A comparison of impact evaluations ideally to be used for energy efficiency measures and evaluations used in practice: how can we close the gap?

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ABSTRACT

A growing number of energy efficiency (EE) targets at national and European levels make ex-post and ex-ante evaluations of new and existing EE policies more and more important. Especially for existing measures, a mix of ex-post evaluations (to determine the actual impact occurred so far) and the expected impacts based on the so far observed impacts (for example up to 2020) are required. National Energy Efficiency Action Plans (NEEAPs) have provided a major drive to the evaluation of energy saving measures. We base our analysis of methods to evaluate energy savings on the MURE database, which contains a structured overview of EE policies in European countries. By comparing impact evaluations actually used with those suggested as best practice, we investigate in this paper progress made with impact evaluation across European countries, which type of impact evaluations are used and which barriers to impact evaluation continue to exist. We discuss practical approaches to enhance EE evaluation by including multiple benefits into EE measures. The MURE database has set up two facilities (impact evaluation facility and multiple benefits facility), which shall support policy makers with easily accessible information on impact evaluation including multiple benefits. In such a manner, good evaluation practices will be spread out further.

Introduction

Background

A growing number of energy efficiency (EE) targets at national and European (EU) levels make ex-ante evaluations of new and the ex-post evaluation of existing EE policies more and more important. The 20% energy efficiency target of the EU for 2020 and the related National Energy Efficiency Action Plans (NEEAPs) provided a major drive to the evaluation of energy saving measures. Under the Energy and Climate Governance of the EU (European Commission 2016) and in view of the 2030 target frame[1]

[1] At present, a 27% and more recently, a 30% efficiency target have been proposed for 2030. A recent so-called "non-paper" by the European Commission (2018) indicates that due to the lower cost of renewables their target could be increased from presently 27% to 35%. The impacts for the energy efficiency target are unclear but the European Parliament urges to raise the target for EE to 40% by 2030.

new integrated reporting schemes are proposed. According to the proposed new rules, EU countries will be required to develop Integrated National Energy and Climate Plans that cover the five dimensions of the Energy Union for the period 2021 to 2030 (and every subsequent ten year period) based on a common template (energy efficiency being one of the five dimensions). They shall further report on the progress in implementing the Integrated National Energy and Climate Plans, mostly on a biennial basis.

The Commission will monitor the progress of the EU as a whole, notably as part of the annual State of the Energy Union report. In that frame, there will be strong incentives to improve on systematic and broad-based monitoring and impact evaluation procedures. In addition, the Paris Process for Climate Change (UNFCCC 2018) requires regular checking of progress. Energy Efficiency - seen as the first contributor to mitigate climate change - will contribute substantially to this progress and requires reliable evaluation of this progress.

In fact, when we use the wording "measure evaluation" in this paper, it has two components, when we talk about existing energy efficiency measures:

- *an ex-post component*, i.e. the impacts of the measures are evaluated up to a certain point in time in the past. These are the impacts that have actually been observed until a recent moment in time. For example, a thermal building regulation introduced by 2010 would have achieved a certain impact by 2017, which could be determined based on the actual buildings built, their savings against an appropriate baseline, and knowledge on the compliance with building regulation.
- *an ex-ante component,* i.e. the expected impacts of the already implemented measure, if its action would continue smoothly to the future, according to the current measure specifications, for example up to 2020. For the before mentioned thermal building regulation the impacts up to 2020 can be estimated based on assumed future construction rates and assumptions concerning the continuation of observed parameters such as non-compliance.

For measures, which did not yet have impacts in the past, there are only ex-ante estimates of the impacts. These ex-ante estimates are typically less precise than for the ex-ante component of exisiting measures, which is already based on the actual observation of measure impacts from the ex-post component. We base this paper on the analysis of existing measures, hence on the mixed ex-post / ex-ante approach mentioned above.

Scope of the analysis

We base our analysis of the mixed ex-post / ex-ante energy savings on the MURE database (see references), which contains a structured overview of 2500 EE policies in 31 European countries. Around 40% of these policies (in terms of number of policies) contain quantitative energy saving impacts based on detailed evaluations at national level (i.e. the impacts are typically determined for a point in time in the past and extended until 2020). Additionally, information is provided on the evaluation method actually used (which is frequently determined by data or cost limitations) as well as on the most appropriate method ideally to be used if no such limitations existed. The MURE database refers to a classification of impact evaluation methodologies, which was previously developed in the frame of the European EMEEES project (see references). Based on this rich database, the paper investigates the following issues:

- Have evaluation practices made progress since the first introduction of the National Energy Efficiency Action Plans NEEAPs in 2007?

- How are actual evaluation methods of EE policies distributed by sector (private households, transport, industry, services, cross-cutting) and how does this compare to the "ideal" evaluation method for this type of policy?
- Which are major data gaps and barriers, which prevent the most suitable evaluation methods to be used in practice in the European countries? Are data collection cost an important barrier?
- Which recommendations can be derived for evaluators and policy makers to enhance the use of the most appropriate evaluation method?
- How can data tools, as provided by the MURE database, be used to enhance the use of most suitable ex-ante evaluation practices?

We also go beyond pure energy savings and discuss how existing information on quantitative energy saving impacts can enhance evaluations to derive quantitative information on so-called "multiple benefits" of EE. These include further benefits of energy efficiency measures as e.g. GHG savings, positive economic impacts on growth, employment, innovation or competitiveness as well as social benefits on health or poverty alleviation. In our paper, we develop a set of quantitative indicators to quantify these benefits mainly based on the energy savings directly derived from the MURE database.

Methodology

The MURE database on energy efficiency policies and measures in Europe

We base our analysis on the MURE[2] database on EE policies and measures (www.odyssee-mure.eu), which contains a structured overview of around 2500 EE policies in 31 European countries (the EU28, Norway, Switzerland and Serbia). National Teams, cooperating in the Horizon 2020 project ODYSSEE-MURE, collect the measures and classify them by different descriptors, which can be used to retrieve EE measures according to certain criteria (see Table 1). Measures are presented in the four final energy sectors (households, tertiary, industry, services) and cross-cutting measures.

Table 1. Overview of descriptors

Descriptors in the MURE database common to all sectors	**Sector-specific descriptors**
- Country - Measure linked to any of the 4 National Energy Efficiency Action Plans (NEEAP) - Measure proposed under the so-called Article 7 of the Energy Efficiency Directive EED in fulfillment of the 1.5% annual savings target of the EU - Availability of a quantitative impact evaluation in terms of energy/CO_2 savings - In the absence of a quantitative impact evaluation a semi-quantitative expert estimate of the impacts (in three categories low, medium and high impact) - EU-related measure - Measure status (completed, ongoing or proposed) - Starting/end year of the measure - Detailed measure description	Characterization of the measure by sector-specific descriptors: - sector (households, tertiary. industry, services, cross-cutting) - measure type - actors - target audience - targeted end-use - evaluation method used in the impact evaluation

[2] MURE stands for "**M**esures d'**U**tilisation **R**ationelle de l'**É**nergie (measures for the rational use of energy)

An important activity in the MURE database is the collection of quantitative impact estimates in terms of energy or CO_2 savings for a given year in the past (observed ex-post savings) and the future (expected ex-ante savings). Future savings are typically estimated for 2020 (the target year for the 20% saving target of the EU). The source of such information are either the different NEEAPs or detailed national evaluation studies or both (as the NEEAP information is typically based on detailed national evaluation studies). The information on impact evaluations is verified by the National Teams which are typically energy efficiency agencies or expert institutes in the evaluation of energy efficiency measures.

The MURE classification for the evaluation of energy efficiency policies and measures in Europe

The MURE database refers to a classification of impact evaluation methodologies, previously developed in the frame of the European EMEEES project (see references). The EMEEES project discussed systematically the characterization of impact evaluation methods for energy efficiency measures. In particular, the EMEEES Report on Work Package 3 discussed the distinction between the primary data underlying impact evaluations and the methodologies of averaging and sample extrapolation. It further made a distinction between the methodology aiming at establishing the unitary consumption/savings and the number of units for the purpose of impact evaluation. This would lead in practice to a large classification matrix with three dimensions (type of primary data, type of averaging and extrapolation methods to determine secondary data, and calculation methodology). In order to make this manageable a reduced classification set for impact evaluations was developed (see the following overview). The measures can be grouped into **Bottom-up (BU) evaluations** (making use of measure specific data), **Top-down evaluations (TD)** (making use of statistical data) and Integrated BU/TD methods. The EMEEES report discusses that the distinction between BU and TD may be context specific.

Table 2. A practical classification of measure evaluation methodologies

Bottom-up methods → with monitoring of the number of units/participants					←		**Top-Down methods**		**Integrated Bottom-Up and Top-Down methods**
direct measure-ment	billing analysis	enhanced engineering estimates	mixed deemed and ex-post estimate	deemed estimate	BU 6 / TD 1 stock modelling based on stock and market statistics	BU 7 / TD 2 monitoring of diffusion indicators of specific equipment or practice	TD 3 monitoring of specific consumption indicators for whole sectors / end uses	TD 4 econometric modelling (e.g., I/O analysis with price elasticities)	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Source: EMEEES

There are **five clear bottom-up methods** with a monitoring of the number of units/participants (cf. Annex 3 of EMEEES WP3 Report). These methods emphasize the data aspect of the evaluation methodology concentrating on methodologies how to establish the unitary gross annual energy savings for the end-use actions[3] but without an explicit distinction between primary data and methodologies of averaging and sample extrapolation.

1. **Direct measurement** of unitary energy savings (here, the unit usually is a participant).
2. Unitary energy savings are established on the basis of **billing analysis** (unit = participant).
3. **Detailed engineering estimates,** e.g., through calibrated simulation. This implies some more or less complex modelling of the individual unit (e.g. by calculating an energy balance of an

3 The number of units is often simply obtained by participant counting.

individual building or an individual company in the dataset) (hence, the unit is normally a participant).

4. **Mixed deemed and ex-post estimate,** e.g. unitary energy savings are based on equipment sales data, inspection of samples, monitoring of equipment purchased by participants. The unit usually is a piece of equipment, but could be a participant if the end-use actions taken are rather uniform.
5. **Deemed estimate** of unitary energy savings (the unit usually is a piece of equipment, but could sometimes be a participant if the end-use actions taken were rather uniform)

The following two evaluation methods emphasize rather the calculation methodology. It is difficult to allocate them clearly to either bottom-up or top-down. This depends much on the context of the EE measure to be evaluated.

6. **Stock modelling** based on stock and market statistics, and surveys monitoring diffusion / uptake of energy-efficient solutions. This method will be a bottom-up method, if the surveys enable to identify, which end-use actions have been taken that change the energy consumption of the stock, and whether these end-use action were facilitated by EE measures, and by which measures. Otherwise, this will be a top-down method.
7. Indicators of the share of specific equipment or practice in the market (**diffusion indicators**). Monitoring of these indicators will be a bottom-up method, if the change in indicator is entirely due to EE measures (as is, e.g., the case for the installation of solar water heaters in many EU Member States). If this is not the case, and a regression analysis has to be performed to identify the energy savings due to EE measures, this method will be a top-down method.

Two evaluation methods are clearly top-down methods, the first concentrating on indicators, the second on more complex modelling in order to determine the impacts of cross-cutting measures.

8. **Monitoring of energy consumption indicators** (either unit energy consumption for whole sectors or sub-sectors, or specific energy consumption indicators for specific end use equipment.
9. **Econometric modelling** (e.g., I/O analysis with price elasticities)

Finally, there are complex combinations of top-down and bottom-up methodologies in the form of **integrated top-down and bottom-up methods (method 10)**.

MURE has implemented the classification scheme for the measures in the database for which a quantification of impacts exists and enough information is available on details of the evaluation methods.

In parallel with the ACTUAL evaluation method used for the impact evaluations of EE measures which is frequently determined by data or cost limitations), we also attached to each measure type in the MURE classification of measure types an evaluation method ideally to be used (see Annex 1 for the household sector and the MURE website for other sectors). For example for Energy Performance Standards most recommended are stock modelling, specific consumption indicators and billing analysis (or a combination of those evaluation methods). The baseline would be the previous thermal building standard, and the billing analysis would for example help to provide information on the actual behaviour of the users of the building.

Results

Progress of impact evaluation efforts across National Energy Efficiency Action Plans NEEAPS

Figure 1 shows the number of EE measures in the MURE database and how many of them are linked to the different NEEAPs in the different sectors.

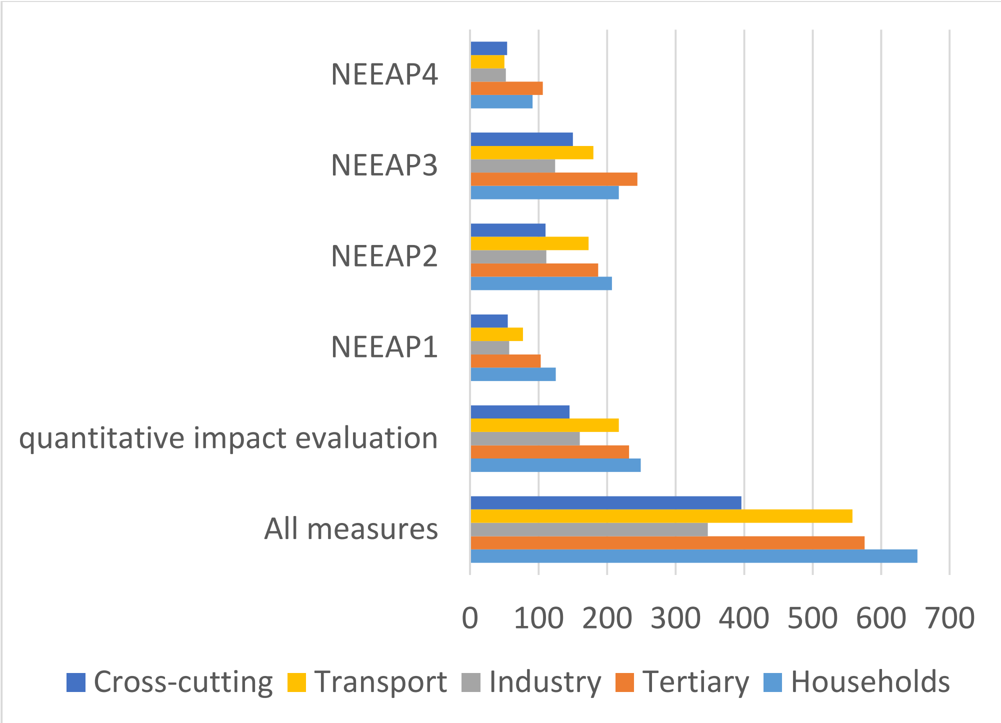


Figure 1. Number of measures in the MURE database on EE measures and link to NEEAPs

The four NEEAPs represent a substantial part of the EE measures introduced by the countries in the different sectors. It should be noted that there are overlaps among the different NEEAPs as quite a number of measures have been carried on through the four NEEAPs which have been established in regular intervals of about three years since 2007. The NEEAP4 have been published in 2017. There is a progress over time with measure coverage up to the NEEAP3. In the NEEAP4 less measures have been presented by the different countries. This is certainly due to, on one hand, a certain consolidation and focus on the most important measures over time in the NEEAP4 but also due to the fact that the NEEAP4 present the transition to the forthcoming National Energy and Climate Plans NECPs which shall streamline the reporting for the transformation of the energy system in Europe and combine reporting on energy efficiency, renewables and climate protection measures. Partly, this may also be the result of the fact that some countries limited reporting to new and revised measures only.

For example, the households sector is covered by around 650 measures in the MURE database, while the NEEAP3 contain nearly 220 measures, the NEEAP4 contain around 100 measures. Least covered is the industry sector with only about 350 measures in MURE in total, around 125 measures in the NEEP3, and about 50 measures in the NEEAP4.

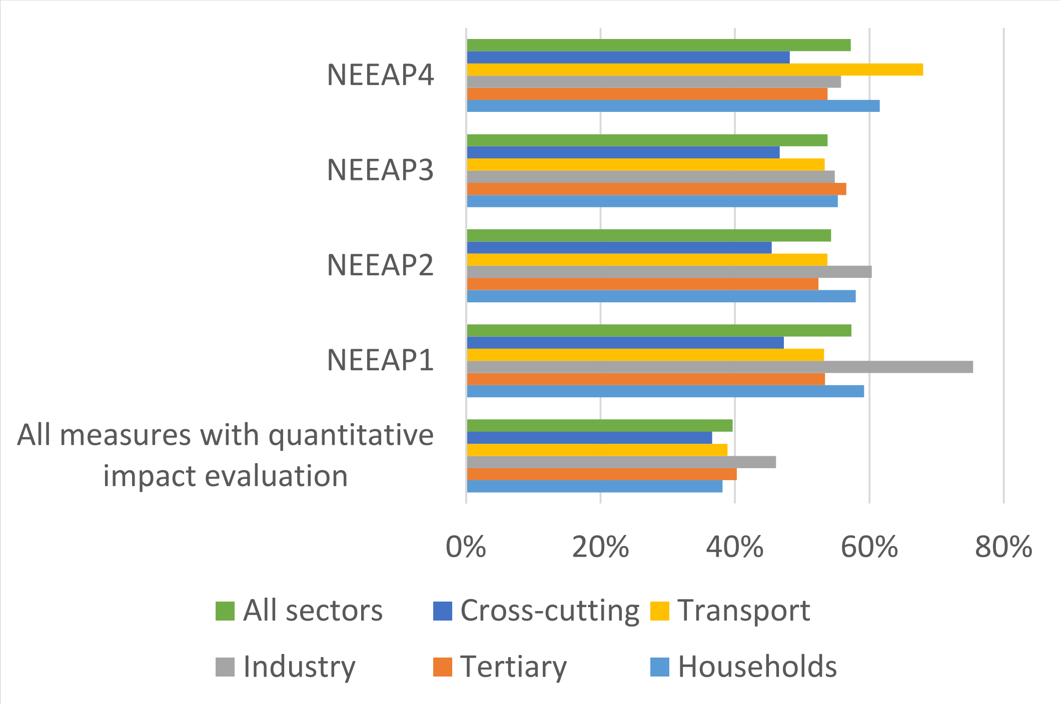
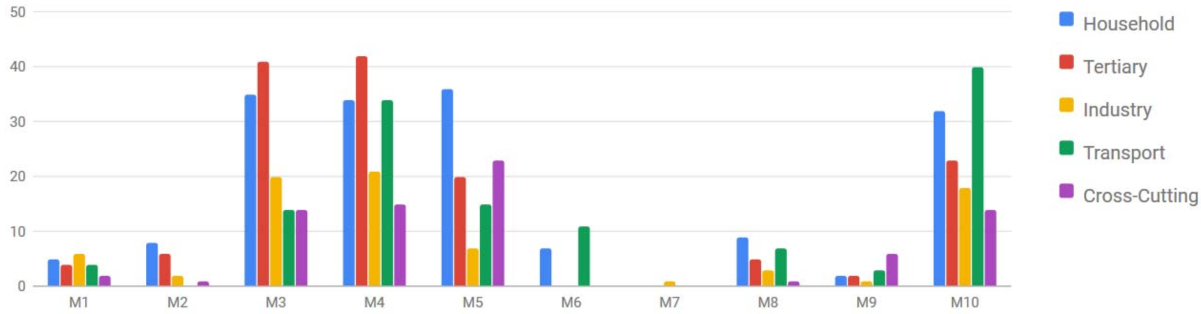


Figure 2. Percentage of measures in the MURE database with quantitative impact evaluations

Barriers which prevent the introduction of the most suitable evaluation methods

Around 40% of the measures in MURE (in terms of number) contain quantitative energy saving impacts until 2020 (see Figure 2). For NEEAP measures, however, the average percentage of impact evaluations is around 55%. This shows the considerable push which the Energy Service Directive from 2007 has provided for impact evaluation (though it may have had less impact in providing ambitious energy efficiency targets). There are still large differences among countries: for example, Poland only has 23% of all measures being evaluated in quantitative terms, though also there, on average the NEEAP process has pushed the measures with quantitative evaluation to a level of 40%.

Figure 3 shows how the impact evaluations distribute on the classification defined in the methodology section. Annex 1 shows more details for the residential sector, how the actual evaluation methods compare with most appropriate ones (according to a characterization by the authors).



Legend:	
M1=Direct measurement M2=Billing analysis M3=Enhanced engineering estimates M4=Mixed deemed and ex-post estimate M5=Deemed estimate unit savings	M6=Stock modelling M7=Diffusion indicators M8=Specific consumption indicators M9=Econometric modelling M10=Integrated BU/TD methods

Figure 3. Number of measures per type of evaluation method in European Countries (EU28, Norway, Switzerland, Serbia). *Source:* Impact Evaluation Facility of the MURE database on Energy Efficiency Measures

The evaluations methods most used are M3 (Enhanced engineering estimates), M4 (Mixed deemed and ex-post estimate), M5 (Deemed estimate unit savings) as well as M10 (Integrated BU/TD methods). These are also indeed, partly, recommended methods, when it comes to the evaluation methods for the residential sector measures (see Annex). However, for example in the case of building regulation or appliance standards, some form of stock model, based on detailed data analysis is required, especially also to derive ex-ante impacts from ongoing measures. This is, however, more rarely used as evidenced from Figure 3 and Annex 1. Specific consumption indicators (M8) and even more stock modelling (M6) suffer apparently from a lack of detailed statistical data.

Much more rare are direct measurement of billing analysis (M1 or M2); hence, the cost of this type of evaluation method seems still a major barrier to its use. For example, in the case of the residential sector the annex suggests to use such type of evaluation methods in the case of legislative-informative measures (in particular energy labels) to control the supposed impacts of the labels. Or it is suggested to use direct measurements to control non-compliance with building regulation. However, according to Annex 1 there are few measures evaluated in such a manner in the residential sector.

Econometric modelling (M9), which is particularly relevant as an evaluation method for cross-cutting measures such as energy or CO_2 taxation, may be hampered by the complexity of the analysis and the large number of factors relevant for the evaluation. Such evaluation methods must still benefit from more implementation in practice and methodological progress. This requires more in-depth inquiries based on sufficiently large samples.

Diffusion indicators are virtually absent though they exist for some products such as the penetration of efficient appliances, heating devices or housing. However, quite some of the data relevant for these indicators are established on a commercial basis and not readily available for public bodies, though in practice, purchasing such data from private entities could be cheaper that establishing own statistics. Bundling the evaluation costs could be a way forward in Europe to improve the situation.

Multiple benefits of energy and CO_2 savings

Energy Efficiency (EE) measures are frequently economic on their own, however, partly with long payback periods. Next to energy savings themselves, and the money saved, other benefits might be important in the formulation of savings policy: new employment, reduced import dependence, less health problems, etc. The EC and national governments are increasingly taking multiple benefits in EU policy on EE into consideration (COM (2014) 520). In addition, national governments are already looking into multiple benefits, such as the employment effects in the recent National Energy Outlook NEO for the Netherlands or in the Monitoring Report of the German "Energiewende" (transformation of the energy system). We use the word "multiple benefits" to characterise those additional impacts. However, various terms have been developed and used to describe the concept over the years: co-benefits, ancillary benefits, non-energy benefits (NEBs), multiple benefits (MBs) or impacts.

So far, multiple benefits have rarely been established in impact evaluations of energy efficiency measures though they provide major additional arguments for EE. This is mainly due to the complexity of the issue. In recent times, two projects have made progress in making multiple benefit approaches accessible for the policy level.

In previous work we developed a comprehensive indicator set for measuring multiple benefits of energy efficiency (MB-EE) (Reuter et al. 2017). The aim was to complement the harmonised approach to energy efficiency indicators and policies, which is realised through the ODYSSEE-MURE project, with an indicator set measuring MB-EE. The **Odyssee-MURE project** has developed, next to the impact evaluation facility also a multiple benefits (MB) facility which allows the policy makers to access in a concentrated manner the multiple benefits of EE. The basic approach of this facility is to link the multiple benefits to an indicator approach (see Table 3) which can be updated on a regular basis and provide support for the policy level. Most of the indicators are linked to energy savings (either top-down savings, i.e. based on statistical data, or bottom-up savings, i.e. based on the evaluation of specific programmes). The indicators have different quality at present: some are based on country-specific values for the relevant parameters, some draw on default values available for a limited number of countries or from in-depth case studies. With time, more case studies and country specific investigations could inform the indicator set and improve country-specifics. A trial version of the facility is available at (http://bfig1.de/mbee/) and will be fully available to the public by the time of the IEPPEC Conference.

The **COMBI project** (see references) is complementary to ODYSSEE-MURE as it digged further into quantifying the multiple non-energy benefits of energy efficiency in the EU-28 area. It developed modelling approaches and results for each EU Member State and more than 20 types of energy end-use efficiency actions for impacts on: emissions, resources, social welfare, macro economy, and the energy system.

The MB indicator set chosen was departing from IEA (2014) and enhancing the set with additional indicators, e.g. indicators describing innovation and competitiveness in the economy through energy efficiency technologies. An indicator approach to MB-EE has advantages and disadvantages: Advantages are that the benefits can be updated on a regular basis, possibly annually, as they are based essentially on annual energy savings and other yearly parameters. This is important for regular reporting and monitoring procedures, which is increasingly a need at the policy level. Another advantage is that such indicators can be established quite rapidly and do not need continuously running of complex energy system or macro-economic models. Disadvantage is that the precision of such indicators may be limited, given that the methodology is simpler than detailed modelling of impacts. However, with time such indicator sets can be improved, as they can be "gauged" with detailed case studies based on modelling or other methodologies, such as COMBI.

Table 3. Set of indicators for the quantification of multiple benefits of energy efficiency (EE).

Category	Sub-category	Indicator
	Energy and Resource Management	
Environmental	Energy savings	Annual energy savings
Environmental	Saving of fossil fuels	Saving on fossil fuels; extension of range of fossil fuels
Environmental	Impacts on RES targets	Lowering of RES target; replacement of RES capacity; reduced need for interconnectors
	Global and Local Pollutants	
Environmental	GHG savings	Annual CO_2 savings linked to energy savings
Environmental	Local air pollution	Emission factors for avoided local pollutants (incl. electricity)
	Energy poverty	
Social	Alleviation of energy poverty	Impact of savings on energy cost shares in household income
	Living comfort	
Social	Health and well-being	Externalities linked to health impacts
Social	Disposable household income	Shares of energy costs in household income
	Innovation and Competitiveness	
Economic	Innovation impacts	Patent indicators
Economic	Competitiveness	Indicators on foreign trade with EE products
Economic	Turnover of EE goods	Production statistics
	Economy (Macro)	
Economic	Impact on GDP	Impact of energy savings on GDP growth
Economic	Employment effects	Input-Output (I/O) analysis
Economic	Impact on energy prices	Price elasticities
Economic	Public budgets	State income from employment based on energy savings
	Economy (Micro)	
Economic	Industrial productivity	Semi-quantitative classification of impacts
Economic	Asset value	Valuation of buildings and companies for different end-uses according to energy efficiency benefits
	Energy Security and Energy Delivery	
Economic	Energy security (A)	Import dependency (conversion to primary energy necessary)
Economic	Energy security (B)	Impact on supplier diversity (Herfindahl-Hirschman-Index)
Economic	Impact on integration of renewables	Demand-response potentials by country

Source: Reuter et al. 2017

In the indicator approach developed, the MB-EEs were classified into three groups: environmental, economic, and social-related MBs (Table 3). The first group contains most relevant and direct aspects of energy efficiency such as energy savings and reduced GHG emissions. The second group comprises, among others, positive macro-economic impacts on economic growth, for innovation and competitiveness as well as import dependency. The third group of impacts covers aspects such as health benefits, poverty alleviation and employment. A main characteristic of those indicators is that they are - as far as possible - derived from energy savings. Such energy savings can be derived either from a top-down perspective, i.e. related to statistical EE indicators such as those developed under the ODYSSEE-MURE project, or the bottom-up perspective, i.e. related to savings established for individual energy efficiency measures. The main difference is that the first includes also autonomous energy savings while the latter only comprises policy related energy savings.

Conclusions

The present paper discussed the progress made with the evaluation of EE measures. The following main conclusions and recommendations arise:

- The process of introducing National Energy Efficiency Action Plans NEEAPS has spurred major progress in the impact evaluation of EE measures. However, major differences still persist among countries providing scope for harmonisation in the forthcoming process of the National Energy and Climate Plans arising under the EU Governance
- Frequently, already a broad range of evaluation methods have been introduced over the past decades; however some are still largely absent due to (perceived) cost (direct measurements), due to a lack of detailed statistical data (stock modelling), due to private ownership of data (diffusion indicators), or methodological limitations arising from a lack in in-depth inquiries (e.g. in the case of econometric analyses of energy or CO_2 taxation). However, bundling efforts for impact evaluations among member states may help to substantially lower cost, as some of the data are available but from the private sector. However, purchasing such data may still be less costly that developing own statistics.
- Including methodological improvements for monitoring into regulatory requirements for EU Member States may provide additional incentives to Member States to set up appropriate monitoring schemes for EE measures.
- While energy savings frequently are already beneficial for the economy as a whole, Multiple Benefits of Energy Efficiency (MB-EE) enhance the value of energy savings. Today, however, the knowledge on MB-EE is scattered and not easily available for monitoring purposes and to feed policy instruments for energy efficiency. Knowledge made available in new tools and projects, such as the ODYSSEE-MURE facility on multiple benefits, can therefore make such information more easily accessible for the policy level.
- In particular, the economic MB indicators discussed in this paper enhance the quantitative knowledge on the relevance of energy savings for companies and the overall economy. Even in times of booming economies, it is important to be able to argue that EE policies contribute to strengthen the competitiveness of the economy and maintain employment, the more in times when economies are less growing.
- We suggest therefore that policy makers should systematically include such type of MB-EE when presenting the impacts of EE policies. Companies should develop, at the micro-level, similar type of indicators when evaluating EE measures.

Acknowledgements

This paper was developed based on the ODYSSEE-MURE project on energy efficiency indicators and policies (www.odyssee-mure.eu). We acknowledge the support from the European Commission (EASME) under the H2020 programme as well as from national governments for the project.

References

COMBI. Calculating and Operationalising the Multiple Benefits of Energy Efficiency in Europe. Accessed online 10 January 2018 at: https://combi-project.eu/.

EMEEES. *Evaluation and Monitoring for the EU Directive on Energy End-Use Efficiency and Energy Services. Report on measures and appropriate evaluation methods (WP 3)*. Accessed online 10 January 2018 at: http://www.evaluate-energy-savings.eu/emeees/en/home/index.php.

European Commission 2014. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A policy framework for climate and energy in the period from 2020 to 2030*. Accessed online 10 January 2018 at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:-52014DC0015R(01).

European Commission 2017. National Energy Efficiency Action Plans and Annual Reports. Accessed online 10 January 2018 at: https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans.

European Commission 2018. *Non paper on complementary economic modelling.* Accessed online 10 January 2018 at: https://www.euractiv.com/section/energy/news/leaked-eu-analysis-makes-case-for-higher-renewables-energy-saving-goals/.

IEA 2014. *Capturing Multiple Benefits of Energy Efficiency. A Guide to Quantifying the Value Added.* Paris: OECD Publishing. Available online at http://gbv.eblib.com/patron/FullRecord.aspx?p=-1825955.

MURE. Mesures d'Utilisation Rationelle de l'Énergie. Database on European energy efficiency policies and Measures. Accessed online 10 January 2018 at: http://www.odyssee-mure.eu

Reuter, M., C. Müller, B. Schlomann, and W. Eichhammer. *A comprehensive indicator set for measuring multiple benefits of energy efficiency*. European Council For an Energy Efficiency Economy ECEEE, 2017 Summer Study, Paper 8-314-17. Accessed online 10 January 2018 at: https://proceedings.eceee.org/visabstrakt.php?event=7&doc=8-314-17.

UNFCCC 2017. Countries Prepare How to Check Paris Progress in 2018. Rabat Meeting Advances Ideas on Facilitative Dialogue. Accessed online 10 January 2018 at: http://newsroom.unfccc.int/paris-agreement/countries-prepare-how-to-check-paris-progress-in-2018/.

Annex 1: Recommended evaluation methods per measures types compared to the actual distribution of impact evaluations) - Household Sector

The numbers in the columns indicate the number of measures which have been evaluated with this evaluation type (see http://www.measures-odyssee-mure.eu/impact-evaluation-matrix.asp). The stars indicates a characterization by the authors of the methods: *** the method is recommended, ** the method provides reliable results, * it is possible to use the method of others are not available.

***: the method is recommended, **: the method provides reliable results, *: it is possible to use this method if the others are not possible

		Bottom Up										Bottom Up/Top Down				Top Down				Integrated BU/TD	
		Direct measurement		Billing analysis		Enhanced engineering estimates		Mixed deemed and ex-post estimate		Deemed estimate unit savings		Stock modelling		Diffusion indicators		Specific consumption indicators		Econometric modelling		Integrated BU/TD methods	
Legislative/Normative																					
Mandatory Standards for Buildings																					
1	Energy Performance Standards	*	0	***	1	**	4		7		5	***	3	**	0	***	4		0	***	6
2	Minimum thermal insulation standards	*	0		0	**	2		2		0	***	0	**	0	***	1		0		6
Regulation for Heating Systems and hot water systems																					
3	Minimum efficiency standards for boilers	*	0		0		0		1	***	1	***	0		0	***	0		0		2
4	Compulsory replacement of old boilers above a certain age	*	0		0		0		0	***	0	***	0		0	***	0		0		0
5	Thermostatic zone control	**	0		0		0		0	***	0		0	***	0	***	0		0		0
6	Control systems for heating (Regulation)	**	0		0		1		0	***	0		0	***	0	***	0		0		0
7	Mandatory heating pipe insulation	*	0		1		1		0	***	0		0	***	0	***	0		0		2
8	Periodic mandatory inspection of boilers	**	0		1		0		3	***	2		0		0	***	1		0		0
9	Periodic mandatory inspection of Heating/Ventilation/AC (HVAC)	**	0		1		0		3	***	2		0		0	***	0		0		0
10	Mandatory use of solar thermal energy in buildings	*	0		0	***	1		1	***	0	***	0	**	0		1		0		1
Other Regulation in the Field of Buildings																					
11	Individual billing (multi-family houses)	**	0	***	1		0		1	**	1		0	**	0	***	0		0		0
12	Maximum indoor temperature limit(s)/limitation heating period	**	0		1		0		0	***	0		0		0	***	0		0		1
Mandatory Standards for Electrical Appliances																					
13	Minimum efficiency standards for electrical appliances	*	0		0		1		1	***	2	***	1	***	0	***	0		0	**	3
14	Mandatory measures for efficient lighting	*	0		0		2		2		0		1	***	0	***	1		0		5
Legislative/Informative																					
15	Mandatory labelling of heating equipment	***	0		0		1		0		0		0	***	0	***	1		0		1
16	Mandatory energy labelling of electrical appliances	***	0		0		3		1		1	***	0	***	0	***	0		1		1
17	Mandatory energy efficiency certificates for existing buildings	***	0		0	***	3		3	***	2	***	0	***	0	***	1		0		4
18	Mandatory energy efficiency certificates for new buildings	***	0		1	***	2		3		2	***	0	***	0	***	1		0		4
19	Mandatory audits in large residential buildings	***	0	***	0	***	1		0		0	***	0		0	***	2		0		0
20	Mandatory audits in small residential buildings	***	0	***	0	**	1		0	***	0	***	0		0	***	2		0		0
Financial																					
Grants / Subsidies																					
21	For investments in new buildings exceeding building regulation	***	0		0	***	0		2		2	***	0	***	0	***	0		0	**	5
22	For investments in energy efficient building renovation	***	2	***	2	***	13	***	8	***	5	***	1		0	***	2		0	***	11
23	For the purchase of more efficient boilers	***	0		0		10	***	4	***	1		1	***	0	***	0		0		6
24	For the purchase of highly efficient electrical appliances	***	0		0		0	***	3	***	0		1	***	0	***	1		0		5
25	For other energy efficiency investments	***	0		0		6	***	3	***	7		0	***	0	***	0		0		3
26	For investment in renewables	***	2		2		5	***	5	***	3		0	***	0		1		0	**	5
27	For CHP investments	***	0		0	***	0	***	1	***	0		0	***	0	***	0		0		2
28	For energy audits	***	0		0	***	1	***	2	***	3		0		0	***	0		0		4
Loans/Others																					
29	Reduced interest rates (soft loans)	***	0		1		2	***	2	***	3	***	0		0	***	1		0		1
30	Leasing of energy efficient equipment	***	0		0		0	***	0	***	1		0		0	***	0		0		0

(continued)

Fiscal/Tariffs																					
	Tax Exemption / Reduction																				
31	VAT reduction on retrofitting investment	***	0		0	***	0	***	0		0	***	0		0	***	0		0		0
32	VAT reduction on equipment	***	0		0		1		0	***	0	***	0		0	***	1		0		0
33	Income tax reduction	***	0		0		0	***	0	***	0	***	0		0	***	0		1		0
34	Income tax credit	***	0		0		0	***	0	***	0	***	0		0	***	0		1		0
	Tariffs																				
35	Linear electricity tariffs	***	0	***	0		0		0		0		0		0	***	0		0		0
Information/Education																					
36	Voluntary labelling of buildings/components (existent and new)	***	0		0		0		1		0	***	0	***	0	***	0		0		0
37	Information campaigns (by energy agencies, energy suppliers etc)	***	0	***	0		2	***	2	***	3		0	***	0	***	0		0		2
38	Detailed energy/electrical bill aiming at EE improvement	***	1	***	0		0		0		2		0		0	***	0		0		0
39	Regional and local information centre on energy efficiency	***	0		0		0	***	0	***	2		0	***	0	***	0		0		0
Co-operative Measures																					
40	Vol./Negot. agreements with producers of White / Brown Goods	***	0		0		0		0	***	0		0	***	0	***	0		0	**	1
41	Vol./Negot. agreements with producers of ICT (e.g. on stand-by)	***	0		0		0		0	***	0		0	***	0	***	0		0		0
42	Voluntary DSM measures of energy suppliers and distributors	***	0		0	***	0	***	0	***	0		0	***	0	***	0		0		0
43	Technology procurement for en. efficient appliances and buildings	***	0		0		0		1	***	0		1	***	0	***	0		0		0
Cross-cutting with sector-specific characteristics																					
44	Eco-tax on electricity/energy consumption or CO2 - emissions	***	0		0		0		0		0		0		0	***	0	***	0	**	1
45	Eco-tax with income (mainly) recycled to en. eff. / renewables	***	0		0		0		0		0		0		0	***	0	***	0		0
46	Eco-tax with income recycled to indirect labour cost	***	0		0		0		0		0		0		0	***	0	***	0		0
47	Eco-tax with reduced rates for the industrial sector	***	0		0		0		0		0		0		0	***	0	***	0		0