verification of EE&C projects as 'engineering inputs, engineering assumptions, engineering best practices', being unable to accommodate actual variability, fall under this category.

This gap has been eloquently explained by the Federal Energy Management Program guidelines for M&V(Webster et al. 2015) as:

When engineering estimates are used in lieu of actual measurements, uncertainty is introduced. This uncertainty itself must often be estimated based on the expected accuracy of the estimated values. For example, the efficiency of a boiler may be estimated rather than measured directly. The estimation would be based on the type and age of the boiler, and may result in an estimated stipulation error of ± 20 % (e.g., 75 %, between 60 % and 90 %). If a building engineer who is familiar with the boiler, gives additional operational information about the boiler, the uncertainty may be less, such as ± 10 % (e.g., 75 %, between 67.5 % and 82.5 %). Although these examples highlight the equipment-efficiency basis, the idea is to show that building, as a complex integration of these systems, include further assumption variability.

Similarly, at implementation level, evaluation or M&V practitioners decide what approaches to use for a certain energy efficiency activity, based on their own experience and perceptions of budget, needs for certainty, data availability, schedules, program characteristics and other factors. In effect, it is the practitioner's experience that guides many EM&V decisions rather than actual protocols (Schiller, Goldman, and Galawish 2011, 27).

Analysis of the literature related to this barrier, indicates it as one of the most emphasized barrier in impact evaluations for EE&C project and programs (Blanchar et al. 2012, 2.8). This gap needs to be understood because of its nomenclature used in this

paper. It can be categorized into two types of common assumptions that incorporate the 'uncertainty' within the Realization gap. Additionally, this categorization is linked with the whole-facility approach so to drive actionable research.

1. Assumptions within facility/technology/measurement boundary

It includes operational-variability related assumptions of the facility/technology and usually is categorized within the measurement boundary of M&V approach.

Examples include from a micro-scale like 'selecting coefficient of performance (COP) for a single EE recommendation' to macro-scale like 'facility hours' selection' or using prescribed ASHRAE winter/summer heating/cooling penalties for ventilation'.

2. Assumptions outside the physical boundaries of facility/technology

These assumptions are typically termed as weather related assumptions but they also include CDDs/HDDs/RH/Light Intensity etc. calculations (based on previous practices or modeling projection). They are explicitly or implicitly dependent upon outside conditions, typically weather.

5.1.2.3 Categorization Remarks

A category is dynamic in nature. It can either include or exclude certain subsets or transfer them to the 'utilization gap' when/once they are available, accepted and established. It can also work in reverse, under certain external/internal interventions, where a technology advancement may transfer the currently defined inherent gap of behavior to be actionable and is also part of the current trends in EM&V. This property of the realization gap make this categorization independent of market transformation. Other remarks related to the subject matter include:

1. The assumptions made above may or may not include inputs to Option D (Efficiency Valuation Organisation 2012) approach of IPMVP (calibrated simulations).
2. These assumptions may or may not include engineering best practices, energy auditor observations, and weather related variance etc.
3. Inherently the categorization attempts to attribute the reason of the gap mainly to the 'energy analyst' (human influence) who uses certain assumptions which have variance on the actual facility/technology and 'outside facility related parameters'.

Although these remarks could be classified as being able to be addressed by technology/cost elements yet they are inherently related to the human understanding, capacity and competence to infer.

5.1.3 Utilization Gap

Utilizing the literature reviewed, I have defined the utilization gap as All those gaps, risks or variances, that are avoidable while 'utilizing' the accepted and established M&V (Efficiency Valuation Organisation 2012) frameworks, fall under this category.

This gap or categorization has been referred to as 'opportunity-specific barriers' in the Energy Efficiency Gap report by McKinsey in a holistic manner (Granade et al. 2009).

5.1.3.1 Technology Gap / Barrier

Technology gap, mostly referred as 'performance gap' is the most well researched and analyzed element of this Realization gap. Significant advances have been made in adjusting the predicted performance with behavior of building on a

continuous basis with modeling, calibration and data analytics (van Dronkelaar et al. 2016, 2; Grueneich 2015). The narrative of this branch of research is the longitudinal perspective (Burman, Mumovic, and Kimpian 2014) of changes in the building lifecycle. Thus, it addresses the longitudinal variability of operation within the building lifecycle (van Dronkelaar et al. 2016, 8).

Terminology of this gap needs to be understood in the context of presenting or viewing this gap and its problem as a 'performance element'. Implicitly, it does not include inherent gap as a narrative and thus present technology centered solutions as a narrative while only catering the utilization gap. Although significant advancement in technological solutions has been made, yet the narrative, and how we frame the question and categorize the problem, needs to be appreciated.

In this and following paragraph we specifically discuss the technology gap in the context of our scope. This technology gap is especially important in the perspective of our scope of 'public buildings'. When no significant retrofits on building envelope or plants can be done, savings can be achieved by designing intelligent Information and Communications technology (ICT)-based service, to monitor and control environmental conditions, energy loads and plants operation (Aghemo et al. 2013). This development opens doors for transformation of this market segment.

In existing federal buildings (not public buildings), calculating uncertainty in the estimated savings is not required (Webster et al. 2015, 5–4). This is mentioned in the FEMP document just after the M&V costs which shows the implicit dynamic inter-relation between technology and costs within Realization gap. Similarly, the advances in technology can counter for its more utilization by reducing the cost element.

In this and following paragraph we specifically discuss the link between technology and estimator's assumption gap earlier highlighted in this section. This established literature has already shifted the previous static performance gap to dynamic performance gap. However, it reduces the estimator's prerogative for assumption in the operating condition elements of the estimation only (van Dronkelaar et al. 2016).

Furthermore, it can be inferred from the knowledge above, how the solutions from utilization gap affect the inherent gap and its associated barriers, which further leads to appreciation of proposed categorization for its inclusive nature.

5.1.3.2 Cost Gap / Barrier

Perhaps one of the most logically actionable items for closing some part of the Realization gap, is making the M&V process cost-effective. This is by far the most important barrier, but needs to be understood in the macroscopic perspective of a 'utilization gap'. An estimation puts the overall annual M&V costs at 2 % to 5 % of a typical annual project cost savings (Webster et al. 2015, 5–4). However, the costs of EM&V as mentioned for DESEU non-profit and government audit program remain at 30 %. This is included in the 6th Chapter.

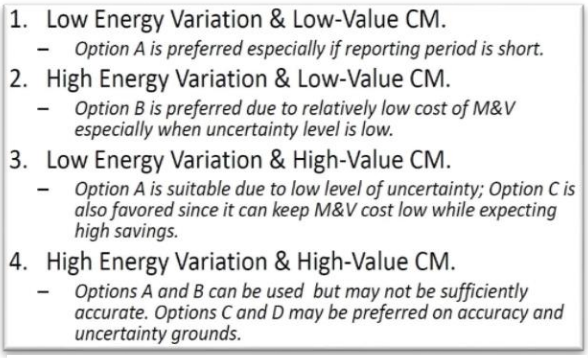
1. Low Energy Variation & Low-Value CM.
   - *Option A is preferred especially if reporting period is short.*
2. High Energy Variation & Low-Value CM.
   - *Option B is preferred due to relatively low cost of M&V especially when uncertainty level is low.*
3. Low Energy Variation & High-Value CM.
   - *Option A is suitable due to low level of uncertainty; Option C is also favored since it can keep M&V cost low while expecting high savings.*
4. High Energy Variation & High-Value CM.
   - *Options A and B can be used but may not be sufficiently accurate. Options C and D may be preferred on accuracy and uncertainty grounds.*

Figure 6: Guidelines for balancing uncertainty and costs

Option A	Fewer measurement points; simpler method of estimation; lower cost and higher uncertainty than B.
Option B	Length of the reporting period longer than A.
Option C	Less costly for long reporting periods and when multiple CMs are installed at one site.
Option D	Time-consuming and costly; but provides highly accurate estimates and is appropriate when designing complex retrofits.

Figure 7: Comparison of M&V costs w.r.t. M&V

One can link this gap with technology gap under various settings, as it keeps banking on the advances of technology to reduce it. It also holds true for the recent trend of managing risks and uncertainty for EE&C projects as part of the technology-gap narrative. The narrative is further coupled with;

- Process level best practices in selecting M&V approaches (Taminiau et al. 2017).
- Market-level approaches of energy savings insurance (Mills 2003) , mortgage financing (Sanderford et al. 2015), cost allocation and investor confidence enhancement [18] (Mills et al. 2006).

However, the narrative introduced above needs to be viewed in terms of market trends which were discussed in previous chapters. It is to be noted in the perspective of public buildings, as per FEMP (Webster et al. 2015), and as per the finding of this paper, that unfortunately, there is no easy way to define the cost-effectiveness at this point, and one must rely upon judgment and experience to determine what is cost-effective and what is not. This interpretation holds true generally for buildings.

Certain cost-effective measures within the EM&V gap are also depicted in Figure 6 and Figure 7 (Taminiau et al. 2017) which also forms the analysis for our categorization of the Realization gap.

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[18] Investor Confidence Project of Environmental Defense Fund. http://www.eeperformance.org/

5.1.4 Remarks on Realization Gap and its Categorization for Addressing Problem Statement of the Thesis

The utilization gap advocates on a macro-perspective where technological advances and cost reduction is the current way forward to fill this gap. The advocacy overshadows the inherent gap as part of realization gap problem and thus aims for silver bullet solutions of technology.

It can be argued with respect to the use of M&V in public buildings, that an attempt to quantify uncertainty, will only be utilized if it is cost-effective. For the same market segment, one can infer that the real value may lie in simply identifying the categorization of/within Realization gap and then link each one to different type of uncertainty since it is already worked upon. This linkage should then be followed by qualifying their unique as well as shared risks, and developing approaches or methods, to address these areas and to reduce the uncertainty associated with them.

5.1.5 Concluding Remarks for Impact Level Analysis

It is to be noted that more literature available on advocating and using technology interventions for closing the Realization gaps is present than on reducing or managing the cost. The same can be said for performance gap and its related uncertainty elements. Comparably, far less research has been conducted to qualitatively and quantitatively analyze the 'Inherent Realization Gap'. However, the categorization of EM&V gap specifically helps us in establishing how differently it portrays the question than other typical gaps.

Few recommendations at the end of our impact level response are thus included below.

- It is highly recommended for immediate action to use the available & accepted cost-effective M&V systems or to adopt one's program towards low cost M&V

options. Not to mention that the cost component in utilization of M&V is currently the most actionable way in accelerating the use of M&V systems.

- It is highly recommended to accept, establish and analyze the inherent gap. Similarly, the use of technology as a silver bullet solution for closing these gaps needs to be thoroughly reviewed.
- It is suggested that different M&V approaches based on behavior/occupancy, technology, end-use and whole-building etc. on the availability of technology and lowest cost, should be opted due to different program structures of such approach based programs.
- Program structures flexibility to accommodate for market transformation and market trends needs to be analyzed.
- The utilization gap can be effectively reduced if performance based program structures align with the performance based incentives and EE&C programs. This alignment is viewed to be a synergic effort in reducing the utilization gap of our EM&V problem statement.

5.2 Process Level Response

As discussed earlier, this section tries to provide with a proposed process evaluation criterion, based on the strengths and challenges within the process evaluation diversity. It tries to come up with three criteria or basic ingredients that should be included within a process evaluation. These three criteria are then applied to a single page form which is then filled by the program administrators directly.

5.2.1 Process Evaluation Criteria

The methodology of selecting process evaluation criteria is based on the following two points:

1. Criteria or parameters that can accommodate the diversity of literature reviewed (interviews, evaluation reports and research papers)
2. Criteria or parameters that can link with our unaddressed issue of 'No incentive for using M&V'.

ACEEE study has focused on systems' approach to planning, conducting and funding evaluations of energy efficiency programs (Brown et al. 2005). Regarding buildings and facilities, analogous systems' approaches have been utilized and studied (Gabbar, Musharavati, and Pokharel 2014). Similar approaches like 'theory based policy evaluations' use the whole design and implementation cycle and thus can be regarded as an analogous holistic approach on the same grounds [19] (Khan et al. 2007). Utilizing a similar 'systems approach' in the context of project management, reviewed literature tends to point towards few basic ingredients that can be found in every EE&C program/project. These ingredients have been discussed in detail below.

5.2.1.1 Financing or Flow of Capital

Issues related to capital, finance, budget and allocation, constitute the first ingredient that can be found in the majority of the process evaluations (SBW Consulting 2013, iv) and are also listed in policy evaluations (Harmelink, Nilsson, and Harmsen

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[19] Towards Effective NAMAs'
http://www.sqconsult.com/content/newsletter_html/SQ_Towards_effective_NAMAs_tapping_knowledge_from_policy_evaluation.html

2008, 137). This ingredient needs to be understood within the context of financing being partially or heavily dependent on single source of tax payers' money for related programs. In other cases, financing and its execution is typically utility (ESCO model) driven, whereas utilities derive half of their revenues from this market (Kim et al. 2012, 5). This ingredient is one of the most powerful in establishing the influence of stakeholders for the life of project or program and can be linked from confidence gap and accelerating climate action goals to stakeholder participation and 'guaranteed savings' issue.

It is considered prudent to mention here that 'guaranteed saving' are not part of (or included in) the Realization gap, but, the categorization of guaranteed savings as a concept is linked with EPS contracts. This 'guaranteed saving', being viewed as a hurdle for this paper, wherein the financier (ESCO, Utility or Government agency etc.) demands guaranteed savings to invest in project. Otherwise, the financier could be the energy consumer and the ESCO provides the financier with guarantee savings. However, the concept and the demand of guaranteed savings inherently represent the confidence gap from the investing party. To provide guaranteed savings, EE&C savings estimation tend to be underestimated, to remain on the safe side. Additionally, if a party is unable to guarantee savings, securing financing becomes a bigger challenge (Research Into Action, Inc 2015, 88). In contrast, guaranteed savings ensure M&V utilization either as a diagnostic or conflict resolution tool. In addition, they also lower the cost of borrowing while ensuring focus on M&V within the contract as well as part of the whole project lifecycle (Stetz, Webster, and Bradford 2001).

5.2.1.2 Distribution of Benefits

This ingredient investigates how the benefits of EE&C projects or programs are distributed among stakeholders and communities in general. It can also be found in majority of the process evaluations, while discussing cost, energy, environmental, and societal benefits and their effective delivery (Peters et al. 2008; ACEEE 2014). With reference to our scope of public buildings segment, utilities remain one of the major stakeholder in delivering programs (Peters and McRae 2009, 17).

Another advantage of using this ingredient is the inclusion of the 'stakeholder's element' within the EE&C projects or programs. The role of the stakeholders' engagement is highlighted by most of the process evaluations (Research Into Action, Inc 2016). This ingredient investigates and poses questions related to distribution of benefits among stakeholders in the context of the financing party. This instrument helps us in formulating the question of disincentive to utilize M&V among stakeholders within the context of distribution of benefits.

5.2.1.3 Organization/Management / Program Structure

Distribution of benefits primarily investigates what is the story of a program, detailing what a program is going to do, and how the organizational structure supports that process. Typically, it deals with the program structure and the issues related to the management of the program (Peters and McRae 2009, 24–26). Forms of market transformations and evaluations are also included within this ingredient, considering the dynamics of EE&C in buildings (The TecMarket Works Team 2006, 29). A unique element within few process level evaluations tend to advocate a program of 'one-stop shop or single program implementer'(Drake et al. 2014; Johnson 2013). This also links with benefits distribution and their awareness by a single program implementer.

It is to be noted that this process evaluation criterion's ingredient appreciates the synergic approach of one-stop shop or single program implementer, yet does not advocate its supremacy. Program objectives and their transformation within market transformation remain the driving force behind program structure basis. Based on the above process evaluation criterion and its three ingredients, a questionnaire in the form of a Table 5 has been developed to illustrate how the programs can be investigated under this approach and which relevant questions do the evaluators need to ask. Similarly, the two tables (Table 6 and Table 7), illustrate the objective answers for the two different EE&C programs in the Public Buildings segment. Brief details about the program and basis of their inclusion in the paper is elaborated after Table 5.

Table 4: Process Evaluation Criteria and Basis for Investigation

Process Evaluation Criteria (PEC)	Process-level Analysis: Energy Efficiency in Buildings (Projects/Programs)
P.E Ingredient	**Questions to ask: Terms of Reference (TOR) for Investigation**
Financing / Flow of Capital	• How much financing/capital flow is diversified? • How are the budgets linked to the targets/goals? • Either capital flow or financing is linked with M&V or EM&V and how?
Distribution of Benefits	• Is there any form of carrot/stick policy for meeting targeted or estimated savings or for meeting the initial set of qualitative goals? • How are the benefits/social welfare (energy and non-energy) distributed among the stakeholders? • Is there a 'one-stop shop' for distributing benefits?
Organization or / and Program Structure or / and Management Theory	• How is the technology diffusion and market transformation is linked with management theory and organization structure? • How does the management structure encourages 3rd party M&V or EM&V? • Program Structure' 'Reach' towards grass-root or local consumers/stakeholders?

Table 5: Process Evaluation Criteria and Basis for Investigation

Process Evaluation Criteria (PEC)	Process-level Analysis: Energy Efficiency in Buildings (Projects/Programs)
P.E Ingredient	**Questions to ask: Terms of Reference (TOR) for Investigation**
Financing / Flow of Capital	• How much financing/capital flow is diversified? ▪ Single or Multi Source? • How are the budgets linked to the targets/goals? ▪ Is there an existing KPI (key performance indicator) or any other indicator with this linkage? • Either capital flow or financing is linked with M&V or EM&V and how? ▪ Is there an existing KPI or any other indicator with this linkage?
Distribution of Benefits	• Is there any form of carrot/stick policy for meeting targeted or estimated savings or for meeting the initial set of qualitative goals? ▪ How rewards or its equivalent 'opposite' is distributed (Are both included) among stakeholders? ▪ What is the incentive of utilizing M&V among stakeholders? • How the benefits/social welfare (energy and non-energy) distributed among the stakeholders? ▪ Framing the question in context of not only community but stakeholders that are involved. • Is there a 'one-stop shop' for distributing benefits? ▪ Integrated approach for communicating and delivering benefits? ▪ For certain program needs it may not be required.

Organization or / and Program Structure or / and Management Theory	• How is the technology diffusion and market transformation is linked with management theory and organization structure? ▪ Does it include anyone of the above or both (Are both included)? • How does the management structure encourages 3rd party M&V or EM&V? ▪ How is it included in the structure or reporting requirements? • Program Structure' 'Reach' towards grass-root or local consumers/stakeholders?

5.2.2 Application of Process Evaluation Criterion

This section deals with utilizing the proposed process evaluation criterion and its ingredients as instruments to investigate. These instruments to investigate can be further divided into different questions which have been shown in a flexible manner. Applying the concept of investigation of the two individual programs are then briefly introduced in next two headings.

The foundation for applying our process evaluation criterion to these two programs is mentioned in the following two points:

1- Thesis writer has worked as a part of these two programs in different capacities.

2- Both programs represent how projects are implemented through programs within our EE&C public buildings scope.

   a. Accelerated Conservation and Efficiency Program (ACE) utilizes Multifacility, Single-Energy Conservation Measure (ECM) projects or Separated ECMs as an Implementation Mechanism.

   b. Delaware Sustainable Energy Utility (DESEU): Energy Assessment Program for Nonprofit and Government Agencies (EAPNGA)

utilizes Single-facility, Multi EE&C Measure (ECM) projects or Bundled ECMs as an Implementation Mechanism.

5.2.2.1 Accelerated Conservation and Efficiency Program (ACE)

Launched in June 2013, by New York City Department of Citywide Administrative Services (NYC DCAS), Division of Energy Management DEM, the Accelerated Conservation and Efficiency program (ACE) streamlines funding for energy capital projects. These projects are independently identified, managed, and implemented by partner City agencies. ACE encourages agency staff to identify key energy-saving projects based on their understanding of building needs. Through ACE, DCAS solicits proposals from agencies and reviews them based on energy and cost savings, greenhouse gas (GHG) reductions, and other benefits for the City. Capital funding is then allocated for selected projects.

ACE is a critical component of the City's strategy to reduce GHG emissions. Through six rounds of solicitations, ACE has allocated approximately $358 million to 16 City agencies for projects in more than 650 buildings. These projects are expected to result in GHG reductions of nearly 125,000 metric tons [20]. Projects currently funded through ACE include:

- Boiler control upgrades at over 70 schools;
- Chiller retrofit at the Queens Museum, in partnership with the Department of Cultural Affairs;
- Co-funding LED upgrades at street lighting fixtures in all five boroughs;

[20] DCAS DEM Municipal Energy Use &GHG Emissions – ACE http://www.nyc.gov/html/dem/html/Programs_and_Projects/ace.shtml

- Comprehensive energy upgrades at three hospitals and one diagnostic center.

It is to be noted that typically the is Implementation Mechanism is 'Multi-facility Single Energy Conservation Measures (ECM)' where ECM and its technology nature determines the nature of Implementation Mechanism.

The PEC has been completed by the Program Manager of ACE which is listed in Table 6.

Table 6: Application of Process Evaluation Criteria for EE&C programs

Process Evaluation Criteria (PEC)	**Process-level Analysis: NYC ACE Program Energy Efficiency in Public Buildings**
P.E Instrument	**Terms of Reference (TOR) for Investigation**
Financing / Flow of Capital	• How much financing/capital inflow is diversified? ▪ Single Source from tax payers coming out of the Mayor's Executive Budget. ▪ Encouraged to use part of agency finances as split financing however not mandatory. ▪ Also, utilize incentive funds from state and utilities when projects are eligible for such funds. • How are the budgets linked to the targets/goals? ▪ The goal of the program is to enable the City to reach the Mayor's targets of reducing GHG emissions in City government by 35% by 2025 and by 80% by 2050. The projects are expected to be cost effective and we award projects based on a comprehensive evaluation criteria that includes the project cost per MT of GHG reduction. Thus, projects will not be funded indiscriminately; they must show estimated GHG reductions that could be verified and the project should be cost effective at realizing GHG reductions. Invoices are collected and M&V is conducted to ensure savings are realized. • Either capital flow or financing linked with the M&V or EM&V and how? ▪ Only those projects are eligible to get funding that submit a M&V plan.

	▪ We now have a third-party provider that conducts the bulk of our M&V process. Agencies that are awarded funding are expected to comply with our M&V process. By not doing so, they put the project's funding and future eligibility to participate in the ACE program at risk.
Distribution of Benefits	• <u>Is there any form of carrot/stick policy for meeting targeted or estimated savings for meeting the initial set of qualitative goals?</u> ▪ Agencies are of course expected to meet their savings goals. If there is a change in scope of work that work needs to be approved by DCAS before the project may continue. If the scope of work modification is expected to reduce GHG emissions, DCAS has the right to withdraw funds from the project. ▪ If the project is completed and the GHG reductions were not realized, then future projects that the Agency proposes in the competitive funding program may be deducted points hindering chances for future awards. This is done at the discretion of the ACE Program Management. • <u>How are the benefits/social welfare (energy and non-energy) distributed among the stakeholders?</u> ▪ Energy related benefits are accrued by the NYC DCAS since it pays for the city agencies. Non-Energy benefits of low carbon emissions, improved facilities/infrastructure (such as improved street lighting) and jobs etc. are shared between community. ▪ M&V used as a reporting tool. • <u>Is there a 'one-stop shop' for distributing benefits?</u> ▪ ACE as a subset of NYC Climate action goals does not include this as a program objective. NYC Mayor's office of sustainability can be regarded as a one-stop shop for sharing and communicating benefits. ▪ DCAS is a one-stop shop for energy management of municipal buildings, whereas the Mayor's Office of

	Sustainability is the one stop shop for all of NYC's sustainability efforts.
Organization or/and Program Structure or/and Management Theory	• <u>How the technology diffusion and market transformation is linked with management theory and organization structure?</u> ▪ Not sure if this is the correct way to address this question, but in terms of organization structure, it is our energy managers and facilities directors at the respective agencies that are proposing the projects to DCAS, which as the central energy management hub for municipal operations. To help inform their project proposals, we have hired consultants to review our facilities and based on representative buildings in each building category, they have provided a list of potential projects based on feasibility, cost of implementation, energy savings, and GHG reduction. Furthermore, DCAS uses the new technology pilot program (IDEA) to test out new technologies and then share findings with the agencies. Thus, we try to support the agencies and provide resources that could help them improve their project proposals. We also encourage agencies to utilize energy efficiency reports generated from building audits and to request funds for feasibility studies to help inform project proposals. • <u>How the management structure encourages 3rd party M&V or EM&V?</u> ▪ Included in reporting and eligibility requirements for financing. • <u>Program Structure 'Reach' towards grass-root or local consumers/stakeholders?</u> ▪ Not Known? ▪ The ACE program only reaches out to our fellow City agencies with a reporting line to the Mayor's Office. It generally does not reach out to local consumers. The only caveat to that would be to share lessons learned from the program, which we provide through publications and/or conference participation/speeches. We also work with the

	utilities through their incentive programs to them achieve their energy goals.

5.2.2.2 Delaware Sustainable Energy Utility (DESEU): Energy Assessment Program for Nonprofit and Government Agencies (EAPNGA)

DESEU act as a single program implementer or one stop shop for various stakeholders in public, commercial and residential buildings sector for EE&C projects (Houck and Rickerson 2009). Only Energy Assessment Program for nonprofit and government agencies is included while applying the proposed analysis.

It is to be noted that the Implementation Mechanism is 'Single-facility Bundled Energy Conservation Measures' where facility to facility audits determine the nature of implementation mechanisms.

Through the EAPNGA, the DESEU funds energy assessments for nonresidential buildings operated by nonprofits or government agencies. The SEU partners with the University of Delaware's Industrial Assessment Center (IAC) to deliver the program. Graduate students, under the supervision of the center's directors, perform the energy assessments and identify opportunities for energy savings within the facilities. The SEU covers 90 % of the audit cost and provides information on low-interest financing options (through the Revolving Loan Program) for participants who make recommended improvements (DESEU 2017). Additional program information can be found on the program website:
http://www.energizedelaware.org/Industrial-Assessment-Program/

The PEC has been completed by the Executive Director of DESEU which is listed in Table 7.

Table 7: Application of Process Evaluation Criteria for EE&C programs

Process Evaluation Criteria (PEC)	Process-level Analysis: **DESEU EAPNGA Program** Energy Efficiency in Public Buildings
P.E Instrument	**Terms of Reference (TOR) for Investigation**
Financing / Flow of Capital	• How much financing/capital inflow is diversified? It is not diversified. The Energy Assessment Program for Non-Profits and Governments (EAPNG) is solely funded through RGGI funds. • How are the budgets linked to the targets/goals? ▪ The target goal for this program is the number of participants that we anticipated based on previous year activity. We budget based on anticipated activity. ▪ EM&V has separate budget allocation within fiscal year. • Either capital flow or financing linked with the M&V or EM&V? and how? ▪ Every program has a detailed EM&V plan, the goal for this program is to do an impact evaluation based on a sample of participants after three or four years of operations. However, impact studies of individual project (audit facility) is not done for every program.
Benefits Distribution	• Is there any form of carrot/stick policy for meeting targeted or estimated savings for meeting the initial set of qualitative goals? Post Assessment every participant meets with DESEU to discuss grants and low interest loan options that may be available incent them to move forward with recommendations • How are the benefits/social welfare (energy and non-energy) distributed among the stakeholders? ▪ Energy related benefits gets accrued by participant institutions and financing party if implemented within this program. Non-Energy benefits remain qualitatively shared between community. • Is there a 'one-stop shop' for distributing benefits?

	▪ The included program act as a subset of DESEU, which in turn act as a one-stop shop. It acts as a single program implementer as well as one-stop shop for implementing, supporting and communicating benefits.
Organization or and Program Structure or and Management Theory	• How is the technology diffusion and market transformation is linked with management theory and organization structure? ▪ You will need to better define these terms, they are very academic and mean almost nothing to the practitioner • How does the management structure encourages 3rd party M&V or EM&V? Having a very simple management structure where priorities are set by the Board and the Executive Director so both value best practices for the industry and both of these are view as best practices in the industry. • Program Structure' 'Reach' towards grass-root or local consumers/stakeholders? ▪ Through meetings, workshops, networking and marketing material. IAC Director does direct calls to potential participants.

5.2.3 Process Evaluation Criterion and Categorization as an Attempt for filling the Realization Gap

The chapter utilized the initially expressed purpose to propose a holistic and inclusive process evaluation criterion that can be applied to different process evaluations of same or different market segments. It is to be noted that 'rating a program' does not remain the objective. However, the purpose here is to utilize an approach that serves the following two purposes:

1. To present the problem from an impact and process evaluation level.

2. Utilize the synergies between above two mentioned level as well as between engineering savings and program structures.

Using above two points, this chapter adds to the growing literature on process-level analysis, where different EE&C programs/projects can be generalized under a single platform of broad criterion. Therefore, this approach summarizes focus on the 'flow' from financing to benefits distribution within the context of management/organization of the program in question.

To utilize synergy between the impact and process level analysis in the public policy perspective as well as to connect the previous chapter with this one, we can therefore infer that the inherent risk associated with Realization gap in EE&C projects. The disincentive to use M&V for Public Buildings projects have not been correlated or established by any study and therefore mentioned as the findings of this thesis.

CHAPTER 6

PROGRAM AND POLICY PROPOSAL

Program and Policy proposal chapter tries to provide with an actionable proposal that can utilize the synergies to fill the realization gap. This chapter incorporates the process evaluation criterion developed in the response section to propose a program structure and its pilot project. Furthermore, a case study has been established here which provides with the proposals for alternative set of approaches that can be applied in the Public buildings EE&C market. These set of new approaches originate from the impact level response of categorization of realization gap as well as from embedding the incentive to use M&V within the program and policy structure.

Actual and verified energy savings vary and differ based on utilization and inherent Realization gap, as established before. Utilizing the defined concepts of occupant behavior variability and estimator's assumption variability within our inherent gap, this chapter serves to include 'occupant' and 'estimator' as a project stakeholder. A program redesign based on our focus on stakeholders and process valuation criterion, is proposed. It utilizes synergies of impact and process level Analysis as well as Response. Our initial perspective in identifying the Realization gap is now translated from engineering and process level into people and stakeholders of the project or program. Similarly, the problem of 'disincentive to use M&V' is translated to 'no incentive for stakeholders to utilize M&V'.

Additionally, from the knowledge of previous two chapters, it can be inferred that actual impact of energy efficiency improvements is much more dependent on consumer and stakeholder's behavior and decision system rather than on the hard-core engineering element. The use of stakeholders within our public buildings segment

therefore forms the initial part of this chapter. The intent of the proposal is to engage stakeholders in utilizing M&V as well as incentivizing it which then also addresses our two Policy Issues for attaining and accelerating climate action goals.

6.1 Stakeholders under Scope

The concept of stakeholders needs to be viewed as a systems' approach within the project lifecycle of financing, benefit distribution, and management. This systems' approach was also used as part of the thesis' Research Design. These projects are usually funded by the tax payer's money whereas the stakeholders include but are not limited to:

1- "Government" as a financier and decision maker.
2- Utility or ESCO, as financing or implementing party or/and as an enabler's actors.
3- Public Employees as "enablers" of energy efficiency projects in our project scope.
4- Public Employees as "occupants" of public buildings.
5- Contractors as "enabler' actors"
6- Community always remain a stakeholder but omitted for simplicity in public buildings segment.

Conclusively, all the stakeholders mentioned above are considered necessary for the effectiveness of the EE projects, however, as per our focus on incentivizing stakeholder, their interests are not aligned and are not being incentivized by any policy instrument in current market segment of public buildings. Stakeholders as ESCOs, Utilities and Governments have been utilized as institutional stakeholders whereas building owners

and occupants, contractors and communities have been categorized as individual stakeholders.

6.2 Proposed Financing Structure

Current financing tools include energy performance contracts, tax-exempt lease purchase, 0% loan programs for certain market segments and others. These have been already established and analyzed. The salient features of the proposed financing structure are as follow:

6.2.1 Diversifying Financing Portfolio

1. It suggests using multiple sources of financing including but not limited to taxpayer money, revolving funds, bonds, utility and private investment
2. It suggests using stakeholders' engagement by encouraging them to participate in financing and receiving benefits.
3. The Proposed Structure provides a platform for the employees to invest in the energy efficiency projects of their own buildings in return for direct profit margins against the amount invested.

6.2.2 Restricted Stakeholder Crowd Financing (RSCF)

All the government employees involved in the implementation, planning, contracting, accounts, and procurement etc. of these projects are to be given voluntary options of participating in financing of energy efficiency projects. Similarly, contractors, occupants or staff involved in the project's effectiveness are also eligible for such financing.

No institution can participate in RSCF that is not directly involved in the EE&C efforts for the said project or program. Utility, as a key stakeholder can separately participate as an institution diversifying the financing portfolio. However, utility or any other institution cannot take part in RSCF. To illustrate only as an example how a financing diversification would translate into stakeholder financing share see Figure 8.

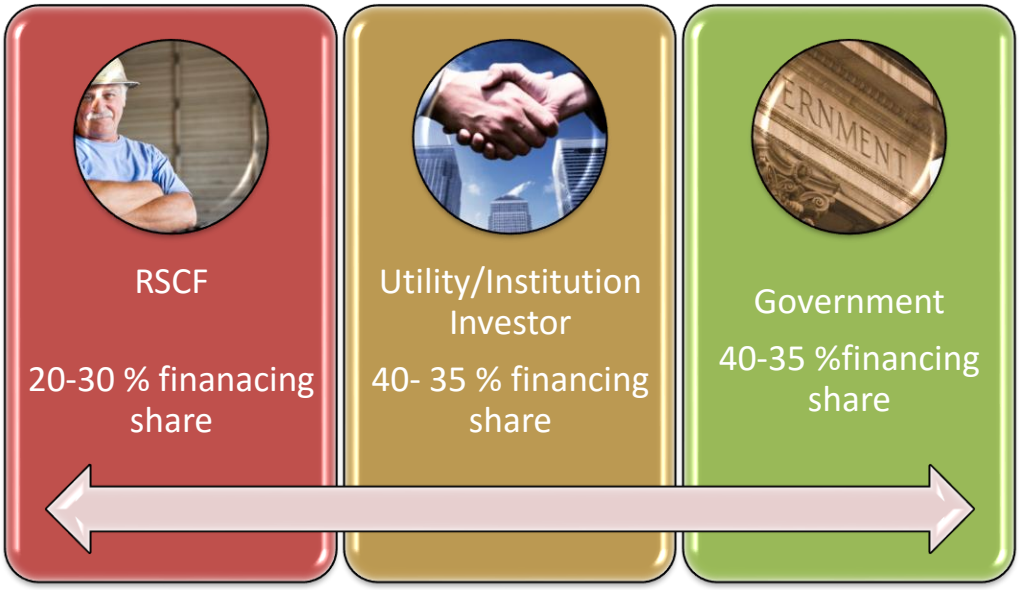

Figure 8: An example of financing percentage between different Stakeholders

It is to be noted that the purpose of this financing structure within EE&C program structure should always remain on inclusion of diverse participation and not on capital accumulation. Similarly, RSCF is only part of the diverse financing portfolio, recommended for the program structure, and not an independent financing instrument. Moreover, the percentage of RSCF within the project or program financing has been discussed in the upcoming Results and Comments section of our Chapter 7.

For the purpose of understanding only, it can be viewed as an initial public offer (IPO) of a company being initially listed in stock market, wherein employees can buy the shares of the company they work in.

6.3 Proposed Distribution of Benefits

Distribution of benefits here only represents the monetary benefits between the stakeholders, as a part of flow of capital. For business as usual (BAU) case, these monetary benefits were accrued by the external financing party as profits and by the government as low costs. However, for proposed case, they will be accrued more diversely by including stakeholders.

6.3.1 Incentive Structure

The incentive structure for participating in RSCF is rooted in our analysis of 'guaranteed savings'. An improved structure of guaranteed savings has been formulated here. This has been termed as Risk-free Incentivized return.

This Risk-free Incentivized return establishes a lower-capped guaranteed return with no upper-cap on returns. It utilizes the principle that energy savings under the scope settings vary, based on the inherent and utilization gap. Thus, at one end it guarantees the return to safeguard the investments and on the other end it provides the incentive to earn more than the guaranteed savings. It further can be explained in terms of categorizing uncertainty into risk as well as incentive. It has been illustrated below as a conceptual framework.

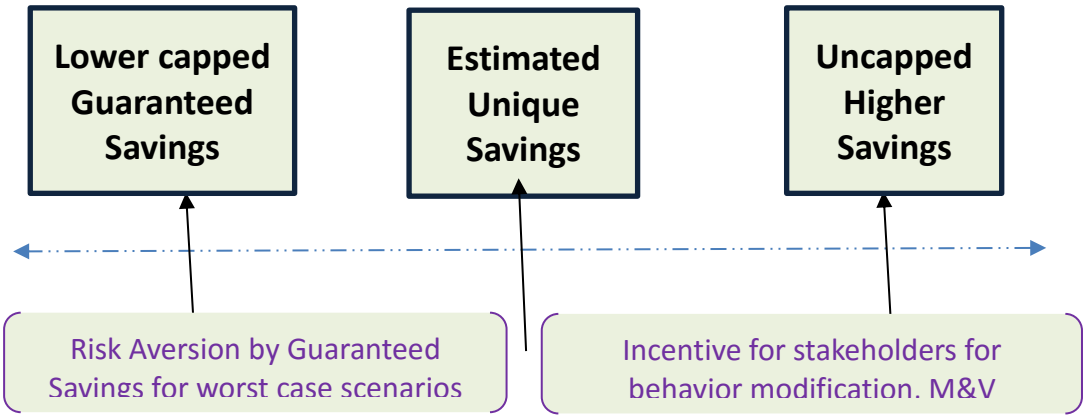

Figure 9: Conceptual Framework for Incentive Structure

6.3.2 M&V embedded in Incentive Structure

Our proposed distribution of benefits due to the incentive structure adopted has M&V as an essential concept. Not only M&V but also increased stakeholder engagement is in-built to the proposed structure. Increased employee engagement can increase the effectiveness of energy efficiency projects as the investors are the very same people working on different details of the project. The verification of energy savings is an essential part of disbursing the benefits among the shareholders and other financing institutions (govt., utility, ESCO etc.). Therefore, it inherently embeds itself in the foundation of this financing regime.

From public employees and contractor's perspective, the employees are now retrieving additional benefits of doing the same amount of work. Thus, increasing the project's implementation and effectiveness of its verification of savings. Instead of giving them to the private investors, the benefits are now shared among the public employees who are the project stakeholders since they are the managers as well as the consumers.

6.4 Guidelines on Organization and Management Structure

The major structural changes in the organization and management part of our proposed criterion has not been done in this paper. However, following suggestions are included:

1. A one-stop shop for coordinating and distributing benefits is preferred but remain dependent on program objectives.
2. Third party EM&V needs to be incorporated into the program structure.
3. The program structure needs to effectively and efficiently constitute the stakeholders in the swift decision-making process through the utilization of technology.
4. It is recommended to implement the financing and benefit distribution structure as a pilot plot for a single project. Brief guidelines for such pilot project are discussed next.

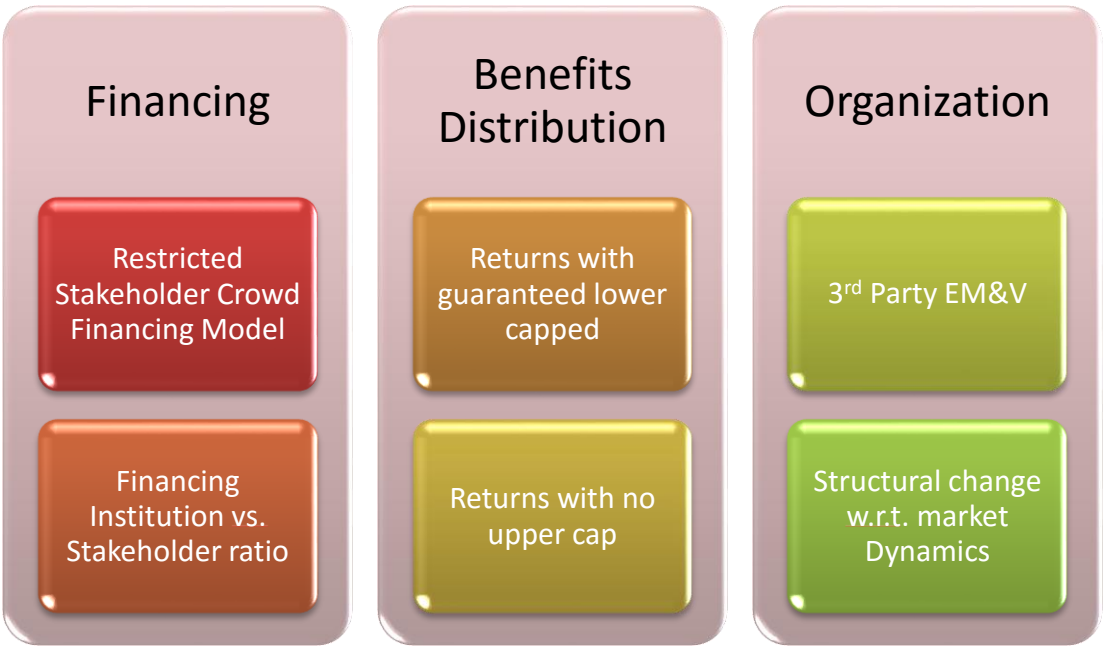

Figure 10: Summarized Proposed Program Structure

6.5 Beneficiaries from the Proposed Structure

From city/state/federal government's or other utility, ESCOs, and project implementers' perspective, the employees typically constitute a lower financing share (15-30 % only, as an example) of the project. For the best-case scenario, the incentive structure creates an increase in the rate of investment (ROI) of the entire project through stakeholder engagement. In this way, the ROI of the government also increases, being the part of the project ROI. However, government's higher financing share (70-85 %) of investment makes the savings return much more in volume. This increases government's dollar energy savings enormously and facilitate the governmental entity to have additional budget for more energy efficiency projects, as the budget load has now been financially shared by stakeholders.

From employees', contractors' or other stakeholders' (not including institutions) perspective, they can receive monetary benefits for doing exactly the same job and amount of work. They are already shielded from risk and are encouraged to achieve more savings as an incentive to no upper-capped incentive structure. This also provides economic rationale for employees to engage in such programs. Government, if it realizes the potential through this structure, while being the major beneficiary, can help in easing the process for employees to invest by utilizing mechanism of in-pay deductions, 401K or revolving funds, and others. Micro details like divesting the employee shares anytime similar to stock market, are not the part of this paper. Nevertheless, further research on making a detailed practical operating plan for a pilot project is recommended.

Other institutional stakeholders such as utility, ESCO or private investors, which are the part of the project cycle, can form part of financing and thus the beneficiaries of the proposed structure. Utilities and ESCOs either guarantee or demand risk sharing for

financing due to the already established EM&V gap. However, the proposed structure provides them with the opportunity to lower their business as usual (BAU) risk and gather valuable data of how the stakeholder engagement can induce results on actual and verified savings.

Last but not the least, beneficiary of the proposed methodology is the thesis writer himself.

With its focus on stakeholders, this Restricted Stakeholder Crowd Financed model truly symbolizes synergy between sharing benefits of energy efficiency and conservation with its consumers, project handlers, energy managers and contractors etc.

Continuing our discussion of the beneficiaries of the proposed structure, it is considered prudent to also discuss the risk tolerance and its heterogeneity among the stakeholders of our public buildings segment. This discussion on heterogeneity serves as a counter argument for exploring synergies in our proposed structure. It is to be noted that in terms of financing and risk appetite that utilities are likely to be the most conservative, partially because they are regulated and cannot easily invest funds in individual non-utility projects. Additionally, utilities are very reluctant to be a source of capital for anything outside of their own infrastructure or asset allocation, or individual non-utility programs. When they do this, it's usually part of "on-bill" financing, and even then, they prefer to use external sources of capital and act as a vehicle for delivering the financing (McEwen and Miller 2014, 8) [21]. However, utilities, ESCOs or other project parties are major beneficiaries of the proposed structure since they get higher incentive due to higher financing share.

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[21] Reviewer Contribution by Ralph Nigro

As a critique, reducing the conservatism of the savings estimates also increases investment risk. The essence of this thesis is to advocate a portfolio approach to financing energy efficiency projects by expanding the list of stakeholders beyond the usual financing sources. Additionally, it also diversifies the uncertainty into risk and incentive among project stakeholders, as shown in Figure 9. However, every participant will have different tolerance for financial risk, and therefore, more risk aversion is recommended for stakeholders of employees, contractors and individual actors within project lifecycle to encourage participation.

The building occupants and employees, in the context of risk and uncertainty, may be willing to invest in specific projects however, these investments would be competing with more conventional investments like mutual funds, tax-exempt retirement plans, and others.

6.6 Proposed Structure Addressing Policy Issues

The proposed structure addresses the problem statement of realization gap by firstly admitting an inherent gap within realization gap. Secondly, it isolates and separately defines the other variance inducing factors from utilization gap which is only present due to non-utilization of current M&V and EM&V approaches.

Additionally, it incorporates the incentive of utilizing M&V by introducing Risk Free Incentivized Return, therefore, addressing the previously identified unaddressed reason for the realization gap. The proposed project or program structure addresses the policy issue explicitly in following two ways:

1. Increase the number of projects currently under consideration, as it reduces the load of financing on tax payer money and thus opens new financing channel.

2. Increase EE project effectiveness with the help of incentivizing benefits by involving stakeholders.

Thus, accelerating the energy efficiency projects in absolute numbers as well as improving the verified savings of the projects, will greatly help in attaining and accelerating climate action efforts.

6.7 Critique and Limitations

A brief critique on heterogeneity of the risk appetite and tolerance has already been mentioned in our section of the Beneficiaries from the Proposed Structure. Furthermore, this section has three major critique dimensions to this proposed project or program structure which are elaborated briefly underneath.

6.7.1 Narrow Scope and Less Absolute Impact

Energy Efficiency & Conservation as an instrument remain a subset in achieving climate action goals. Now consider the scope of the energy efficiency in buildings only with further reduction in scope to include only public buildings. Therefore, the already small impact of energy efficiency projects in public buildings versus the total energy efficiency space in buildings, transport, appliances etc. is huge. So, improving effectiveness of only these types of projects under special conditions of larger institutional size with unknown employee interest is complicating the already diverse problem. Therefore, even if implemented, can only result in a few percentage increases which in absolute numbers of reduced carbon emissions is lower. Thus, the proposed policy structure may include more implications than benefits.

6.7.1.1 Comments

The proposed structure, as well as the methodology of this thesis, thrives on the holistic process evaluation criterion. These criteria of financing, benefits distribution and management may well be applied to another market segment such as commercial or residential. At the same time, market and policy interventions were included at different levels of methodology to the scoped problem. Therefore, in actual the current methodology helps inspiring other market segments to initiate actions on same grounds.

However, it is also true that the proposed structure thrives on the larger institutional size with respect to employee number. Proposing the structure for public buildings is partially due to the reason of small number of stakeholders, therefore classifying and aligning the needs of stakeholder becomes easier.

6.7.2 Core Assumption of Changing Behavior with Direct Incentives

The whole proposed structure lies on the principle that 'Directly incentivizing (monetary) public employees or other stakeholders will increase the energy savings than usual scenario'. The assumption may seem appropriate but the heterogeneity among consumers, and stakeholders can be analogized or compared to the consumer behavior towards incentives, which has long been viewed with skepticism.

What if the employees invest but do not change behaviors and keep getting guaranteed returns, whereas the actual savings are still below the guaranteed return, thus enforcing negative cash burden on government and other institutional side of financing? Also, it is to be noted that this assumption may change the rate of return for EE&C projects in either positive or negative direction and therefore such policy instruments be analyzed for different scenarios.

6.7.2.1 Comments

The core assumption is established, inferred or implicitly derived from the details of defined EM&V Inherent Gap. Therefore, the heterogeneity must be treated as the uncertainty which can be further classified and applied to avert risk and incentivize higher savings as illustrated in Figure 9: Conceptual Framework for Incentive Structure.

The notion of stakeholders not changing the behavior and still accruing guaranteed returns refer to the worst-case scenario which has been analyzed in Scenario Analysis. Similarly utilizing large institutions in RSCF subsides this core assumption to some extent where only 1-3 % of employees are enough for participation due to huge employee size.

6.7.3 Feeble Structure

The financing as well as the incentive structure for disbursing the benefits seem feeble and very elastic since various public employee organizations vary a lot in size, thus varying the space for such financing structures to be utilized. Similarly, the structure must elaborate upon what is the optimal ratio of financing between employees and other financiers for different project sizes.

6.7.3.1 Comments

The above two arguments may seem limitation but it also provides the additional financial space and room to government wherein which they can experiment and find optimal balance of variables (ROI, financing ratios, estimated and guaranteed savings etc.) within this system.

Additionally, the difference between conservative energy savings estimate and an over-projected estimate must be translated into a quantitative range of “rate of

returns" within which a government must analyze and then decide upon a "Risk-free Incentivized Return". This has been advocated throughout Chapter 7.

CHAPTER 7

WAY AHEAD AND CONCLUSION

Finally, the ‘Way Ahead’ chapter develops on how the proposed set of approaches (estimation and evaluation) can be synthesized to further synergize the existing estimation approach and financing mechanism. This is essentially the final chapter which tries to elaborate on what type of future works can be done and how the research in this direction be proceeded to allow more coherence and explore more synergies in our ‘estimating, financing and evaluating approaches’ for EE&C efforts. On the process-level, it briefly elaborates on a pilot project that follows the Program and Policy Proposal. It further establishes this case by analyzing various financing scenarios.

On an impact level, the Way Ahead briefly explains how the financial and estimation synergies could be explored with the new set of estimation approaches. How can this be done in future research and which data is required for such analysis, is discussed within the impact-level of this chapter. This new set of estimating, and financing approaches, along with previously developed evaluating approaches, within our analysis, then form a counter narrative of ‘exploring synergies’ to individual technological, economic and social narratives which are prevalent within the current approaches. These proposed set of approaches along with the counter narrative is considered the best mix to fill the realization gap under investigation.

7.1 Way Ahead on Process Level

7.1.1 Guidelines or Pre-Requisites for Pilot project on Proposed Structure

1. Generally, our proposed structure is more suited for large organization like NYPD, Department of Education, and other larger institutions. Therefore, firstly, a survey should be conducted by communicating this project structure to evaluate the percentage of employees that would be interested in such option.
2. The guaranteed return needs to be higher than the rate provided by the savings bank account or other tax-exempt retirement plans and revolving funds available to them.
3. Calculations of guaranteed returns need to be based upon initially conservative estimated savings as per feasibility studies or ECM potential assessment. Based on the actual savings, these estimates will then be adjusted for future savings and guaranteed returns calculation.
4. Only employees that are directly or indirectly involved with the project or program and its implementation should be part of the investment scheme and no other employee or institution etc. can participate only on the basis of capital offering.
5. If the savings are below the guaranteed return, then City would be liable to pay the employees for the difference. One must see this discouraging scenario with the perspective of time value of money as well. This issue has been further established in Results and Conclusions.

6. These scenarios will add strong feedbacks into the M&V system of project where accurate initial estimation would be encouraged as it all also includes the estimator as a project stakeholder.
7. The returns on investment must be limited to the useful life of savings which is dependent on the useful life of equipment.
8. After the period for returned investments is over, the asset (boiler, VFD etc.) savings will be completely used by the City/State/Govt. or original institution.

This chapter takes its inspiration from the EM&V categorization in general, and inherent gap of Realization gap in particular. Utilizing the inherent gap, this chapter tries to categorize quantification of individual elements of the inherent gap as a synergic approach. The intent is to at least appreciate and then utilize the range of variability within estimated energy savings while categorizing the variability from inherent EM&V gap.

7.1.2 Scenario Analysis based on cash flows

Although the policy instrument sketches the painting, yet, having no colors make it incomplete as well as provides the painter with various options.

Based on the three dimensions of our critique, the first one is considered addressed, by the thesis methodology used which can also work for other markets of EE&C. The next two dimensions revolves around the skepticism about how this proposed structure would work under various financial and economic scenarios, such as when the actual energy savings becomes higher or lower than project savings. Scenarios are thus based on few basic market parameters which are as below:

1- Project Size in terms of capital.

2- Financing ratio between government and employees.

3- Worst case scenarios based on lower IRR (Internal Rate of Return).

4- NPV for employee investment.

Thus, to understand how the economics of such proposed structure would work under various scenarios, an excel based scenario analysis has been conducted with simple spreadsheet and project parameters assumptions which is attached in the Appendix D.

7.1.3 Results and Comments

1- The Project Financing ratio between government and employees must be prepared for any worst-case scenario, as a pre-requisite. Therefore, as we increase the govt. share of financing from 50 % to higher, the project sensitivity to variation becomes more reliable and secure. It is therefore recommended that govt. or combined institutional share must always be greater than 70 %.

2- It is recommended to choose an IRR as a balance between conservative projected energy savings and a rate of return that is attractive for employees to invest in.

3- Even if the projected savings are less than the anticipated ones, with recommended financing ratios (30-70 % as an example), then for a fiscal year, the returns are sustainable enough to guarantee a good enough rate of return for employees.

4- The major beneficiary party is the government or institution which increases its returns to a great deal, due to the high percentage share of financing.

5- A new term “NPV of incentive for govt. to promote EE financing” quantifies the additional benefits that govt. would render due to this approach as compared to other program structures. Therefore, the scenario analysis provides

an absolute figure by which govt. returns would increase for each financing situation.

6- EE&C financing through this method, can only render best results under certain project conditions of project size, IRR, NPV, financing ratio etc. More sample studies are needed to stimulate additional conditions. Pilot projects under this financing structure would be much more beneficial than sample studies due to their higher correlation with experimentation rather than statistics.

7.1.4 Conclusions & Recommendations (C&R)

The conclusions and recommendations are divided into two sections:

7.1.4.1 Project Specific C&R

I. IRR can only be increased or decreased to a certain extent even after applying all the techniques of employee and consumer's motivation. This needs to be understood in the context of Realization gap, since the stakeholder engagement may only reduce the utilization gap while the inherent gap or its constituents may still be affecting our realized savings. On the contrary, even this slightest margin on positive side can bear fruits in high absolute savings.

II. Project Managers should review the "NPV of incentive for Govt. to promote EE financing", to check which projects are more suitable for this financing mechanism. Similarly, this term elaborates why the Govt. should adopt this policy instrument rather than the one currently employed or available in the market.

III. Micro-level details regarding “Buy-Out” for those employees leaving the company should be developed. Similarly, the govt. should encourage employees to invest by offering employees for “in-pay deductions” from their salaries rather than a single upfront payment. Other mechanisms on these lines should be established.

7.1.4.2 Program-level C&R

I. Although the scope may only yield and focus on public sector, yet the same can be analyzed and deemed appropriate for other efficiency projects in the private sector as well, given that major stakeholders are incentivized as a condition.

II. Incentive structure may seem common but is based on the principles of equity whereby the benefits are distributed among a larger volume of people rather than a single investor/bank which gets all the benefits only due to the availability of capital.

III. More policy instruments should be developed along the lines of ‘distributed benefit school of thought’ rather than benefits for entities that have capital (Agyeman 2008). The policy argument implies that giving benefits to people who are “invested” in terms of money, time and labor, can increase the overall effectiveness of policies and such programs.

7.2 Way Ahead on Impact Level

7.2.1 Methodology

Initially developed methodology for this chapter reflects the purpose of initiating a detailed strategic approach for catering this diverse gap. A detailed strategic approach

requires, utilizing already published quantification attempts as well as the concepts formulated in this paper. Therefore, the first step includes the categorization of variables that help in quantifying inherent gap or its constituents.

7.2.2 Estimating context for Proposed Structure

First categorization of variables is done on the engineering (estimation) context. From already defined inherent Realization gap categorization, we consider the following variables in terms of either increasing or lowering actual savings (range) from estimated value:

1. Occupant Behavior Variability
2. Occupancy Variability
3. Estimator's Assumption Variability
    a. Climate Variability initially linked within estimator's variability.

For conceptual or theoretical purposes, the above-mentioned variables are initially viewed as 'microscopic variability' within each project related to EE&C.

Second categorization of variables is done by utilizing literature reviewed categorizations which can help in quantifying the variability as an in-built, default or inherent gap within current thesis' scope.

1. Deep Retrofit Variability
2. Shallow Retrofits Variability

For conceptual or theoretical purposes, the above-mentioned variables are initially viewed as 'macroscopic variability' based on the project. implementation mechanism as introduced in Implementation Mechanisms section.
section.

In addition of the above two categorizations of variables following contexts or scenarios for applying the above considered variables have been formulated:

1. Technology type of EE&C (type of upgrade or action e.g. lighting or VFD or boiler upgrade)
2. Occupancy (it has been chosen again, since it can affect the variability in multiple ways)
3. Building type (office, school, police station etc. it should reflect the inherent building variability element)

This would further help in establishing the off-the shelf estimates for certain building types, technology types or occupancy types. This would further help in understanding the diversity of variability of Realization gap, as literature tends to investigate the gap in these terms with empirical evidence.

7.2.3 Financial Context for Proposed Structure

For this part, the context or scenario chosen are below:

1. Project Cost in dollars.
2. Project Cost to Savings ratio
3. Analysis of the above parameters for each financing ratio and IRR scenarios between institutional (government or other) and other project stakeholders (employees).

As a simplification, this can be regarded as financial sensitivity analysis of the already set context between macroscopic and microscopic variability parameters.

7.2.4 Data Required

The data required in terms of our categories of building, technology, occupancy, deep or shallow retrofit, capital cost, financing ratios, behavior variability etc., for establishing confidence interval on projected ranges, is not the part of this research. However, to encourage research in these directions, the micro-level data, required from projects or programs for establishing the ranges, is of the nature as shown below.

Table 8: Data Required for Range-based Estimation Approach

Capital Cost	Type of EE Recommendation (Single/Multiple facility types)	Description of EE recommendation	Estimated Savings (Annual)	Estimated Savings year when it was estimated
Verified Savings	Building Type	Number of facilities in this building type	Adjustment to Weather and through which approach	

Technology type	Occupancy (Hours of facility per year)	Facility Consumption	Verified by (Facility consumption, sub-metering)	Life of Improvement

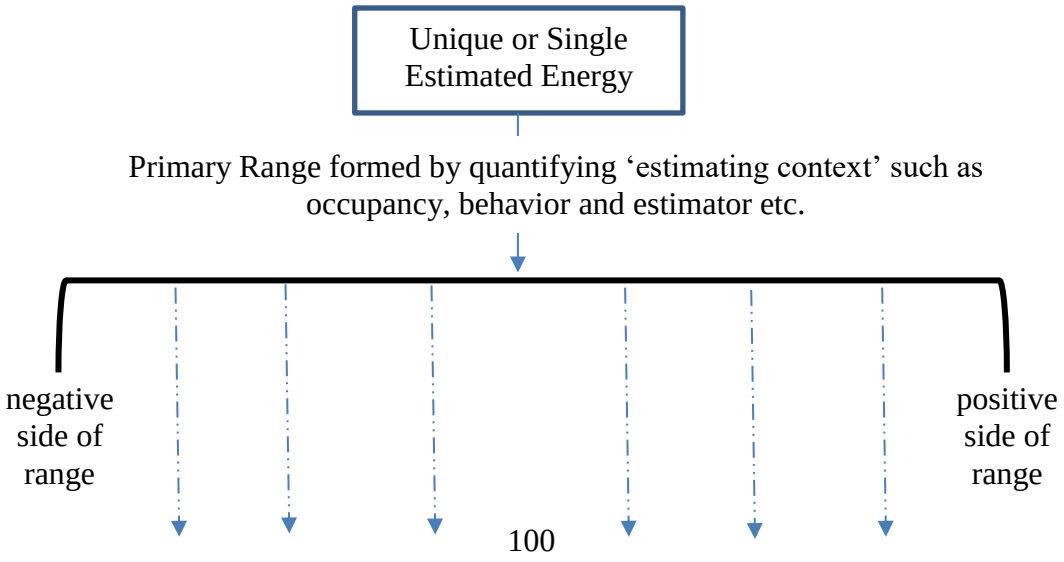
7.3 Redesigning the Estimation and Financial approaches in Synergy for Future Work

The ranges formulated due to the financial sensitivity analysis as described above and utilized in heading 1, would give the researcher ranges of IRR and financing ratios under which an attractive 'Risk-free Incentivized return' can be proposed.

Similarly, quantifying the variability of energy savings by utilizing the financial and estimating context of proposed structure within the scenarios of technology,

occupancy and building type will also result in ranges of projected savings rather than a unique estimated energy savings number.

The objective of this future work section is to utilize the above two engineering and financial ranges in conjunction with each other. Thus, to intelligently project and choose ranges of energy savings and dollar returns for proposed pilot project initiation. This objective and range methodology is illustrated in Figure 10: Conceptual framework for Future Works. It is highly recommended to view conceptual framework in relation to Figure 9: Conceptual Framework for Incentive Structuresince it needs to be viewed in the perspective of risk aversion and incentivizing uncertainty.



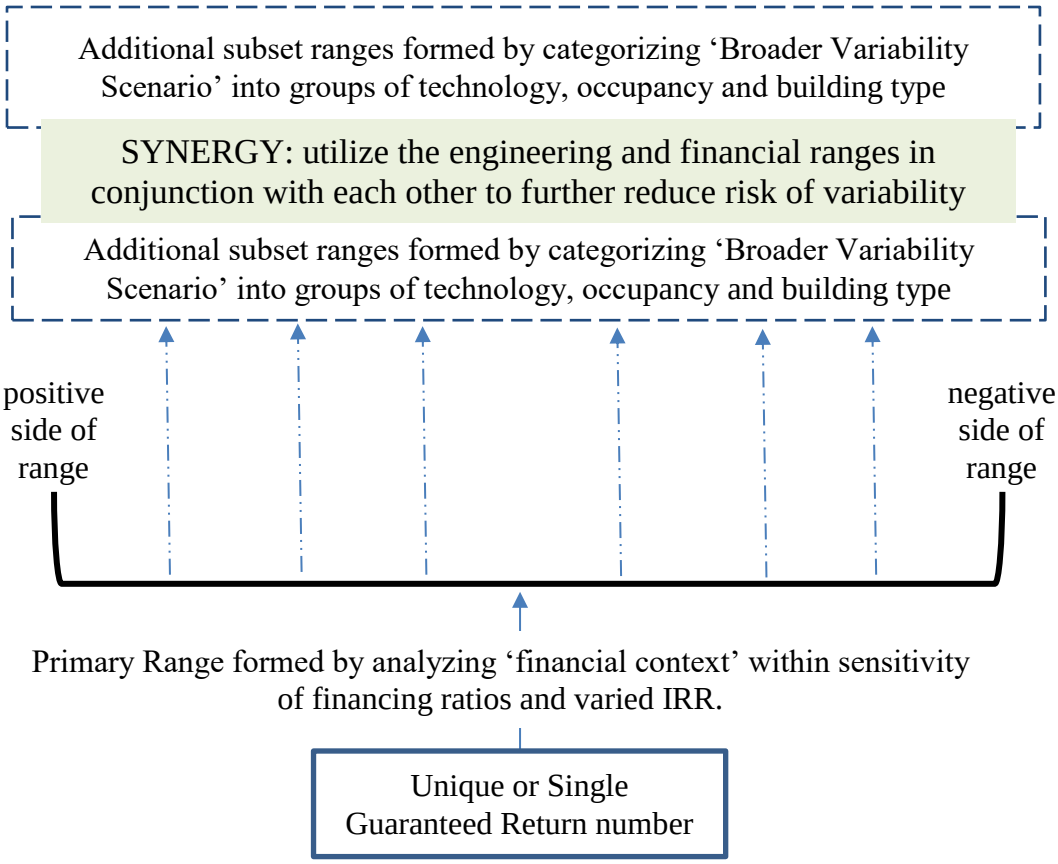


Figure 10: Conceptual framework for Future Works

7.4 Summarizing Remarks

To sum up all the research and interpretations presented in this Way Ahead or future works section, following are the important remarks;

1. Data required has been considered for the sake of 'simplicity' in attaining relevant information and to somewhat be 'inclusive' in representing the broad dynamics of a pilot program or project.

2. The future works section has attempted to provide a skeleton, brief enough to encourage research on this line. Its provision is in conjunction with the implementation of the proposed program or project structure presented in Chapter 6.
3. Every possible attempt has been made to create synergies between diverse concepts and multi-disciplinary problem.
4. In nutshell, the synergy demands the rethinking of our approach towards only estimating a unique energy savings number. This innovative synergic approach advocates to utilize ranges of estimated and projected savings while considering variability as an inbuilt and default element to Energy Efficiency and Conservation projects or programs.

With reference to the summarized remarks for the thesis, in nutshell, three proposed set of approaches for estimating, financing and evaluating EE&C efforts have been proposed. These three set of approaches are believed to synergize better than the prevalent approaches of M&V and EM&V currently in practice. The proposed set of approaches can be summarized as below:

- Estimating approach needs to be range-based rather than the unique energy savings. The estimating approach must take inherent realization gap into consideration.
- Financing approaches of Restricted Stakeholder Crowd Financing with Risk Free Incentivized return contain the incentive to utilize M&V, which is also embedded within the financing and program structure.
- Current Evaluation approaches must connect and synergize more clearly. A bottom up approach of connecting impact evaluations to process evaluation be done rather

than the other way around. Standardized and holistic process evaluation criterion are proposed in this regard as well.

These three approaches are believed to form a counter narrative in opposition to prevalent individual narratives of technology, program development, and engineering etc.

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APPENDIX A

IPMVP Options in Summary

International Performance Measurement and Verification Protocol (IPMVP):

- Four (4) main options (two geared toward ECMs; two geared toward whole building):

Option A	Customer Assurance	M&V Investment
	↑	↑

Option A – Retrofit Isolation: Key Parameter Measurement

- Field Measurement on a selected sample of locations of the significant parameter.
- Rigorous sampling using 80% Confidence and 20% Precision as a minimum.
- Example – **Lighting fixture retrofit**.

Option B	Customer Assurance	M&V Investment
	↑↑	↑↑

Option B – Retrofit Isolation: All Parameter Measurement

- Field Measurement on a selected sample of locations of all parameters related to the equipment energy use.
- Similar sampling criteria as Option A.
- Example – **Lighting fixture upgrade with Occupancy Controls**.

Option C	Customer Assurance	M&V Investment
	↑↑↑	↑↑↑

Option C – Whole Building Utility Analysis

- Affected utilities are metered continuously.
- Baseline consumption and demand are analyzed to determine the impact of various known variables such as weather and occupancy.
- Actual performance period readings are compared to Baseline energy usage adjusted for the same operating variables.
- Typically used when numerous ECMs impact a building and accurate tracking of required variables is available
- Example – Multiple ECMs (complex HVAC Replacements) with reliable baseline utility data.

Option D	Customer Assurance	M&V Investment
	↑↑↑	↑↑↑↑

Option D – Calibrated Building Model

- A virtual model of the facility is created using geographic orientation, building equipment, construction type and materials, and operating habits.
- Typically used when there are several interactive ECMs, reliable information on operating variables are not available, or in cases lacking building sub-metering.
- Example – Multiple ECMs (i.e. HVAC & BMS), buildings w/out reliable baseline utility data or with complex ECMs that cannot traditionally be measured under Options A , B or C.

APPENDIX B

Timeline of evolution of EM&V and subsequent Narrative development

Timeline	Market Characteristics: Energy Efficiency in Buildings (Projects/Programs)
1960-1975	• A formal energy efficiency industry was just starting to emerge with no standard methods for M&V • The first attempts for verifying savings were simply to compare utility bills before and after an energy efficiency project is done at the facility/meter level.
1975-1990's	• 'Utility Bills difference approach' proved highly inaccurate. It is partially due to the diversity of inherent variability (occupancy, weather etc.) as well as the meter-noise. • Industry at that time, answered with developing retrofit isolation methods for breaking down the complexity and diversity of EE&C projects in buildings. • Social Scientists answered by regression methods for billing analysis utilizing statistically adjusted engineering model approach *Narrative of timeline:* *In the early days, this approach was referred to as the utility bill comparison approach which then incorporated statistical adjustment. Later, it would be referred to as the whole-facility approach, and IPMVP option C. The industry first answered by utilizing evaluation methodologies of regression and then by developing retrofit isolation methods. These methods remain preferred as the industry pushed to reduce M&V costs.*
1990's -2010	1990-1997 and then 1997-2010's is the categorized period which led to establishment of recent trends in M&V world.
	1990-1997 (Performance gap narrative) • M&V market direction towards data/technology for enhanced improvement. • Performance enhancements to Energy Savings Performance Contracting • IPMVP: Establish and formalize the existing methodologies (retrofit/regression) *Narrative of timeline:*

	A more concentric and continuous approach within EE&C projects remain at forefront through establishing IPMVP to include best practices available.
	1997-2010 (Technology solution narrative) • Transition from Short-term M&V to Long Term M&V • Guaranteed savings as a market solution • Post 2003 expansion of EE&C projects • IPMVP: A widely accepted standard throughout the world! *Narrative of timeline:* *Technological interventions, evaluation methodologies (market, process and impact) and behavioral modifications remain at forefront in EE&C.* *2010 marked the milestone of translating IPMVP and the access to standardization within 12 languages. However, it only formalized the approach and remained flexible and feeble in structure to address the performance gap.*
Recent trends	Major Interventions/forces currently leading the Market • Data Analytics/ICT • Standardization within building, & OpenSource Collaboration *Narrative of timeline:* *It might be time to revisit the whole performance gap narrative and its technology driven solutions. Similarly, guaranteed savings approach to mitigate financier confidence gap needs to be redesigned.*
2017 – onwards	Still Developing

APPENDIX C

Summary of Evaluation types and its Application

EVALUATION CATEGORY	PHASE AT WHICH IT IS IMPLEMENTED	EVALUATION OR ANALYSIS TYPE	ASSESSMENT LEVEL
Formative	Pre-program Planning Phase	Market Assessment Analyses (includes characterization, baseline)	Market, Portfolio, Program
		Potential or Feasibility Analyses Portfolio, Program, Project	Portfolio, Program, Project
	Implementation Phase and Ongoing and/or After Program Implementation	Process Evaluations	Portfolio, Program
		Market Effects Assessments	Portfolio, Program
Outcomes	Implementation Phase— Ongoing and/or After Program Implementation	Impact Evaluations	Program, Project, Measure
		Market Effects Evaluations	Market, Portfolio
		Cost-Effectiveness Analyses	Portfolio, Program, Project

APPENDIX D

Pilot Project Scenario Analysis

A city/state/federal government project on energy efficiency has a capital cost of $100000/- and load reduction 70 kW resulting from the project All the stakeholders involved will have the option to purchase bonds/IPO/Stocks for 100$ if they need to participate in Employee financing thus needing 300 employees for this project. Based on the IRR of the specific project and how much it can be changed with respect to higher or lower stakeholder (employee) involvement, determine what is the most suitable guaranteed return that state/city needs to give its employees for financing this project. Consider best, average and worst case scenario! The project suggests a 4-5 years' payback period very evident in public building energy efficiency projects.

Project Cash Flows Under Various IRR.

Project Basics			
$/kwh=7cents	*Annual Operating Hours*	*3000*	*hours*
$/kw=8.	Motor Load Reduction (kW) due to retrofit	70	kW
	Annual Demand Cost Savings 1st year	$6,720.00	
	Annual kWh Saved	*210,000*	*kWh*
	Annual Energy Cost Savings 1st year	*$14,700.00*	
	Total First Year Energy and Demand Cost Savings	*$21,420*	
	Escalation Rate	2%	
	Discount Rate	2%	

Business as Usual Cashflows	Year	Project Cashflow	Shareholder Equity Cashflow	Govt. Cashflow
Per Employee Share over 100$	0	$ (100,000.00)	$ (30,000.00)	$(70,000.0)
$ 21.42	1	$ 21,420	$ 6,426	$ 14,994
$ 21.85	2	$ 21,848	$ 6,555	$ 15,294
$ 22.29	3	$ 22,285	$ 6,686	$ 15,600
$ 22.73	4	$ 22,731	$ 6,819	$ 15,912
$ 23.19	5	$ 23,186	$ 6,956	$ 16,230
$ 23.65	6	$ 23,649	$ 7,095	$ 16,555
$ 24.12	7	$ 24,122	$ 7,237	$ 16,886
$ 24.60	8	$ 24,605	$ 7,381	$ 17,223
$ 25.10	9	$ 25,097	$ 7,529	$ 17,568
$ 25.60	10	$ 25,599	$ 7,680	$ 17,919
	NPV	110,000	33,000	77,000
	IRR	18.729%	18.729%	18.729%

At 4% IRR	Year	Project Cashflow	Shareholder Equity cashflow	Govt. Cashflow
Per Employee Share over 100$	0	$ (100,000.00)	$ (30,000.00)	$(70,000.00)
$ 2.14	1	$ 2,142	$ 643	$ 1,499
$ 4.37	2	$ 4,370	$ 1,311	$ 3,059
$ 6.69	3	$ 6,686	$ 2,006	$ 4,680
$ 9.09	4	$ 9,092	$ 2,728	$ 6,365
$ 11.59	5	$ 11,593	$ 3,478	$ 8,115
$ 14.19	6	$ 14,190	$ 4,257	$ 9,933
$ 16.89	7	$ 16,886	$ 5,066	$ 11,820
$ 19.68	8	$ 19,684	$ 5,905	$ 13,779
$ 22.59	9	$ 22,587	$ 6,776	$ 15,811
$ 25.60	10	$ 25,599	$ 7,680	$ 17,919
	NPV	15,500	9,848	22,980
	IRR	4.141%	4.141%	4.141%

At 9% IRR		Year	Project Cashflow	Shareholder Equity cashflow	Govt. Cashflow
	Per Employee Share over 100$		$	$	$
		0	(100,000.00)	(30,000.00)	(70,000.0)
	$ 10.71	1	$ 10,710	$ 3,213	$ 7,497
	$ 10.92	2	$ 10,924	$ 3,277	$ 7,647
	$ 11.14	3	$ 11,143	$ 3,343	$ 7,800
	$ 13.64	4	$ 13,639	$ 4,092	$ 9,547
	$ 16.23	5	$ 16,230	$ 4,869	$ 11,361
	$ 18.92	6	$ 18,920	$ 5,676	$ 13,244
	$ 21.71	7	$ 21,710	$ 6,513	$ 15,197
	$ 22.14	8	$ 22,144	$ 6,643	$ 15,501
	$ 20.08	9	$ 20,078	$ 6,023	$ 14,054
	$ 20.48	10	$ 20,479	$ 6,144	$ 14,335
NPV for Employee $100	47	NPV	47,000	19,793	46,183
		IRR	9.000%	9.000%	9.000%

At 15% IRR		Year	Project Cashflow	Shareholder Equity cashflow	Govt. Cashflow
	Per Employee Share over 100$		$	$	$
		0	(100,000.00)	(30,000.00)	(70,000.00)
	$ 19.28	1	$ 19,278	$ 5,783	$ 13,495
	$ 19.66	2	$ 19,664	$ 5,899	$ 13,764
	$ 20.06	3	$ 20,057	$ 6,017	$ 14,040
	$ 20.46	4	$ 20,458	$ 6,137	$ 14,321
	$ 19.71	5	$ 19,708	$ 5,912	$ 13,795
	$ 21.28	6	$ 21,284	$ 6,385	$ 14,899
	$ 19.30	7	$ 19,298	$ 5,789	$ 13,509
	$ 19.68	8	$ 19,684	$ 5,905	$ 13,779
	$ 20.08	9	$ 20,078	$ 6,023	$ 14,054
	$ 20.48	10	$ 20,479	$ 6,144	$ 14,335
NPV for Employee $100	80	NPV	79,550	29,996	69,991
		IRR	14.994%	14.994%	14.994%

At 20% IRR		Year	Project Cashflow	Shareholder Equity cashflow	Govt. Cashflow
	Per Employee Share over 100$	0	$ (100,000.00)	$ (30,000.00)	$ (70,000.0)
	$ 23.78	1	$ 23,776	$ 7,133	$ 16,643
	$ 23.38	2	$ 23,378	$ 7,013	$ 16,364
	$ 22.51	3	$ 22,508	$ 6,752	$ 15,756
	$ 22.96	4	$ 22,958	$ 6,888	$ 16,071
	$ 25.74	5	$ 25,736	$ 7,721	$ 18,015
	$ 23.89	6	$ 23,886	$ 7,166	$ 16,720
	$ 24.36	7	$ 24,364	$ 7,309	$ 17,055
	$ 24.85	8	$ 24,851	$ 7,455	$ 17,396
	$ 25.35	9	$ 25,348	$ 7,604	$ 17,744
	$ 25.85	10	$ 25,855	$ 7,756	$ 18,098
NPV for Employee $100	118	NPV	117,560	35,268	82,292
		IRR	20.045%	20.045%	20.045%

At 25% IRR		Year	Project Cashflow	Shareholder Equity cashflow	Govt. Cashflow
	Per Employee Share over 100$	0	$ (100,000.00)	$ (30,000.00)	$(70,000.00)
	$ 26.78	1	$ 26,775	$ 8,033	$ 18,743
	$ 27.31	2	$ 27,311	$ 8,193	$ 19,117
	$ 26.74	3	$ 26,742	$ 8,023	$ 18,720
	$ 29.55	4	$ 29,550	$ 8,865	$ 20,685
	$ 27.82	5	$ 27,823	$ 8,347	$ 19,476
	$ 29.56	6	$ 29,562	$ 8,869	$ 20,693
	$ 29.43	7	$ 29,429	$ 8,829	$ 20,601
	$ 30.76	8	$ 30,756	$ 9,227	$ 21,529
	$ 30.87	9	$ 30,869	$ 9,261	$ 21,608
	$ 28.16	10	$ 28,159	$ 8,448	$ 19,711
NPV for Employee $100	157	NPV	157,250	47,175	110,075
		IRR	25.019%	25.019%	25.019%

Project Cash Flows Under Various Scenarios with Guaranteed 9% ROR
Based on the above cash flows under various IRR, we chose 9% ROR to be on conservative side for worst case scenario.

At 9% IRR-Guaranteed with actual 4% IRR (Worst case Scenario)		Year	Project Cashflow @ worst case scenario IRR	Guaranteed Shareholder Equity cashflow	Govt. Cashflow
	Per Employee Share over 100$	0	$ (100,000.00)	$ (30,000.00)	$ (70,000.00)
	$ 10.71	1	$ 11,353	$ 3,213	$ 8,140
	$ 10.92	2	$ 11,580	$ 3,277	$ 8,302
	$ 11.14	3	$ 11,811	$ 3,343	$ 8,468
	$ 13.64	4	$ 12,047	$ 4,092	$ 7,956
	$ 16.23	5	$ 12,288	$ 4,869	$ 7,419
	$ 18.92	6	$ 12,534	$ 5,676	$ 6,858
	$ 21.71	7	$ 12,785	$ 6,513	$ 6,272
	$ 22.14	8	$ 13,041	$ 6,643	$ 6,397
	$ 20.08	9	$ 13,301	$ 6,023	$ 7,278
	$ 20.48	10	$ 13,567	$ 6,144	$ 7,424
NPV for Employee	47	**NPV**	**11,300**	**14,100**	**(2,800)**
		IRR	**4.035%**	**9.000%**	**1.197%**

At 9% IRR-Guaranteed with actual 9% IRR (BAU Scenario)		Year	Project Cashflow @ Guaranteed IRR	Guaranteed Shareholder Equity cashflow	Govt. Cashflow
	Per Employee Share over 100$	0	$ (100,000.00)	$ (30,000.00)	$(70,000.00)
	$ 10.71	1	$ 10,710	$ 3,213	$ 7,497
	$ 10.92	2	$ 10,924	$ 3,277	$ 7,647
	$ 11.14	3	$ 11,143	$ 3,343	$ 7,800
	$ 13.64	4	$ 13,639	$ 4,092	$ 9,547
	$ 16.23	5	$ 16,230	$ 4,869	$ 11,361
	$ 18.92	6	$ 18,920	$ 5,676	$ 13,244
	$ 21.71	7	$ 21,710	$ 6,513	$ 15,197
	$ 22.14	8	$ 22,144	$ 6,643	$ 15,501
	$ 20.08	9	$ 20,078	$ 6,023	$ 14,054
	$ 20.48	10	$ 20,479	$ 6,144	$ 14,335

At 9% IRR-Guaranteed with actual 20% IRR (Good case Scenario)		Year	Project Cashflow @ 20% IRR	Guaranteed Shareholder Equity cashflow	Govt. Cashflow	
Incentive for going beyond Guaranteed returns	**Per Employee Share over 100$**	**0**	$ (100,000.00)	$ (30,000.00)	$(70,000.00)	Incentive for Govt. to encourage EE Financing
$ 13.07	$ 23.78	**1**	$ 23,776	$ 7,132.86	$ 16,643	$ 8,504
$ 12.45	$ 23.38	**2**	$ 23,378	$ 7,013.34	$ 16,364	$ 8,062
$ 11.37	$ 22.51	**3**	$ 22,508	$ 6,752.47	$ 15,756	$ 7,287
$ 9.32	$ 22.96	**4**	$ 22,958	$ 6,887.52	$ 16,071	$ 8,115
$ 9.51	$ 25.74	**5**	$ 25,736	$ 7,720.84	$ 18,015	$ 10,596
$ 4.97	$ 23.89	**6**	$ 23,886	$ 7,165.77	$ 16,720	$ 9,862
$ 2.65	$ 24.36	**7**	$ 24,364	$ 7,309.09	$ 17,055	$ 10,783
$ 2.71	$ 24.85	**8**	$ 24,851	$ 7,455.27	$ 17,396	$ 10,998
$ 5.27	$ 25.35	**9**	$ 25,348	$ 7,604.37	$ 17,744	$ 10,465
$ 5.38	$ 25.85	**10**	$ 25,855	$ 7,756.46	$ 18,098	$ 10,675
NPV for Employee	118	**NPV**	117,560	35,268	82,292	85,092
		IRR	20.045%	20.045%	20.045%	NPV of Govt. Incentive Only

Project Cash Flows Under Various Financing Scenarios with Guaranteed ROR

Project Financing Scenario 1	Employee Share	15.00%
	Govt. Share	85.00%

At 9% IRR-Guaranteed with actual 4% IRR (Worst case Scenario)		Year	Total Cost Savings @ worst case scenario IRR	Guaranteed Shareholder Equity cashflow	Total Govt. Cashflow
Per Employee Share over 100$		**0**	$ (100,000.00)	$ (15,000.00)	$ (85,000)
$	10.71	**1**	$ 11,353	$ 1,606.50	$ 9,746
$	10.92	**2**	$ 11,580	$ 1,638.63	$ 9,941
$	11.14	**3**	$ 11,811	$ 1,671.40	$ 10,140
$	13.64	**4**	$ 12,047	$ 2,045.80	$ 10,002
$	16.23	**5**	$ 12,288	$ 2,434.50	$ 9,854
$	18.92	**6**	$ 12,534	$ 2,837.93	$ 9,696
$	21.71	**7**	$ 12,785	$ 3,256.52	$ 9,528
$	22.14	**8**	$ 13,041	$ 3,321.65	$ 9,719
$	20.08	**9**	$ 13,301	$ 3,011.63	$ 10,290
$	20.48	**10**	$ 13,567	$ 3,071.87	$ 10,496
		NPV	11,300	7,050	4,250
NPV for Employee	47	**IRR**	4.035%	9.000%	2.939%

At 9% IRR-Guaranteed with actual 20% IRR (Good case Scenario)		Year	Total Cost Savings @ worst case scenario IRR	Total Shareholder Equity cashflow	Total Govt. Cashflow	
Incentive for going beyond Guaranteed returns	**Per Employee Share over 100$**	**0**	$(100,000.00)	$ (15,000.00)	$(85,000)	Incentive for Govt. to encourage EE Financing
$ 13.07	$ 23.78	**1**	$ 23,776	$ 3,566.43	$ 20,210	$ 10,464
$ 12.45	$ 23.38	**2**	$ 23,378	$ 3,506.67	$ 19,871	$ 9,930
$ 11.37	$ 22.51	**3**	$ 22,508	$ 3,376.23	$ 19,132	$ 8,992
$ 9.32	$ 22.96	**4**	$ 22,958	$ 3,443.76	$ 19,515	$ 9,513
$ 9.51	$ 25.74	**5**	$ 25,736	$ 3,860.42	$ 21,876	$ 12,022
$ 4.97	$ 23.89	**6**	$ 23,886	$ 3,582.89	$ 20,303	$ 10,607
$ 2.65	$ 24.36	**7**	$ 24,364	$ 3,654.54	$ 20,709	$ 11,181
$ 2.71	$ 24.85	**8**	$ 24,851	$ 3,727.63	$ 21,123	$ 11,404
$ 5.27	$ 25.35	**9**	$ 25,348	$ 3,802.19	$ 21,546	$ 11,256
$ 5.38	$ 25.85	**10**	$ 25,855	$ 3,878.23	$ 21,977	$ 11,481
		NPV	117,560	17,634	99,926	95,676
NPV for Employee	118	**IRR**	20.045%	20.045%	20.045%	NPV of Govt. Incentive Only

Project Financing Scenario 2	Employee Share	50.00%
	Govt. Share	50.00%

At 9% IRR-Guaranteed with actual 4% IRR (Worst case Scenario)		Year	Total Cost Savings @ worst case scenario IRR	Guaranteed Shareholder Equity cashflow	Total Govt. Cashflow
	Per Employee Share over 100$	0	$ (100,000.00)	$ (50,000.00)	$ (50,000)
	$ 10.71	1	$ 11,353	$ 5,355.00	$ 5,998
	$ 10.92	2	$ 11,580	$ 5,462.10	$ 6,118
	$ 11.14	3	$ 11,811	$ 5,571.34	$ 6,240
	$ 13.64	4	$ 12,047	$ 6,819.32	$ 5,228
	$ 16.23	5	$ 12,288	$ 8,114.99	$ 4,173
	$ 18.92	6	$ 12,534	$ 9,459.76	$ 3,074
	$ 21.71	7	$ 12,785	$ 10,855.08	$ 1,930
	$ 22.14	8	$ 13,041	$ 11,072.18	$ 1,968
	$ 20.08	9	$ 13,301	$ 10,038.78	$ 3,263
	$ 20.48	10	$ 13,567	$ 10,239.55	$ 3,328
NPV for Employee	47	NPV	11,300	23,500	(12,200)
		IRR	4.035%	9.000%	-3.940%

Project Financing Scenario 3	Employee Share	75.00%
	Govt. Share	25.00%

At 9% IRR-Guaranteed with actual 4% IRR (Worst case Scenario)		Year	Total Cost Savings @ worst case scenario IRR	Guaranteed Shareholder Equity cashflow	Total Govt. Cashflow
	Per Employee Share over 100$	**0**	$ (100,000.00)	$ (75,000.00)	$ (25,000)
	$ 22.00	**1**	$ 11,353	$ 11,000.00	$ 353
	$ 23.00	**2**	$ 11,580	$ 11,500.00	$ 80
	$ 22.00	**3**	$ 11,811	$ 11,000.00	$ 811
	$ 23.00	**5**	$ 12,288	$ 11,500.00	$ 788
	$ 24.00	**6**	$ 12,534	$ 12,000.00	$ 534
	$ 24.60	**7**	$ 12,785	$ 12,300.00	$ 485
	$ 25.00	**8**	$ 13,041	$ 12,500.00	$ 541
	$ 25.00	**9**	$ 13,301	$ 12,500.00	$ 801
	$ 26.00	**10**	$ 13,567	$ 13,000.00	$ 567
		NPV	11,300	30,984	(19,684)
NPV for Employee	112	**IRR**	4.035%	8.992%	-19.645%