Capturing the Multiple Benefits of Energy Efficiency:
Roundtable on Industrial Productivity and Competitiveness
Discussion Paper

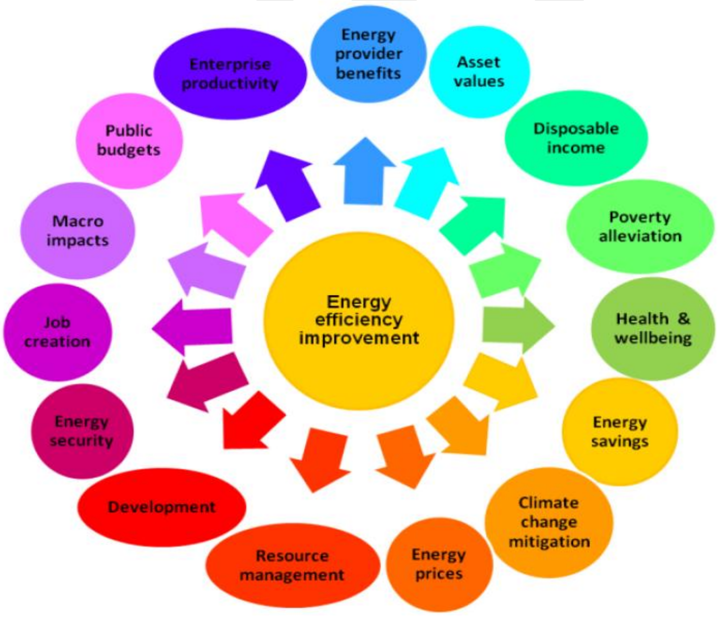
International Energy Agency Headquarters
Monday, 27 January 2014, Paris, France

1. Background

In addition to the well accepted benefits of energy savings and emissions reduction, energy efficiency improvements can lead to a broader range of impacts, which the International Energy Agency (IEA) terms the *multiple benefits* of energy efficiency (Ryan and Campbell, 2012). As part of its project on *Capturing the Multiple Benefits of Energy Efficiency,* the IEA is conducting an in depth analysis of five key benefits of energy efficiency measures, including industrial productivity and competitiveness (Figure 1). The goal of this project is to identify appropriate evaluation frameworks and support development of the practical tools necessary to incorporate the multiple benefits of energy efficiency into policy development and evaluation.

The term "multiple benefits" can be used interchangeably with terms such as "co-benefits" or "non-energy benefits" which is more commonly used in the context of studies in the industrial sector.

Figure 1: The multiple benefits of energy efficiency.



With regards to multiple benefits in the industrial sector, the IEA project aims to:

- Confirm that non-energy benefits related to industrial energy efficiency are quantifiable
- Confirm that there is a value for stakeholders in collecting data on non-energy benefits, and including them in assessment of energy efficiency investments and programmes.
- Provide guidance on the types of benefits that could be of relevance
- Provide guidance on possible approaches to quantifying them and using quantified values in assessment of energy efficiency measures and programmes
- Explore whether multipliers could be developed to calculate expected benefits or if a project by project approach is the only realistic option.

2. Introduction

The impact of industrial energy efficiency measures is routinely calculated in terms of energy savings, and often greenhouse gas abatement, but industrial energy efficiency projects can also generate multiple benefits for companies and the economy. These include indirect or "non-energy benefits" such as operations and maintenance (O&M) savings, immediate and future capital cost avoidance, and avoided compliance costs associated with meeting environmental regulatory requirements. Monetary savings or gains from these outcomes can contribute to increased company-level productivity, profitability and competitiveness. From a wider perspective, energy efficiency projects can contribute to sector-wide or industry-wide improvements in terms of international competitiveness, industrial productivity and other values for society such as the creation of wealth and jobs.

The IEA uses the term "industry" to include a range of large industrial processes, small-medium enterprises and a range of commercial (or tertiary) activities such as retail, financial services; commercial transport services such as couriers, freight forwarding; as well as operational activities by governments such as health and education sectors. In these activities both the core process and the energy services that enable provision of the core service (computing, space conditioning, etc) have energy efficiency potentials which can be realised and contribute to business performance. This investigation will initially tend to focus on the manufacturing industry. Also note that within the broader IEA study on the multiple benefits of energy efficiency improvements, the general case of macroeconomic outcome benefits will be addressed separately.

Energy efficiency investments compete against other investments that companies make. Companies typically prioritise investments that are strategic i.e. that are directly linked with the company's core business (Cooremans, 2012). A quantified assessment of the non-energy benefits that energy efficiency projects can deliver would improve the assessment of investment worthiness of these projects before implementation. Indeed, in the boardroom, it is often the non-energy benefits rather than the value of the possible reductions in energy use that motivate or support decisions to invest in energy efficient technologies (Mills and Rosenfield, 1996).

Despite the lack of recognised methods to consistently measure non-energy benefits, it is clear that these benefits exist and are substantial. Work to date indicates the value of non-energy benefits can be in the range of 40-50% of the value of energy savings per measure or as much as 2.5 times the value of energy savings (Lilly, P. and D. Pearson, 1999; Pearson and Skumatz, 2002). Conventional financial assessments tend to focus on the short term (e.g. simple payback; rate of return) or may use longer term investment analysis frameworks (net present value; and more complex assessments). Neither approach typically includes non-energy benefits. This leads to an underestimation of the economic potential of industrial energy efficiency measures and of their potentially transformative impact on business processes and productivity. Likewise, the benefit-cost ratio of industrial energy efficiency policies is routinely underestimated when non-energy benefits are excluded from policy appraisal and evaluation.

There is currently a lack of established methodologies to measure, verify, monetise, and report these benefits. Quantifying industrial non-energy benefits is not an easy task but the potentially game-changing nature of these impacts makes a strong case to start tracking and quantifying them. The lack of standard methodology is not an insurmountable barrier. There are approaches within accepted financial and economic analysis frameworks that can provide a starting point for collecting and processing data on non-energy benefits. Initial data collection efforts can in turn be utilised to further refine approaches, working towards an increasingly robust methodological framework.

3. The business case for quantifying multiple benefits in the industrial sector

Identifying, quantifying and incorporating non-energy benefits into assessment frameworks is of relevance to a number of stakeholders – company managers, shareholders, energy service providers, the financial sector (institutions that provide finance for energy efficiency projects), programme managers, industrial energy efficiency policy makers and strategic level policy makers.

Table 1: The business case for quantifying multiple benefits in industry

Type of stakeholder	Benefits of quantifying non-energy benefits
Site or company level	• More comprehensive assessment of costs and benefits of energy efficiency investments. • Increase benefit-cost ratios - shorter payback periods. • Enable deeper energy savings. • Enhanced sustainability reporting.
Energy service or financial sector	• Enhanced business models – strengthened business case for energy efficiency projects. • Improved bankability of energy efficiency projects.
Shareholders	• Increased understanding of how key resources affect business • Richer understanding of business investment performance • Better return on investment
Programme or policy level	• More comprehensive assessment of results and impacts from programmes or policies and assessment of the cost-effectiveness of programmes or policies that can be used to identify best options to develop the potential for economic outcomes, justify funding and additional resources, programme continuation or expansion. • Improved ability to engage industry in programmes by showing quantified benefits beyond cost reductions from reduced energy use.
Wider sector or economy level	• Justification for investing in policies to promote energy efficiency. • Improved decision-making basis for where to allocate resources – energy efficiency, new generation or other measures.

3.1 What drives investment decisions?

Companies prioritise strategic investments that contribute to core business by increasing competitive advantage. Competitive advantage is composed of three interrelated constituents:

- costs;
- value; and
- risk. (Cooremans, 2012)

Energy efficiency investments are frequently perceived as non- to moderately strategic (Cooremans, 2012). While energy efficiency projects are typically viewed as contributing to the cost constituent, the perspective of an energy costs reduction may not be a particularly powerful factor in motivating companies toward investing in energy-efficient technology. Energy cost-reduction is a stimulating factor, but may not be sufficient to motivate energy efficiency investments (Cooremans, 2012). Labour, capital and other resource costs tend to eclipse energy costs in all but a limited range of energy-intensive process industries. Research indicates that company demands on payback periods are much shorter for energy efficiency investments than for other investments (Reinaud and Goldberg, 2011). Many companies require payback periods for energy efficiency of 2-5 years or less, which is equivalent to a discount rate of more than 20% (McKinsey Global Institute, 2007).

Identifying and quantifying the non-energy benefits of energy efficiency projects in terms of cost reduction, value generation and risk mitigation, and inclusion of these into investment assessments could contribute significantly to raising the profile of energy efficiency investments.

How can we quantify the more strategic outcomes from energy efficiency such as changes in competitive advantage, improved market share etc?

4. The range of benefits in the industrial sector

Studies reviewed by the IEA highlight that energy efficiency measures in industry have been shown to provide a range of direct benefits for businesses beyond energy savings. Such benefits include reduced environmental compliance costs, enhanced productivity and competitiveness, decreased maintenance costs, extended equipment life-time, reduced waste disposal costs, improved process and product quality, and improved work conditions and decreased liability. The implementation of energy efficiency measures has also been associated with the generation of business opportunities and access to new markets (Mundaca et al., 2010). There are a number of broader socio-economic benefits related to improved energy efficiency in industry, such as reductions in local and global pollution, employment creation, stimulation of new business sectors (e.g. energy efficiency service and technology providers) and enhanced energy security (these impacts are addressed in chapter x of this Handbook).

4.1 Framing the non-energy benefits

Literally hundreds of individual benefits to industry have been identified in past studies and surveys, making it hard to produce a definitive list of the most important non-energy benefits. The relative importance of individual benefits could be influenced by:

- The question being asked: non-energy benefits relevant for assessing the business case for an energy efficiency investment, will differ from those for assessing the results from energy efficiency policies.
- The stakeholder asking: Companies may be more interested in additional revenue, while policy makers may be more interested in by changing policy targets, e.g. environmental benefits.
- The type of project, the industry and the specific industry processes used.
- The cost of input materials, services such as maintenance and waste disposal, labour costs, environmental taxes or fees.
- The social, economic or regulatory context in which a company operates.

In these circumstances, a useful place to start is to classify non-energy benefits into broad type groups which are relevant to industry and other stakeholders irrespective of the variables noted above. This helps clarify analytical priorities and optimise data collection and quantification approaches. Table 2 below presents a typology as a starting point to support future analysis.

Table 2: A typology of industrial non-energy benefits

Category of Benefit	Non -Energy Benefit	Commentary
Production	Production improvements	To quantify production benefits from energy efficiency measures requires deliberate and targeted project evaluation. More efficient equipment or processes can lead to shorter process times and use of lower cost factors of production (labour, water, waste, materials), which can enable higher product output.
	Product quality	Downstream improvements in reductions in product waste and warranty claims aren't currently linked to process changes.
	Product value	Improved quality and consistency can be central to added value in some markets, but again the downstream impacts aren't assessed
	Plant capital	Optimising processes or upgrading equipment – can defer the need for capital costs in replacing equipment. Optimising processes for energy efficiency can also lead to situations where certain equipment is no longer needed.
Operation and Maintenance		These benefits could include reduced maintenance materials and labour and are sometimes as large as the direct energy cost reductions. Some case study evidence from programmes like the NZ CEELS programme which deliberately tracks O&M costs as part of investment payback. Improved plant utilisation and reliability (reduced equipment downtime, reduced number of shutdowns, can occur but few of these are monitored. Reduced process time.
Working Environment	Site environmental quality	Improved working environment from improved thermal comfort, lighting, acoustics and ventilation. Can help retain and attract skilled staff. This could be difficult to quantify in terms of productivity and competitiveness and is not easily recognized as important by industry stakeholders
	Health and Safety	Reduced health insurance costs and medical expenses. Key indicator is changes in the number of sick days (related to e.g. respiratory illnesses) causality an issue as there are a number of factors that will influence human health and absenteeism
	Increased worker safety	Process improvements and equipment upgrades implemented as part of energy efficiency projects can reduce the risk and incidence of work-related accidents. Key indicators are cost savings from changes in the number of accidents in a given area or process
	Labour productivity	Improved work absenteeism; less hours worked
Environmental	Local or regional emissions	Process changes reduce combustion and process parasitic emissions which can be important to industry when there are regulatory or compliance issues and associated cost savings include avoiding fines or taxes for hazardous wastes.
	Global emissions	SO_x, NO_x CO, CFCs, HFCs, as well as CO_2 and associated credit or compliance costs.
Business competitiveness and strategic objectives	Market share	**Can the firm expand capacity or evolve new product features that enable new markets to be entered?**
	Ability to enter new markets	**Can energy efficiency improvements help overcome technical barriers to trade or overcome market perceptions or resistance (e.g. perception about CO_2 footprints)?**
	Improved competitive advantage	**Does the energy efficiency intervention enable a firm to access and capitalise on a new complementary or substitute factor of production and in doing so open up new opportunities for growth?**
	Corporate risk	**Does the intervention mitigate corporate risk or help achieve regulatory compliance?**

How could this typology for the non-energy benefits of energy efficiency interventions be improved?

5. Possible indicators & methodological options

The starting point for the development of a methodology for the quantification of non-energy benefits of energy efficiency measures in industry should be to enable analysis at enterprise-level direct benefits that:

- Drive a rapid return on investment
- Contribute to cost reduction, value generation and risk mitigation;
- Are relevant to industry and are expected to have a relatively high monetary value;
- Can be clearly linked to implementation of specific projects; and
- For which there is a good availability and accessibility of information and data.

5.1 Steps towards a non-energy benefit assessment

A step-by-step process is needed to begin appraising the potential non-energy benefits of energy efficiency measures, which takes into account different situations in terms of data, expertise and other resources. The process may vary slightly between a company and policy making context.

Company level

i. Develop a structured list of relevant possible non-energy benefits
ii. Assess level of available information and data, and identify new data needs
iii. Choose a methodological framework
iv. Select key benefits (criteria could include relevance to business needs)
v. Establish a system for data collection and reporting before and during intervention (placing priority on ease of reporting, synergies with other types of reporting systems)
vi. Establish counterfactual and develop baseline
vii. Apply usual approach to estimate energy savings as a result of the programme
viii. Undertake cost assessment of the non-energy benefits
ix. Include the results of the assessment for company level progress reporting
x. Explore methods for extrapolating new and improved data on non-energy benefits

Policy maker/programme practitioner level

i. Develop a structured list of relevant possible non-energy benefits
ii. Assess, with industry participants, the feasibility and cost of data collection for these benefits
iii. Choose a methodological framework
iv. Select key benefits (criteria could include stated policy objectives)
v. Develop and communicate a business case for industry reporting on benefits (i.e. provide participants with supporting incentives or argumentation) and provide sufficient security as to confidentiality and competitiveness issues.
vi. Establish a system for data collection and reporting before and during intervention (placing priority on ease of reporting, synergies with other types of reporting systems)
vii. Provide industry programme participants with guidelines/instructions for required data collection and reporting
viii. Establish counterfactual and develop baseline
ix. Apply usual approach to estimate energy savings as a result of the programme
x. Undertake cost assessment of the non-energy benefits
xi. Prepare the results of the assessment for presentation to support the policy decision-making process and further efforts in this area
xii. Explore methods for extrapolating new and improved data on non-energy benefits

5.2 Data collection, indicators and monetisation

A key step is to identify and collect baseline data from the time of the project's conception. For some types of non-energy benefits, information may be already available within the company. It is important to investigate what data is being collected that could be of use and develop a system for collecting multiple benefits data by the team/person tasked with energy efficiency. Strategies should then be developed to obtain accurate data to plug any gaps in existing data.

It is vital to nominate indicators and metrics at the project and/or policy design stage so that baseline measurements can be used for comparison, reporting and evaluation (Crittenden, 2013). Existing studies have tested a range of metrics for different non-energy benefits. For example, metrics can be assigned to non-energy benefits by calculating the impact of a specific energy efficiency measure, or by calculating benefits using organisation-wide budget data (Woodroof et al., 2012). Experience suggests that it may be preferable to collect actual savings data, where possible, and that cost estimates can and should be adjusted to reflect individual projects and situations.

Going forward, it would be beneficial to establish consistent approaches in order to simplify and expand experience sharing in this process. Please refer to the **table in Annex 1** in which the IEA proposes a non-comprehensive overview of types of benefits that can be generated through energy efficiency projects and the possible metrics that could be used to quantify them.

5.3 A framework for impact estimation and analysis

Because so few studies focused on non-energy benefits have been carried out in the industry sector to date, methodologies for quantifying non-energy benefits in industry are still in development stages. Learning from the studies have taken on this challenge, some direction is available, providing a good starting point for assessing the suitability of various possible approaches for quantification of non-energy benefits in industry.

In general terms, once the desired metrics have been gathered, the chosen methodology should enable calculation of annual impacts on the selected indicators from the particular energy efficiency project in question, as compared to a baseline. These impacts (hopefully savings) should then be compared to the investment costs of the project so that the benefit-cost ratio and payback period can be determined. The results gathered regarding non-energy impacts can (then be translated to annual cost savings) and be compared against direct the energy savings generated from the same project, and finally included in the overall impact assessment of the project. It is of course necessary to develop a counterfactual (a clear scenario analysing the outcome if no action is taken) at policy inception to enable a comparison between the status quo and the proposed energy efficiency investment(s). An evaluation of an energy saving measure applied to fluorescent lighting in an industrial context (Woodroof et al., 2012) used this approach to calculate that an additional benefit equivalent to a further 31% in addition to the direct energy savings was generated in non-energy savings[1].

The value of indirect outcomes can be difficult to quantify. Impacts such as avoided environmental degradation present particular problems in both in establishing a clear causal link and in identifying metrics that can be used to accurately quantify the impact. Ideally, an appropriate analytical process

[1] The non-energy benefit indicators calculated in that study were: reduced maintenance material; reduced maintenance labour; avoided purchase of offsets and reduced sales taxes and environmental penalties.

for quantifying these impacts will build on existing accepted analytical processes and use existing data or values from similar interventions.

In many cases, however, process-unique variables and local conditions will require a unique analytical framework and tailored research to assess specific non-energy outcomes. Using external expertise in this process creates a necessary independence from internal project drivers and interests and offers evaluation skills that may not be available in house. It is useful to recognise that the existing base of accepted practices was developed from an historical base of experimental research so it is appropriate to continue to expand that established base with new and credible assessments, testing results by peer review and publishing to expand the accepted knowledge base, this publication is part of that ongoing process.

Can we develop an inventory of accepted analytical processes and data from existing projects that can be used as an agreed resource for assessing costs and benefits of indirect outcome?

Company investment decision-making is generally facilitated by capital budgeting tools to assess the profitability of the investment. Provided non-energy benefits can be quantified, there should be no methodological barriers for incorporating them into these kinds of financial assessments. Methods described in the literature include:

- Conventional modelling of payback calculations/ Lifecycle cost assessment (LCCA)
- Benefit to cost ratios/ Cost-benefit analysis (CBA)
- Net present value (NPV)
- Internal rate of return (IRR)
- Total resource cost (TRC)
- Conservation supply curves (CSC) / Cost of conserved energy (CCE)

Which of these approaches are most promising for assessing costs and benefits of non-energy benefits and why, in what circumstances?

Lifecycle Cost Assessment (LCCA)
LCCA can be used to compare the costs and benefits of existing equipment against the costs over the same time period of an energy efficiency measure. Life-cycle costs are the sum of present values of investment costs, capital costs, installation costs, energy costs, operating costs, maintenance costs, and disposal costs over the life-time of the project, product, or measure as well as the present values of identifiable outcome benefits from each of these outcome categories.

There are options available where relevant data is not already being collected. An example is the use of a **willingness to pay** approach, i.e., assessing the maximum amount a business would be willing to pay, sacrifice or exchange in order to receive a good or to avoid something undesired, such as environmental pollution. This approach then estimates the minimum amount an individual or company would need to receive in order to give up a good or to accept something undesirable. There are a range of methods to estimate this including take-it-or-leave it offers, Vickrey auctions, nth-price auctions and stated preference methods such as contingent valuation and conjoint analysis.

Quantifying effects by conservation supply curves (CSC)
Calculating benefits from a specific measure i.e., a “bottom-up” approach of constructing a CSC for a specific project, is an established method for determining the benefits of energy efficiency measures (Hasanbeigi et al., 2010). Energy savings are routinely used in CSCs but it is less common to incorporate non-energy savings into CSCs.

As non-energy savings are better understood and measured, CSCs present another structure for evaluating the comprehensive economic effects of energy efficiency measures. Use of bottom-up energy CSC and calculated costs of conserved energy (CCE) to estimate the impact of non-energy savings for energy efficiency measures have shown interesting results. Using these methods, a decrease in payback period from 4.2 to 1.9 years was estimated when non-energy benefits were included (Lung et al, 2005). The net financial savings from the studied energy efficiency measures varied greatly and ranged from 0.03 to 70% of the total savings upon the inclusion of non-energy savings (Worrel et al. 2003). Other studies have evaluated the effect of non-energy savings by calculating payback periods for 2 scenarios, one incorporating non-energy savings and one with energy savings only. By including non-energy savings into the CSC, the payback period was reduced by 69% from 1.43 years to 0.99 (Lung et al., 2005).

Including non-energy benefits in models

Initial research indicates that the Industrial Sector Technology Use Model (ISTUM) model could be a promising method because its framework allows for productivity benefits to be to be incorporated into cost calculations (Worrell et al, 2003). The ISTUM approach is to specify particular end-use energy services (e.g., bleaching in the pulp and paper industry) and to compare technologies providing similar services and outputs in order to predict minimum, direct, lifecycle costs. The model's fundamental decision criterion, minimum lifecycle costs, is used to assess market penetration levels of each competing energy service technology. This is then used to project total energy demand, fuel mix, and energy-related investment for each industry and for the overall industrial sector.

Are you aware of competent analytical models that enable analysis of the wider outcomes from changes in energy processes and energy management in businesses?

Table 3: Examples of methods used for assigning indicators and methods

	Project Summary	Methods used	Savings impact
Worrell (2003)	Over 70 industry case studies were analysed in order to incorporate energy and non-energy saving from energy efficiency measures into energy modelling.	The adopted method included the following: 1. Identify and describe the productivity benefits associated with a given measure 2. Quantify these impacts as much as possible. 3. Identify all the assumptions need to translate the benefits into cost impacts. 4. Calculate cost impacts of productivity benefits	After the cost evaluation of productivity benefits, the cost benefits were incorporated into conservation supply curves (CSC).
Lilly and Pearson (1999)	Five case studies were evaluated for the impact of energy efficiency measures. The projects were funded by the Bonneville Power Administration and Seattle City Light.	The methodology that was used to determine the energy and demand savings: 1. Meeting with energy management analysts, plant management, production and maintenance to discuss and determine an approach plan including discussing availability of data. 2. A evaluation plan was used to outline the electrical metering plan, production and non-energy data acquisition, non-energy benefits assessment. 3. Developing energy savings regression models that were compatible with the collected data.	Energy savings regression models were developed and used. In the five sites studied, there was an estimated 24% of customer economic benefit from non energy impacts.
Hall and Roth (2003)	Studies with 210 participants were undertaken to determine the comprehensive benefits of energy efficiency measures. The participants were customers in Wisconsin's Focus on Energy program.	The strategy used to assess the full benefits of energy efficiency methods used an "interview" method. The interviews were conducted with personal involved in the evaluation, management and implementation of the energy efficiency measures. Through the interview process. Non-energy benefit indicators and metrics were identified **and ranked** in importance.	Benefit to case ratios were used to estimate the savings of each energy efficiency measure.

6. Issues to consider

There are a number of challenges in quantifying non energy benefits – establishing causality, inter-linkages or overlaps between benefits, understanding direct and indirect benefits, changes in the value of non-energy benefits over time.

Which of the issues below are most important to address in developing guidance on non-energy benefits in industry? What reactions or solutions might be proposed?

6.1 Dealing with causality and un-bundling variables

Creating a clear causal link between an energy efficiency measure and a specific set of outcomes is essential since in many cases there may be a number of variables (not just the energy efficiency measure) that influence a specific outcome. A good example is the use of external environmental indices such as heating-degree days to normalise space heating performance variability. While this is applicable to residential space heating performance, it is not usually a causal variable in commercial or industrial applications where internal processes are the dominant variable in space heating system performance.

An energy efficiency measure that improves the ventilation system and reduces dust levels can be expected to have a positive effect on employee respiratory health. However, there are a number of exogenous factors that can positively influence respiratory health. Crediting the energy efficiency measure with all the cost savings from reduced medical expenses may lead to overestimating such non-energy benefits. Initially, it may make sense to focus on non-energy benefits where it is comparably easy to establish a link. Causality tests may be helpful but more thinking will be needed to decide what tests are appropriate in what circumstances.

6.2 Setting boundaries

Upon starting to measure and track non-energy benefits, another challenge is deciding what to include and what not to include. For instance, should only benefits that are achieved as a direct result of implementing energy efficiency measures or also include benefits achieved through other improvements made at the same time as energy efficiency measures – e.g. improving insulation and at the same time removing asbestos?

6.3 Transferability of experience

Non-energy benefits are not necessarily achieved consistently in all contexts. Due to the influence of a number of variables, the same benefits may not be relevant each time a similar energy efficiency project is implemented. This poses a challenge for developing factors on the basis of project implementation that could be used by other companies to estimate potential savings/gains from non-energy benefits from a certain type of energy efficiency project (Lung et al., 2005).

6.4 Tracking benefits over time - long-term vs. short term cost savings

Another challenge is to take into consideration is any changes in the value of savings (or avoided costs) over time and the question of how to determine appropriate timeframes. For instance, it can be expected that cost savings from reduced maintenance costs will decrease as the equipment or system ages. Similarly, if the value of product outputs increases then the value of production-related benefits could increase over time. In some cases, some costs could increase initially e.g. maintenance costs upon installing new equipment, while in a longer-term perspective those maintenance costs could decrease. Thus, a longer timeframe may be needed, in order to capture the long-term benefits of an energy efficiency measure.

6.5 Privacy or liability issues

There may be restrictions in terms of access of data needed to quantify certain non-energy benefits e.g. benefits related to employee health and productivity. This may simply influence the choice of benefits to be measured, but perhaps there are ways that this can be overcome.

6.6 Qualitative or intangible benefits

Qualitative benefits or intangible benefits are, in some instances, regarded as highly relevant by stakeholders. Qualitative benefits could include matters such as enhanced company reputation, improved customer loyalty, or improved branding. Intangible or more difficult to quantify benefits could include avoided risk. While challenging, there are approaches that could be used to try to quantify or at least further explore such benefits. Approaches could include surveys in customer perceptions or the development of scenarios to show counterfactual situation and assess the likeliness of such scenarios e.g. the event of different types of risks and the costs for the company (or in a wider context) of such risks taking place.

6.7 Subjectivity

For more intangible benefits e.g. better worker morale or better working environment where direct quantification is not possible, there is a risk that different stakeholders would assign different values (Lung et al., 2005) and would thereby distort evaluation results.

6.8 Negative impacts from energy efficiency

In order to accurately quantify the effects of energy efficiency measures, the negative impacts should also be represented in benefit-cost assessments. Negative productivity aspects could include, for example, decreases in productivity due to down time and personnel training for equipment upgrades. Quantifying negative productivity aspects involves similar challenges as quantifying non-energy benefits, but it will be essential to take these into account in order to ensure the robustness of any assessment.

6.9 Industrial non-energy benefits in a wider perspective

Energy is increasingly required to add value to labour and capital in modern manufacturing processes and service sectors. Energy efficiency therefore has a role to play in stimulating growth, with the potential to impact economic development and welfare. It would be valuable to go beyond operational cost reductions to better understand the degree to which energy efficiency drives the broader strategic capability of businesses in the industrial sector. For example, to identify the impacts on competitive advantage; developing market share; improved international and regional competitiveness; lower cost of capital; improved labour productivity and performance (refer Table 2 above). Energy models help to explain complex technical systems that drive the derived demand for energy and can be used to develop energy efficiency policy by assessing a measure's impact on variables such as energy consumption and economic welfare. Options could be explored for extending these models to better capture the impact on productivity, competitiveness and other factors which have significant implications for the broader economy.

7. Next steps for this area of evaluation

(1) Creation of well-defined valuation approach for measuring non-energy benefits generated through the implementation of energy efficiency projects in industry

- Is it realistic to establish a common approach?
- What organisations should/could be involved in the creation of such an approach?

(2) Further research

- Carry out a retrospective analysis of past policy actions seeking to identify any non-energy benefits missed out of standard cost assessments, and attempt to quantify these.
- Implement a targeted collection of non-energy data through industry surveys, investigations of implemented energy savings projects, and in-depth interviews, possibly in connection to programme evaluations.

(3) Develop an international database on industrial non-energy benefits

- What data would be included in such a database?
- How could differences in methodology be dealt with?
- Are there data confidentiality issues that would need to be considered?

(4) Sharing experiences from integrating non-energy benefits in policies/programmes

- What is the best platform for doing so?

(5) Integrating non-energy benefits into the policy decision-making process

- What stakeholders should be involved?
- What information would be required by policy makers, treasuries and others implicated in the policy process?
- How should the message of non-energy benefits in industry be packaged for policy makers?
- How should the message of non-energy benefits in industry be packaged for industry stakeholders in order to engage them in the necessary data collection and measurement efforts?

Annex 1: Industrial non-energy benefit table

The relevance and expected magnitude of values is expected to vary significantly between different types of projects, industrial sectors and countries. The tentative rating (<= high; /=Medium; >=Low) aims to provide a basis for discussions around priority setting. (While the some of the individual benefits may be low-rated for policy makers, cumulatively, being able to assign additional monetary value to industrial energy efficiency projects is of high relevance.

Type of non-energy benefit	Metrics	Type of saving – income – productivity benefit	Relevant to industry	Relevant to policy makers	Expected magnitude of value	Easy to get data – relate to measure	Easy to monetise
Production benefits							
Reduced waste (ash) from fuel combustion	tons/year	Reduced waste collection costs; reduced cost for delivery to landfill (transport fuel, labour cost)	>	>	>	/	/
Reduced water consumption e.g. for cooling, due to process/ operational change	m3/year	Reduced payments for water, reduced payments for waste-water	/	>	>	>	>
Reduced product waste through process/operational change	m3/year	Waste collection costs; cost avoidance for delivery to landfill; additional income from reworked scraps	/	<	>	/	>
Materials reduction	tons/year	Reduced cost of materials; cost of transport, packaging, storage, better utilisation of space for other activities	<	>	<	>	/
Improved production capacity utilisation	hours of operation/year	Reduction of down time, reduction of time needed to restart operations	<	>	/		>
Increased product output/yields	tons/year	Additional revenue	<	>	/	/	/
Reductions in labour requirements	man-hours/year	Reduced labour costs	/	>	>	>	/
Improved product quality	qualitative Purity %	Additional revenue; improved competitive edge	<	>	/	>	/
Operation and maintenance							
Improved equipment performance	hrs of operation/year Throughput	Reduced maintenance costs; reduced wasted labour costs (e.g. reduced down-time)	/	>	<	<	/
Increased reliability in production	hrs downtime/ number of prod. stops	Reduction of lost/wasted labour costs; reduction of maintenance costs; lower material/water losses; reduction of cleaning costs	<	>	<	/ or <	/

Shorter process times	hr/per process Throughput	Increased production output; improved labour productivity	<	>	<	/ or <	/
Deferring need for additional equipment		Avoided capital costs	<	>	<	<	/
Reduced ancillary operations	hrs, labour, energy	Reduced labour costs; reduced indirect energy costs	/	>	>	/	>
Improved equipment lifetime	operation time	Deferred cost of replacement; reduced maintenance costs	/	>	/	/ or <	>
Environmental							
Reduced hazardous waste	tons/year	Waste collection and treatment costs Delivery (transport fuel, labour cost)	<	<	>	>	<
Dust	tons/year	Reduced compliance costs, employee heath benefits	>	<	>	/	>
CO, CO2, NOx, SOx	tons/year	Reduced compliance costs, lower environmental taxes, societal-environmental benefits, income via emissions trading schemes if applicable; avoidance of payment of fines if applicable	<	<	>	/	/
Work environment							
Reduced noise levels	dB	Reduced medical expenses, improved worker well-being	>	>	>	/	>
Improved lighting	lumens/m2, quality	Improved labour productivity; product quality	/	>	>	/	>
Improved indoor temperature control	Degrees, stability, comfort level	Improved worker productivity	>	>	>	/	>
Improved safety	number of accidents/year	Reduced lost labour, medical coverage, insurance costs, re-training costs	<	<	/	>	/
Other							
Decreased liability/risks	Risk probability	Reduced insurance premium costs	<	<	<	>	>
Possibilities for re-investment of savings from lower energy bills	monetary value	New income streams; increased production capacity etc.	<	<	/	/	>
Achieved rebates/incentives	monetary value	Additional income	<	<	> or /	<	<
Compliance with regulation	yes/no	Cost savings from not having to pay fines	<	<	> or /	<	<

Do you agree with the assessments made in the above table? Please provide any commentary, alternative suggestions and prioritise indicators

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