The rule of thumb reigning over the lands of data scarcity: streamlining multiple impacts around energy savings as primary input

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Abstract

Since IEA's 2014 landmark publication "Capturing the Multiple Benefits of Energy Efficiency", several EU projects and articles have advanced the concept of multiple impacts (also known as multiple benefits, co-benefits, or ancillary benefits). A generous collection of indicators has been developed to quantify and monetise a myriad of impacts. However, this approach has shown shortcomings, when it comes to the necessary data to apply these indicator sets. As a consequence, these assessments could generally merely be realised by experts with access to significant data volumes and expert guesses.

Yet, in light of the enshrinement of wider benefits into EU legislation (as key component of the Energy Efficiency First Principle under the EED's Article 3), more practitioners and policymakers will need to assess multiple impacts thoroughly. Therefore, in the course of the MICAT project (Multiple Impacts CAlculation Tool), existing indicator sets have been streamlined to require only energy savings as input data. Thereby, the approach has been drastically simplified to enable a significantly wider group to assess multiple impacts of energy efficiency.

While additional data and parameters (i.e. investment costs, energy prices, energy mixes, measure lifetimes, and monetisation factors) still improve the results' accuracy, they are not necessary, as the tool can fall back on default values and standard conversion equations. This allows users with different data availabilities to receive the best possible results.

This paper describes the underlying methodologies and assumptions taken to develop the streamlined indicator set at the core of the MICATool, the easy-to-use, free, and open-source online tool developed in the framework of the MICAT project. Considering the implications and resulting inaccuracies, assumptions and fallback values are discussed. Thereby, the paper describes the progress necessary to expand the group of users able to assess the multiple impacts of energy efficiency.

Introduction

The multiple impacts of energy efficiency have gained significant attention in recent years as a comprehensive approach to assessing the outcomes of energy efficiency measures (Selvakkumaran and Limmeechokchai, 2013; Hasanbeigi et al., 2013; Jakob, 2006). This concept goes beyond the traditional measure of energy savings and encompasses a wide range of positive and negative effects on environmental, social, and economic sustainability. Environmental benefits include reductions in CO_2 emissions, contributions to EU Renewable Energy Source (RES) targets, and the reduction of air pollution. Social benefits encompass alleviation of energy poverty, improved indoor air quality, and enhanced health outcomes. Improved energy security, increased asset values, and positive impacts on GDP (gross domestic product) and employment are counted as economic benefits.

The International Energy Agency (IEA) has played a vital role in promoting the broader perspective of energy efficiency and recognizing the importance of quantifying its multiple impacts (Heffner and Campbell, 2011; Ryan and Campbell, 2012). In its landmark report published in 2014, titled "Capturing the

Multiple Benefits of Energy Efficiency," the IEA outlined an approach to assess a range of non-energy benefits associated with energy efficiency measures (Campbell et al., 2014). This report marked a significant step towards quantifying and recognizing the multiple impacts of energy efficiency, providing a foundation for policymakers and investors to make informed decisions about energy efficiency investments.

The growing recognition of the multiple impacts of energy efficiency has led to an abundance of scientific papers and funded projects focused on understanding and quantifying these effects (Reuter et al., 2020; Payne et al., 2015; Kerr et al., 2017; Fawcett and Killip, 2019; Killip et al., 2019). Projects such as COMBI (Calculating and Operationalising the Multiple Benefits of Energy Efficiency in Europe), the Odyssee-Mure Multiple Benefits Facility, and M-Benefits have contributed to quantifying and monetizing the expected multiple benefits of energy efficiency and assessing the impacts of energy efficiency measures across various sectors.

While these projects and papers have been instrumental in promoting the concept of multiple impacts, it is essential to acknowledge that they were developed for specific use cases with significant data availability. Odyssee-Mure and COMBI looked at the past on Member State level and the next two decades on EU level, respectively, whereas M-Benefits has assessed ex-ante multiple impacts at company level, in cooperation with businesses providing insights and data.

However, in the future, multiple impact assessments will become more commonplace, due to the Energy Efficiency First Principle outlined in the recast Energy Efficiency Directive's (EED) Article 3, which states that large-scale energy-related investments should be assessed based on their cost-effectiveness and multiple impacts (European Union, 2023). This will thus apply to a wide range of cases, inter alia many with very limited data availability.

Hence, in order to facilitate the assessment of multiple impacts even in case of data scarcity, a streamlined approach is necessary to accommodate cases with scarce data. This has been developed in the MICAT project. The developed approach simplifies the evaluation process by requiring only energy savings as input data. Furthermore, it allows to assess measures both ex-post and ex-ante.

To address this issue, the EU-funded MICAT project has developed the MICATool, an easy-to-use online tool implementing this streamlined approach, allowing a wider group of practitioners and policymakers to assess the comprehensive impacts of energy efficiency without the need for extensive data. The tool returns the results in physical values (i.e. avoided deaths, number of people lifted out of energy poverty) as well as in monetised terms, where possible, allowing to use the integrated cost-benefit assessment tool. While applications on a company level are not explicitly excluded, the MICATool mainly focuses on top-down applications using related statistical data.

Moreover, as an open-source tool that can be extended, enhanced, and improved by any interested scientist or practitioner, new functions can always be added to better cater to certain needs, for instance specific reporting obligations. While additional data and parameters can enhance the accuracy of the results, the tool provides default values and standard conversion equations as fallback options, ensuring that users with varying data availability can still obtain valuable insights.

As a result, all kinds of user-defined energy efficiency measures and scenarios can swiftly be assessed, either in a quick manner using default fallback values or more precisely by altering parameters. This paper describes how the quantification approach has been adapted for several important impacts to merely require energy savings as input and discusses the assumptions necessary to achieve this streamlining even in cases of data scarcity.

Materials and methods

As input, merely energy savings are necessary, as well as the specification of the time range and the geographical study area. All additional input, either in the form of global parameters applying to all measures or advanced parameters concerning a specific measure, improve the results' accuracy and can be input in the MICATool. In the following, the specification concerning the used accounting approach to energy savings, the consideration of ex-post and ex-ante assessments, and the approach to calculating impacts in the framework of the MICAT methodology and the resulting MICATool are described in greater detail.

DEFINITION OF ENERGY SAVINGS

Energy savings can mainly be accounted in three different ways: new annual savings, total annual savings, and cumulative savings. The first describes savings from measures carried out in a given year (Figure 1a.). The second includes all savings generated in a given year from all measures, including those carried out in the past (Figure 1b.). The third option comprises all savings generated across all years since the first measures have been implemented (Figure 1c.). However, for all accounting ways, savings are merely accounted for a period equivalent to the measure's lifetime.

The MICATool uses total annual savings as input, since this is the most common way of providing savings in scenarios and measure projections. Furthermore, the resulting annual benefits typically scale with total annual savings. However, for some indicators requiring new annual savings (i.e. Impact on GDP or employment effects), these are converted by subtracting the prior year's from a given year's total annual savings.

DIFFERENTIATION BETWEEN EX-POST AND EX-ANTE

The MICATool distinguishes between ex-post (called "Past") and ex-ante ("Future") assessment (Figure 2). While there is some overlap in the selectable years, the difference lies in the used reference baseline and in the direction of savings. For ex-post assessment, Eurostat's complete energy balances are used as reference baseline, since this data can be considered very accurate and close to reality when it comes to energy consumption across sectors and energy carriers. It is assumed that the Eurostat reference includes the savings input to the tool and is then compared to a counterfactual scenario, where these savings have not been generated. Thus, the counterfactual scenario is generated by adding these savings to the baseline, as if they had not been achieved.

When assessing measures and scenarios ex-ante, PRIMES' Reference Scenario 2020 data is used as reference baseline (European Commission et al., 2021). In contrast to measures in the past, the PRIMES reference is assumed to be the counterfactual

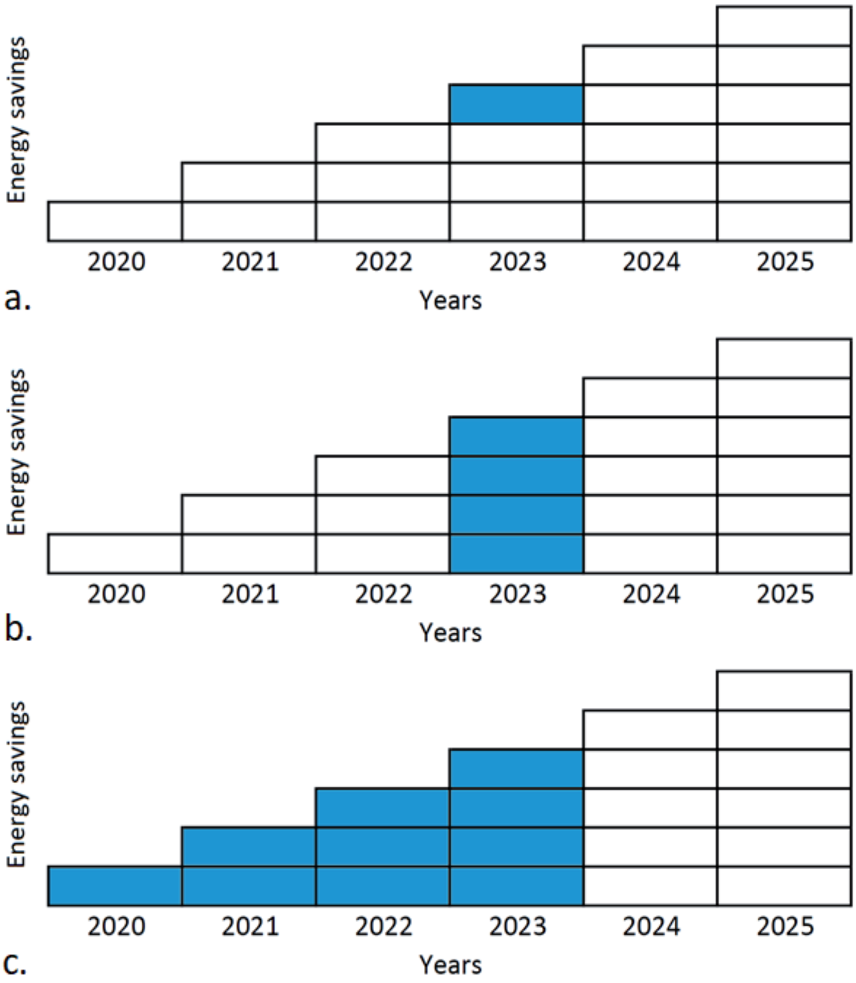

Figure 1. The three approaches to accounting energy savings: new annual savings (a.), total annual savings (b.), and total annual savings (c.).

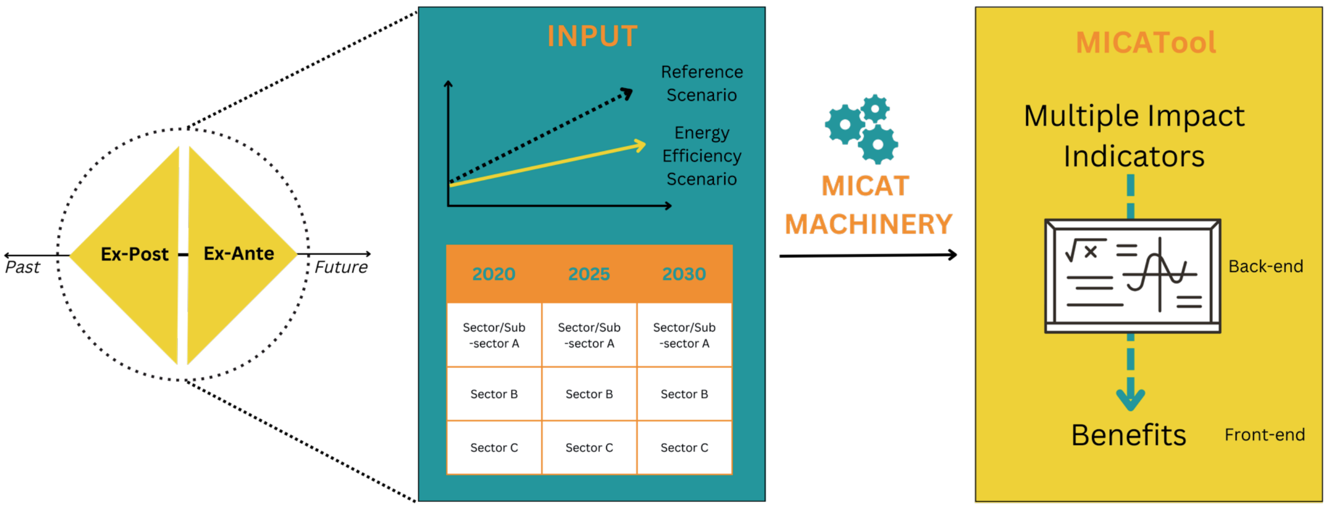

Figure 2. Schematic depiction of the MICATool's workflow, from inputs for either ex-post or ex-ante assessments, over the generation of a counterfactual scenario to assess impacts against to the quantification and monetisation of impacts in the back-end to the display and cost-benefit analysis of multiple impacts in the front-end.

scenario, while the energy savings scenario is created by subtracting the input energy savings from this reference.

However, many figures used in the tool are relative values, such as the energy mix, which is expressed in share of total energy consumption or energy poverty rate, expressed as share of the population. Thus, the baseline is merely relevant for non-linear indicators requiring absolute values, such as energy intensity or import dependence. In these cases, the reference baseline is used to calculate the impact with and without energy savings.

MULTIPLE IMPACT INDICATORS

In order to produce a swift and responsive online tool, the MICATool works with rather simple functional relationships to calculate multiple impacts in contrast to wide-ranging modelling. This also encompasses a renunciation to feedback loops and high-level interdependencies between indicators (i.e. energy savings do not entail a change in energy prices in the MICATool, in spite of the probability of such an effect).

These functional relationships are sets of formulas that can be calculated at runtime in a single iteration. This can range from a single equation to two dozen equations depending on the assessed indicator. However, in order to ensure the MICATool's celerity, all data points not depending on inputs to the tool are combined into coefficients.

In the following, the indicators that needed to be adjusted or improved to properly scale with energy savings are described. However, similar indicators have been grouped in order to improve the paper's clarity. Some indicators have been carried over unaltered from COMBI and the Odyssee-Mure Multiple Benefits facility and are thus not described here. The methods behind monetisation (similar for all indicators, quantified value times monetisation factor) and cost-benefit analysis are also not described, since they have already been implemented and extensively documented in previous projects (inter alia COMBI). However, underlying methodologies as well as all indicators including possible monetisation are described in more detail in the MICATool's extensive documentation, in one fact sheet per indicator, and in methodological deliverables describing the frameworks for quantification, monetisation, and cost-benefit analysis.

Results and discussion

ENERGY MIX OF FINAL ENERGY SAVINGS

A key difficulty in providing input to indicators is the determination of the saved energy mix, so which energy carriers have been saved to which degree. The most straight-forward approach is to assume that all energy carriers' consumption has been reduced proportionally to their share in the (sub-)sector, end-use, or improvement action (a specific type of measures, such as thermal insulation of a building or replacement of a heating system). The MICATool is mainly based on improvement actions differentiated by (sub-)sectors, due to the stronger correlation between improvement actions and multiple impacts. However, when considering the energy mix on improvement action level, which is at the MICATool's core, there is no available data across sectors and subsectors. Instead, energy mixes are typically provided by statistical offices or the EU Reference Scenario 2020 on a (sub-)sector or end-use basis, not considering improvement actions as used in MICAT. To overcome this, the tool uses a workaround by using a conversion vector to convert the sectoral energy mix to an improvement action energy mix.

The calculation of the coefficient vectors involves a combination of past statistical and scenario data. These coefficients are derived by dividing the improvement actions' energy mix by the (sub-)sectoral energy mix, using data from a consistent source or scenario. As some of these sources and scenarios are not publicly accessible, only the coefficients are stored in the database, not the underlying datasets and scenarios. This results in one stored coefficient vector for each country, sector (or subsector), and improvement action in the database. To calculate the energy mix on improvement action level, this vector is multiplied elementwise with the sector's (or subsector's) energy mix vector. After normalizing the vector, the improvement action-energy mix is obtained.

This approach has the advantage of utilizing widely available sectoral energy mix data. Since the coefficient vector is relatively stable over time, only the sectoral data needs periodic updating. Additionally, this allows users to adjust the data to suit their specific needs by modifying the sectoral data, which is much easier to gather at EU, national, regional, or local levels.

In case of improvement actions relating to fuel switches, the approach is more complex. Using the efficiency of the main combustion technologies linked to energy carriers and user-input shares of removed and newly installed energy carriers, the total energy demand as well as the energy mix before and after the measure's implementation are calculated. The difference of both results in an energy mix vector with typically some negative values (negative savings, which means added consumption for some energy carriers, i.e. electricity in the case of electrification and heat pump installation). Thus, the positive impacts of the removed technologies are combined with the negative impacts of the replacement technologies.

While the default assumptions using the fall-back values are of course prone to inaccuracies, inter alia due to regional deviations of national averages and the unlikelihood of an absolute time-constancy of the sector-to-improvement action coefficient. As a result, significant inaccuracies might occur when relying on the MICATool's fallback values, which still allow users with little data to generate approximate results. However, thanks to users' option to adjust the affected energy carrier shares (as well as the energy carrier shares of removed and newly installed technologies), the results' accuracy can be significantly increased.

ENERGY MIX OF PRIMARY ENERGY SAVINGS

To address the need for primary energy consumption values in certain indicators, the MICATool includes a module that converts these values.

For primary energy carriers that also exist as final energy carriers (e.g., oil, coal, gas, biomass, and renewable waste), they are allocated to the corresponding category. Currently, there is no factor considering transformation losses between primary and final energy consumption for these products.

For H_2 and synthetic fuels, a conversion from electricity is chosen using an efficiency coefficient. This conversion assumes the national energy mix for electricity generation. As the market for these fuels grows, the conversion method will be adapted to include more ways of producing hydrogen.

The energy quantities of primary energy carriers required to generate one unit of electricity or heat are described in separate vectors. The user can modify these vectors in the global parameters. If no modifications are made, the vectors are calculated based on dedicated electricity or heat generation, including cogeneration (CHP). For dedicated electricity and heat generation sources, the total input quantities from the six primary energy carriers are divided by the total transformed energy output.

In the case of cogeneration, allocating inputs to the two different outputs poses a challenge. Among various possible methods, the MICATool uses an "equivalence number method" to address this. This method does not require additional external values or assumptions. It assumes that the average efficiency of dedicated electricity and heat generation improves proportionally for both energy carriers when generated in a cogeneration process to achieve the higher efficiency of CHP.

These two components (dedicated and cogeneration) are weighted based on the share of energy generated by each type of power plant, resulting in conversion vectors from final to primary energy carriers. The input values are sourced from Eurostat complete energy balances and the EU Reference Scenario 2020.

The main shortcoming of the primary energy savings energy mix is the oblivion of energy market effects. Effectively, according to the merit-order principle energy markets adhere to, some energy carriers are more likely to be saved when less electricity or heat (the latter merely in large networks with several generators) is needed. Therefore, a merit-order-based analysis would result in different energy carriers being saved in the short term than just their general share in electricity and heat generation. However, due to the inexistent time resolution in the MICATool, the merit-order cannot properly be applied, since the inputs do not allow for sound assumptions of the times of day when energy savings would occur. However, the low timely resolution of energy efficiency scenarios does not render an alleviation of this issue evident.

Similarly, a long-term reduction of energy consumption or lowering of energy consumption increases would result in certain power generators being decommissioned or not constructed in the first place. However, in the course of the energy transition, decommissioning and new construction of power generation capacity have become political decisions rather than market-driven results. Thus, it is difficult to predict the effects for all EU Member States. Thus, in order to provide consistent figures, energy shares in generation are used to predict saved energy carriers. Moreover, users still have the opportunity to adjust the assumed energy mix of savings in electricity and heat generation in the MICATool's global parameters.

INVESTMENTS

Although a paramount input to quantify several impacts and to the cost-benefit analysis, the provision of triggered investment costs is not necessary to run the MICATool. In order to accommodate this, conversion factors for typically triggered investment costs of energy savings for different improvement actions are provided. Nonetheless, it is recommended to input triggered investments to improve the results' accuracy, in case data is available.

LOCAL AND GLOBAL POLLUTANTS

While the Odyssee-Mure and COMBI already relied on straightforward methodologies to calculate emissions of local and global pollutants scaling with energy savings, these have been significantly improved in the MICATool. Based on IIASA's (International Institute for Applied Systems Analysis) GAINS model (Greenhouse Gas – Air Pollution Interactions and Synergies), average coefficients for nitrogen oxides (NO_X), sulphur dioxide (SO_2), particulate matter smaller than 2.5µm (PM2.5), carbon dioxide (CO_2) for each energy carrier, Member State, sector and subsector, and five-year step are provided in the tool. These are then multiplied with the respective energy savings.

Although these are merely average values and emissions, particularly for local pollutants, strongly depend on the combustion technology, the accuracy can be considered comparably high, since all energy carriers have quite specific emission ranges and several distinctions are made attempting to account for the typical technology consuming the energy carrier depending on sector, year, etc.

ENERGY POVERTY

The MICATool assesses the number of people lifted out of poverty using threshold values from two indicators, M/2 and 2M. M/2 defines energy poor households as those underspending on energy, spending less than half the median household on heating and cooling. This mainly addresses households without the means to afford a basic level of energy services. In contrast, 2M defines households overspending on energy as energy poor, spending more than double the median on energy.

In order to assess these indicators, it is essential to know on how many households the energy savings are split. To do this, a module assuming the number of affected dwellings (i.e. households) has been programmed. It assumes the number of affected dwellings for residential measures, as it is necessary for the calculation of energy poverty and indoor climate-related indicators.

The modules encompass three staggered approaches:

- If the user specified the number of affected dwellings, this figure is directly used.
- If a renovation rate is specified, it is multiplied with the respective national building stock figure. The database features the values for all Member States and the European Union. For the local level, these are scaled proportionally to the population of the examined region or municipality. Alternatively, users can also explicitly provide a figure for the area's dwelling stock.
- If none of the above is provided, the number of dwellings is assumed from a coefficient describing the typical energy savings per dwelling for different improvement actions.

Expanding on the module's assumption, the calculations for both indicators are made to determine the number of people lifted out of energy poverty, considering both tenants and owner-occupiers. To determine the percentage of measures targeting energy poor households, as a default the latest national energy poverty rate is utilised. However, adjustments can be made in the advanced parameters. The algorithm then assesses whether the saved energy costs per household surpass the energy poverty gap (difference between household energy spending and half or twice the median spending on energy, respectively) of each decile, taking inter alia investment costs, likely rent increases, subsidy rates, or national average rents of energy poor households into account.

The standardised quantification of energy poverty on an EU level is prone to inaccuracies due to data scarcity. Already the selection of indicators is more than controversial, considering that the threshold values for both M/2 and 2M are no precise estimators of energy poverty and could also assign the energy poverty status to well-off households, either living in very well insulated buildings, overheating their dwelling, or occupying large floor spaces with proportionate heating costs. To account for this, the energy poverty gap deciles for the M/2 indicator have been calculated only for households in the lower five income deciles. However, despite these shortcomings, the indicator provides a very good ballpark.

HEALTH EFFECTS

The methodology used for the assessment of positive health effects linked to reduced air pollution and to improved indoor climate is fundamentally different. For effects linked to air pollution, coefficients similar to those used for local and global pollutants are generated using the GAINS model to indicate the effects of energy efficiency on premature mortality, hospital stays, and lost working days.

Currently, the assessment of health impacts related to improved indoor climate focuses on the reduction of asthma cases. This involves making assumptions about the proportion of renovations taking place in damp and mouldy buildings, as well as the proportion of renovations considered as medium and deep renovations. The default values used for these assumptions are the projected rates in PRIMES and the current national prevalence of damp and mould buildings. Additionally, a national coefficient has been derived from historical data to quantify the number of disability-adjusted life years lost per damp or mould building. This coefficient serves as the impact factor. The methodology is quite similar to the approach used for energy poverty, with several similar parameters.

Compared to the quantification of air pollutants, the quantification of linked health effects is significantly more error-prone. As energy savings are not localised within the geographical study area, these results come with some margins of error, since the difference between emissions in densely populated and rural areas cannot be accounted for. Nevertheless, compared to previous approaches in Odyssee-Mure and COMBI, the strong differentiation of coefficients significantly improves the results' accuracy.

Similarly, health effects due to improved indoor health climate carry non-negligible margins of error. Based on national reporting on damp and mould housing, which strongly varies across Member States, and approximate assumptions on the number of these dwellings affected by the input energy efficiency measures, results should not be considered exact but rather a ballpark, although users have the possibility to adjust parameters to improve them.

Conclusions and outlook

The streamlining approach developed in the framework of the MICAT project allows a significantly wider group of researchers, but also practitioners and policymakers to assess multiple impacts for very specific use cases. Thus, the MICATool allows moving from a status quo, where multiple impacts assessments are carried out exclusively by researchers involving extensive manual calculations and the need for good data, to the possibility for anyone to generate good approximations of multiple impacts.

In order to further improve the quality and accuracy of results, where possible, further disaggregations of coefficients should be envisaged, which will be part of MICAT's follow-up project SEED MICAT (Support Energy Efficiency Deployment with the Multiple Impacts CAlculation Tool). This includes inter alia further differentiations for specific costs of energy savings, different energy poverty gaps, hydrogen generation processes, etc.

Moreover, the multiple impacts approach needs to adjust to the legislative leap that is the Energy Efficiency First Principle. Thus, it is paramount to include the multiple impacts of supply-side options to make them comparable. Therefore, as foreseen in the SEED MICAT project, the general baseline of multiple impacts needs to shift from the status quo to alternative ways to decarbonise, in order to enable researchers, practitioners, and policymakers to identify the most expedient measures to decarbonise all kinds of different cases.

References

Campbell, N., Ryan, L., Rozite, V., Lees, E., and Heffner, G., 2014. Capturing the multiple benefits of energy efficiency. IEA, https://www.iea.org/reports/capturing-the-multiple-benefits-of-energy-efficiency.

European Commission, Directorate-General for Climate Action, Directorate-General for Energy, Directorate-General for Mobility and Transport, De Vita, A., Capros, P., Paroussos, L., 2021. EU reference scenario 2020 : energy, transport and GHG emissions: trends to 2050, Publications Office. https://data.europa.eu/doi/10.2833/35750

European Union, 2023. Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast). Official Journal of the European Union, 66: 1–111. ISSN: 1977-0677, http://data.europa.eu/eli/dir/2023/1791/oj.

Fawcett, T. and Killip, G., 2019. Re-thinking energy efficiency in European policy: Practitioners' use of 'multiple benefits' arguments. Journal of Cleaner Production, 210: 1171–1179. ISSN: 0959-6526, DOI: 10.1016/j.jclepro.2018.11.026.

Hasanbeigi, A., Lobscheid, A., Lu, H., Price, L., and Dai, Y., 2013. Quantifying the co-benefits of energy-efficiency policies: A case study of the cement industry in Shandong Province, China. Science of The Total Environment, 458-460: 624–636. DOI:10.1016/j.scitotenv.2013.04.031.

Heffner, G. and Campbell, N., 2011. Evaluating the co-benefits of low-income energy efficiency programmes. https://www.osti.gov/etdeweb/servlets/purl/21467293

Jakob, M., 2006. Marginal costs and co-benefits of energy efficiency investments. Energy Policy, 34 (2): 172–187. DOI: 10.1016/j.enpol.2004.08.039.

Kerr, N., Gouldson, A., and Barrett, J., 2017. The rationale for energy efficiency policy: Assessing the recognition of the multiple benefits of energy efficiency retrofit policy. Energy Policy, 106: 212–221. ISSN: 0301-4215, DOI: 10.1016/j.enpol.2017.03.053.

Killip, G., Fawcett, T., Cooremans, C., Wijns-Craus, W., Subramani, K., and Voswinkel, F., 2019. Multiple benefits of energy efficiency at the firm level: a literature review. In eceee Summer Study proceedings. European Council for an Energy Efficient Economy. https://rb.gy/acspm

Payne, J., Weatherall, D., and Downy, F., 2015. Capturing the "multiple benefits" of energy efficiency in practice: the UK example. Energy Savings Trust Summer Study Proceedings. https://energysavingtrust.org.uk/sites/default/files/reports/1-424-15_Payne.pdf

Reuter, M., Patel, M. K., Eichhammer, W., Lapillonne, B., and Pollier, K., 2020. A comprehensive indicator set for measuring multiple benefits of energy efficiency. Energy policy, 139: 111284. DOI: 10.1016/j.enpol.2020.111284.

Ryan, L. and Campbell, N., 2012. Spreading the Net: The Multiple Benefits of Energy Efficiency Improvements. IEA. DOI: 10.1787/5k9crzjbpkkc-en.

Selvakkumaran, S. and Limmeechokchai, B., 2013. Energy security and co-benefits of energy efficiency improvement in three Asian countries. Renewable and Sustainable Energy Reviews, 20: 491–503. DOI: 10.1016/j.rser.2012.12.004.

Endnotes

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