International Energy Agency

SPREADING THE NET

The Multiple Benefits of Energy Efficiency Improvements

INFORMATION PAPER

Lisa RYAN and Nina CAMPBELL

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Executive Summary

Context and objective

Improving energy efficiency can deliver a range of benefits to the economy and society. However energy efficiency programmes are often evaluated only on the basis of the energy savings they deliver. As a result, the full value of energy efficiency improvements in both national and global economies may be significantly underestimated. This also means that energy efficiency policy may not be optimised to target the potential of the full range of outcomes possible. Moreover, when the merit of energy efficiency programmes is judged solely on reductions in energy demand, programmes are susceptible to criticisms related to the rebound effect when the energy savings are less than expected due to other welfare gains.

There are several reasons why the full range of outcomes from energy efficiency policy is not generally evaluated. First, it is due to the non-market, somewhat intangible, nature of the socioeconomic benefits, which makes them difficult to quantify. Second, the effects due to energy efficiency alone can be complex to isolate and to determine causality. Third, evaluators and policy makers working in the energy efficiency sphere are usually energy professionals, working for an energy agency or ministry, with little experience of how energy efficiency might impact other non-energy sectors. The result is an under-appreciation – and related underinvestment – in energy efficiency, and as a consequence, missed opportunities and benefits. These foregone benefits represent the 'opportunity cost' of failing to adequately evaluate and prioritize energy efficiency investments.

The objective of this report is to fully outline the array of different benefits from improved energy efficiency and investigate their implications for policy design. By better understanding the different benefits arising from energy efficiency it should be easier for policy makers to prioritise the most significant outcomes, in addition to energy savings, in optimising energy efficiency policy design. The paper also discusses the "rebound effect", which can imply that energy efficiency measures produce less energy savings than expected, but should be reconsidered in light of the variety of other benefits which are generated.

The benefits

In this report, the International Energy Agency (IEA) describes the wider socioeconomic outcomes that can arise from energy efficiency improvement, aside from energy savings. The report enumerates many of the most prominent multiple benefits of energy efficiency and, although the list is not exhaustive, it provides a rich menu of the variety of the benefits that may be of interest to policy makers. Based on a review of existing literature, this report summarises the significance of each of these potential outcomes of energy efficiency measures.

Outcomes are produced at different levels of the economy: at the individual level (individuals, households and enterprises); at the sectoral level (by economic sector such as transport, residential, industrial sectors); at the national level (including macro-economic benefits, and benefits to national budgets); and at the international level (reflecting the international public good of these benefits). In many cases, a ripple effect emerges when energy efficiency improvements take effect at the individual level, triggering benefits for a household and/or enterprise that have a multiplier effect on a specific sector and possibly the whole economy. Similarly, national and international level benefits often improve the quality of life of individuals and support strengthened sector-level performance. While there are a variety of ways to

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categorise the various benefits of energy efficiency, the individual/sectoral/national/ international typology is used as the organizing framework for purposes of this report.

Below is a list of these benefits covered in this report, using the afore-mentioned typology regarding the levels of benefits:

Individual level (individuals, households, enterprises)

a. Health and well being impacts

This mainly relates to the public health improvements observed as a result of improved heating and cooling of buildings and air quality from more efficient transport and power generation and less demand for both.

b. Poverty alleviation: Energy affordability and access

As energy demand and bills are reduced for the poor, these households have the ability to acquire more and better energy services, as well as free up income to spend on satisfying other critical needs. In addition, as utilities (notably in developing countries) improve their supply-side efficiency, they can provide more electricity to more households, thereby supporting increased access initiatives which is often an important stated objective of supply-side energy efficiency activities in developing countries.

c. Increased disposable income

Across all income levels, when energy efficiency improves, reduced energy bills provide increased disposable income for households, individuals, and enterprises. The effect of increased spending and investment can in turn result in positive macroeconomic effects described below.

Sectoral level (economic sectors – industrial, transport, residential, commercial)

d. Industrial productivity and competitiveness

Benefits for industrial firms from improvements in energy efficiency improvements include reductions in resource use and pollution, improved production and capacity utilisation, and less operation and maintenance, which leads to improved productivity and competitiveness.

e. Energy provider and infrastructure benefits

Improved energy efficiency can help energy providers provide better energy services for their customers, reducing operating costs and improving profit margins.

f. Increased asset values

There is evidence that investors are willing to pay a rental and sales premium for property with better energy performance. Some values of this premium have been estimated for commercial property.

National level

g. Job creation

Investment in energy efficiency and the increased disposable income can lead to direct and indirect job creation in energy and other sectors. This makes energy efficiency an important part of governments' green growth strategies.

h. Reduced energy-related public expenditures

The public budgetary position can be improved through lower expenditures on energy in the public sector (including by government agencies on energy consumption and state-owned utilities on fuel purchases). In countries where fuels are imported there is a related likely positive

impact on currency reserves, and in energy-exporting countries domestic energy efficiency can free up more fuels for export. In addition, for countries with energy consumption subsidies, reduced consumption means lowered government budgetary outlays to finance these subsidies.

i. Energy security

Improvements in energy efficiency leading to reduced demand for energy can improve the security of energy systems across the four dimensions of risk: fuel availability (geological), accessibility (geopolitical), affordability (economic) and acceptability (environmental and social) (APERC, 2007; Kruyt *et al.*, 2009). The IEA's existing work on energy security underlines the contribution that energy efficiency improvement can make to energy security. While policy makers are alert to this connection, the multidimensional nature of energy security makes it difficult to quantify and few studies have attempted this on a comprehensive, economy-wide scale.

j. Macroeconomic effects

Energy efficiency can have positive macroeconomic impacts, including increases in GDP, and the cumulative benefits of the above-mentioned impacts of improved trade balance (for fuel-importing countries), national competitiveness, and employment support. These are mainly indirect effects resulting from increased consumer spending and economy-wide investment in energy efficiency, as well as from lower energy expenditures.

International level

k. Reduced GHG emissions

Greenhouse gas (GHG) emissions are reduced when energy efficiency improvements result in reduced demand for fossil fuel energy. Many climate change mitigation strategies put energy efficiency measures at their core as the most cost-effective way to reduce greenhouse gas emissions.

l. Moderating energy prices

If energy demand is reduced significantly across several markets, energy prices can be reduced, particularly relative to the impact of the counter-factual of increased energy demand. This can have implications on economic competitiveness of countries, and, for individuals across borders, improves the affordability of energy services and the availability of resources for other expenditures. .

m. Natural resource management

At an aggregated international level, less demand can reduce pressure on resources, with potential beneficial impacts on prices (at least for importing countries), as well as overall resource management. For example, in the context of peak oil and related supply constraints, energy efficiency can help to relieve pressure on a scarce resource. Similarly, expanding demand for oil etc., is pushing industry to increasingly challenging contexts for extraction (such as deep off-shore and shale oil extraction), with related incremental investment costs and technological and environmental uncertainties.

n. Development goals

Improved energy efficiency is important in achieving economic and social goals in developing countries, including improved access to energy services, eradicating poverty, improving environmental sustainability, and economic development. Advancing development in these countries in a sustainable way is a shared international goal with benefits for developing countries themselves and for OECD countries alike.

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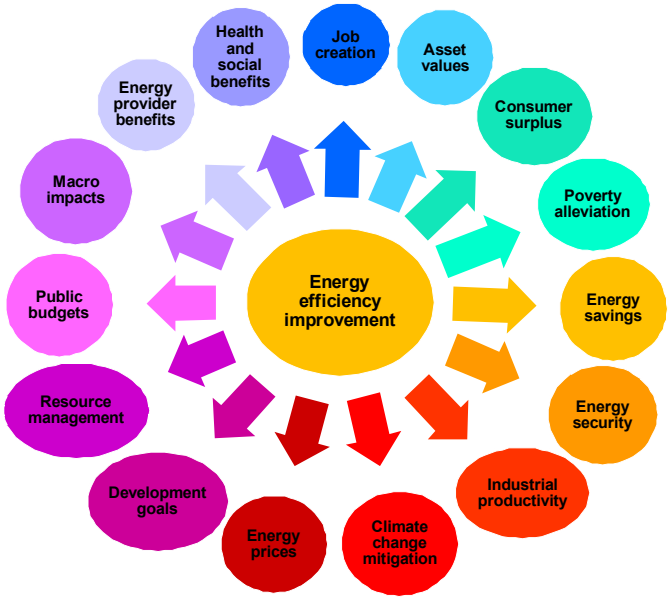
Figure 1 • The multiple benefits of energy efficiency



The rebound effect

While there is a range of potential benefits to energy efficiency, there are also important claims that key energy savings benefits are often not realised, because improved efficiency gains are undermined and counter-balanced by increased consumption and expenditures, the so-called 'rebound' effect. The multiple benefits outlined above lead to welfare gains, but sometimes at the expense of energy consumption. For example, as industrial competitiveness improves, some of the energy saved from the initial energy efficiency measure may be taken back as production is increased. This kind of effect is often perceived negatively as it leads to fewer reductions in energy demand than anticipated but, viewed objectively, it simply represents a trade-off between welfare gains and the reduced potential for energy savings.

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 reduced consumption does not result. Policy-makers may well consider other benefits to be satisfactory outcomes of these investments in light of broader national priorities. 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 its citizenry. This paper illustrates that energy savings are just one outcome, albeit central, of many delivered by energy efficiency. When viewed in this context, some of the rebound or take-back effects may represent desirable welfare gains that cater to other high priorities for governments. The discussion of the rebound effect versus the welfare gains from energy efficiency illustrates the need for better evaluation of the outcomes from energy efficiency measures.

The cost and the challenge

The failure to properly evaluate the benefits of energy efficiency likely results in underinvestment in energy efficiency. The foregone benefits represent the 'opportunity cost' of failing to adequately evaluate and prioritize energy efficiency investments. This opportunity cost may be very large, and in particular in a context of increasing global demand, stress on resources, and climate concerns, they may represent a cost that we cannot afford to bear.

With estimates of GDP growth resulting from energy efficiency converging on around 1%, energy efficiency should be considered as part of mainstream economic policy rather than an energy issue only. Further analysis and evidence is required to ensure that the full socioeconomic potential of energy efficiency measures is being delivered.

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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. The impact of energy efficiency measures can go far beyond energy savings and energy efficiency improvements can be a key contributor to economic growth and social development. The significant impacts indicated by work on these benefits to date, suggests that the pursuit of energy savings should no longer be seen as a goal in and of itself, but rather, should be considered as a means to pursue a range of practical improvements for various levels of society. This paper investigates the range of outcomes from energy efficiency improvements which extend to benefits that are significantly wider than energy savings alone.

Context

Optimists describe a myriad of benefits from energy efficiency to all stakeholders in society, whereas naysayers contend that even if the technical energy efficiency could be exploited, the anticipated energy savings would not be achieved because of the much vaunted "rebound effect". Closer examination of this phenomenon reveals that the same effects that are called rebound effect by some can also be considered as welfare gains to the individual and society.

It is important to explore and understand what really occurs when energy efficiency improves. This paper asks where the truth lies between these different points of view: what is the potential value of energy efficiency to society and how can its potential be fully exploited?

There are serious consequences to under- or over-estimating the outcomes of energy efficiency. If improving energy efficiency achieves much more than just reducing energy consumption and delivers much wider public benefits, perhaps we should be investing more in it. On the other hand, since climate change mitigation strategies lean so heavily on energy efficiency improvements to reduce energy consumption, confidence that energy efficiency strategies can deliver the energy savings expected is needed.

The benefits attributed to energy efficiency are multiple and range from localised benefits, such as energy affordability, social development and improved health and wellbeing, to sectoral benefits, such as industrial productivity, improved asset values and reduced environmental damage. Economy-wide outcomes such as energy security, national competitiveness, greenhouse gas emissions mitigation and poverty alleviation in both developed and developing countries, are also attributed to energy efficiency measures.

Energy efficiency specialists tend to focus solely on energy-related outcomes when evaluating the impacts of energy efficiency programmes. Professionals in other fields are unlikely to consider energy efficiency improvements as relevant to achieving outcomes in their own area of concern. Without interdisciplinary cooperation, the extent to which two different sets of interests might overlap is difficult to discern and it is fully possible that the non-energy saving outcomes from energy efficiency might never be fully examined.

Policymakers should aim to distinguish between desired and undesirable outcomes of energy efficiency and understand the interplay of various social and economic drivers that cause them. For example, a regular criticism of energy efficiency improvements relates to the much misused "rebound effect", in which energy efficiency does not deliver the full expected savings. Thorough evaluation of the multiple benefits of energy efficiency beyond energy savings might allow part of the rebound effect to be appreciated as a positive result for other social and economic sectors. It could also improve the cost/benefit assessment of energy efficiency outcomes and help decision-

makers reconcile a perceived trade-off between supporting economic growth and reducing energy use. Better evaluation of wider socioeconomic outcomes of energy efficiency policy may equally help policy makers design policy to mitigate the less wanted outcomes.

Why are the wider outcomes from energy efficiency not measured?

The interesting issue is why this is not generally done, when in fact improvements in energy efficiency can deliver more important benefits to society than energy savings alone. Benefits to health, employment, or competitiveness, for example, would generally rate higher in societal and hence politicians' consciousness's than savings in energy consumption or demand, yet they tend not to be as well-known in relation to energy efficiency. Strategies to improve energy efficiency are likely to be considered as technical measures best left to engineers and energy ministries. However, efficiency in energy use and production can be shown to be beneficial not only from an energy systems point of view but for the wider economy and society as a whole.

Not all energy efficiency policies have net benefits. There are costs associated with every measure and a full benefit-cost assessment should be carried out as part of any regulatory impact assessment to check that the benefits outweigh the costs.

We find that many of the benefits are non-market, diffuse, indirect and difficult to monetise. However, this does not make the benefits any less significant, it just makes the task more difficult. The big question is what is the full value of the net benefits of energy efficiency improvements?

Key concepts

It is important to clarify the terminology and concepts used in the context of analysing energy efficiency, notably of "energy efficiency", "energy intensity", and "energy conservation", as confusion around these concepts can sometimes obscure the understanding of the potential of energy efficiency for non-specialists. Below definitions are provided for some of the key terms and concepts surrounding the energy efficiency debate.

Energy efficiency can be defined as the level of energy consumption to provide a given service, and typically refers to an improvement in this relationship. It is a concept that can be difficult to define since it can mean different things to different people. One difference of opinion usually lies in whether energy efficiency encompasses only the technical efficiency of an energy service, *i.e.* the energy consumed as a result of a technological performance, or whether non-technical factors such as behaviour are included in the interpretation of energy efficiency. For example, is there an improvement in energy efficiency when a light bulb is used less, or is it only when a less energy-consuming light bulb is substituted? At the IEA, the term energy efficiency is interpreted in the broad sense and includes both the technical and non-technical factors contributing to the amount of energy consumed for a given energy service.

However, whatever the standpoint, energy efficiency is always a matter of individual behaviour to some extent; be it in selecting a type of equipment with a particular level of energy performance or the way it is operated. Improving energy efficiency implies improving the technical energy performance of the energy delivery mechanism but can also include improving energy management or organisation.

'Same with Less' versus 'More with Same': A connected point is to distinguish between two important impacts of energy efficiency. Traditionally, the focus of energy efficiency, in particular in OECD countries, is the use of less energy for the same energy service. However, energy efficiency can also have the effect of generating more service for the same amount of energy

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used[1]; this is particularly important for emerging economies. *Therefore an improvement in energy efficiency can be when either less energy is consumed to provide the same level of services, or the same energy is consumed for a higher level of services.*

End-Use versus Supply-Side Energy Efficiency: Energy efficiency activities can target principally either (a) the modes of supplying energy or (b) the modes of consuming energy. Most energy efficiency interventions (at least those commonly identified as such) involve the latter, such as consumption by appliances, lighting, buildings and vehicle efficiency. Supply-side efficiency also represents an important aspect of energy efficiency, and targets activities such as loss-reductions within power generation, or improved efficiency in industrial activities. Both forms of energy efficiency are important.

***Energy intensity*:** the energy intensity of an economy is a measure of how much energy is required to produce each unit of national revenue. The terms is often used synonymously with energy efficiency but in fact is a broader term that is determined by many factors such as energy efficiency, the size of the country and structure of the economy, as well as the type of industry base, climate, and exchange rate. Therefore changes in energy intensity can be affected by changes in economy-wide energy efficiency, but can also be affected by other factors (including shifts in industry that generate GDP, notably a move from energy intensive heavy industry to less energy intensive service sector activities). It is generally measured as energy consumed divided by GDP, or in a given sector it is the energy consumed divided by value-added for the sector.

Energy conservation: implies meeting our needs with less energy consumption. Energy conservation is measured in terms of reduced energy units alone or the ratio of before and after energy consumption. Improving energy efficiency is an important part of any energy conservation strategy. The main difference between energy conservation and energy efficiency is that reducing energy demand is the primary goal of energy conservation while improved energy efficiency aims to reduce the energy consumed in delivering a given energy service. A discussion on which is better – energy conservation or energy efficiency – is not relevant for this report. However, the distinction between the two mirrors the debate on the importance of the rebound effect. It is likely that the rebound effect will be of greater concern to energy conservationists than to proponents of energy efficiency whose the goals are broader than reduced energy demand.

Energy savings: is the estimated energy saved through a particular (energy efficiency improving) measure. This can be difficult to quantify, as it requires an estimation of the energy that would have been consumed if the measure had not been put into place. There are different ways of doing this including modelling or straightforward examination of the energy consumed beforehand and after. The method varies depending on the sector and measure. One problem associated with energy efficiency is the difficulty in quantifying the energy savings from improvements in energy efficiency, as well as establishing the contribution of energy efficiency measures in achieving energy savings. This is important because it means that to non-specialists there may appear to be uncertainty around the achievement of energy savings objectives through energy efficiency measures and hence a level of risk associated with energy efficiency.

Additional important terms for definition are:

Multiple benefits: One of the challenges is to capture the multiplicity of benefits from energy efficiency improvements. The term multiple benefits has been chosen because this term evokes the varied and numerous outcomes that can be derived from energy efficiency. It is used by

[1] For example, insulating a home so that it retains heat better, and then keeping the increased temperature, rather than turning down the heating. Is this still considered to be an improvement in energy efficiency, although the energy bills have not been significantly reduced? We would argue that yes, this is an improvement in energy efficiency as although the energy consumed has not changed, the services provided have significantly increased and there has been a welfare gain for the dweller.

several important organisations, including the US Environmental Protection Agency (US EPA, 2012). It appears to be the broadest and most inclusive term relating to the outcomes of energy efficiency policy, covering the terms co-benefits, non-energy benefits, and ancillary benefits. It does not rank or prioritise the outcomes as primary or secondary or energy or non-energy benefits (which arguably is implicit in the use of such terms as "co-benefits").

Rebound effect: The concept that some or all of the expected energy savings from energy efficiency improvements do not occur because of increasing demand for energy and other services. This concept is described in greater detail in the chapter titled "The rebound effect" below.

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Proposed typology for benefits

Energy is fundamentally linked with social and economic development, so it is not hard to imagine that energy efficiency could be a means to realising policy goals beyond the energy sector. Some outcomes may be indirect, or be the product of a chain of actions which are difficult to attribute to energy efficiency. Energy efficiency measures can nevertheless be seen to have impacts on various areas in the economy, often in different areas at the same time, and a direct impact in one area of the economy may have flow-on effects in other.

In order to give structure to this complex discussion, the IEA has adopted a typology to categorise the large number and variety of multiple benefits discussed here by economic level, *i.e.* the individual, sectoral, national and international levels. This approach provides some insight into the ripple effect that can occur from improvements in energy efficiency throughout the economy, and may be helpful to policy makers in designing well-targeted policies. This section presents the levels typology used in the report.

This is just one possible approach to categorisation of these benefits. For example, alternative ways to categorise the benefits would be to examine them in terms of the types of beneficiaries (*e.g.* public versus private), the nature of the impact (*e.g.* financial, environmental, etc.), along a temporal scale (*e.g.* impacts that are felt in the short, medium or long term), the character of the impact (*e.g.* energy versus other). Some of these categorisations can provide important insights into the nature of the benefits, and are discussed in greater detail in the chapter titled "Towards a better understanding of multiple benefits: additional dynamics" below. However, for purposes of this paper, the individual/sector/national/international typology has been chosen as an effective organizational tool, that can be of particular use to policy makers looking to identify and analyze the multiplicity and variety of benefits. The complex interrelationships between effects at different levels of the economy have been explored to some degree in this paper, but would merit a more in-depth treatment in the future.

- ***Individual:*** individual benefits are those which are experienced at a personal, household and enterprise level. Although they have ramifications at a wider level, it is useful for policy-makers to consider these issues in terms of their impact on the livelihood of individual citizens. This report discusses three individual-level benefits: health and wellbeing; poverty alleviation (energy affordability and access); and increased disposable income.

  Health benefits will have economy-wide implications through public health spending, and consumer surplus will link to GDP growth at the national level, but direct impacts are more easily discussed at the individual level. Similarly, energy affordability and poverty alleviation also have implications at the international level and for development goals, but we have chosen to separate these discussions. Enterprise benefits at scale can lead to benefits for the whole industrial sector.

  Sectoral: Sector-level multiple benefits may be considered in a 'partial-equilibrium' context. Sector-specific benefits are those which may not affect the individual or broader economy in a significant way, but have important impacts and implications for particular sectors or industries, for example the transport sector, individual industrial subsectors or the industrial sector as a whole. This report discusses three benefits at the sectoral level: industrial productivity and competitiveness; energy provider and infrastructure benefits; and increased asset values. All three of these have implications for development of the whole economy but can be most clearly investigated at sectoral level.

- ***National:*** these economy-wide benefits affect a variety of sectors and markets and are often the sum of impacts occurring at other levels, or will have trickle-down effects for them. This

report discusses four benefits at the national level: job creation; reduced energy-related public expenditures; energy security; and macroeconomic effects.

Job creation can be discussed on a sectoral basis with regards to different jobs created and is relevant to individual benefit also. Job creation is discussed at economy level in part because of its current importance in supporting economic recovery.

- ***International:*** international level benefits are those which have an impact on countries other than the country where the energy efficiency improvement has occurred. Many of the benefits of energy efficiency extend beyond national borders, reflecting the global nature of the energy sector. This report discusses four benefits at international level: reduced GHG emissions; moderating energy prices; natural resource management; and meeting development goals.

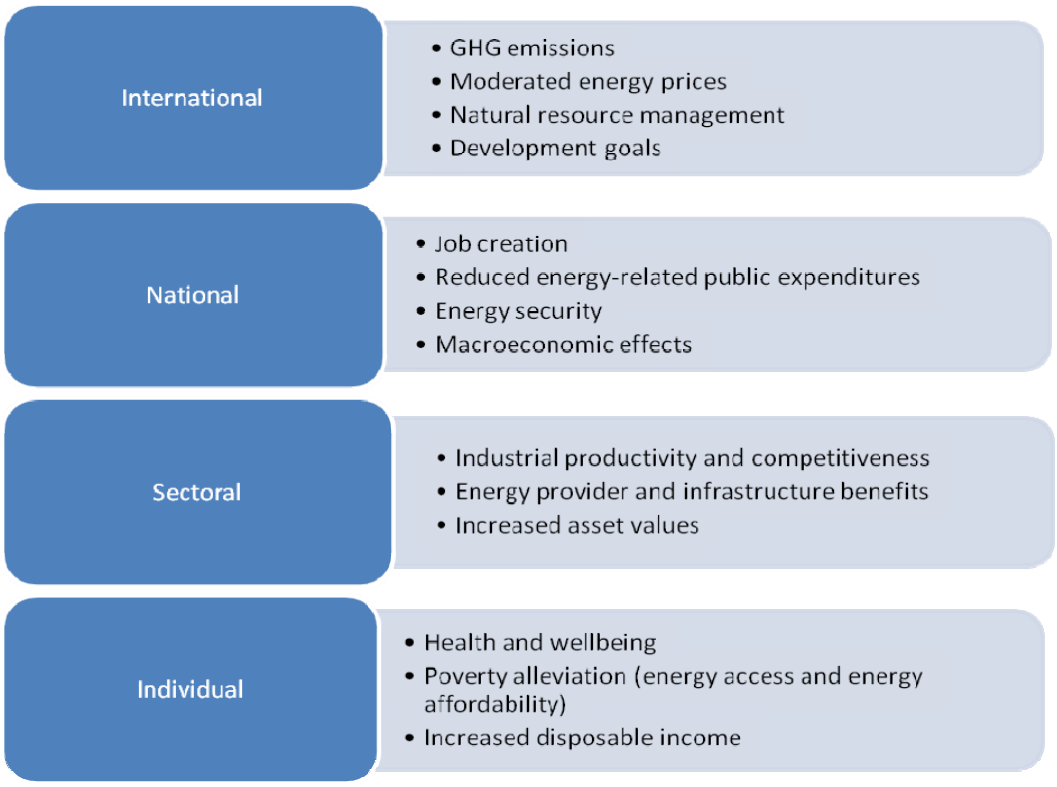
  Lowered energy demand may have an impact on prices on the global energy markets, discussed in this paper at the international level, but prices will also have implications at the national level for net energy importing countries. GHG emissions reductions are important for national targets and climate change mitigation strategies, but can be useful treated as international concern in light of their global implications and international agreements.

Figure 2 depicts these various levels of benefits.

A caution

The benefits from improvements in energy efficiency can be observed to simultaneously impact on various levels and so it is useful to discuss and assess their impacts separately at each level. Nevertheless, it remains extremely important to avoid double-counting these effects when carrying out final cost/benefit evaluations of measures or programmes as a whole.

Figure 2 • 'Levels' typology of the multiple benefits from energy efficiency improvement (with illustrative benefits)



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The multiple benefits of energy efficiency: energy savings and beyond

Energy efficiency improvements can yield substantial multiple benefits across a wide range of sectors. Before we begin a discussion of the broader socioeconomic benefits of energy efficiency, it is important to give some consideration to the traditional outcome of energy efficiency measures benefit, namely energy savings, which should remain the primary target of energy efficiency measures.

Energy savings

Even in the context of an enlarged view of the potential outcomes of energy efficiency improvements, the role of energy savings as the primary objective of energy efficiency policy remains unchanged. Reducing energy consumption will remain a goal of energy ministries and well-targeted policies are the best way to achieve energy conservation. Energy efficiency can produce energy savings at all levels – individual, sectoral, national or international – and the impacts of those energy savings can trickle through to generate wider socioeconomic outcomes. If the actual savings delivered by an energy efficiency measure turn out to be lower than predicted, this is often considered to undermine the success of the intervention. In these cases, policy evaluators should investigate why lower than expected energy savings have been achieved, and consider how implementation could be adjusted to capture more energy savings. But it is also important to consider what other benefits may have resulted from the measure. It may be that additional energy consumption can be explained as a consequence of achieving those other benefits. While some multiple benefits can be seen as a result of energy savings and should be counted in addition to energy savings achieved, others can occur independently of energy savings and could provide a different measure of success of energy efficiency programmes, to be considered where energy savings are low. Policy-makers should consider any such trade-off between reduced energy savings and socioeconomic welfare gains arising from particular energy efficiency measure and how the balance should be struck between energy savings and other benefits in designing energy efficiency policy.

Beyond energy savings

Below is an inventory of the broader multiple benefits which may be delivered by an energy efficiency measure. It is not an exhaustive list, but aims to demonstrate the breadth of benefits that exist and provide some insight into several which are most relevant to policy-maker decision making. This could serve as a menu of potential outcomes that policy-makers could use when designing energy efficiency policy, to consider the relative priority of various national goals alongside energy savings.

Individual level benefits

Energy efficiency produces a variety of benefits for individuals, for households and for companies:

Health and wellbeing

A particularly strong case is developing about the positive impacts that energy efficiency in the residential sector has for public health and associated social impacts. 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. Improved energy efficiency in the buildings sector, in particular, can bring a wide array of appreciable benefits for the health of residential occupants, office workers, and many other groups, as well as the population as a whole. Health impacts have equally been linked to inefficient housing and appliances in the developing world. The *Global Alliance for Clean Cookstoves* estimates that reducing black carbon by replacing traditional cookstoves with energy efficient ones will reduce the incidence of child pneumonia by 50%[2].

Air pollution from transport and power generation emissions contributes to a range of respiratory and cardiovascular diseases and traffic congestion is responsible for road traffic accidents and noise-related stress. The WHO estimates that these factors alone are responsible for some 2.6 million deaths annually (WHO, 2011). Energy efficiency policies promoting improved vehicles and fuels; transport pricing strategies; transport and land use policies promoting modal shifts to non-motorised or public transport can all reduce transport-associated health risks for the local population. Reducing the demand for energy will also reduce the emissions from fossil-fuel burning power plants.

The number of robust clinical studies emerging around energy efficiency improvements means that health has been recognised by several governments as a driver of their energy efficiency policy.

Poverty alleviation: energy affordability

The alleviation of poverty in both developed and developing countries is a central concern for many governments. Energy affordability issues are both a cause and a symptom of poverty. Faced with high energy prices and financial limitations, the poor are often unable to afford enough energy services to maintain healthy living conditions, forced to under-heat the home, to endure poor indoor air quality and/or to forgo other necessities of life such as food – a phenomenon sometimes known as "heat or eat". This situation is generally described as 'fuel poverty' and European studies estimate that 50 million to 125 million Europeans are fuel poor (EPEE, 2012). In turn, the poor are also most likely to live in inefficient housing[3], and have less access to energy subsidies and therefore face higher energy costs than the rich.

Energy efficiency can address this by intervening at the household level to reduce energy bills through insulation and design, delivering efficient appliances, space and water heating equipment and lighting, while providing training in efficient energy-use-behaviour among occupants. Such programmes increase occupant comfort and health, well-being and livelihood. The Warm Front home energy efficiency scheme in the United Kingdom has a budget of USD 573 million (GBP 350 million) and delivered a potential USD 952 (GBP 610) reduction in energy bills for each of the 127 930 targeted households (DECC, 2011) and improved building energy performance (SAP[4]) ratings by an average of 27 points, from 32 to 59. Replacing traditional biomass cookstoves with energy efficient ones would also improve the living standards of half a million people across Africa, significantly reducing fuel costs as well as the burden on time, health and the local environment.

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[2] The Global Alliance for Clean cookstoves aims for 100 million homes to adopt clean and efficient stoves and fuels by 2020 (Global Alliance for Clean Cookstoves, 2012).

[3] The average annual residential energy use of the fuel poor is 13% higher than the average for all US consumers (Power, 2006).

[4] Standard Assessment Procedure (SAP) for building quality in the United Kingdom.

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Poverty alleviation: access to energy services

Access to adequate energy services is fundamental to pulling communities out of poverty by providing the raw material for social and economic development. Energy access issues are mostly faced in developing countries, and the nexus between poverty and energy access in this context is often discussed as a question of "energy poverty" [5] (Heffner and Campbell, 2011). Many developing countries with less than universal access rates but limited resources look to improve the efficiency of the supply-side in order to extend energy access to households off the grid. Energy efficiency measures undertaken by energy providers can free up additional resources by reducing technical losses in their energy generation and distribution systems. Regional infrastructure extensions in developing countries do not always benefit the poorest households, so local level programmes that effectively build on local technical capacity to target local needs remain essential part of the policy approach to poverty alleviation[6] (IEA, 2011c) through increased access to energy. Energy access issues also exist in terms of end-use energy efficiency, notably to help to maintain access in the face of power shortages, such as in South Africa and Ethiopia where CFL substitution programmes were instituted in the face of power shortages to maintain their ability to supply a broader set of customers.

Increased disposable income

When an improvement in energy efficiency causes a reduced energy bill for the same energy consumption, there are monetary savings that translate into increased disposable income. This can hold equally for the individual consumer or for an energy-using enterprise. The surplus of disposable income can be spent in different ways and, depending which option is chosen, can have significant impacts on individual, company, sectoral, and economy-wide energy consumption. The consumer or company could choose to:

- save the money;
- spend the money on non-energy or less energy-intensive activities (*i.e.* less energy-intensive than the activity of generating the energy saved);
- spend the money on more energy-intensive activities either by increasing the level of energy service consumed (*i.e.* for the consumer increasing the temperature in a building, or for a company, investing in increased production capacity, the direct rebound effect) and/or spending the money on additional goods and services (by going on holidays by airplane or hiring more staff in a company for example, the indirect rebound effect).

Factors determining the consumer choice on how to spend increased disposable income are numerous and a mixture of the following: income level, demographics, personal preferences, behavioural factors, education and availability of information, and the substitutive options available. Similarly, a number of drivers are important in determining enterprises' investment decisions such as their financial situation, knowledge of energy efficiency potential, commitment to the environment and energy efficiency, public and market demands, and policy obligations (IEA, 2011d).

The implications for these choices are important for macro-economic development, *e.g.* when the consumer or enterprise spends the savings on low energy-intensity activities, overall welfare and energy consumption are implicated. Increased disposable income can also be seen in terms

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5 The terms are often used interchangeably and in this paper the term 'fuel poverty' is used to refer to challenges faced in both developed and developing countries.

6 To provide universal modern energy access by 2030 a cumulative investment of one trillion is needed – an average of 48 billion per year, more than five times the level in 2009. The IEA's New Policies Scenario projects that investments between 2010 and 2030 are set to increase by 56% on 2009 investments, but this is not nearly enough.

of energy affordability where lower income households can pay their energy bills with less money and be able to afford other items, which the household budget might otherwise have been unable to allow. Implications for energy consumption are also strong; if the surplus is spent on energy-using activities, fewer savings from improvement in energy efficiency will be realised.

Sectoral level benefits

Benefits at sectoral level include those benefits that may occur at scale in a particular sector, such as the residential or industrial sector; these may or may not trickle through to the national level. For example, jobs may be created in one sector but not in another and the net benefit at national level may be insignificant.

Industrial productivity and competitiveness

There are many improvements in industrial productivity that energy efficiency can deliver. These include increased profit, safer working conditions, consistency and improvement in quality and output, reduced capital and operating costs and reductions in scrap and energy use. Indeed, a 2001 Ernest Orlando Lawrence Berkeley National Laboratory report (Worrell *et al.*, 2011) examined the relationship between energy efficiency improvement measures and productivity in industry and identified 224 different "non-energy benefits" among the 77 case studies it dealt with. The benefits can be reaped by industries on a global level, through enhanced competitiveness, and can extend to individual workers' everyday working conditions, safety and job satisfaction. An integrated, multi-disciplinary approach is therefore necessary in order to develop accurate models to assess the extent of industrial energy efficiency improvement projects.

Benefits from improved energy efficiency in industry not only improve plants and bring firms profits, but can positively affect the competitiveness of industry at large. Studies suggest that the multiple benefits in the overall industrial sector may be in the order of 24% of total annual savings to 40 to 50% of the value of energy savings per measure and up to 2.5 times the value of energy savings (Lilly and Pearson, 1999; Pearson and Skumatz, 2002; Gudbjerg, 2011).

It is clear that encouragement and incentives for such measures should come not only from government policies, but from the financial sector and industry itself since these benefits are accrued as private benefits to the individual companies.

Energy provider and infrastructure benefits

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 in terms of providing better energy services to customers, reducing operating costs and improving profit margins. As much as 10% of the total benefits flowing from energy efficiency measures are likely to accrue directly to energy providers, which explains why many utilities are already pursuing ambitious demand-side management measures, spurred in many countries by statutory energy efficiency obligations.

Depending on market structure and regulatory frameworks, energy providers can be impacted by a reduction of sales as a result of energy efficiency measures; however, this can be mitigated through use of decoupling mechanisms to buffer revenues and profits from sales volumes[7]. Increased energy sales require increased capacity, and the cost of installing new capacity and transmission capability is almost always more expensive than energy efficiency measures, so

[7] Decoupling generally increases rates to ensure return on equity when sales volumes are below target.

slowing demand growth generally provides net benefits to energy providers. Aside from reducing costs, avoiding the need to increase generation capacity with more power plants, and more pipelines and electricity transmission and distribution lines helps avoid the range of problems that come with building big energy infrastructure, such as NIMBYism (Not In My Back-Yard syndrome). In most countries it can be a very difficult and lengthy process to obtain planning for large pieces of infrastructure like power plants. The opportunity costs associated with planning and commissioning energy infrastructure are high and are best avoided if possible.

A large body of evidence, focused on direct financial impact of energy savings on energy providers' bottom line through reduction of arrearages, already indicates that "for both electric and gas utilities, energy efficiency investments consistently lower costs over time for both utilities and customers" (DOE, 2007). Several studies show a much broader range of benefits, in financial, reliability, system and network, market price and marketing terms, which could accrue to energy providers, but work is needed to refine approaches to measuring these.

Increased asset values

There is some evidence that investors are willing to pay rentals and sales premiums for a property with better energy performance. Energy is one of the highest operating costs in most offices, for example, so the net present value of future energy savings can be added to the resale value. Studies demonstrate that the market is increasingly reflecting this reasoning.

The United States Environmental Protection Agency (US EPA) states that for every USD 1 invested in energy efficiency, asset value increases by an estimated USD 3 (FYP, 2012). From a business point of view, energy efficiency can provide a valuable stimulus to growth, especially in income properties where any reduction in operating costs directly translates into an increase in net operating income (NOI). For commercial real estate, *EnergyStar* gives the example of a 200,000 square foot (sq. ft.) office building that pays USD 2 per sq. ft. in energy costs. A 10% reduction in energy consumption can translate into an additional USD 40 000 in NOI. At a cap rate of 8%, this could mean a potential asset value boost of USD 500 000.

Existing analyses of data demonstrate that "green" buildings have increased resale value and rental rates, and a offer a wider array of benefits even beyond asset values: they have higher occupancy rates, improved comfort, lower operating expenses and lower capitalisation rates and higher productivity gains.

Similarly, recent historically high fuel prices, combined with renewed interest in fuel economy and greenhouse gas emissions standards for automobiles have engendered a number of new assessments, many specifically aimed at understanding the effects of fuel prices and fuel economy on consumers' vehicle choices.

National level benefits

Energy efficiency benefits at a national level, including for the economy (including macro-economic benefit), as well as for national budgets (for simplicity, these are included as the public sector benefits, aggregating the sovereign and sub-sovereign levels) are discussed in this section.

Job creation

Investment in energy efficiency programmes has significant potential to create jobs with a short lead time. A net improvement in employment rates can be attributed to energy efficiency programmes through direct job creation and indirectly through consumer surplus spending, in addition to other benefits for national budgets, such as reduced unemployment benefits.

Direct jobs generated in the delivery of energy efficiency measures are easiest to measure and they are likely to be plentiful. Indirect jobs can also be generated further upstream in producing feed materials, however, these jobs may only endure for the period of the particular energy efficiency programme. The value of created jobs depends on various factors such as their labour intensity, local content, wage rates (Pollin, Heintz and 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. Estimates vary greatly, from studies reporting a "positive but relatively small" net employment benefit (Jeeninga *et al.*, 1999) to others generating specific numbers in the range of 26.6 jobs created for every EUR 1 million spent in an energy efficiency intervention (Wade *et al.*, 2000). A certain degree of consensus can be seen forming around an estimated net impact of about 17 to 19 jobs created for every million Euros spent on energy efficiency interventions (BPIE, 2011). If the effect of government finance in leveraging additional private finance is also taken into account – often suggested at around five to one (Jansen, 2012) – then the figure in fact comes closer to 90 jobs generated for every EUR 1 million spent on energy efficiency.

An expenditure shift effect, as a result of energy bill savings and new workers' wages, may also create jobs across all sectors, and while causal links are more difficult to establish, these jobs are more durable than others, with potential to last the period of the energy efficiency improvement itself, *i.e.* the 20 year lifetime of your improved heating system, rather than of the energy efficiency programme. It should be noted that employment impacts are often demographically and spatially dependent.

Reduced energy-related public expenditures

Another interesting perspective is that of the public sector as a distinct entity in the economy. Energy efficiency improvements will have an impact in reducing pressure on national budgets and improving fiscal balance.

The public budgetary position can be improved through lower expenditures on energy in several ways. Reduced end-use energy demand in the public sector will reduce public expenditure considerably in most countries. In countries with state-owned enterprises, notably utilities, reduced energy demand means less public expenditure on fuel. This can be particularly important in fuel-importing countries where foreign currency reserves may be depleted through high fuel imports.

Conversely in countries with fuel exports, domestic energy efficiency remains important, as reduced energy demand domestically releases capacity for revenue-raising exports. In addition, for countries with energy consumption subsidies, reduced consumption means lowered government outlays to finance these subsidies. This is very important with EUR 409 billion spent globally in 2010 on fossil fuel subsidies.

Energy security

Energy efficiency has a role to play in making countries less reliant on imports for their energy needs, and therefore helps bring about a diverse energy mix. The effects that trickle through to energy security are structurally dependent, reliant on the energy sector in a given country. Bodies such as the United States Environmental Protection Agency (EPA), the Renewable Energy & Energy Efficiency Partnership (REEEP) and the European Union have recognised the vital role of energy efficiency to delivering energy security (EPA, 2012; REEEP, 2012).

Consideration of long-term energy security typically considers the four 'As' of risk – fuel availability (geological), accessibility (geopolitical), affordability (economic) and acceptability (environmental and social) (APERC, 2007; Kruyt *et al.*, 2009), while short-term approaches to

energy security, like the one taken by the IEA's model of short-term security (IEA, 2011b), often consider three aspects: robustness (adequacy and reliability of resources and infrastructure), sovereignty (exposure to threats from foreign actors) and resilience (ability to respond to diverse disruptions). Energy efficiency resulting in reduced energy demand can assist with all of these.

The impact of various energy efficiency measures on the various energy security indicators depends significantly on the energy mix in individual countries. In the 2011 IEA publication *Saving Electricity in a Hurry* the benefits of emergency energy efficiency measures to energy security are measured by the absolute electricity demand reduction. That study indicated energy savings ranging from 0.5% (France) to 40% (Juneau, Alaska). These savings helped countries avoid blackouts and other costly results of power shortfalls.

While energy security is generally considered to be an economy-wide issue, it can also be seen at the individual and household levels, to the extent that lack of energy security for some households may lead to energy precariousness and an inability to pay energy bills.

Macroeconomic effects

Improvements in energy efficiency can produce significant positive macroeconomic impacts such as increases in GDP, trade balance, economy restructuring, employment, and national competitiveness to name but a few. These can have a significant impact on a country's fiscal budget.

Investment in energy efficiency implies a transfer of capital from energy 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.

A study of the macroeconomic effects of energy efficiency improvements in the United Kingdom has separated into three the drivers of the macroeconomic outcomes: namely the consumer surplus, *i.e.* the increased spending due to reduced energy bills; the increased investment in energy efficiency products and services; and reduced energy prices and costs for industry leading to increased production and exports (Barker and Foxton, 2008).

There are several examples of analyses of energy efficiency programmes using CGE models.The few studies examining the macroeconomic effects of improved energy efficiency (where energy demand is reduced by 8 to 15%) suggest significant potential impacts including increases in GDP ranging from 0.8% to 1.26%. In summary, it appears that the case for energy efficiency from a macroeconomic growth perspective is good. Although the effects are estimated to be relatively small, they remain positive.

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.

Greenhouse gas emissions reduction

Improvements in energy efficiency which lead to reduced fossil fuel energy consumption result in a reduction in greenhouse gas emissions. Indeed, energy efficiency measures are expected to contribute 44% of the carbon abatement needed by 2035 to have a chance of reaching international climate change targets. Compared with other greenhouse gas emissions measures, improving energy efficiency is generally more cost effective and can be implemented quickly Energy efficiency offers a unique opportunity to begin making emissions reductions immediately,

with a much smaller initial costs and shorter lead times for emissions reductions than other important technologies such as renewable energy generation. GHG reductions are already acknowledged as a main outcome of energy efficiency measures and are often already measured as a matter of course in existing energy efficiency programme evaluation. However, 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.

Moderating energy consumption 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 fall, and energy efficiency improvements are expected to deliver the necessary energy demand reductions. In 2010, global primary energy demand increased by 4.7% (IEA, 2011c).

It should be said that the impact of reduced energy demand on energy prices is not likely to be felt when the change in demand is limited to local or national level and only over a short period of time. The global nature of energy markets means that the excess capacity from a reduction of demand in one market can be offset by higher demand in another market. For energy efficiency improvements to impact energy prices, there needs to be a sustained reduction in energy demand across many countries.

Natural resource management

Another familiar, but unmeasured, category of benefit from reduced energy demand is the alleviation of pressure on natural resources. Given that global production of conventional crude oil will be declining by 2035 (IEA, 2011c) and in light of other related supply constraints, energy efficiency will be increasingly important measure to relieve pressure on scarce resources. At the same time, oil demand is projected to increase along with economic growth, particularly as a result of needs in the transport sector. As options for fuel substitution are limited, energy efficiency will again provide an important response in this sector, reducing emissions of black carbon and other internationally monitored toxic gases, through measures such as fuel efficiency standards, eco-driving, public transport and logistics efficiency. Energy efficiency is also a vehicle for environmental protection at the local level, helping to reduce waste and emissions detrimental to local air and water supplies and to delicate ecosystems.

Demand is pushing the energy supply industry to increasingly challenging contexts for fossil fuel extraction such as deep off-shore and Arctic oil exploration as well as shale oil extraction. Reducing demand through energy efficiency measures will help to reduce the incentive to pursue these avenues which all come with incremental investment costs, uncertainties in the effectiveness of new technologies and largely unknown potential environmental impacts.

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 United Nations (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.

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The potential of energy efficiency programmes to directly support development is being pursued through various local-level projects such as the UN's Millennium Villages project, which highlights the value and feasibility of community-level investments by promoting innovative technologies such as fuel-efficient cookstoves to replace traditional biomass stoves[8]. The impact of energy efficiency policies for improving living standards 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 and improving environmental sustainability, promoting social inclusion and reducing poverty.

In Serbia and Montenegro, where energy intensity is three times higher than the rest of Europe, a UN study (UNDP, 2004) identified that energy efficiency measures could boost the GDP growth rate to 5% to 7% a year by improving households' ability to participate more productively in society. No other single measure could secure this kind of increase in growth as quickly.

[8] The Global Alliance for Clean Cookstoves is another major local-level energy efficiency initiative. It aims for 100 million homes to adopt clean and efficient stoves and fuels by 2020. Reducing fuel costs as well as the burden on time, health and the local environment, fuel efficient cookstoves are expected to improve the living standards of half a million people across Africa (Global Alliance for Clean Cookstoves, 2012).

The rebound effect

While there are potential benefits to energy efficiency, there are also important claims that these benefits are often not realised as improved efficiency gains are undermined and counter-balanced by increased consumption and expenditures, the so-called 'rebound' effect. The claim that energy efficiency improvements do not deliver energy savings because of the rebound effect resurfaces regularly (*The New Yorker*, 2010; *The Economist*, 2008; *The Wall Street Journal*, 2009; *The New York Times*, 2011). Many of these articles question whether mainstream energy efficiency policies such as those recommended by the IEA are in fact worthwhile in terms of energy savings. This commentary has created uncertainty around energy efficiency as an effective strategy for government energy officials and politicians.

The preceding investigation in this paper, into the broad range of multiple benefits beyond energy savings that may be delivered by energy efficiency improvements, suggests that reinvestment of energy savings can act as a driver for achievement of many other policy goals. Many of these benefits, in particular poverty alleviation, health improvements, consumer surplus and development goals, come with an energy consumption price tag and thus are drivers of the rebound effect. However, from a societal perspective, these rebound effects can be seen as a positive overall outcome.

If rebound is not necessarily a negative outcome for policy-makers, then the impact of the rebound effect argument is significantly reduced. While the rebound effect remains an important effect to be considered in energy savings accounting, it poses no challenge to the important role of energy efficiency in delivering socioeconomic goals.

What is the rebound effect?

Rebound in energy demand can be attributed in the first instance to energy-use behaviour and secondarily to increased spending and investment across the economy. When an energy-using technology or process becomes more efficient, the user can take advantage of the increased service delivered, rather than accepting the same service at a lower energy or financial cost. When savings are translated to lower monthly energy bills, the savings accrued can be invested in services or production that leads to further demand for energy.

Three distinct rebound effects surface in the energy efficiency discussion (shown with examples in Table 1):

- ***Direct rebound*** occurs when a consumer or producer reduces their energy costs by investing in an energy-efficient piece of equipment and then chooses to increase production or consumption using proceeds of the energy saved.
- ***Indirect rebound*** occurs when consumers and businesses invest the savings due to energy efficiency improvements in other goods. The indirect rebound effect is more difficult to study than the direct rebound and so and there are fewer comparable studies.
- ***Macroeconomic or economy-wide rebound*** occurs when improved energy efficiency leads to increased energy productivity and economic growth. This effect is the least well-documented and is the subject of some mischief, as evidenced by Jevons Paradox-style arguments, which hold that energy efficiency policies will "backfire' with increased energy productivity and economic growth. This results in an increase in energy consumption compared with a business-as-usual case of no energy efficiency policy.

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Table 1 • Examples of different rebound effects

Rebound Effects	Consumer		Producer	
	Income	Substitution	Output	Substitution
Direct	Turning up the heat, driving more	Buying a bigger house	Increasing production	More energy use relative to other factors
Indirect	Taking a holiday		Lower cost cars lead to more transport consumption	
Macroeconomic	Lower prices for energy services increase demand for all goods and services economy-wide; increased employment		Increased productivity, higher profits/dividends implies investment in the economy	

What does it mean for energy efficiency?

Many economists and engineers have studied the rebound effect both empirically and theoretically and the vast majority has concluded that it does exist but is not strong enough to outweigh the energy and financial savings resulting from energy efficiency. To the extent that this report outlines significant additional benefits from energy efficiency, it should tip the balance even further in terms of encouraging energy efficiency actions.

Nevertheless, rebound factors can and should be factored into policy planning and into evaluation when calculating the benefit-costs of a policy. This involves understanding the dynamics and magnitude of rebound effects to be able to judge the policy implications and changed expectations in reducing energy demand that could arise. Some immediate implications are:

- Adjusting for the rebound effect may reduce the assumed contributions of energy efficiency to climate change mitigation.
- Targets and goals (*e.g.* the European Union's 20-20-20 target[9]) may be harder and more costly to meet.
- Abatement curves may need to be adjusted, and the order of mitigation and relative policy priority of different abatement policies may change.

Establishing baselines

In estimating the benefits of energy efficiency, an important consideration is what the energy consumption and socioeconomic situation would have been without improved energy efficiency, or in other words the counterfactual or baseline. In many cases there would have been even higher energy consumption leading to higher costs in the long run.

It is especially important in developing countries on a high path of economic growth where improvements in energy efficiency are likely to improve the productivity of the country and lead to further economic development. It is for governments to prioritise the needs of their country and this may mean that benefits such as economic growth, job creation or industrial productivity are given equal weight, or even favoured over energy savings. Reconsidering the outcomes from energy efficiency improvements in terms of welfare gains rather than energy savings alone could transform the rebound effect discussion from one of negative impacts to a quantification of the wider socioeconomic impacts of energy efficiency improvements.

[9] The European Commission set a series of climate and energy targets to be met by 2020: 20% reduction in GHG emissions below 1990 levels; 20% of energy consumption from renewable resources; 20% reduction in primary energy use through improvement energy efficiency. http://ec.europa.eu/clima/policies/package/index_en.htm.

What is needed?

A more nuanced discussion of the balance between the potential energy savings and trade-off against other goals is required, as well as broader analysis of the outcomes of energy efficiency policies, which includes both effects on energy consumption and also the range of other socioeconomic impacts. The IEA published a report in 1998 and a short summary in 2005 (IEA, 1998; IEA, 2005) highlighting the need to "drill down" further in understanding with regard to the rebound effect of different end-uses, end-users and policies, and better distinguish the rebound effect from a broader multiple benefits perspective.

Improved understanding of the complexities of the rebound effect in different consuming sectors will help governments appreciate when rebound effect considerations should be factored into energy efficiency policy making. One finding of research into the rebound effect on consumers and producers is the discovery that some end-uses and energy efficiency policies have a relatively small and stable direct rebound effect (*e.g.* appliance MEPS) while other policies have a larger, more volatile, and harder to estimate rebound effect (*e.g.* improving industrial processes). Good data on the rebound effect will continue to be important for policy-makers and evaluators, in order to design policy that maximises energy savings and addresses undesirable elements of the rebound effect.

Table 2 • Summary of outcomes from improvement energy efficiency

Benefits		Time-frame for effect		Level at which outcome takes effect			Country context dependency		Depends on energy saving?	Rebound effect
		Short	Long	Individual	National	International	Energy mix	Developing country		Impact on energy consumption?
Social	Health	X		X	X			X	N	+
	Energy affordability	X		X				X	Y	+
	Energy access		X	X	X			X	N	+
	Development	X			X	X	X	X	N	+
	Job creation	X		X	X			X	N	+
Economic	Asset values	X		X	X				N	-
	Disposable income	X		X	X			X	Y	+
	Industrial productivity	X		X	X			X	N	+
	Energy provider benefits and infrastructure	X	X	X	X		X	X	Y	-
	Energy prices	X	X		X	X	X	X	Y	+
	Public budgets		X		X	X	X	X	Y	+
	Energy security		X		X		X	X	Y	-
	Macro-economic effects		X		X			X	N	+
Environment	Greenhouse gas emissions	X			X	X	X	X	Y	-
	Resource management	X		X	X	X	X	X	Y	-
	Air/water pollutants	X		X	X		X	X	Y	-

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Towards a better understanding of multiple benefits: additional dynamics

Estimating the multiple benefits of energy efficiency can be difficult – the nature of the different kinds of benefits and the complex interactions between them need careful treatment. The dynamics of energy efficiency measures at the point where they are implemented needs to be considered alongside any broader benefits which might emerge at other levels as a direct or indirect result. When considering the relevance of various multiple benefits to the design and evaluation of energy efficiency measures in a particular country, policy-makers will need to take into account a range of contributing factors, including the country context, the balance between public and private benefits, and the rapidity of outcomes needed. These matters are likely to be deciding factors in tailoring energy efficiency policy to meet prioritised targets. Another consideration is that the methodologies for estimating the multiple benefits of energy efficiency, which are crucial in valuing the magnitude of benefits in a transparent, rigorous manner, are still under development in many cases. This section describes some of the most important dynamics in the discussion of multiple benefits associated with energy efficiency measures and outlines the relationship with energy efficiency policy.

The interplay of the different levels of benefits

Using the levels categorisation described in the chapter titled “Proposed typology for benefits” above, it is possible to assess any particular measure on the basis of its contribution to all of these potential benefits. Some of the benefits at “bottom-end”, more individual, levels can lead to further benefits at “top end” levels, sometimes called the multiplier effect and care must also be taken not to double count benefits arising on different levels. Figure 3 illustrates the range of benefits at different levels from one energy efficiency measure, in this example the insulation of a building. The example highlights how benefits such as lower energy bills or improved health can begin at the individual level and trickle through the economy so that at scale, there is potentially an impact on the economy of a country and even globally. This is helpful in providing a holistic view of outcomes, but care must always be taken in formal evaluation not to double count benefits which are visible on various levels.

Public versus private benefits

Of the large array of potential benefits accruing from improved energy efficiency, as described below, it is helpful to distinguish between those that accrue to society overall and those that benefit the private individuals or entities. This is particularly relevant to a government in deciding which policies are appropriate to support with public money. It may not be in the interest of society to subsidise measures that only deliver increased private benefits to a company or person.

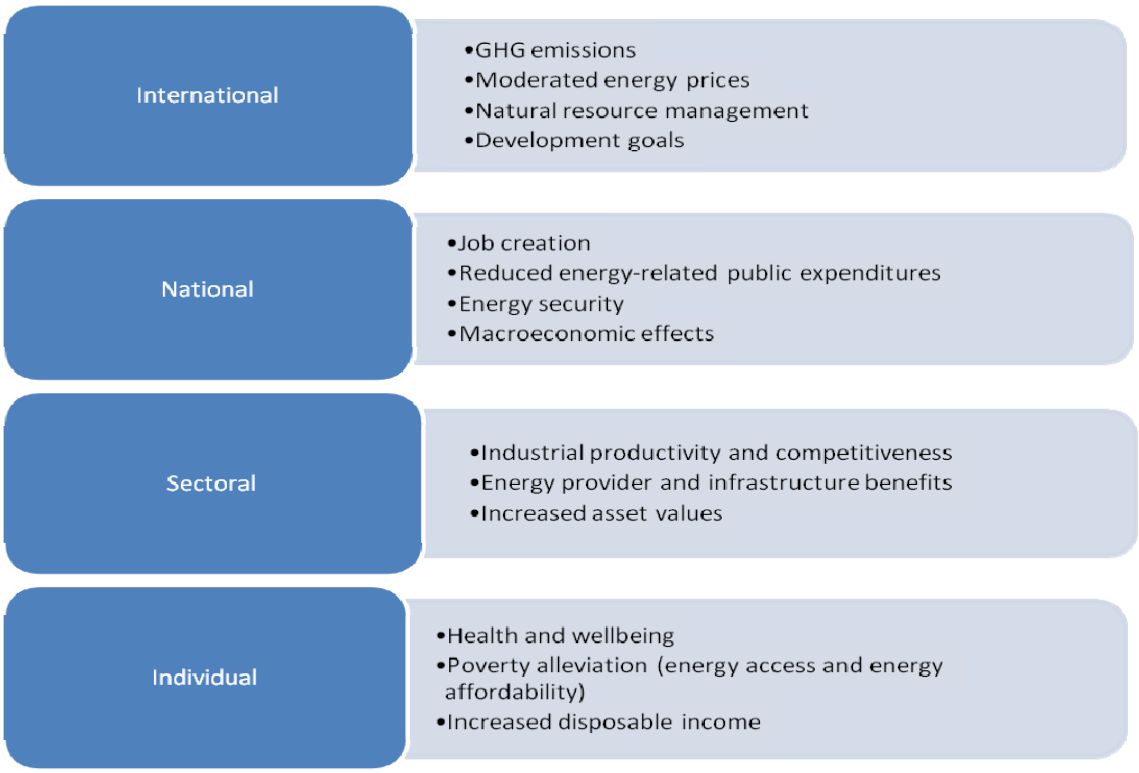
For example, improved energy efficiency in industrial production processes increases productivity and hence production, which are private benefits for the owner company. Yet if the energy source used in production is a fossil fuel, the reduced energy demand reduces greenhouse gas and air pollutant emissions and potentially improves national energy security, as well as reducing local environmental impacts, all of which are public benefits. These latter public benefits justify public intervention, even though the private benefits will generate profits for the individual company. Because of these top level benefits the public policy intervention may be better targeted at existing barriers to implementation, providing as technical assistance rather than financial support.

Direct versus indirect benefits

Another way to examine the benefits from energy efficiency measures is in terms of direct and indirect outcomes from energy efficiency. There are important direct impacts from energy efficiency measures, primarily energy savings, but also health improvements, reduced greenhouse gas emissions and increased consumer spending power. Job creation may also be a direct effect if a new job is created simply to implement the energy efficiency measure, but employment may also be an indirect impact where increased consumer spending causes job creation across the economy.

Indirect effects are those that are triggered as a result of the direct effects. For example, energy savings are at the heart of many of the indirect effects such as consumer surplus, lower energy prices resource management, energy security, and public budget outlays. There can be even second order indirect effects, or induced effects, arising from the first order indirect effects such as consumer surplus.

Figure 3 • Example multiple benefits at different levels of the economy from insulation of a building



Temporal impacts (short versus medium versus long-term)

One advantage of energy efficiency actions compared with other measures is the rapidity with which results are produced. For this reason, energy efficiency is often cited as one of the best near-term options to reduce energy demand and greenhouse gas emissions. An improvement in technical efficiency can have immediate effect on energy consumption and, especially in the case of smaller projects, can be relatively quick to put in place.

This is an important feature of energy efficiency improvements as society considers which measures are likely to deliver the benefits needed at different moments in time. The short-term outcomes possible through energy efficiency improvements are crucial in helping solve problems

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facing policy makers such as sudden changes in unemployment, energy supply, energy affordability to name a few. Energy efficiency improvements in other areas can provide longer-term outcomes such as national competitiveness, reduced public health costs, and energy security that ensure economic sustainability for the future.

Country contexts

The outcomes from energy efficiency improvements depend greatly on the country context. Several factors can play an important role in determining the level and type of outcomes that an energy efficiency measure will deliver, such as the geographic situation, the level of economic development, energy resource endowments and demographics. The geographic situation of the country will influence the climate and hence the energy needs of households, so, for example, hot countries may require cooling services while buildings in cold countries will have heating needs. A country's energy supply and energy mix also determine the kind of energy efficiency outcomes that can be achieved and hence the measures that should be put in place. For example, a country with an abundant supply of renewable energy for power should choose to focus on energy efficiency measures in the sectors or at the times where fossil fuel is most needed. In many countries this will mean targeting road transport.

An IEA study measured how improved energy efficiency and conservation can lower the risks to long-term energy security, by investigating how countries could reduce their CO_2 emissions by 5% in 2030 as a result of energy efficiency improvements (IEA, 2007). The decrease in power generation needed to achieve this target varied by country according to fuel mix; France, for example, relies predominantly on nuclear energy for power generation, and would therefore need to decrease total power generation 22%, compared with 12% in the Netherlands.

Role for energy efficiency within stimulus policies

There are some examples of energy efficiency policies being applied as recession recovery or stimulus policies. These policies tend to target unemployment and other impacts of recession. Recessionary responses are best applied within particular sectors and are most usefully targeted when addressing specific surplus capacity.

Analysis of the stimulatory impact of energy efficiency policies is therefore best achieved by undertaking a net national benefit analysis at the sector targeted by the energy efficiency policy intervention. To be an effective response to recession, policies should:

- maintain or increase aggregate demand in the short term;
- be economically efficient and sensible over longer term; and
- help to reduce uncertainty.

Energy efficiency policies have a sound track record at meeting these criteria.

How can we measure the multiple benefits of energy efficiency improvements?

Developing methodologies for measuring multiple benefits is an essential step in bringing them into the energy efficiency discussion. Various methodologies are possible in estimating the multiple benefits of energy efficiency and a technical discussion is emerging among evaluation practitioners about what methods best fit the various novel issues presented by multiple benefits

in various levels of the economy. Part of the IEA's future work in this area will include a review of methodologies being used to evaluate multiple benefits, with a view to providing some suggestions about what developments are needed to allow multiple benefits to be better incorporated into the evaluation of energy efficiency policy.

An overview of methodologies is provided in several reports and the main types are computational approaches using primary, secondary or regression estimates, a variety of surveys such as contingent valuation, willingness to pay (WTP) or willingness to accept (WTA), or relative scaling methods, ranking approaches, hedonic regression, and factor-importance judgments (also called reported motivations) (Heffner and Campbell, 2011; Skumatz, Khawaja, Colby, 2009). At a macroeconomic level computable general equilibrium models, input/output, and integrated approach models are used. Skumatz (2002) has compared the values of multiple benefit estimates from a combination of these methods and finds that comparative valuations and labelled magnitude scaling approaches give more consistent results than "willingness to pay" surveys (Skumatz, 2002).

Economic and institutional systems are of fundamental importance to developing a sold analytical baseline. Economic and institutional systems include labour markets, tax systems, and existing regulations. Taking such systems into account adds complexity and depth to the benefits analysis. Different technological, economic and institutional structures often make results situation and country-dependent.

Linking energy efficiency to green growth

Many countries are interested in green growth as an economic strategy. The benefits from improved energy efficiency can match well the aspirations of the related concepts of green growth and sustainable development. Green growth means "fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies" (OECD, 2011). Improvements in energy efficiency exhibit many of the characteristics that governments are looking for to achieve strategies of green growth: cost-effectiveness, positive societal and individual welfare gains, environmental benefits, while contributing to economic development and growth. With GDP growth from improved energy efficiency estimated at around 1%, energy efficiency should no longer be viewed as part of an environmental objective but rather as an element of mainstream economic good sense.

The characteristics of the identified benefits of energy efficiency are summarised in Table 2. There are benefits across the three dimensions of society, the economy and the environment. Nearly all are relevant for both developed and developing countries and several operate at multiple levels of the individual, the economy and the international. A majority of the benefits can take immediate effect with long-lasting results.

As noted above under the discussion of the rebound effect, some of the welfare gains from improved energy efficiency translate into energy consumption (final column of Table 2) and consequently can lead to less energy savings than might have been originally expected from improvements in energy efficiency. A discussion of the rebound effect in energy efficiency is needed that incorporates not just the expected energy savings from energy efficiency but also the wider socioeconomic outcomes.

Although energy efficiency improvements appear to make a substantial contribution to green growth, there are still barriers to releasing this potential. Policy measures are needed to overcome the market and behavioural failures that lead to less investment in energy efficiency than is optimal. The IEA 25 Energy Efficiency Policy Recommendations provide a policy

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framework in this context (IEA, 2011a). It is important to overcome critical challenges that involve complex synergies and trade-offs among the different aspects of energy efficiency policy. To maximise the potential for welfare gains, the three dimensions of sustainable development (social, economic and environmental) should be taken into account based on the understanding of interactions among these dimensions and their complementarities. In this regard energy efficiency policies should be designed and assessed with the broader perspective of achieving the potential of green growth in mind rather than simply reducing energy consumption.

Next steps

It is clear that the outcomes from improved energy efficiency are not limited to energy savings, but include a wide range of other benefits. They cross areas as disparate as improvements in health to industrial productivity and imply welfare gains across the whole of society. This can be generally described as a pattern of growth in which resource use meets human needs while preserving the environment so that these needs can be met for generations to come. Therefore when examining the benefits of energy efficiency, it is not enough to solely look to the energy savings achieved but rather at the outcomes in terms of economic, social and environmental development.

This report is a first step in communicating the wider socioeconomic benefits of energy efficiency. Although there appears to be clear evidence of multiple benefits resulting in welfare gains from energy efficiency improvements, they are difficult to quantify in many cases. A scan of the multiple benefits identified in this report would indicate that, aside from energy savings, the benefits associated with energy security, improved health, energy affordability, economic growth, and job creation are all outcomes that are also current priorities for governments. This may require a fundamental adjustment in how the role of energy efficiency policy is viewed generally. The view of energy efficiency needs to evolve so that it not seen as a policy approach solely driven by energy ministries to manage society's energy usage, but also as a complementary policy approach to achieving policy goals of other ministries, requiring collaboration across government departments. It will be necessary to communicate the broader rationale for energy efficiency policy sufficiently to encourage this view.

In terms of reducing the impact on energy savings, energy efficiency policy can and should integrate consideration of the rebound effect into the design stages in order to maximise the potential for energy savings. Policies should address the rebound effect by targeting consumer behaviour, by educating energy-users about the benefits of reduced energy consumption and ensuring that sufficient information and options are available for consumers to reduce their energy consumption. These can be supported by policies that create disincentives to increase use of the more efficient product, such as setting carbon and energy prices (Maxwell *et al.*, 2011). The choice as to which policy mix is needed will depend on other policy goals on the national agenda. Similarly, governments need to consider how best to design energy efficiency policies that maximise the full range of multiple benefits, while keeping energy savings as the primary goal.

As benefits resulting from government policies, it is important to be able to evaluate them and include their value in policy impact assessments and benefit-cost analyses. A deeper analysis is needed that will require **data collection** in some of these areas in order to be able to carry out non-market valuation. From this initial work, we can begin to identify where the data gaps lie and focus future work on collecting data in targeted areas. The input of EEWP delegates and both energy and non-energy experts will assist in this process. Using the data and literature, a range of default values should be developed as **benchmarks** for policy makers to use in assessing the outcomes from energy efficiency policy. This will enable governments assess the potential of energy efficiency policy to meet their priorities.

Estimating the wider benefits of energy efficiency improvements can also assist with putting a value on the **return on investment in energy efficiency**. A longer term goal would be to begin to calculate this for different countries and regions and ultimately for the global economy. This can help channel funds into investments in energy efficiency.

Recognition by governments that energy efficiency is a fundament of economic policy would be a first step in maximising the welfare gains that can be achieved through energy efficiency improvements. The IEA will work with governments to promote and collect evidence in support of this idea at the highest level.

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