Biden School Journal of Public Policy 1 (2020) 115- 40

BIDEN SCHOOL JOURNAL of PUBLIC POLICY


Volume: 12
Issue No. 1
April 2020

ISSN 2575-8535(PRINT)
ISSN 2575-842X (ONLINE)

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Published by:
Biden School of Public Policy & Administration,
University of Delaware,
111 Academy Street
184 Graham Hall, Newark,
Delaware 19716, USA.

What is the 'Energy Efficiency Gap'? Analyzing market failures to energy efficiency

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ARTICLE INFO

Article history:
Received: Jan 31, 2020
Revised: Feb 21, 2020
Accepted: Apr 4, 2020

ABSTRACT

Energy efficiency is key to establishing a sustainable and clean environment for present and future generations. Without initiatives to develop energy efficiency, there are doubts that the path towards greater sustainability can ever be achieved. The literature on energy efficiency has long demonstrated the presence and persistence of an 'energy efficiency gap.' This paper examines the nature and size of this gap, identifies vital explanatory factors, and explores approaches by which to bridge the gap between potential and actual improvements in energy efficiency for sustainable development.

1.0 INTRODUCTION

Over the last several decades, a large body of literature seeking ways to alter energy consumption and production, and to improve energy efficiency and conservation approaches, has been developed. Research has been undertaken in nearly all sectors where energy is utilized, namely, in industrial facilities and manufacturing sectors (Abdelaziz et al., 2011; Rohdin & Thollander, 2006; Tanaka, 2011, Hasan et al., 2019), in the household sector (Chegut et al., 2016; Copiello, 2015; Thondhlana & Kua, 2016), and in building services (Abu Baker et al., 2015; Hou et al., 2016; Fossati et al., 2016; Tan et al., 2016) just to name a few.

Research has focused on countries from "developed" to developing, including Sweden, Vietnam, Indonesia, Brazil, the United States, China, Bangladesh, and others. This research is in an array of fields, ranging from technological aspects of energy production (Xu et al., 2016) to policy-based studies (Bird & Hernandez, 2012; Geller et al., 2006; Schleich, 2009; Viholainen et al., 2016), behavioural attitudes and consumer responses to energy efficiency policies (Ma et al., 2013; Lopes et al., 2012; Wijaya & Tezuka, 2013), and economic aspects of energy efficiency (Cantore et al., 2016; Linares & Labandeira, 2010; Gillingham et al., 2009; Jaffe et al., 2004).

Energy efficiency has gathered international interest as it can mitigate the effects of climate change and meet international obligations, to increase resilience against energy security issues, to improve industrial competitiveness and reduce production costs, and to reduce air pollution and improve human health, among other benefits at both micro and macroeconomic level (IEA, 2010).

Despite considerable research in the area of energy efficiency, it is noted that consumers and businesses do not always adopt cost-effective energy efficiency measures and technologies to the degree that is considered justified on a financial basis (Gerarden et al., 2015). This gap between consumer demand and the existing financial rationale exemplifies the existence of an 'energy efficiency gap' — the difference between actual use and optimal use of energy (Hirst & Brown, 1990; Jaffe & Stavins, 1994; Gerarden et al., 2015), this arises because of economic failures in the energy efficiency market (Allcott & Greenstone, 2012; DeCanio, 1998; Rohdin & Thollander, 2005; Sanstad & Howarth, 1994; Stadelmann, 2017).

This energy efficiency gap necessitates examination and assessment for accurate decision-making and the design of conducive energy policy interventions in the energy efficiency domain. Therefore, this article examines the origin and causes of the energy efficiency gap. The article reviews the literature to identify five energy efficiency market failures: (i) asymmetric information, (ii) split incentives and the principal-agent problem, (iii) externalities, (iv) poor regulatory policies, and (v) behavioural 'anomalies', which contribute to the energy efficiency gap. This article thus contributes to the ongoing debate on energy efficiency market failures. It provides a concise review to policymakers and other interested stakeholders an understanding of the complexity behind the 'energy efficiency gap.'

2.0 ENERGY EFFICIENCY MARKET FAILURES

The rich literature on energy efficiency depicts numerous barriers that are hindering energy efficiency measures. Market failures can be defined as any flaw that causes an economy to deliver an outcome other than the efficiency maximizing level, leading to a social welfare loss (Gruber, 2011, pp. 3). These are caused by violations of the assumptions made in neoclassical economic theory, which include asymmetric information, split incentives, negative externalities, and distortional regulatory policies (Brown, 2001; Jaffe & Stavins, 1994; Stadelmann, 2017). Neoclassical economic theory also assumes that consumers are rational individuals with stable preferences. However, the novel area of 'behavioural economics' research has identified inconsistencies in consumer behaviour that deviate from the utility–maximization model, forcing consumers to make some irrational decisions (Lopes et al., 2012). These behavioural 'anomalies' can also be regarded as a type of market failure. The literature also discusses 'market barriers', which are defined as any impediments that slow the rate of diffusion and adoption of energy efficiency measures and technologies, despite their cost-effectiveness (Brown, 2001; Jaffe & Stavins, 1994). However, 'market barriers' are likely to be derivatives or 'side-effects' of market failures as most originate from them. Market failures are discussed in the sub-sections below.

2.1. Market failure 1 – Asymmetric information

Suboptimal investment in energy efficiency occurs due to asymmetric or incomplete information or if obtaining information is too costly (Brown, 2001; Sanstad & Howarth, 1994). Since energy is consumed in terms of the services it offers and information about energy consumption is not readily available to consumers, it is difficult for them to obtain an estimation of their consumption and associated cost, this leads to energy efficiency getting little priority over investment or purchasing decisions (DeCanio, 1993; Trianni et al., 2013; Thollander et al., 2007). Asymmetric information also leads to uncertainties and increases the level of financial risk between stakeholders of any given transaction (Schleich & Gruber, 2008). For instance, a borrower seeking capital to make a high investment in an energy efficiency project can find his application rejected if the lender is not a risk-taker. For some efficiency technologies, in the industrial sector, in particular, the investment cost is high, this creates liquidity constraints and leads to difficulties in securing finances for energy efficiency projects.

There is evidence of asymmetrical information hindering development in energy efficiency. Ma et al. (2013) showed that citizens of Chongqing, China are willing to save energy provided that their level of comfort is not compromised and that their level of information and guidance on the subject is limited. Meyers (2018) revealed that in a situation where tenants lack information, and it becomes difficult for landlords to capitalize energy efficiency investment into higher rents, landlords underinvest in energy efficiency in the housing rental market in the U.S. Brown (2004) used the example of cases in which vehicles may have the same level of energy efficiency, however, the consumer is unable to identify which is more energy-efficient. There is also empirical evidence which shows that the lack of access to energy information on consumer products can lead to under-investment in energy efficiency (Ward et al., 2011; Allcott, 2011; Davis & Metcalf, 2015; Houde, 2018; Newell & Siikamäki, 2013; Cattaneo, 2019), this implies that consumers require complete information in order for them to decide on investing in energy efficiency. This failure of transparency makes consumers worse off because it causes them to bear higher energy bills and lose trust in energy efficiency endeavours.

A special form of asymmetric information that arises when one party involved in a transaction has a greater level of information than the other one is the adverse selection (Akerlof, 1970). Suppose a buyer is looking for an energy-efficient house. Given that the seller has more information than the buyer, he can flaunt the merits of appliances or weatherization in the house, making the buyer worse off if the house is not as energy efficient as desired by the buyer. A study by Hyland et al. (2013) shows that in Ireland, property buyers and tenants are willing to pay more for energy-efficient properties, this provides an incentive for realtors to increase the selling price or rent of such more energy-efficient properties. Empirical evidence of adverse selection has also been found by Qiu et al. (2017), where households having low energy consumption during peak hours voluntarily enroll for Time-of-Use pricing programs, this implies that utility companies might undergo a net loss in revenues, which will be passed onto consumers and subsequently undermine the progress for the whole program.

To overcome asymmetrical information problems, the simplest solution is to provide adequate information to consumers for them to make informed decisions concerning the purchase of energy-efficient goods or consumption of energy. The provision of information is expected to induce consumers to make more rational decisions and reduce transaction costs (Sanstad & Howarth, 1994), this can be done in many ways, namely through product labelling, feedback programs, or energy audits. Though there seems to be a consensus that all these policies are adequate, it is still debated how efficient these measures are in altering consumers' energy consumption patterns or the adoption of energy efficiency products. There is evidence that consumers tend to consider appliances' labelling when making purchasing decisions, though the influence of the energy efficiency factor is not clear yet (Cattaneo, 2019).

Newell & Siikamäki (2013) found that information on the physical energy consumption of an appliance guide purchasing decisions, even though financial information remains a higher priority. Ward et al. (2011) showed that consumers are willing to pay higher prices for ENERGY STAR products, but willingness to pay decreases with age and is different between genders. Murray and Mills (2011) found that willingness to pay for products is also different based on socioeconomic status and ethnicity. Countries like the United Kingdom, the United States, and Ireland have moved a step forward by establishing appropriate indices that show the energy efficiency attributes of a property. However, Carroll et al. (2016) found that the index is under-utilized by potential renters in Ireland.

Other studies have discussed the importance of feedback on energy consumption to inform consumers better, but results have been mixed (Fischer, 2008; Schleich et al., 2013; Allcott, 2014; Ayres et al., 2012). In Linz, Austria, Schleich et al. (2013) showed that feedback on electricity consumption had increased electricity savings by 4.5% and cost savings of some $30 (USD) annually. Ayres et al. (2012) showed that feedback reports to customers have led to a reduction of energy consumption by 2.1% in Sacramento, California, and 1.2% in Puget Sound, Washington. They also demonstrated that this decrease is sustained over months (12 months in Sacramento and seven months in Puget Sound). However, Allcott & Rodgers (2014) showed that while feedback reports spur energy conservation in the short-term, over time, customers get accustomed to receiving reports and eventually efforts to decrease energy consumption decay, this is not to say that the strategy of providing feedback forms to consumers is not working, but rather that a better formulation of this strategy is needed for it to provide long-term positive effects. On a short-term basis, this strategy seems to be providing positive results.

In the industrial and small to medium business sectors, some countries have implemented energy audit services, which act as decision-making support for firms to make more accurate decisions on their anticipated energy consumption. In response to economic incentives, such as a subsidy, firms are willing to participate in energy audits. The adoption of energy efficiency measures is dependent on several factors, cost implications being the first. Fleiter et al. (2012) showed that the German energy audit program has been very effective in reducing carbon dioxide (CO_2) emissions. Studies also show that energy efficiency measures in small and medium-sized companies also required low investment costs making them more cost-effective than business as usual (Fleiter et al. 2012).

In the case of the United States, Anderson & Newell (2004) showed that energy audits have led to the adoption of over 50% of energy efficiency measures proposed by the auditor in manufacturing plants. The adoption of these measures was also greatly influenced by low implementation costs, short payback period, and economic incentives (Anderson & Newell, 2004). A prior study by Harris et al. (2000) made similar observations that Australian firms are likely to participate in energy audits, but that there are hurdles, mostly financial when it comes to investment. Thollander et al. (2007) and more recently, Kalantzis & Revoltella (2019), found similar results in the cases of Sweden and Europe, respectively.

2.2. Market failure 2 – Split incentives and the PA problem

Split incentives are regarded as a market failure and originate from the Agency Theory, and a situation commonly referred to as the principal-agent (PA) problem (Eisenhardt, 1989; Hirst and Brown, 1990; Gillingham & Palmer, 2014). The PA problem is driven by incomplete and asymmetric information, as discussed above. Due to information asymmetry between a 'principal' and an 'agent,' the principal has to bear the cost of an investment they did not make, allowing the agent to trade energy efficiency to reduced capital costs.[1] A classic example of the PA problem is the landlord and tenant example, where a landlord seeks to minimize capital costs in

1 To note that the PA problem is different from the free rider problem. In a free rider problem, the individual making the investment enjoy the benefits compared to the PA problem who do not.

the house put to rent, and subsequently underinvests in energy efficiency. As it usually is difficult for tenants to have this information, they have to bear the energy costs in their monthly energy bill for an investment they did not make (Case II in Fig. 2). Hence, the Agency Theory posits that the divergence in the objective of the landlord (whose objective is to minimize cost) and that of the tenant (whose objective is to minimize energy consumption and associated costs), as well as the fact that the tenant cannot verify or follow the actions of the landlord, constitutes a PA problem.

This situation produces three possible relationships between the principal and the agent, as given in Fig. 2, where Cases II-IV represents such a PA problem. For an owner (see Case I), the principal and the agent are the same individual and therefore chooses energy efficiency and pays for energy bills eliminating all kinds of market failures (IEA, 2007). Case III is a situation in which the landlord does not pay the energy bill, and the onus of paying the energy bill lies on the tenant. In this situation, the tenant has no incentive to reduce energy consumption (usage problem) or to invest in energy efficiency. Case IV depicts a condition where the marginal cost of the individual renting the place is zero, this posits a 'moral hazard' problem where the energy bill of the tenant is passed on to the landlord, and the renter has no incentives to reduce energy consumption, as the landlord pays for their energy bills.

	The individual owns the place	Individual rents the place
Individual pays for energy costs	Case I: No PA problem (Principal and Agent same entity)	Case II: Efficiency problem (Agent chooses technology and principal pays for energy costs)
The individual does not pay energy costs	Case III: Both efficiency and usage problem	Case IV: 'Moral Hazard' problem (Energy costs are passed to the agent tied in an agreement)

Table 1 – Possible relationships between principal and agent ('landlord-tenant' example) (Adapted from IEA, 2007)

Studies have provided empirical evidence of the problem and magnitude of split incentives. Levinson & Niemann (2004) showed that tenants use more heating and turn down the thermostats less when they are away from their homes. Therefore they recommended energy costs to be included in rents as landlord-led energy efficiency measures yielding greater efficiency in housing units. Gillingham et al. (2012) found that when landlords pay energy bills in California, tenants do not adjust their temperature accordingly, resulting in a higher energy use per unit area (energy intensity) in their homes. Similar findings were previously made by Maruejols & Young (2011) in landlord-energy included Canadian multi-family dwellings, where the latter set temperatures significantly higher and do not adjust temperature settings when the house is unoccupied, confirming the split incentive problem. Melvin (2018) confirmed the split incentives problem and found that tenants use 3.9% more natural gas, 1.2% more electricity, 2.2% more propane/LP, and 2.6% more fuel oil when landlords pay the energy bill.

Some authors (Bird & Hernandez, 2012; Charlier, 2015) have suggested solutions to the split incentive problem. These include enforcing public policies, such as a well-defined contract between landlord and tenant, concierge services, and regulations between the 'principal' and the 'agent.' The overarching solution in this context is the implementation of green building codes and confirmation that all housing units conform to some form of energy efficiency measure. Leadership in Energy and Environmental Design (LEED) is a type of building code implemented in the U.S. housing market to curb the magnitude of the split incentive problem. The issue, however, is that green building codes apply only to new buildings and exclude existing ones (Bird & Hernandez, 2012). Concierge service is another welcomed initiative where policymakers provide an "all-in" transformation of homes. Examples include the Green London Concierge Service and the British Columbia Green Landlords project. Concierge service models include weatherization upgrades in homes and other services, such as the provision of soft loans, grants, education, and other degrees of oversight (Bird & Hernandez, 2012). The problem with these solutions is that they require political support as well as significant financial resources, which are both challenging to secure (Bird & Hernandez, 2012).

2.3. Market failure 3 – Externalities

What happens when the price of a good or service does not capture the total cost of production? Production and consumption of goods and services affect people that are not part of a transaction, and when these effects are large enough, they can be problematic, this is what economists call 'externalities.' Externalities can be both positive and negative.

An externality is a consequence of an activity that affects other parties without being reflected in market prices. The use of an energy-inefficient technology (termed as a *black* technology) can thus be considered as a *negative externality* due to the pollution it produces from the consumption of a relatively large amount of energy when low energy technology is an option. In this respect, a *green* technology that produces lesser pollution levels can be considered a *positive externality*. Energy markets do not address externalities and thus lead to market failure. The use of a vehicle powered by gasoline, therefore, produces a negative externality from the pollution it produces, which is not reflected in the selling price of the gasoline or vehicle (consumers get a private benefit). The monetary effects of the pollution are borne by society as a whole, who has not demanded to incur these costs (society incurs a social cost). A zero-emission vehicle, on the other hand, produces a positive externality.

Government intervention can correct negative externalities by offering financial incentives like tax credits, rebates, tax deductions, or grants and loans for energy efficiency programs or the purchase of energy efficiency equipment. An additional financial incentive is the levying of an energy tax on an energy-inefficient technology. The idea is to invest in *green* technology less costly than one in *black* technology. Financial incentives, in many cases, have been considered adequate, as they are transparent and promote behavioral change among consumers (Cattaneo, 2019). However, taxes or credits have also been criticized for two reasons.

Firstly, the impact of an energy tax is limited if the price elasticity of energy demand is small; this is the current situation, according to a meta-analysis by Labandeira et al. (2017). As price elasticities of a variety of energy sources are inelastic, consumers are less responsive to price changes and taxes imposed to decrease the use of these energy sources, and the energy services these sources provide become less effective. Secondly, financial policy instruments are associated with a rebound effect. This is a phenomenon that increases energy efficiency, but energy savings are less than expected (Gillingham et al., 2016). In the example of Gillingham et al. (2016): "Buy a fuel-efficient car, drive more." The fact that the car consumes less fuel per mile travelled means that one can drive more, ending up using the same amount, or more, of fuel. Energy efficiency programs have often been criticized because of the rebound effect when these programs 'backfire' and result in higher energy use.

There are four ways in which the rebound effect manifests itself in energy efficiency, which are summarized in Table 1. Some studies have detected the presence of some form of a rebound effect. Davis et al. (2014) detected rebound effects in Mexico's *Cash for Coolers* (C4C) program to substitute air conditioners and refrigerators against a payment incentive given by the government.

Davis et al. (2014) found that there is no visible decrease in energy use when consumers change their refrigerators for a more energy-efficient one against a payment they receive from the government. In the case of households which have replaced their air conditioners, they found that these households have increased their consumption of energy, rather than reduce their energy use, as initially expected. The rebound effect, in this case, has caused a net reduction of CO_2 at $500 a ton and was deemed too expensive (Davis et al., 2014). In other settings, the rebound effect was also detected Alberini et al. (2016), where incentive takers replaced their heat pump with that of a higher size one when providing a tax credit, leading to a net increase in usage of energy.

The rebound effect figured in the scientific literature for long, but there is still some research needed to understand the rebound effect fully. Sorrell et al. (2009) have tried to provide some empirical estimates of the rebound effect, but as they acknowledged, their results are indicative rather than accurate and consistent. Hence, internalizing externalities come up with another set of issues which have to be carefully addressed during policymaking. These issues, however, should not be a distraction in progress towards more energy efficiency but rather a source of more significant action for the sustainable development of the world (Gilingham et al., 2013).

Types of a rebound effect	Description
'Direct' rebound effect	'Direct' rebound effect occurs when an increase in the price of an energy service leads to an increase in the demand of the said energy service when the contrary should normally be happening.
'Indirect' rebound effect	'Indirect' rebound effect occurs when the money saved from an efficient energy service is used to purchase another energy service that is energy-intensive in its manufacture or use.
'Macroeconomic' effects	*Effect 1*: One type of macroeconomic effect can occur when energy efficiency development increases in one sector cause opportunities in another sector, which consumes more energy. *Effect 2*: Another way, if energy efficiency leads to a drop in a fuel economy like the United States, then global oil prices may drop too, and people globally might be encouraged to drive more.

Table 2: Types of rebound effect (Adapted from Gillingham et al., 2013)

2.4. Market failure 4 – Poor regulatory policies

Another market failure often cited within the literature, which is slowing down energy efficiency measures is distortionary regulatory policies (Brown, 2001). Any investment is motivated based on social and economic goals, and with above-discussed market failures, a certain degree of risk management. Comprehensive energy policies are essential to keep any growth in energy efficiency going. An absence of a proper regulatory system can impede such development. Berg (2015) identifies ten critical functions of regulators who are responsible for creating a survival climate for energy efficiency policy programs, which can be broadly classified into administrative functions, organizational tasks, and policy and decision-making tasks. Among, a policy-making task of a regulator is to design policies favouring investment in energy efficiency, but the literature suggests some policies which do not favour the same. Previous researchers (Gillingham et al., 2009; Golove & Eto, 1996) point out the structure of energy pricing might promote underinvest in energy efficiency rather than optimal investment. As electricity prices are mostly fixed based on average costs (regulated price) rather than marginal costs (market price), and as average costs are below marginal costs, underinvestment in energy efficiency is more likely. To correct for this mispricing in energy tariffs, policymakers came up with Time-Of-Use (TOU) and real-time pricing (RTP) schemes where consumers can adjust their energy consumption based on time of use. However, there are few empirical studies that prove that these schemes favor energy efficiency and conservation.

Poor regulatory policies also reflect the inability of regulators to develop human resources. Studies have often highlighted that there is a lack of capacity and knowledge base to implement or monitor energy efficiency management systems in industries (DOE, 2015; Palm & Thollander, 2010; Raghoo et al., 2017; Timilsina et al., 2016; Trianni et al., 2013). Brown (2001) attributes the lack of education and training of practitioners due to the public good nature of education. Deviating from the classic definition of the public good of non-excludability and non-rivalry, the question of who has the responsibility to educate and form energy efficiency experts often surfaces. Some firms hesitate to invest in providing training and equip employees with new skills, and there is no guarantee that employees will work for the company till the time the company gets an adequate return on the investment made on the employee. There seem to be expectations that they mostly overlook training and education on energy efficiency to come from regulators. The question of who is going to provide training remains unresolved.

2.5. Market failure – Behavioral 'anomalies' and cognitive barriers

As mentioned above, the economic concept of utility-maximization assumes that consumers behave rationally; however, there are shreds of evidence that consumers do not behave rationally even though complete information is available (Lopes et al., 2012). From the literature, four market failures that arise because of individual preferences and behavior with regards to energy efficiency programs or investment decisions — in the energy efficiency jargon, behavioral 'anomalies' — can be identified. These are (a) time discounting, (b) positive illusions, (c) egocentrism, and (d) irrational behavior (Lopes et al., 2012; Stadelmann, 2017; Bazerman, 2009; Cattaneo, 2019).

2.5.1 Time discounting

Research has shown that we tend to put more emphasis on a high discounting rate and tend to overweight short-term considerations. For example, we would prefer to get $10,000 now, instead of $12,000 after a year — even though, if we wait for a year we will get more money. Still, human decision-making processes will favor more the money we will get in the present over the added benefits we might get in the future. This, in behavioral economics, is called being present bias. Time discounting reflects the level of impatience that we have as an individual and has been regarded as a cognitive barrier in adopting energy efficiency practices.

We tend to devalue future rewards for present gains. In the context of energy efficiency, since we have a high hyperbolic discounting rate, we are expected to be less willing to carry out energy-saving investments because we have little consideration of the benefits we might get from energy savings in the future. Fuerst & Singh (2018) show that in Delhi (India), individuals who are more patient and less present-bias are more likely to purchase energy efficiency appliances. Among other findings, Bradford et al. (2014) show that the more patient and less present biased individuals are more likely to use less air conditioning in the summer. It is not only as individuals that we tend to discount the future but also as an organization too. For example, Bazerman (2009) cites the case of construction works in a university where the organization has emphasized the reduction of current costs over the long-term costs of running the building, hence neglecting any investment in energy efficiency if that means higher costs.

The reasons behind the attitude that we, as humans, tend to discount the future because we are uncertain what the prospects of future cost savings are, or what are the risks associated with technical performance. Thus, people who are reluctant to take risks (risk-averse people) are less likely to adopt energy efficiency appliances, or retrofit their houses or choose hybrid cars, as some studies have revealed, as they are not sure what are the cost savings are and whether these savings justify present investments in energy efficiency. As Bazerman (2009) explains that we tend to 'over discount' the future when it comes to passing the costs to future generations, as we 'view them as vague groups of people living in a distant time.' Passing the costs to future generations is considered as being a low-stakes gamble which people prefer. This also explains why projects and policies on climate change mitigation are faced with much debate because some people think that it is not worth it to invest now for benefits that this generation will never get. As Bazerman (2009) said in his paper that, “overweighting the present can be viewed not as a foolish but also immoral as it robs the future generation of opportunities and resources” — a severe consequence of a high time discounting preference.

2.5.2 Positive illusions

People having ‘positive illusions’ tend to have a reverse effect when it comes to making decisions, especially in the context of energy efficiency. During the oil embargo, when oil prices hit $4 a gallon mark, it would be logical for consumers to reduce their automobile use. Still, people did not modify their consumption and were struck by the embargo. One reason that Bazerman (2009) advances for this occurrence is that we tend to have positive illusions about the future. Having positive illusions have benefits such as in improving self-esteem, increasing commitment to action, coping diversity, and persistence to face different tasks, but having positive illusions also reduces our quality to make conducive decisions and have a role in preventing us from acting on time (Bazerman, 2006). We tend to believe that the future will be better, and the problems that we face now will fade away soon. Researchers have found that this collective mindset of ours forces us to believe that the effects on climate change will be less significant than the scientific community perceives them to be. This compels us to take little action when it comes to climate change mitigation or adopting energy efficiency initiatives when, in a positive spirit, this way of thinking forces us to believe that we will be fine in the future, where the contrary might happen as with this belief we are not taking actions towards the safeguard of the environment and towards limiting climate change.

2.5.3 Egocentrism

According to Bazerman (2006, 2009), egocentrism is our tendency to make self-serving judgements regarding allocations of blame and credit, a phenomenon that in turn leads to differing assessments of what a fair solution to a problem would be. Bazerman exemplifies the egocentrism concept with the failure of the Kyoto Agreement. The Kyoto Protocol which was enforced in 2005 got mostly negative reviews because India and China which were the biggest carbon emitters (36% of the total global carbon dioxide) were excluded from the Kyoto Agreement under the principle of ‘common but differentiated responsibilities,’ and this was unacceptable by the United States which emitted 15% of carbon dioxide at the time. For then-President George W. Bush, enforcing the Kyoto Protocol meant that he has to launch the necessary mechanisms to decrease carbon emissions which might undermine growth for the United States, while the biggest polluters were exempted from the Agreement, but they will also get the benefits despite doing little to cater for their pollution level. Eventually, as the egocentric behaviour of the United States leads to nothing more than an unfair solution, we have seen that the United States withdrew too from the Agreement to join the two other polluters. These three accounted for almost 51% of carbon dioxide emissions that were left out without regulations. The central tenet of reducing carbon emissions was then on over hundreds of countries which contributed less than 50% of carbon dioxide; most of them contributed less than 1% of carbon dioxide to the global total.

For social scientists, the United States is looking at its benefits first and then to the benefits that a particular policy or program can impart to others. Psychologists will frame the failure of the Kyoto Protocol on the issue of egocentrism. Economists like Cattaneo (2019) will more likely frame this question as a ‘free-rider’ problem. For President Bush, the United States endorsing the Kyoto Protocol and working towards achieving its goals meant that China and India — which have no obligation to reduce greenhouse gases — will tend to ‘free ride,’ that is they will reap the benefits of the reduction of carbon dioxide which entirely come from the efforts done by the United States and other countries with targets, without any investment done by them.

The problem of egocentrism is exacerbated by the lack of conclusive scientific and technological information about a particular policy, and eventually reinforces the PA problem between a landlord and a tenant, highlighted earlier. A landlord will not invest in energy-efficient appliances in the house if energy bills are paid by the tenants as he will not reap the benefits of such investment — it is not in his/her self-serving interests to invest in energy-efficient appliances as he/she can use this investment on other projects where he/she gets a more direct return. This is another barrier to the adoption of energy efficiency in households.

2.5.4 Irrational behavior

The idea of rational behavior is rooted in different areas of study, including economics and sociology. Economics theories typically assume that individuals are rational decision-makers, working to obtain what is most beneficial to them with minimum investment. For instance, the economic theory posits that if the price of gasoline increases, the demand for gasoline will decrease; this assumes that humans are rational thinkers. However, when the price of gasoline increases that does not necessarily mean that people are going to reduce their consumption of gasoline — it might be that the person has a habit to drive his car and does not want to change or he is simply happy to drive, despite any increase in oil prices. These outlying events are not captured by neoclassical economics and tend to compromise the design of energy policies as well as its efficacy of policies.

More recent research on this topic tends to consider these behavioral irrationalities of people and how, outside of rational economic thinking, people make key decisions. With regards to energy efficiency issues, there are three general considerations, including (a) reference dependence, (b) rational inattention, and (c) bounded rationality (Cattaneo, 2019; Stadelmann, 2017), these are discussed below;

(a) Reference dependence (or loss aversion)

The fields of cognitive psychology and decision theory have well established the claim that consumers are more loss averse than gain averse, that is consumers tend to weigh losses more heavily than gains of equal magnitude and this has contributed significantly towards increasing the energy efficiency gap (Greene, 2011; Stadelmann, 2017). In the household sector for example, since there are uncertainties in future energy costs between an efficient and an inefficient appliance (depending on how the appliance is used or changes in energy prices, etc.), there is a probability that an efficient appliance can prove to be non-profitable in the long-term in retrospect (Greene, 2011; Stadelmann, 2017), this eventually leads to some households not investing in energy-efficient appliances and can have an overarching impact when it comes to other sectors.

(b) Rational inattention

The idea of rational inattention most probably stems from the fact that we tend to rank the criteria which we depend on to make a purchase. Additionally, since energy is not visible, and the direct costs with its usage are not always known to the consumer, the energy consumption of an appliance is often overlooked. Studies have shown that energy requirements such as their electrical consumption and associated energy costs of an appliance do not figure among the top criteria that we consider to make a purchase which explains rational inattention. Allcott (2011) found that vehicle buyers do not consider fuel costs when buying a vehicle. It should also be pointed out that neglecting energy consumption of an appliance can be out of choice, or because of 'bounded rationality' (discussed hereunder). Rational inattention increases the energy efficiency gap, and the causes can be numerous such as buyers not knowing the importance of considering energy costs of an appliance or their willingness to ignore energy consumption indicators and focus on other decision criteria like brand, price of the appliance, etc.

(c) Bounded rationality

When we do not have all the information available to us at the time to make a decision, we tend to depend on heuristics; that is, we tend to make decisions based on the information we have in hand and face cognitive constraints and limitations in doing so. This concept is known as bounded rationality. Since people do not have the full information on the energy consumption of an appliance, they are bound to undervalue energy and make purchases based on the information they have, this also explains why energy usage of an appliance does not figure among the top criteria of a purchase because, in the absence of details on the energy consumption of an appliance, we will depend on 'shortcuts' to make a decision. Lacetera et al. (2012) and Turrentine & Kurani (2007) have both found evidence that individuals resort to bounded rationality when deciding on the car market (but they did not find evidence that heuristics favor non-energy efficient cars).

3. CONCLUSION

To rectify market failures, government intervention is required. Government work by passing policies. And to pass policies, a comprehensive understanding of the problem is mandatory. In this paper, a thorough understanding of the energy efficiency gap -- and market failures underpinning the persistence of this gap -- is presented. Five market failures were recognized as follows: (a) asymmetric information, (b) split-incentives, (c) negative production externalities, (d) distortionary regulatory policies, and (e) behavioral 'anomalies'. Issues of externalities can be solved by taxing companies that consume an excessive amount of energy, but the government has to be careful not to affect some sectors and discourage investment disproportionately. Proper classification of each sector has to be done — into small, medium, energy-intensive, and proper tax rates establish for each. Similar, public policies, as mentioned hitherto can solve the split-incentive problem and issues with asymmetric information. However, for the behavioral 'anomalies' observed, more research has to be done to unveil and predict ways people make decisions so as energy efficiency products can be better accepted in households. The paper attempts to describe the problem and to brings out the situation that there is no silver bullet to solve the problem. Research is still underway to solve these problems and reduce the energy efficiency gap. This paper has provided several key insights into the issues associated with the energy efficiency gap. The onus for the solutions now lies with policymakers and scientists to experiment and resolve them, in the quest to maintain a livable world for future generations.

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