Spreading the Net:
Evaluating the Multiple Benefits Delivered by Energy Efficiency Policy

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ABSTRACT

The success of energy efficiency programmes has traditionally been measured in kWh saved, but energy savings are just one of a broad range of benefits which energy efficiency measures can deliver. The nature of these multiple benefits is not yet well understood and methods for quantifying the impact of energy efficiency policy on them are elusive. As a result, a range of benefits are generally neglected in current energy efficiency policy evaluation, leading to an underestimation of the real impact of energy efficiency policy.

The IEA has carried out an inventory of the multiple benefits emerging in various energy efficiency discussions, and has made a preliminary assessment of their scope and impact on the basis of existing academic and evaluation work. A major report investigates twelve key benefits emerging at individual, sectoral, economy-wide and international level including health and social improvements; job creation; energy provider and infrastructure benefits; macroeconomic effects; and sustainable development.

The goal is to ascertain the degree to which inclusion of these benefits in energy efficiency evaluation could change the way energy efficiency is viewed. If achieving energy savings is to evolve from an end in itself, to a means to an end in achieving a range of policy goals, appropriate methodologies are needed to ensure multiple benefits can be reliably measured and accurately quantified. This paper summarises progress in integrating multiple benefits so far and examines the most promising methodologies being used to evaluate them.

Introduction

Improving energy efficiency has long been advocated as a way to increase the productivity and sustainability of society, primarily through the delivery of energy savings. However, the impact of energy efficiency improvements is not limited to energy savings and can be seen to have broader effects on long-term economic development.

The benefits delivered by energy efficiency are multiple, as indicated by the constellation shown in Figure 1 below. They range from localised benefits such as energy affordability and improved health and social development, to sectoral benefits such as industrial productivity, increased asset values and reduced environmental damage, as well as macroeconomic outcomes on energy prices, energy security and national competitiveness as well as supporting international goals in sustainable development and addressing climate change. Efforts to measure the scale of the contribution that energy efficiency improvements can make in these areas are still in their early stages, but results to date suggest that the impact may be significant and merits further study.

This paper explores several of the prominent multiple benefits emerging in the literature to assess the potential value of energy efficiency to society and consider whether it has been underestimated by a focus on energy savings outcomes alone. It investigates progress in integrating multiple benefits into energy efficiency policy so far and the methodologies being used to evaluate them, arriving at some preliminary conclusions about how the task of developing new methodologies in these areas might be approached.

This enquiry must begin in the evaluation space, where evaluators may need to develop new methodologies adapted to capture the particularities of a range of socio-economic impacts from energy efficiency policy. Thorough evaluation of the multiple benefits of energy efficiency beyond energy savings should also inform the regularly surfacing discussion about the potential of rebound effects to undermine the effectiveness of energy efficiency in reducing energy demand. It might help decision-makers reconcile a perceived trade-off between supporting economic growth and reducing energy use. If improving energy efficiency does deliver much wider public benefits than previously considered, perhaps governments should be investing more in it. Increasingly robust evaluation methodologies should allow wider socio-economic objectives to be integrated effectively into energy efficiency policy design and ensure it is optimised to achieve its full potential.

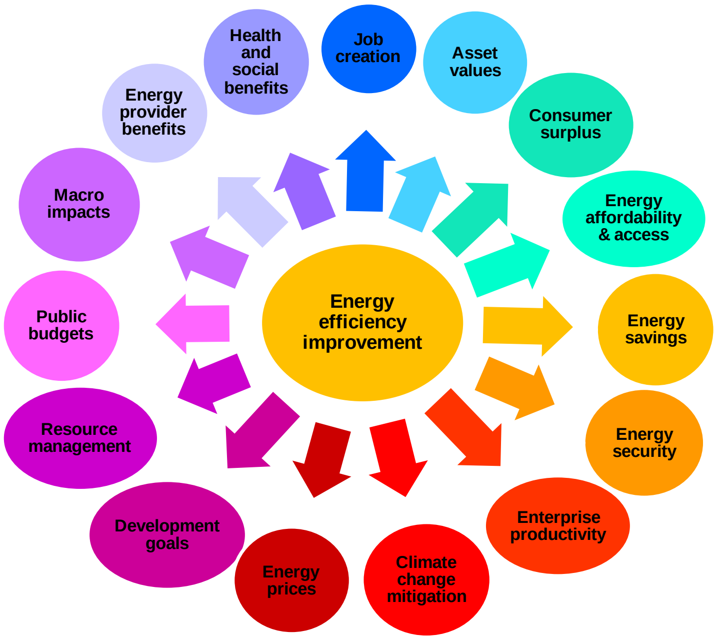

Figure 1: The multiple benefits of energy efficiency improvements

A note on terminology

In the discussion of the wider outcomes of energy efficiency policy, the range of benefits which might accrue have been variously called the "multiple benefits", "co-benefits"1, "ancillary benefits"2 and "non-energy benefits"3. The terms are similar and are occasionally used interchangeably, but they may have differing implications. In the absence of clarity about what each one means and when each one might apply, the IEA has chosen the term "multiple benefits" as the most comprehensive term currently in use. This term is used by several important organisations, including the US Environmental Protection Agency (US EPA 2012). It appears to evoke the numerous and varied outcomes that can be derived from energy efficiency without ranking or prioritising the outcomes as primary or secondary, energy or non-energy benefits.

[1] This term is in widespread use to describe all the benefits aside from energy savings relating to energy efficiency measures, for example by the UNFCCC (http://cdm.unfccc.int/about/ccb/index.html)
[2] This term has been used to describe the ancillary benefits and costs of greenhouse gas mitigation, for example by the OECD (http://www.oecd.org/document/31/0,3746,en_2649_34361_1936607_1_1_1_1,00.html).
[3] This term is in common usage in the US, for example by the National Association of Energy Service Companies (http://www.naesco.org/resources/industry/documents/NAESCO%20NEB%20Report%2012-11-08.pdf) and by Lawrence Berkeley National Laboratory (http://evanmills.lbl.gov/risk-management-nebs.html)

An inventory of the multiple benefits of energy efficiency

Because energy is fundamentally linked with social and economic development, it is not hard to conceive that energy efficiency could be a means to realising policy goals beyond the energy sector. This paper presents evidence that energy efficiency can yield substantial multiple benefits across a wide range of sectors. Outcomes may be linked to energy savings or energy efficiency improvements either directly or indirectly, or as the product of a chain of actions which is more difficult to attribute to energy efficiency. This discussion is not exhaustive, but aims to cover the multiple benefits most often cited.

To assist in the analysis of these benefits, it is useful to consider benefits from energy efficiency in terms of their impact at different levels of the economy namely: individual, sectoral, national and international. This typology, also used to structure this paper, gives an insight into the flow-on effects that can occur between benefits at different levels. Individual level benefits could ultimately affect the whole economy, just as national and international level benefits often improve the quality of life of individuals and support strengthened sector-level productivity. This approach also helps to ensure that multiple benefits observed simultaneously at various levels are not double-counted in cost/benefit analyses.

Individual level benefits

Individual benefits are those which occur at a personal, household or enterprise level. Methodologies used to measure individual-level benefits commonly include surveys, micro-economic modelling, the use of indices, cost-benefit and -effectiveness analysis, and lifecycle analysis (Skumatz et al 2009).

Health and well being

A particularly strong case is developing in relation to the positive impacts of energy efficiency in the residential sector for public health and associated social impacts (Basham et al 2004; Green et al 2008; Kearns et al 2008). A broad range of illnesses, particularly respiratory illness and asthma among children, have been strongly associated to cold indoor temperatures and damp and mould in housing (Mudarri et al 2007). Health impacts have equally been linked to inefficient housing and appliances in the developing world and the Global Alliance for Clean Cookstoves aims to reduce the annual global health burden of indoor air pollution from solid-fuel use, currently at 1.6 million deaths (Hosgood et al 2010), through distribution of energy efficiency cookstoves to replace traditional biomass stoves[4].

A number of robust methodologies are emerging for measuring the health impacts, such as the Net Benefit Model (EECA 2008) used in New Zealand to model the net present value cost: benefit of its Warm Up New Zealand: Heat Smart in light of health impacts of its residential energy efficiency programme. Latest results indicate a cost: benefit ratio of greater than 1:2, with 90% of those benefits in health (Patterson 2012). Health is increasingly recognised by governments as a specific driver of energy efficiency policy, including in the UK, where work is underway on another adapted methodology for measuring the health benefits of energy efficiency (Meagher 2012).

Appraisal: This is an area where considerable progress has already been made. Evaluators could follow the example of emerging methodologies which combine empirical data collection with statistical and epidemiological analysis[5], and use proxies such as days off work and school and hospital admissions to monetise benefits (Thomson et al 2009).

[4] A range of academic studies on this issue are available at: http://cleancookstoves.org/resources/publications-and-reports/

[5] Health survey *Short-Form 36*, based on 4 physical dimensions of health (physical role, physical function, pain and general health), has been used in many energy efficiency studies.

Inter-disciplinary cooperation should inform energy efficiency evaluation and energy efficiency evaluators build broader datasets (ODPM, 2006) which include demographics, health statistics and living conditions.

Poverty alleviation: Energy affordability and access

Access to adequate energy services is fundamental to pulling communities out of poverty by providing the raw material for social and economic development. Energy affordability issues are both a cause and a symptom of poverty. The poor are also most likely to live in inefficient housing (Power 2006), may access less energy subsidies (Dartanto 2012)[6] and therefore face higher energy costs. Well-targeted energy efficiency programmes for fuel-poor households can address this by intervening at the household level to reduce energy bills and provide greater energy services for less energy (Howden-Chapman 2007). Methodologies for outcomes- based evaluations which include the full range of multiple benefits to fuel-poor households are in use in both the developed (DECC 2011) and developing (UNDP 2003) country contexts. The Home Energy Insecurity Scale (Colton 2003) is one such methodology combining eleven practical indicators into a single measurement of improvements in household 'self-sufficiency'. This method identified a 20% improvement in affordability for recipients of the US Weatherisation Assistance Programme, moving most households up the self-sufficiency scale. For use in developing countries, the IEA-developed Energy Development Index (IEA 2010) which uses four energy supply indicators for tracking progress towards universal access to modern fuels, and the Oxford-produced Multidimensional Energy Poverty Index (Nussbaumer et al 2011) are both promising.

Appraisal: Effective targeting of the energy-poor is a priority. National datasets of demographic, housing and energy price statistics should be used to generate nationally appropriate indexes of poverty and fuel poverty as analytical baselines. Evaluations of the impact on the energy spend/household income ratio could be a first indicator of success in this area. Further innovative methodologies are also needed to capture the multi-faceted social development benefits which energy savings can produce downstream, and increased use of qualitative indicators are likely to provide a good starting point before moving to seek proxies to establish quantified values for these benefits.

Increased disposable income

As energy efficiency improves at individual or firm level, energy bills should be reduced for the same energy services, providing increased disposable income. Energy makes up a small share of consumers overall expenditure so while the increased disposable income at an individual level is small (Sorrell 2007), collectively it can have a significant effect. It can lead to increased spending and investment in further energy and other services and can determine macroeconomic effects (Markandya 2009). The implications for increased energy consumption are also strong where the consumer spends the surplus income on energy-using activities and creates a rebound effect (Herring 2011). The factors determining consumer choice on how to use savings are a mixture of income level, behavioural factors, demographics, preferences, education and availability of information, and substitutive options available. Examining changes in disposable income through energy efficiency improvements provides a useful perspective on how energy efficiency investments and policies are affecting the welfare of different income groups (OECD 2012).

[6] A study of energy subsidies in Indonesia showed the highest income group enjoyed fuel subsidies more than 10 times larger than that of the lowest income group. (Dartanto 2012)

Appraisal: Evaluating the consumer surplus from energy efficiency improvements is difficult, as the phenomenon does not have a clearly defined boundary. It has been mainly evaluated in connection with the direct and indirect rebound effect using a combination of micro-economic static modelling (Freire-Gonzalez 2011) case studies (Chalkley 2001), and dynamic modelling (Davis 2010). However, macroeconomic evaluations of the impacts of energy efficiency policies implicitly include consumer surplus to examine the effect on the economy. Increased disposable income is inherently linked to many of the other benefits investigated by this paper so understanding the effects on consumer surplus and better estimates of the level of consumer surplus generated by energy efficiency measures will be important in supporting analysis of the other broader benefits.

Sectoral benefits

Benefits occurring at scale at the sectoral level may be distinct from benefits at the individual or broader economy in a significant way. For example, jobs may be created in one sector but not in another and the net benefit at national level may be insignificant. Methodologies used to measure sector-level benefits tend to focus on input/output and partial equilibrium models.

Industrial productivity and competitiveness

Conventional financial assessments generally evaluate energy efficiency programmes in industry using simple payback, rate of return and net present value approaches. These methods assess payback through energy savings only, leading to an underestimation of the economic potential of energy efficiency measures. As many as 224 "non-energy benefits" have been indentified in industry (Worrell et al 2001)[7] including reduced environmental compliance costs, enhanced productivity and competitiveness, decreased maintenance costs, extended equipment life-time, reduced waste disposal costs, improved process and product quality. Harder to measure benefits include improved individual working conditions, safety and job satisfaction as well as access to new markets (Mundaca et al 2010). Careful attention should also be paid to the increased demand for other inputs (capital, labour, materials, water) and associated energy consumption which could be generated by increasing product output. Evaluation of the benefits of energy efficiency for industry can be difficult because measures to improve energy efficiency are rarely undertaken alone but are normally part of a bundle of other measures that may not be related to energy performance. A comprehensive evaluation could help to address the hurdle-rate barrier (Pye & McKane 2000) and contribute to changing the perception of energy efficiency projects from "a costly and unnecessary extravagance" to a sound business decision (Reinaud & Goldberg 2011).

Appraisal: While the value of multiple benefits for energy efficiency in industry may surpass the value of energy savings, there is currently no consensus method for monetising them as part of a cost: benefit analysis. Some indicators have been identified for measurement of energy efficiency measures in industry (Worrell et al 2003), although the causal relationships between the different types of benefits and means of quantification need further exploration. Building on information from surveys, interviews and reviews of case studies (Hall & Roth 2003), evaluators should engage industry in collection of more comprehensive data on implemented energy savings projects, possibly in connection to other initiatives. The starting point for quantification efforts should perhaps be enterprise-level direct benefits and this could be linked to tools within Energy Management Programmes.

Energy provider and infrastructure benefits

[7] This study reviewed 77 case studies of energy efficiency measures in industry.

At first glance, energy efficiency may appear to run contrary to the commercial interests of energy providers. However, research shows that many benefits accrue to energy providers as a result of improvements in end-use energy efficiency and reduced energy bills for customers. These include reducing customer operations costs, accommodating peak demands without adding new generation or network capacity, reducing price volatility in wholesale markets, reducing resource portfolio cost and risk, and improving reliability. The benefits to energy providers have been widely described, notably in an evaluation guide accompanying the 2007 US National Energy Efficiency Action Plan. This evaluation guide catalogued the multiple benefits of energy efficiency specific to energy providers, programme participants and ratepayers, and suggested that "for both electric and gas utilities, energy efficiency investments consistently lower costs over time for both utilities and customers" (US EPA 2007a).

Appraisal: Most analysis of energy provider multiple benefits, often commissioned by energy providers interested in the impact on their bottom lines, draws from studies of demand side management (DSM) (US DOE 2006; Violette 2006; Quantec 2006; Heffner 2009; Neme and Sedano 2012). However, the same logical frameworks, causality and additionality arguments, and estimation methods can be used for energy efficiency measures. One of the challenges facing energy efficiency multiple benefit evaluators will be extracting promising evaluation methods from the DSM literature and applying them to estimating the multiple benefits of energy efficiency. Some attempts have been made (Skumatz & Dickerson 1998) but additional research is needed, particularly in quantifying the benefits of deferring network additions, wholesale market price effects, and reduced risk in resource portfolios.

Increased asset values

Energy consumption increases a business or individual's operating or household costs. Therefore, any asset - such as a building, a car, or a production facility - that consumes less energy should be of higher value than an equivalent high energy-consuming asset, due to its potential to reduce current and future expenses. There is evidence that investors are willing to pay a rental and sales premium for property with better energy performance (Chegut et al 2012)8. However, this is not always so, due to market failures, particularly information failures and a lack of technical knowledge or understanding of the implications of energy efficiency in the market. The literature suggests that the costs of energy-efficiency tend to be over-estimated (WBCSD 20099) as too much weight is given to "first-cost", rather than life-cycle cost consideration. Property valuation experts need to be able to recognise and quantify the savings that energy efficiency can deliver, thorough appraisal of a building's operating performance over time. This will require preliminary scoping to assess the performance and technical opportunities of an asset over its lifetime, compared with other market factors such as lease terms and tenant requirements in an energy efficient building. Methodologies to evaluate the impact of energy efficiency improvements on asset values have used revealed preference methods and econometric modelling.

Appraisal: A better understanding of how to integrate energy issues into valuation is needed. Studies in this nascent area have commonly compared rental and sales rates of Energy Star rated buildings with those of non-rated buildings (Brounen et al 2009). Detailed data is needed of property energy performance and other building characteristics which may affect their value. Methodologies should account for the range of factors that property purchasers consider when investing in a property (Popescu 2010). The US Green Building

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[8] Studies have indicated that one dollar saving in energy costs of a building is on average associated with a 3.5% higher rent and a 4.9% premium in market valuation.
[9] Perceptions of the cost necessary to achieve greener buildings are likely to be significantly higher than actual cost. The average perception was a 17% premium, but empirical cost studies have shown much lower figures.

Council, developers of the LEED building rating system[10], have made considerable progress in communicating these benefits, such that a recent US Bill[11] proposed that energy costs be included in standard mortgage underwriting equations (Harney 2011). There is considerable room for these and other emerging ideas to be developed and disseminated further.

National level benefits

National level benefits are often the economy-wide sum of impacts occurring in various sectors or levels or will have trickle-down effects for them. This can also include impacts on national budgets and trade balance. General equilibrium models, Keynesian econometric models, and Integrated Assessment Models (IAMs) are examples of the types of methodological frameworks used to measure economy-wide benefits.

Job creation

Energy efficiency programmes appear to have significant potential to create jobs (Wade et al 2000)[12] with a short lead time. A net improvement in employment rates can be attributed to energy efficiency programmes (EST 2000) both as a direct job creation effect and indirectly through an expenditure shift effect, in addition to generating other benefits for national budgets, such as reduced unemployment benefits.

The value of created jobs depends on various factors such as their labour intensity, local content, wage rates (Pollin & Garrett-Peltier 2009) and temporal durability. The effectiveness of an energy efficiency programme in creating jobs will also depend on the size and structure of financing and the type of energy savings intervention being supported. Direct jobs generated in the delivery of energy efficiency measures are easiest to measure (Capros et al 1999), along with indirect jobs generated upstream in producing materials. However these jobs may only endure for the period of the particular energy efficiency programme. It is necessary to measure net impacts on the broader economy also taking into account lost jobs in the energy sector (Jeeninga et al 1999). A re-spending effect, both as a result of energy bill savings and new workers' wages, can also create jobs across all sectors, and while causal links are more difficult to establish, these jobs may be more durable than others (EST, 2000) with potential to last the period of the energy efficiency technology, rather than of the particular energy efficiency programme.

Appraisal: Because empirical data is sparse, estimates have largely been generated from modelling, using input: output models (EST 2000) and general equilibrium models (Capros et al 1999). However, existing studies remain piecemeal and work done on a programmatic basis often lacks transparency so opportunities to transfer results are limited and evaluators face difficulties in building on the existing body of knowledge. In addition to increased collection of ex-post data, consistent definitions and methodologies are essential to generate results which are robust and can be compared across economies. Existing studies which take stock of progress made so far in this area will be a useful resource (Urge-Vorschatz 2010).

Energy security

[10] However, Energy Star remains a better proxy for energy performance in evaluating the impact of energy efficiency on building asset values - the LEED rating system rates the overall environmental performance of the building so energy performance improvements are not obligatory to achieve a good LEED rating.
[11] SAVE (Sensible Accounting to Value Energy) Act [S. 1737] was introduced on October 19, 2011 by Senators Bennet (D-Co.) and Isakson (R-Ga.).
[12] Estimates vary greatly, from studies reporting a "positive but relatively small" net employment benefit (Jeeninga 1999) to others generating specific numbers in the range of 26.6 jobs created for every million Euros spent in an energy efficiency intervention (Wade et al 2000)

Increased energy security is a commonly cited benefit of energy efficiency and conservation. The IEA defines it as "the uninterrupted physical availability of energy at a price which is affordable, while respecting environmental concerns" (IEA 20011b). Long term security generally involves four dimensions of risk – fuel availability, accessibility, affordability and social and environmental acceptability (Jansen & Seebregts 2010). Short-term security often concerns similar issues (Sovacool & Brown 2010), as well as robustness, sovereignty and resilience. Energy efficiency improvements contribute to these dynamics by providing a fast response to shortages and, through decreased demand, decrease the need for energy imports and increased generation capacity, as well as slowing GHG emissions and resource depletion. The IEA has developed the IEA Model for Modelling Short-term Energy Security (MOSES) for measuring impacts on countries, which uses a two-step qualitative method for creating "energy security profiles." Various other methodologies address different aspects of the energy security question, such as the Energy Security Market Concentration (ESMC), a modified measure of market concentration and the Energy Security Index (ESI) (IEA 2007), which measures the exposure of a given country to energy security risks. Other approaches have measured the benefits to energy security in absolute electricity demand reduction situations ex-post as a result of implemented emergency energy efficiency and conservation measures (IEA 2011c).

Appraisal: A range of tools, but few studies, have attempted to quantify this benefit on a comprehensive, economy-wide scale. The multidimensional nature of energy security makes this task difficult, however lessons could be taken from the power sector where studies have been conducted to monetise the benefits of energy efficiency, conservation and demand response on electricity security (Heffner 2009). It appears that countries interested in exploring the impact of energy efficiency measures on their energy systems should begin by taking an inventory of vital energy systems including key threats.

Macroeconomic effects

Investment in energy efficiency implies a transfer of capital from the energy sector to less energy-intensive activities. This can have significant impacts on the wider economy if the transfer involves a restructuring of the economy to more labour-intensive activities. Impacts include increases in GDP, trade balance and national competitiveness. Macroeconomic effects of energy efficiency can be separated into three drivers of the macroeconomic outcomes: namely: consumer surplus (discussed above as increased disposable income); increased investment in energy efficiency products and services; and reduced energy prices and costs for industry leading to increased production and exports (Barker and Foxon 2008). The case is made for energy efficiency on macroeconomic grounds in a recent report, based on a review of the recent literature (Holmes and Mohanty 2012).

Computer general equilibrium (CGE) models have been used to model some of the macro effects of energy efficiency policies and the results are without exception positive in terms of GDP growth. Time series econometric and input: output models are used to calculate that UK energy efficiency policies leading to 8% energy savings have increased GDP by 0.1% over the period 2000-2010 (Barker and Foxon 2008). Some of the studies on the rebound effect at macroeconomic level provide the most detailed results on the positive impact of energy efficiency on the economy (NEXT10 2012). It again shows that what might be considered a negative impact, in terms of energy demand, is generally positive for economic development. A study recently carried out for Germany used a CGE model to forecast the impacts of ambitious energy efficiency policies (Lehr et al 2012)13 on GDP, consumer and public spending, employment, imports and exports. The results were positive

[13] This lead to a reduction in energy demand of approximately 13% by 2030.

for all factors, if small in some cases. Public budgets are also positively affected - evaluation of the public loan programme for energy-efficient building retrofits run by German banking group KfW has estimated that the net positive impact on public budgets is over 100% of the programme costs (Kuckshinrichs et al 2011).

Appraisal: Several attempts have been made to quantify the impact of energy efficiency on GDP but where they are based on improvements in energy intensity, which is traditionally measured by total energy consumption as against annual GDP, assumptions may be flawed. This is an area where the IEA has detected significant interest from governments, who need to see concrete economy-wide numbers to support the case for energy efficiency policy. More studies are needed, in order to address this pressing need for robust supporting evidence.

International level benefits

These energy efficiency benefits cross borders and may be derived from a big increase in energy efficiency in a large energy-using country but are more likely to arise from concerted action to improve energy efficiency across a number of countries. Global general equilibrium models can be used to assess these impacts.

Reduced greenhouse gas (GHG) emissions

Global energy-related carbon-dioxide (CO2) emissions reached 30.4 Gt in 2010 and IEA forecasts suggest they will continue to increase, putting the world on an emissions trajectory consistent with a long-term global temperature increase of more than 3.5°C (IEA 2011a). Energy efficiency, being both the cheapest and the most effective way to drive emissions reductions with a short lead time, will play a central role in the strong policy approach needed to divert the world from this course. Energy efficiency measures across all sectors are expected to account for half the cumulative CO2 abatement needed by 2035. Clearly energy efficiency improvements that do not lead to reduced fossil fuel energy consumption will not cut greenhouse gas emissions. For this reason, it is important to be able to accurately assess the outcomes from energy efficiency measures in order to plan realistic greenhouse gas emissions mitigation strategies.

Appraisal: Because of the central role of energy efficiency in achieving national and global emissions reduction goals, governments commonly include CO2 targets among the stated objectives of energy efficiency policy, and emissions reductions are generally evaluated as a matter of course at the evaluation stage of many energy efficiency policies and programmes. Methodologies for the measurement of impact on CO2 emissions are well established and, as such, this appears to be an area where further development will not be a priority.

Energy prices

Global and national energy prices are determined by several factors such as the level of energy supply, the demand for energy and market trading conditions. All else being equal, if the demand for energy services decreases, energy prices should also fall. In the three energy scenarios proposed by the IEA's World Energy Outlook (IEA 2011a), energy demand differs considerably as a result of the policy choices influencing energy efficiency and infrastructure investments. Improved energy efficiency and structural changes drive reduced energy intensity across the three scenarios with a decline of 44% in the 450 Scenario[14] over the period 2009 to 2035. In the same period, oil prices would rise initially (as fuel switching occured from coal to gas) but then drop as overall demand for energy decreased (IEA 2011a).

[14] The 450 Scenario is based on what needs to happen to achieve 450ppm by 2035 (IEA 2011a)

The macroeconomic implications of changes in energy prices are huge. The oil price spike of the early 1970's drove most countries into recession, whereas lower oil prices in early 2000's coincided with global economic prosperity. However, for energy efficiency improvements to impact energy prices, there usually needs to be a sustained reduction in energy demand across many countries. The global nature of energy markets also means that the excess capacity from a reduction of demand in one market can be offset by higher demand in another market.

Appraisal: Robust methods already exist for modeling the effect of energy efficiency policies on national and global energy prices, such as those developed by the IEA. However, more empirical data is needed to demonstrate this effect. Models are effective in illustrating the correlation between energy demand and energy prices policy but empirical data on actual national impacts adds essential weight to the case for each government.

Development goals

Achieving sustainable development is an international concern and access to modern energy services is critical in delivering the basic necessities for living as well as the conditions for social and economic development. In designating 2012 the International Year of Sustainable Energy for All, the UN called on governments to support its Millennium Development Goals (MDGs) through energy policy, including a specific call to double the rate of improvement in energy efficiency. The impact of energy efficiency policies for improving living standards and generating income creates a ripple effect across economies, with scaled up effects for national development. Energy efficiency policy can be seen as a strategic tool for accelerating growth, developing infrastructure and assuring energy security, as well as strengthening institutions, improving environmental sustainability, promoting social inclusion and reducing poverty.

Appraisal: An appropriate set of indicators for measuring and quantifying the impacts of energy efficiency on sustainable development is still lacking. Energy-related indicators in the MDG methodology are limited to CO2 emissions and GDP per unit of energy use under Goal 7 (UNStats 2008). Short of adding a ninth MDG that directly relates to the role of modern energy services15, work is needed to build connections between existing indexes of social and energy development such as such as the UN's composite Human Development Index (HDI) (UNDP 2011) or the IEA's Energy Development Index (EDI) (IEA 2010), adding energy intensity factors into the equation. In the meantime, new evaluation methods for the range of more specific benefits described above, most of which would have implications for development, could assist in tracking progress towards to sustainable development. Increased collection of data from developing countries will also be needed.

Implications for the rebound effect

The preceding investigation suggests that reinvestment of energy savings can act as a driver for a range of socio-economic benefits that should be counted when evaluating the success of energy efficiency policy. However, it is precisely such reinvestment which gives rise to important claims that energy efficiency policy is undermined and counter-balanced by increased consumption and expenditures, the so-called 'rebound' effect. How should these two points of view be reconciled?

Many of the benefits discussed, in particular increased disposable income, productivity and development goals, come with an energy consumption price tag and thus are drivers of the rebound effect. For example, as industrial competitiveness improves, some of the energy saved from an initial energy efficiency measure may be taken back as production

[15] At the 12th International Energy Forum (IEF) Ministerial in Cancun, Mexico, in March 2010, the IEF called for the international community to set up a ninth goal, specifically related to energy, to consolidate the evident link between modern energy services and achievement of the MDGs.

is increased. This effect is often perceived negatively as it leads to lesser reduction in projected energy demand than anticipated. Viewed objectively, it simply represents a trade-off between welfare gains and the potential for energy savings as consumers make choices in order to maximise the utility of an energy efficiency intervention.

A negative view of rebound effect in such cases is an oversimplification of the dynamics at play and ignores the variety of benefits that flow from energy investments even where energy use is not reduced. Policy-makers may well consider the other benefits to be satisfactory outcomes of these investments, in light of broader national priorities where energy savings are just one goal among many, albeit central. Certainly consumers have expressed their preference, by valuing an improved level of service or welfare ahead of possible energy savings. Deciphering the rebound effect is an important issue for OECD countries and even more so for emerging economies looking to improve the quality of life of their citizenry. When viewed in this context, some of the rebound or take-back effects may represent desirable welfare gains that cater to high priorities for individuals and governments. This more nuanced appreciation of the rebound effect vis-a-vis the welfare gains delivered by energy efficiency further illustrates the need for better economic analysis of the outcomes from energy efficiency measures.

Conclusion

Classical energy efficiency evaluation frameworks are not well suited to evaluating the diffuse, often non-market and indirect benefits of energy efficiency. Some quantified values already exist, providing an indication of the scale of those benefits, but evaluation of the multiple benefits of energy efficiency is still in its relatively early stages. A concrete investigation of multiple benefits would require methodological approaches to evolve, to incorporate a broader range of indicators, sourcing data from innovative sources and applying new estimation methods.

It is clear that there is no one-size-fits-all in this area, so methodologies will likely need to be adapted for each benefit. Evaluation of multiple benefits should be approached with care as there are many uncertainties to be addressed and pitfalls to avoid, such as the potential for double-counting, benefits persistence issues, complexities of monetising benefits, and establishing attribution between interventions and outcomes (Heffner and Campbell 2011). Establishing solid analytical baselines and identifying best-fit methodologies to capture the impacts of energy efficiency measures in new areas will be an important first step. Just as professionals in other fields are unlikely to consider energy efficiency improvements as relevant to achieving outcomes in their own area of concern, energy efficiency policy makers also need to collaborate with non-energy experts. Without interdisciplinary collaboration, the extent to which the interests of different fields might overlap is difficult to discern and evaluators on both sides risk missing an important factor in their respective cost: benefit equations.

Methodological approaches may vary across countries in light of particular economic and institutional circumstances. Each country should engage in a prioritisation exercise to identify which multiple benefits are likely to be most relevant to its own national policy goals. A country's selection of benefits for investigation may also depend on where data and institutional structures is available to support expanded evaluation efforts. In each context, evaluation of the energy savings and other multiple benefits should, of course, be accompanied by a robust assessment of direct and indirect costs, to check whether the benefits do outweigh the costs.

Evaluating all the multiple benefits of energy efficiency is a huge task and in-depth analysis is needed where methodologies are currently lacking. To plan a programme of work, the IEA has carried out its own prioritisation exercise, through preliminary research and a recent workshop seeking views of policy-makers, evaluators and academics on progress so far. The multiple benefits where the need for further work appeared most pressing were identified as improvements in health, economic growth, consumer spending and industrial sector benefits. While robust quantification of improvements in employment are particularly challenging, this is an area of considerable interest to many governments and may also warrant further exploration as part of the IEA work programme.

If first indications summarised in this paper are correct, the view of improved energy efficiency may need to evolve, from an end in and of itself, to a means to an end in achieving a range of practical improvements for various levels of society. Increasingly robust evaluation results across a broader range of benefit areas should allow broader policy goals to be integrated effectively into policy design and ensure that energy efficiency policy is optimised to achieve its full potential.

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