Multiple Impacts Calculation Tool

Empirical basis of Social Impacts Energy Poverty Alleviation

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Executive summary

Energy poverty has gradually emerged as a central policy issue within the EU, which is reflected in both its legislation as well as research agenda. Against the background of the four strategic pillars of the EU energy transition 1) phasing out of fossil fuel-based energy supported by CO_2-pricing, 2) investing in renewable energy sources and associated infrastructure and 3) reducing energy demand via energy efficiency investments and 4) electrification, the equitable distribution of costs and benefits is a central criterion to assess its socially just implementation. Energy poverty levels represent an indication of how well energy policies achieve to fulfil the promise of a just transition that is leaving no one behind.

Within MICAT, energy poverty is defined as a state in which a household uses a disproportionately low level of energy services due to financial hardship, indicated by a low absolute energy expenditure in comparison to a defined national threshold (M/2 indicator) or experience a disproportionately high financial burden related to their energy consumption, indicated by a high share of energy expenditure in income in comparison to a defined national threshold (2M indicator).

The energy poverty alleviation indicator as proposed and defined in MICAT quantifies the impact of policy induced energy cost savings in the residential building sector in terms of the number of persons financially enabled to access a level of energy services above the M/2 energy poverty threshold or decrease their share of expenditure in income below the 2M energy poverty threshold and thus escape the state of energy poverty and its negative consequences.

The calculation of the energy poverty alleviation impact follows a four-step approach, which slightly differs depending on whether building or household targeted energy efficiency improvement (EEI) actions are modelled:

1) Determine the number and type of EEI actions and the corresponding energy cost savings per household and year, 2) define the share/number of EEI actions implemented in energy poor households (Policy Target Factor), 3) define the share/number of energy poor households, for which energy cost savings enable increased access to energy services or decrease their financial burden beyond the threshold (Impact Factor) and 4) multiply the number of these households with the average household size of energy poor households.

The functional relationship to determine the energy poverty alleviation impact in terms of number of persons lifted from energy poverty (ΔEP) is as follows:

For household targeted EEI actions:

$$\Delta EP = N \; x \; PTF \; x \; IF \; x \; SSH$$

For building targeted EEI actions:

$$\Delta EP = \frac{N}{D} \; x \; PTF \; x \; \left(IF_{owner} \; x \; OR + IF_{tenant} \; x \; (1 - OR)\right) x \; SHH$$

N: Number of EEI actions per year
D: Average number of dwellings per building
PTF: Policy Target Factor
IF: Impact Factor for owner occupiers, tenants or all households
OR: Ownership rate among energy poor households
SSH: Average size of energy poor households

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Scope of MI indicator

Definition

Within MICAT, energy poverty is defined as a state in which a household either uses a disproportionately low level of energy services due to financial hardship, indicated by a low absolute energy expenditure in comparison to a defined national threshold (M/2 indicator[1]) or experience a disproportionately high financial burden related to their energy consumption, indicated by a high share of energy expenditure in income in comparison to a defined national threshold (2M indicator[2]). The energy poverty alleviation indicator quantifies the impact of policy induced energy cost savings in the residential building sector in terms of the number of persons financially enabled to access a level of energy services above the M/2 energy poverty threshold or decrease their share of expenditure in income below the 2M energy poverty threshold and thus escape the state of energy poverty and its negative consequences, such as most notably both physical and mental health risks (Jessel et al. 2019; Ballesteros-Arjona et al. 2022).

Relevance on EU, national and/or local level

Energy poverty has gradually emerged as a central policy issue within the EU, which is reflected in both its legislation (European Commission 2020) as well as research agenda (Gangale/Mengolini 2019). Against the background of the four strategic pillars of the EU energy transition 1) phasing out of fossil fuel-based energy supported by CO2-pricing, 2) investing in renewable energy sources and associated infrastructure and 3) reducing energy demand via energy efficiency investments and 4) electrification (Agora Energiewende 2019), the equitable distribution of costs and benefits is a central criterion to assess its socially just implementation. Energy poverty levels represent an indication of how well energy policies achieve to fulfil the promise of a just transition that is leaving no one behind[3]. While at EU level, the ex-ante assessment of energy poverty impacts of legislative proposals is established practice (Politt et al. 2016; European Commission 2021), the measures taken to address the issue are designed and implemented at national and local level respectively. Apart from providing guidance for national and local energy (efficiency) policy designers, the indicator can support monitoring and reporting requirements on energy poverty impacts defined in the pertinent EU Directives.

Impact pathway figure

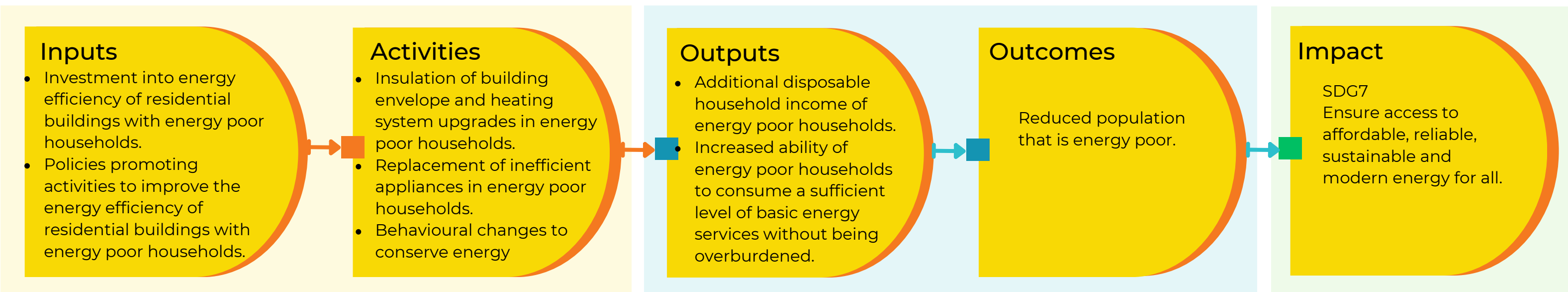

Figure 1 : Logic model (theory of change) for Energy poverty alleviation

[1] The M/2 indicator defines those households as energy poor, whose absolute energy expenditure is below half the national median value. To avoid assigning the status to households, whose low energy expenditure results from high energy efficiency of their dwelling, in MICAT we further restrict the definition to households whose (equivalized) household income is at the same time in the lower five income deciles.

[2] The 2M indicator defines those households as energy poor, whose share of energy expenditure in income is more than twice the national median value.

[3] Cf. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en

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Overlaps with other MI indicators and potential risk of double-counting

The alleviation of energy poverty results from reduced financial requirements for households to use a sufficient level of energy services. If consumption is increased to improve e.g., thermal comfort, no financial savings materialise. Even if households choose to sustain their current level of energy services and use cost savings for other purposes. These savings are however already captured in the monetised energy savings indicator and should not be double counted. Furthermore, there can be an overlapping effect on public budgets if transfer payments to energy poor households or spending on energy subsidies are reduced. However, similar to the positive health impacts, whether and to what extent public budget spending is reduced depends on the respective existence and setup of welfare state institutions and/or targeted energy poverty policies.

Quantification method

Description

To quantify the energy poverty alleviation impact of energy efficiency improvement (EEI) actions in the residential sector, different calculation steps are required depending on the type of user request (cf. Figure 2).

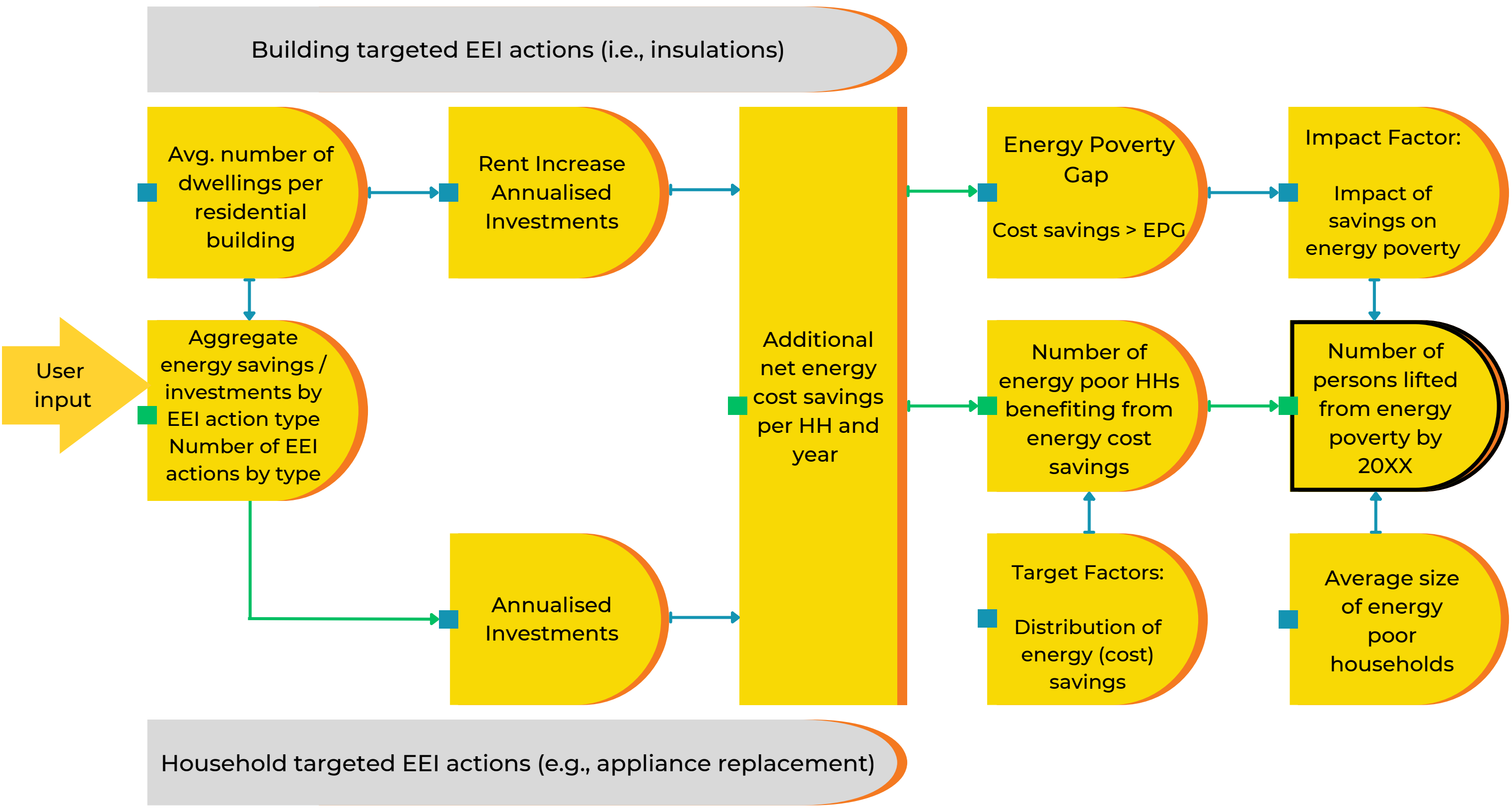

Figure 2: Main calculation steps using user inputs and data in the tool

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In a first step, the number and type of EEI actions and the corresponding investments and energy cost savings per household are determined. Since impacts for this indicator are quantified on the household level, EEI actions directed towards buildings (e.g., insulation) and the corresponding investments and (cost) savings need to be disaggregated, whereas EEI actions that are directly implemented in households (e.g., appliance replacements) equal the number of affected households and household specific investments and savings. In case of building refurbishments, this means to divide the resulting or estimated investments and savings per refurbishment by the average number of dwellings per building. To account for costs accruing to households during the EEI action implementation, the yearly energy cost savings (ΔE) are adjusted by subtraction of annualised average investments for the EEI action (AI) minus possible subsidies (for owner occupiers or household targeted EEI actions (e.g., appliance replacements)) or rent increase (for tenants). The latter is defined as a share of the annual rent expenditure of energy poor tenants calculated from the (inflated) 2015 HBS micro data. Both subsidy rate (SR) as well as the renovation rent premium (RRP) may be defined by the online tool user, with default values being set for SR at 0 (i.e., no subsidy) and tentative rent premiums from the pertinent literature. The net yearly energy cost savings (ΔNECS) resulting from higher efficiency are calculated as follows:

For household targeted EEI actions:

$$\Delta NECS = \Delta E - AI \; x \; (1 - SR)$$

For building targeted EEI actions:

$$\Delta NECS_{Tenants} = \Delta E - RRP \; x \; REP$$

$$\Delta NECS_{Owners} = \Delta E - \frac{AI}{D} \; x \; (1 - SR)$$

ΔE : *Yearly energy cost savings from EEI action*
AI : *Annualised investment for EEI action*
SR : *Subsidy rate*
D : *Average number of dwellings per building*
RRP: *Average renovation rent premium as percentage of average rents paid by energy poor households*
REP : *Average rent of energy poor households*

Secondly, the share/number of EEI actions implemented in energy poor households is determined. To this end, tool users may insert a political target (here defined as Policy Target Factor (PTF)) as a percentage of EEI actions to be implemented in energy poor households (i.e., taking on values between 0 and 1). In case no political target is explicitly defined, as a default the share of energy poor households in the population in the respective country or region is used, following the provisions of the latest draft of the 2022 recast of the EU Energy Efficiency Directive[4].

Third, to calculate the number of households/persons that have been or will be actually lifted from energy poverty due to the EEI action, the number of energy poor households in which EEI actions have been or will be implemented is then multiplied with a weighted Impact Factor (IF) taking on values between 0 and 1. This factor is defined with view to the relationship between the net yearly energy cost savings from the EEI actions and the level and distribution of the Energy Poverty Gap[5] among energy poor owner occupiers and tenants and weighted with view to their respective share in the energy poor population. To define the reference values against which energy cost savings are compared, deciles of the Energy Poverty Gap are formed, with the least severely affected in the first decile and the most severely affected households in the 10th decile. As an example, using the Energy Poverty Gap of the M/2 indicator in Italy, the most severely affected households in the 9th and 10th deciles are underspending more than 700 € (cf. Figure 3).

[4] According to the newly inserted Article 8 on Energy Saving Obligations "Member States shall achieve a share of the required amount of cumulative end-use energy savings among people affected by energy poverty vulnerable customers and, where applicable, people living in social housing. This share shall at least equal the proportion of households in energy poverty as assessed in their National Energy and Climate Plan established in accordance with Article 3(3)(d) of the Governance Regulation 2018/1999."

[5] Meaning here the difference of energy poor households' absolute or relative energy expenditure to the national M/2 or 2M indicator threshold value.

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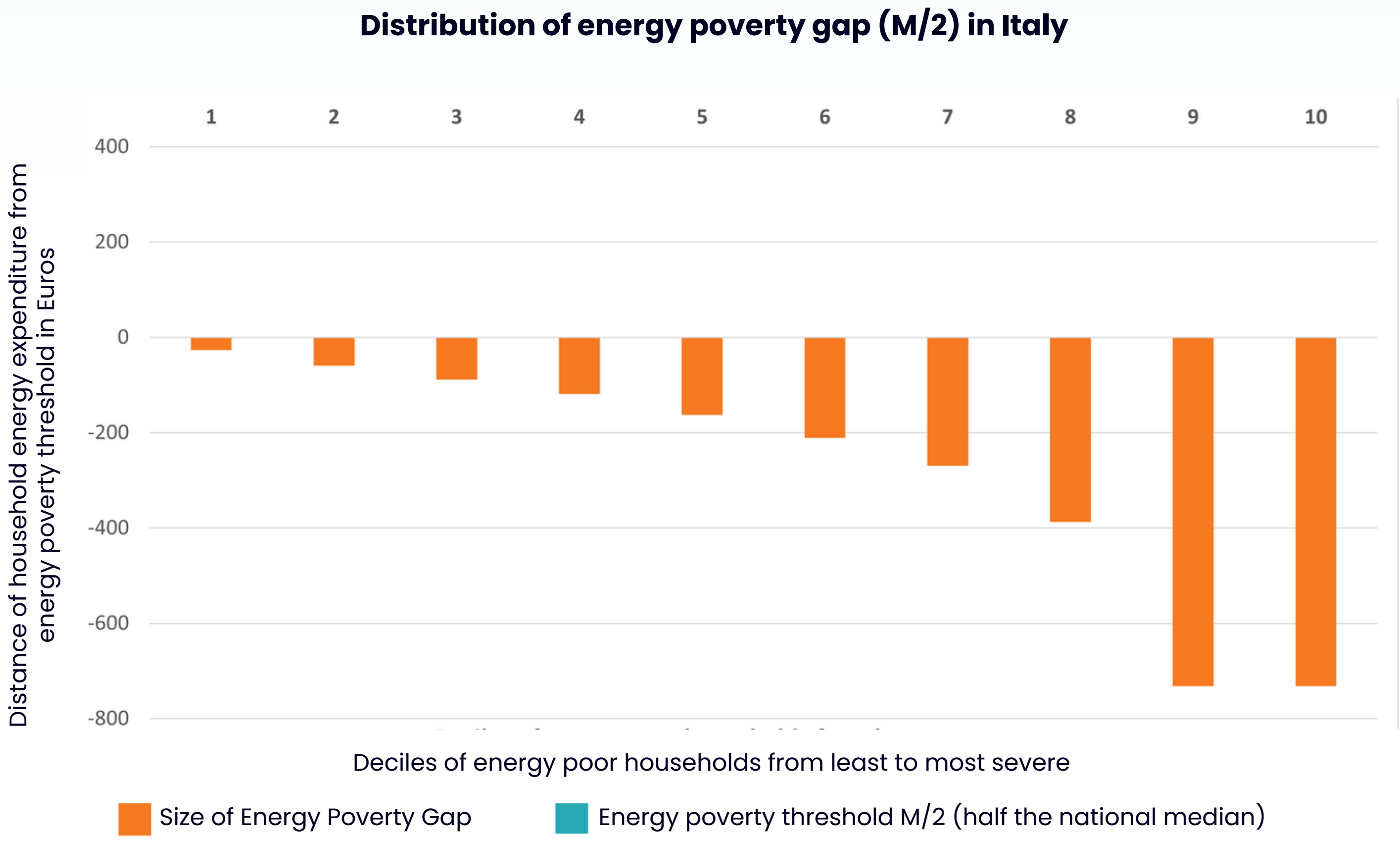

Figure 3: Visualization of distribution of energy poverty Gap for M/2. Example: Italy. Source: HBS 2015

The IF (for owner occupiers and tenants) are then derived by comparing the (adjusted) net yearly energy cost savings with the upper marginal values of the different deciles. The last decile for which the net energy cost savings are greater than the marginal value defines the respective IF, i.e., the share of energy poor households whose absolute or relative energy expenditure is increased or decreased beyond the national energy poverty threshold value. In the exemplary case, net yearly energy cost savings for benefitting households are 200 € on average, which enables 50% of them to increase their energy expenditure/consumption to or beyond the M/2 energy poverty threshold (Figure 4). The IF in this case would thus be 0.5. Once the different IF have been defined, a combined weighted IF is calculated using the share of owner occupier households and its complementary value in the respective energy poor population.

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Lastly, the resulting number of households is multiplied with the average household size of energy poor households to provide a number of persons lifted from energy poverty due to the EEI action.

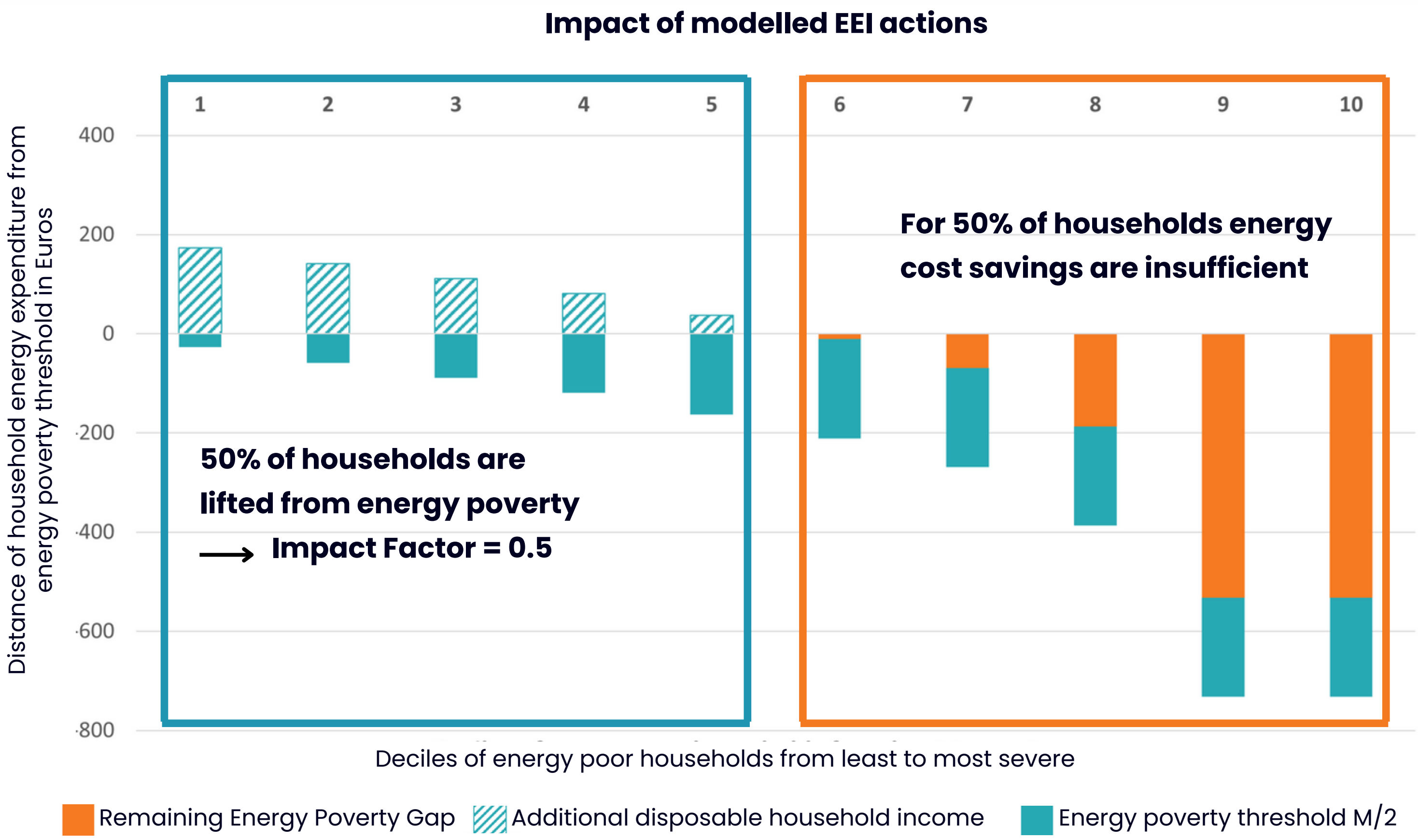

Figure 4: Visualization of Logic to determine the Impact Factor. Example: Italy

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Methodological challenges and limitations

Due to its manifestation on the household level, the quantification of energy poverty impacts from EEI actions requires a multitude of data on the building stock, household characteristics, policy design and the EEI actions themselves, which may not be available from one source and/or at the necessary level of disaggregation. Thus, depending on the tool user request (top-down or bottom-up; scenario, policy or action; local, national or EU level) and the correspondingly provided input data, several assumptions must be made, which introduce uncertainty to the model output.

- First, in cases where the distribution of EEI actions and corresponding energy (cost) savings within the respective population is unknown or users do not specify, the share of savings or number of EEI actions implemented respectively in energy poor households must be assumed. As a default value, in MICAT we use the national energy poverty shares according to the M/2 or 2M indicators for consistency reasons, however knowing that these indicators are rarely used by Member States to capture and report on energy poverty and that the underlying data is rather old (see paragraph below).

- Secondly, whether energy poor households fully benefit from the energy cost savings resulting from the energy efficiency improvement of or in their dwelling, depends on the extent to which the associated investments are borne by them either directly as investors or indirectly via increased rents. Accordingly, the share/level of energy cost savings accrued by energy poor households must be estimated as well.

If no user input is provided defining the Renovation Rent Premium, adjustments of energy cost savings will have to rely on a rather patchy empirical basis regarding rent increases following renovations, which is not available for all Member States. Furthermore, given the variety of manifestations of and corresponding metrics for measuring energy poverty, the required level of energy cost savings/additional disposable household income to "escape" the state of energy poverty is connected to some extent arbitrarily chosen threshold values.

- Lastly, the household expenditure data used to calculate some of the variables in the functions such as the national energy poverty threshold values, the Energy Poverty Gap distributions or average rents of energy poor households is taken from the 2015 HBS micro data, and hence does not reflect current household expenditure against the background of increasing rents and energy prices or energy efficiency improvements. To avoid overestimating the impact of energy cost savings of modelled EEI actions, the micro data has been manipulated to more current levels using EUROSTAT data on average household expenditures for rent and energy by country and income quintile in 2015 and 2020, and then applying the rate of change[6]. Although improving the outdated database, the use of uniform change rates per income quintile does not consider variance within these groups thus introducing possible bias in neglect of differing opportunities of households to change expenditure levels (e.g., through investments in EEI actions or acquisition of real estate).

[6] Once the 2020 wave of the harmonized HBS data has been published by Eurostat, the manipulated data will be replaced.

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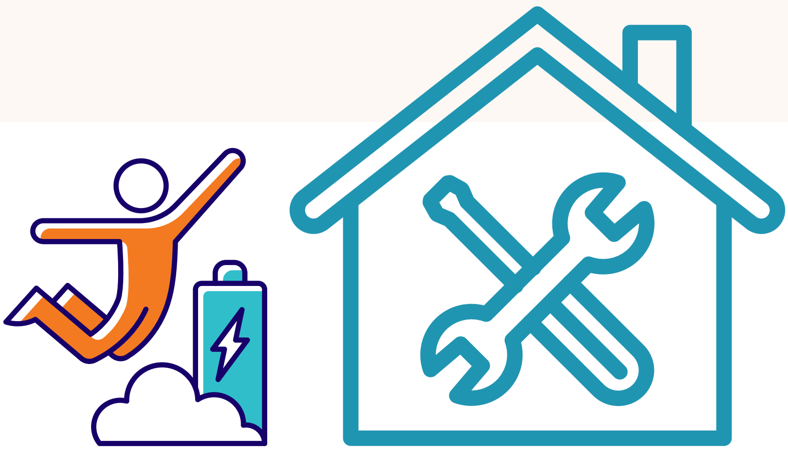
Methodological challenges and limitations

Overall, data used to define default values is mostly available at national level. The calculation of impacts at the local level thus will use these as proxies and in addition requires specific input regarding the number of EEI actions to be modelled by the Tool. Furthermore, due to a lack of certain data for all EU Member States and to not overstrain users with extensive data input requirements, several simplifying assumptions are made in the impact calculation that may not accurately reflect how modelled building targeted EEI actions (i.e., energy renovations) are/were implemented in reality. **First, it is assumed that modelled renovations are equally distributed over different building types** (single, double and multifamily buildings), whereas in reality respective activities are more likely to be implemented in single or double family buildings (e.g., due to diffuse ownership in apartment buildings, complicating decision making).

Secondly, renovations are assumed to be implemented in dwellings of energy poor tenants and owner occupiers proportional to their respective share in the energy poor population of a country, which feeds into building the weighted Impact Factor. Considering the split incentives dilemma, this can be a strong assumption, particularly in Member States with large rental sectors (e.g., Germany or Austria). **Lastly, both investment costs for and energy cost savings from building targeted EEI actions are equally distributed among building occupants** (i.e., total annualised costs and savings per EEI action are divided by the average number of households / dwellings per building), which neglects differing ownership structures as well as saving potentials (e.g., due to a (dis)advantageous location of a dwelling in a building).



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Data requirements

The following data is needed to calculate the energy poverty alleviation impact of EEI actions for different use cases and differing levels of tool user inputs:

Data	User Input	Default Value (Source)	In-Tool Calculation
Final energy savings in residential buildings by EEI action type per year	✓		
Number of (induced) EEI actions or households affected by them respectively per year	✓		Calculation based on yearly deep renovation rates (PRIMES) and occupied dwelling stock/household data (Eurostat)
Number/share of EEI actions implemented in energy poor households per year (Policy Target)	✓	Share of energy poor households according to M/2 or 2M indicator (HBS 2015)	
Subsidy rate for EEI action	✓	0	
Renovation Rent Premium	✓	4% (based on pertinent literature review)	
Occupied dwelling stock/number of households		Household statistics from the Labour Force Survey (LFS Eurostat)	
Yearly deep renovation rate		Taken from the PRIMES REF2020 scenario (PRIMES)	
Average rents of energy poor households		Average rent expenditure of energy poor tenant households according to M/2 or 2M indicator (HBS 2015, inflated)	
Average number of dwellings per residential building		Derived from Hotmaps database [7] (BPIE 2016-2020)	
Ownership rate among energy poor households		Share of energy poor households according to the indicator "Inability to keep home adequately warm living in their own dwelling (SILC 2020)	
Average size of energy poor households		Size of energy poor households according to the indicator "Inability to keep home adequately warm (SILC 2020)	
Energy Poverty Gap		Calculated based on household energy expenditure data (HBS 2015, inflated)	
Final energy cost savings per household and year			Division of aggregate cost savings by standard cost savings per EEI action (and for building targeted EEI actions by the average number of dwellings per building)
Annualised EEI action investments per household			Calculated from energy savings using standard investment values per EEI action (and for building targeted EEI actions divided by the average number of dwellings per building)
Share of energy poor households lifted from energy poverty (Impact)			Calculated with view to the net yearly energy savings and the marginal values of the Energy Poverty Gap (HBS 2015, adjusted)

[7] https://gitlab.com/hotmaps/building-stock/-/blob/196a8efc4d8841b7c062440b1fedbc6a963e7d45/data/building_stock.xlsx]

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Impact factor / functional relationship

The functional relationship to determine the energy poverty alleviation impact in terms of number of persons lifted from energy poverty (ΔEP) is as follows:

For household targeted EEI actions:

$$\Delta EP = N \; x \; PTF \; x \; IF \; x \; SSH$$

For building targeted EEI actions:

$$\Delta EP = \frac{N}{D} \; x \; PTF \; x \; \left(IF_{owner} \; x \; OR \; + \; IF_{Tenant} \; x \; (1 - OR)\right) \; x \; SHH$$

N: Number of EEI actions per year
D: Average number of dwellings per building
PTF: Policy Target Factor
IF: Impact Factor for owner occupiers, tenants or all households
OR: Ownership rate among energy poor households
SSH: Average size of energy poor households

Monetisation

In terms of monetization, the financial benefits of energy refurbishments for energy poor households are captured in the energy cost savings indicator of energy efficiency improvements and may be expressed as a share thereof. While the reduction of household spending on energy may also lead to an unburdening of public finances (e.g., via reduced energy subsidies or other public transfers), the extent of this effect is difficult to quantify as both the distribution of cost savings between landlords and tenants as well as state support frameworks are highly context specific.

Aggregation

The indicator will be aggregated and marked out as part of the energy cost savings indicator and thus included into the Cost-Benefit Analysis.

Conclusion:

This indicator reflects a central promise of the EU to implement a just energy transition and can inform energy efficiency policy design with view to key elements, namely which (sub)targets should be set for energy poor households, what level of energy cost savings per household on average should be aimed for and which subsidy level and or regulatory safeguards to achieve those savings are required or how these elements may be combined to reach a desired outcome. While allowing users to change different variables for this purpose is considered a strength of this approach, it also warrants caution regarding the results, as implausible inputs or combinations thereof may lead to inflated unrealistic outputs.

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