Regional training on indicators « *ODYSSEE-MURE* »

1.Energy efficiency indicators at sub-sector or end-use level

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What are Energy Efficiency Indicators (EEI) ?

What are Energy Efficiency Indicators (EEI)?

- Energy efficiency indicators are used to assess the progress in energy efficiency and to measure energy savings.
- They usually relate the energy consumption to either an indicator of economic activity, measured in physical values (e.g. kWh/m2 or toe/t) or to a consumption unit (dwelling, car, refrigerator) => unit or specific energy consumption consumption
- They can also be indicators of market penetration of efficient technologies and practices.
- Indicators in monetary values, called energy intensities, that relate the consumption to Value Added) (e.g. kWh/$, toe/$) are not considered here as energy efficiency indicators.

Different types of EEI

Types of indicators	Examples
Specific energy consumption of an equipment	Cars (litre/100km), household electrical appliance (kWh/year)
Unit energy consumption	Electricity consumption per employee in services, heating fuel consumption per household
Market diffusion of energy saving technology or practice	Modal share for transport of goods or passengers, share of solar water heaters, share of cogeneration, share of efficient lamps or appliances…

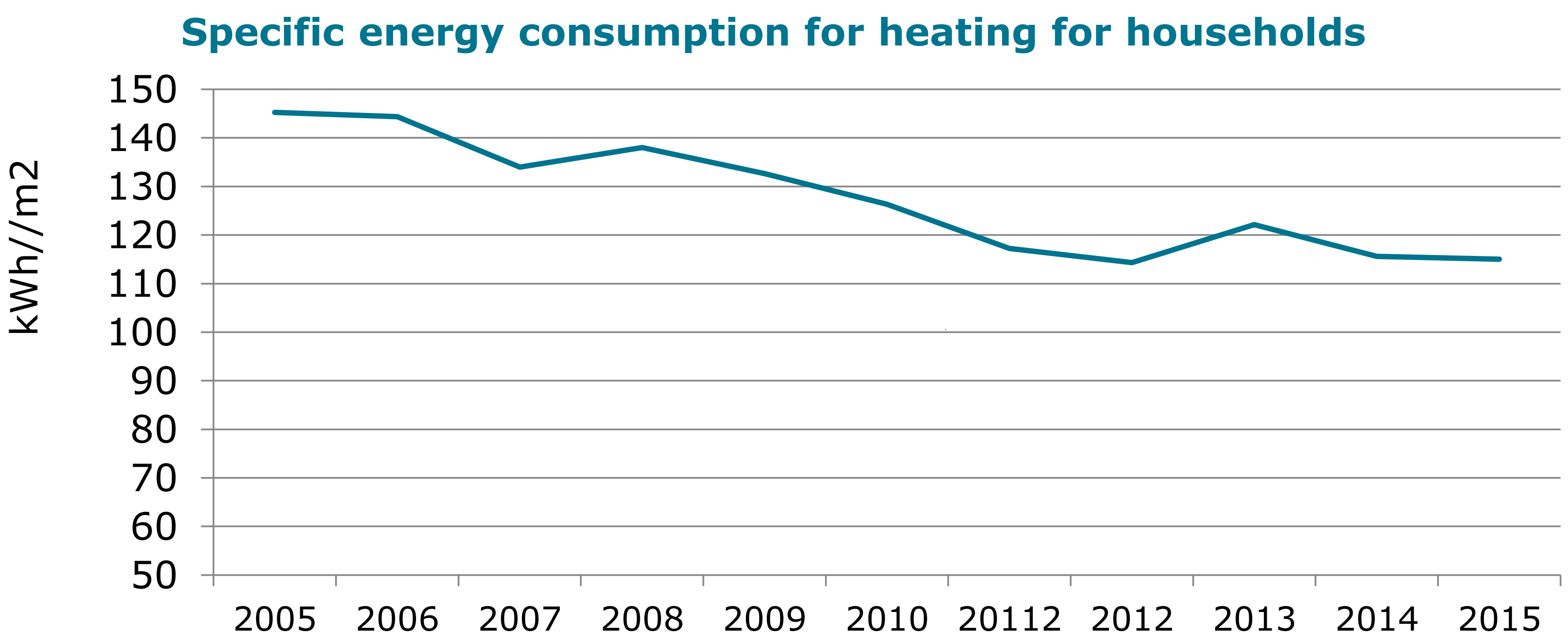
Measuring energy efficiency progress

Measuring energy efficiency progress

- Energy efficiency progress can be measured in two ways with energy efficiency indicators:
  - From the reduction in an indicator of specific or unit consumption (eg toe, GJ or kWh/t in industry);
  - From the increase in the market penetration of an efficient equipment (“indicator of diffusion”) (eg efficient electric motors)

Measuring energy efficiency progress at the level of a sub-sector: space heating

The average specific energy consumption of households for heating decreased from 145 to 115 kWh/m2 between 2005 and 2015, we can say that the energy efficiency progress was 33%* or 2.3%/year**.

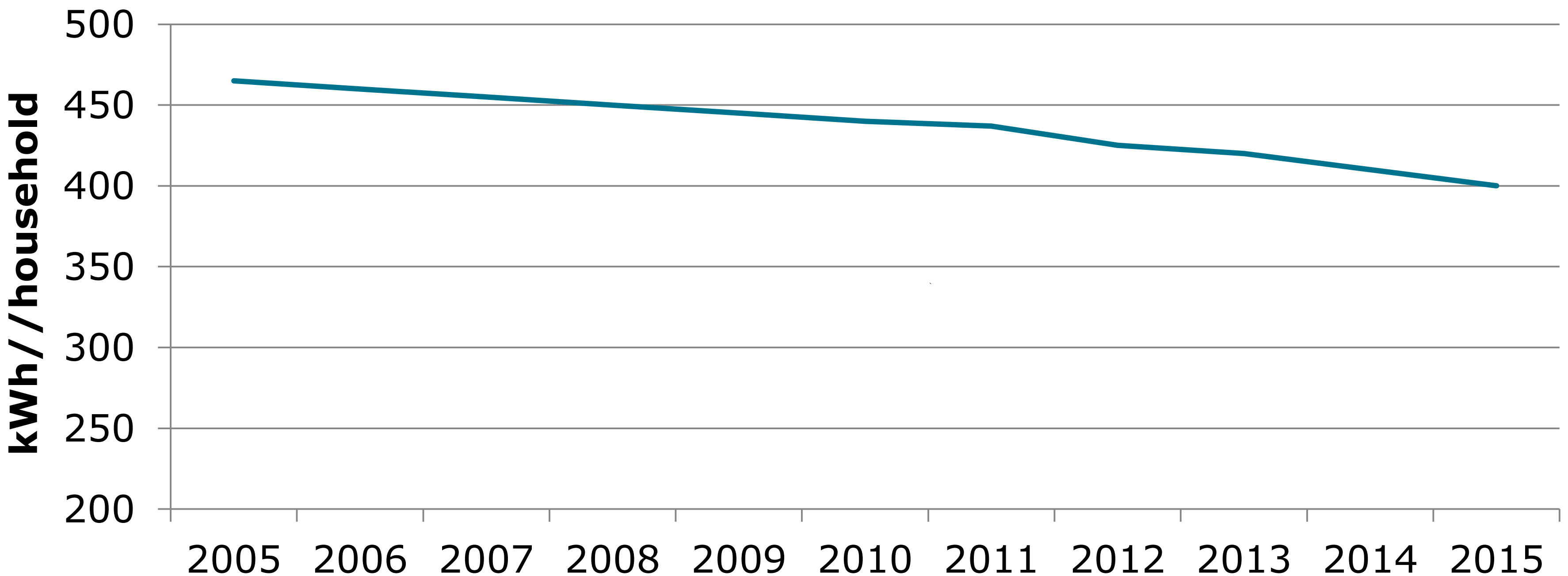


*(115/145) -1)=21%
**((115/145)^(1/10))-1= 2.3%/year

Measuring energy efficiency progress at the level of an end-use: example of refrigerators

- For instance, if the average specific electricity consumption of refrigerators has decreased from 460 to 400 kWh between 2005 and 2015, we can say that energy efficiency improved by 14%* or 1.5%/year**

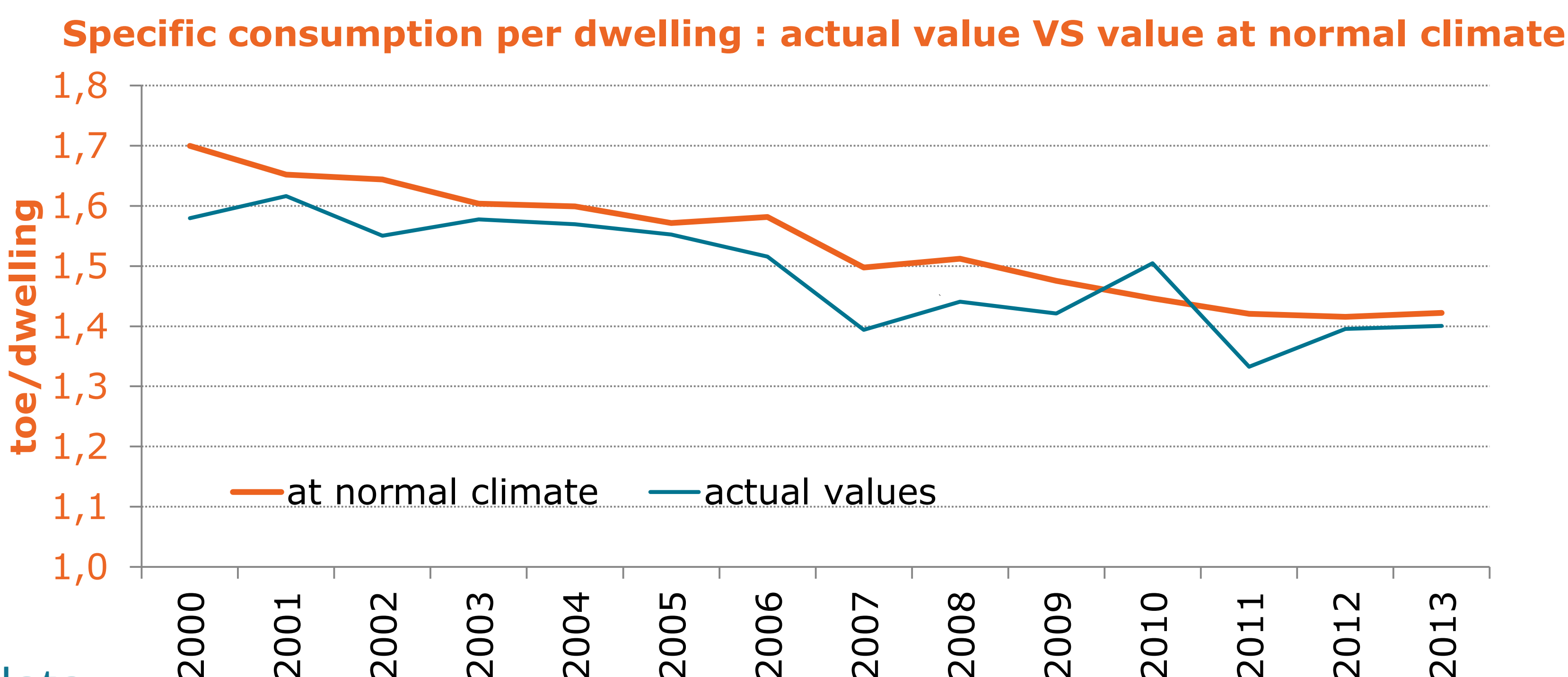
Specific electricity consumption of refrigerators per household

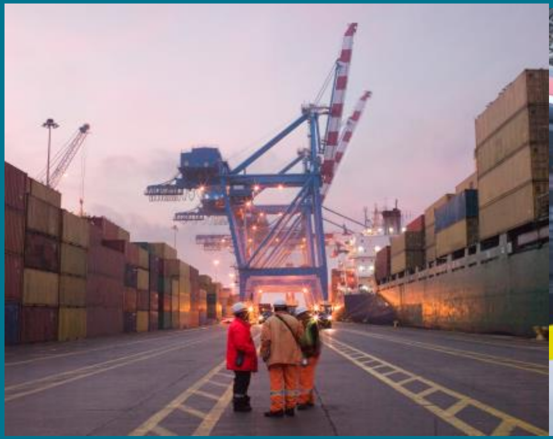


*(460/400) -1= 14%
**((460/400)^(1/10))-1=1.5%/year

Measuring energy efficiency progress for space heating and cooling: need of climate corrections

- The indicators of specific consumption for heating and cooling will vary from one year to the other because of variations in the average winter or summer average climate.
- For this reason energy efficiency indicators for heating and cooling should be measured at normal climate, i.e. with climatic corrections; this is always the case in ODYSSEE (see method in Annex)





Measuring energy savings

Measuring energy savings

- Energy savings can be measured in two ways with energy efficiency indicators:

  - As the energy not consumed because of a reduction in a specific consumption.

  - As the energy saved from the penetration of an efficient equipment (e.g. solar water heaters, efficient electric motors) or practice (e.g. public transport);

- This approach was referred to as Top-Down method in the ESD Directive and the method used in ODYSSEE and presented here is the same as the method proposed by the EU Commission for the monitoring of ESD.

Calculation of energy savings by sub-sector or end-use with a specific consumption

- Energy savings for a given year t are calculated in comparison to a base year 0, from the decrease of the energy consumption E_i due to a reduction in the specific energy consumption SEC_i ($=E_i/A_i$) between base year and t:

$$A_{i,t}*(SEC_{i,0}-SEC_{i,t}) = A_{i,t}*(E_{i,0}/A_{i,0}-E_{i,t}/A_{i,t})$$

with A_i indicator of activity (production, number of equipment..)

- This method is similar to the "t*op-down method" recommended to calculate energy savings for the monitoring of ESD.*

- Savings are positive if there is a decrease of specific consumption.
- .

Calculation of energy savings by end-use : example of refrigerators

- Case of refrigerators in a country, with the following characteristics:

	2000	2015
Specific consumption	400 kWh	300 kWh
Number of refrigerators		2 M

- Energy savings in 2015 = $(400-300)*2*10^6 = 200*10^6$ kWh = 200 GWh (compared to 2000).
- Without these energy savings the energy used would have been 200 GWh higher in 2015, i.e. equal to 800 GWh instead of 600 GWh ➔ rate of energy savings or energy efficiency progress: (1-(600/800))*100 = 25%

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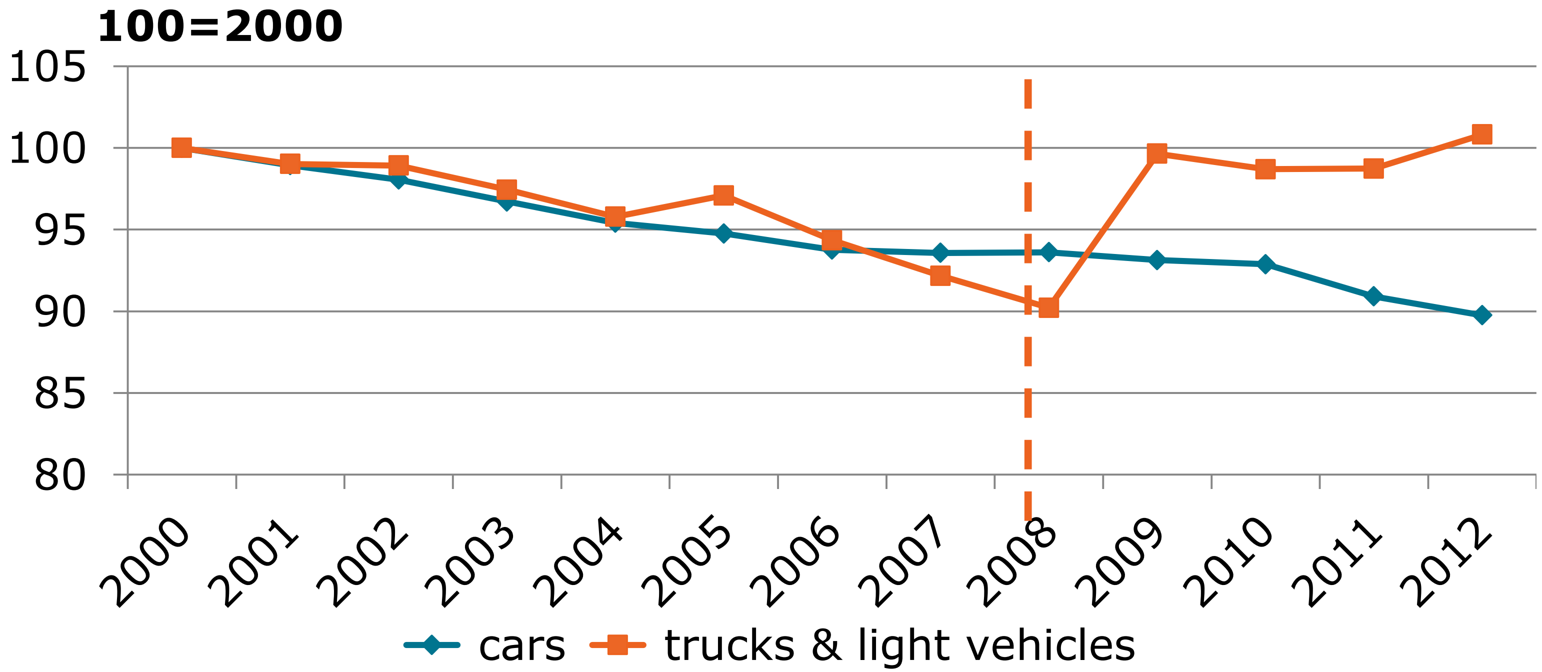
Measuring energy efficiency progress at the level of end-use/sub-sectors : calculation issue with EEI

- The indicators may increase or decrease less than expected because of other factors ➔ in that case the calculation will measure negative savings or underestimate the actual savings.
  - For instance, low reduction in specific consumption of refrigerators or TV because of increasing size, despite the fact they are more efficient.
  - Increase of specific consumption during periods of recession due to an inefficient operation of equipment in industry (kilns, boilers, motors) and freight transport (trucks) because of low rate of capacity utilization… although the existing equipment are not less efficient from a technical point of view.

- Necessity to get additional data, whenever possible, to clean the indicator trends from these other effects
  - For instance by disaggregating in more detailed sub sectors
  - By using kWh/litre for refrigerators to remove the size effect.

Increase in specific consumption: trucks



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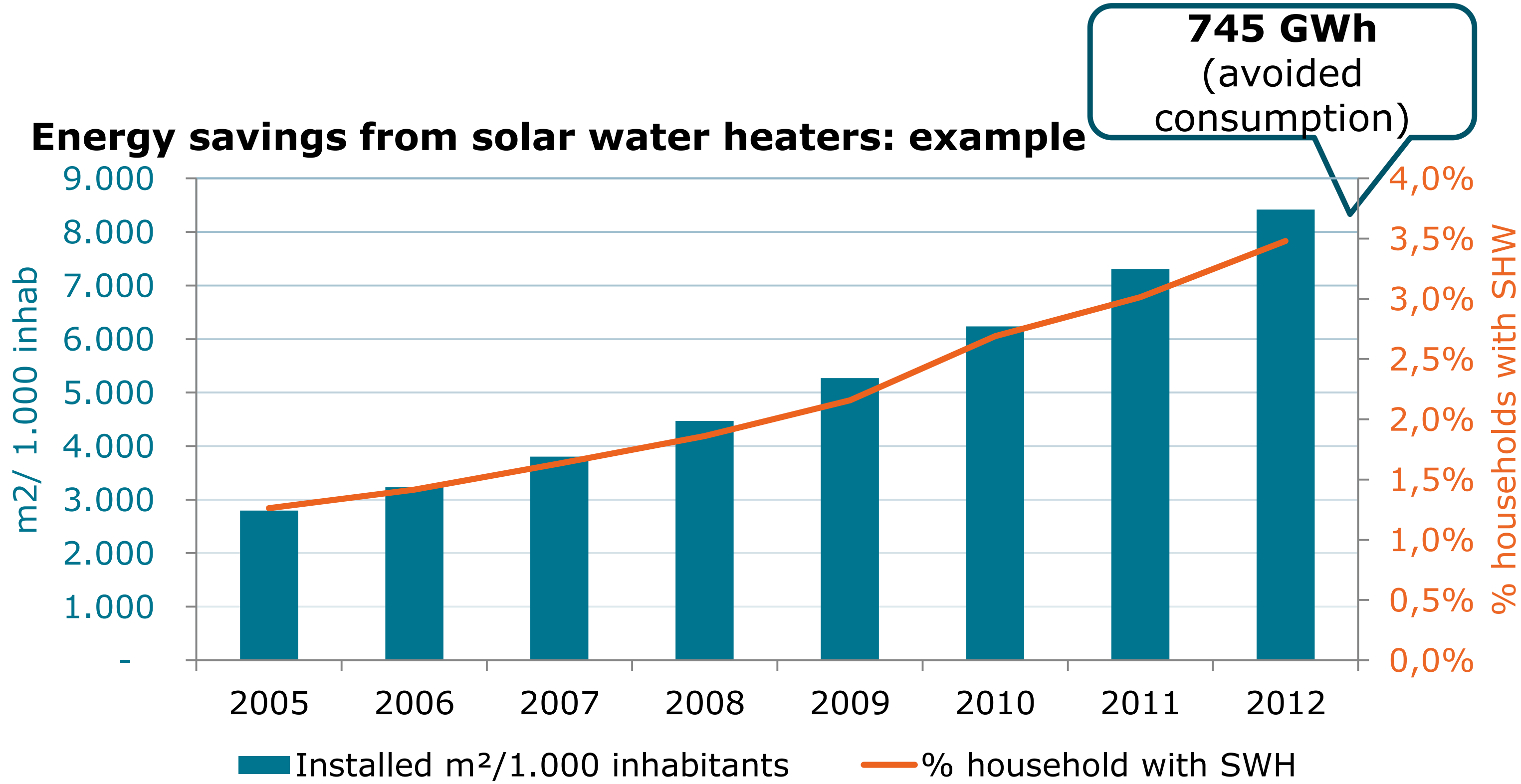
Energy savings from diffusion indicators

- Energy savings calculated from diffusion indicators are equal to the number of efficient appliances sold (or distributed) multiplied by the average saving per appliance, i.e. the difference of specific consumption between that of the efficient appliance and of a reference appliance.



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Top-down savings vs bottom-up savings (1/2)

- Energy savings calculated with EEI are usually referred to as "top-down" savings.

- They are often opposed or compared to the so-called "bottom-up" savings , that assess the energy savings associated to a specific energy efficiency measure; in that case they represent the sum of savings of all consumers that have implemented the measure

- Both types of savings rely on the same indicators: for instance kWh/m2 for buildings ➔ only their scope and interpretation differ.

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Top-down savings vs bottom-up savings (2/2)

- The calculation formula of BU savings is similar to that of TD savings : only the reference may be different:
  - In top-down the reference is the average performance (i.e. specific consumption) at base year;
  - In bottom up, various references may be considered:
    - ✓ The average of the market (i.e. what consumers would normally buy)
    - ✓ The average replaced appliances (i.e. similar to top-down)

- Their scope differ:
  - Top-down indicators measure all types of energy savings, i.e. total savings, whatever the driving factor: policy measure, energy prices ,autonomous trend.
  - "Bottom-up" savings assess the impact of a specific energy efficiency programme.

Top-down vs bottom-up energy efficiency assessment: case of Solar Water Heaters (SWH)

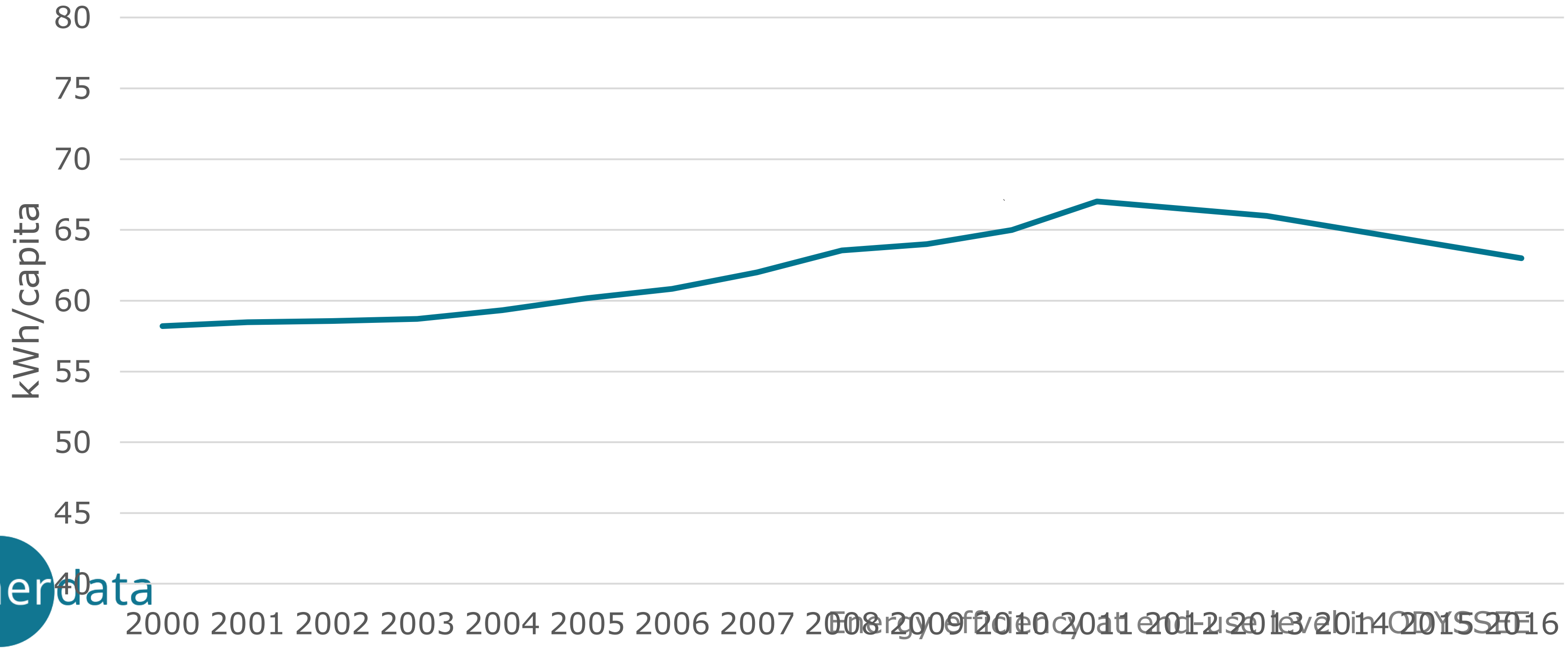
- **Top down**: assess total energy savings from Solar Water Heaters.
  - Energy savings = total area of SHW installed in the country * average saving per m2 (=20 GWh), with:
    - Total area based on national statistics of annual sales and cumulated over the period (e.g. 200 000 m2)
    - Average saving per m2 based on solar radiation and hours of use of SWH (heat supplied by SHW) (e.g 100 kWh/m2)

- **Bottom-up**: assess the savings linked to a specific policy measure (e.g. subsidies):
  - Savings = total area of subsidized solar water heaters installed in the country benefiting from the subsidy (e.g. 150 000) * average saving per m2 (=15 GWh);
  - Average saving per m2 : same as for top down (or measured from a sample survey)

Top-down vs bottom-up energy savings: public lighting

- Top-down energy savings since 2012 as specific consumption start decreasing from 67 kWh in 2011 to 63 kWh/cap in 2016: 400 GWh (100 M inhabitants).
- BU savings calculated from the number of lamps replaced by efficient lamps from a national programme (i.e. 100 000 per year between 2012 and 2016 with an average saving of 500 kWh/lamp ➔ BU saving=500 000*500=250 GWh

Specific electricity consumption for public lighting



What are the best indicators to use?

Various energy efficiency indicators by sub-sector/ end-use

- Various alternative energy efficiency indicators may be considered to measure energy efficiency improvements (or energy savings) by end-use/sub-sector; their selection depends on 3 main criteria:

    - The definition of energy efficiency (economic efficiency versus technical efficiency) ;

    - The type of policy measures to evaluate (e.g. for cars measures to improve the efficiency of vehicles vs measures on car sharing or modal shift);

- Depending on the objective some indicators are more suited ("preferred").

- However, depending on the availability of data: alternative indicators to the "preferred" indicators are often necessary to cope with data gaps.

Alternative EEI for heating

- Specific consumption per m2 at normal climate (kWh, toe or GJ/m2)
- Specific consumption per dwelling at normal climate (kWh, toe or GJ/dwelling)
- Specific consumption per m2 per dwelling equivalent with central heating (important for countries with a diffusion of central heating, e.g. Ireland, southern Europe)

	kWh/dwelling	kWh/m2	kWh/m2 (per dwelling equiv with central heating)
Pros		•Corrected for change in the average size of dwellings	•Corrected for the change in dwelling size and penetration of central heating
Cons	•Reduces the energy savings when dwelling size increases		•Implies an estimate on increased energy use with central heating compared to stove heating (+50%)

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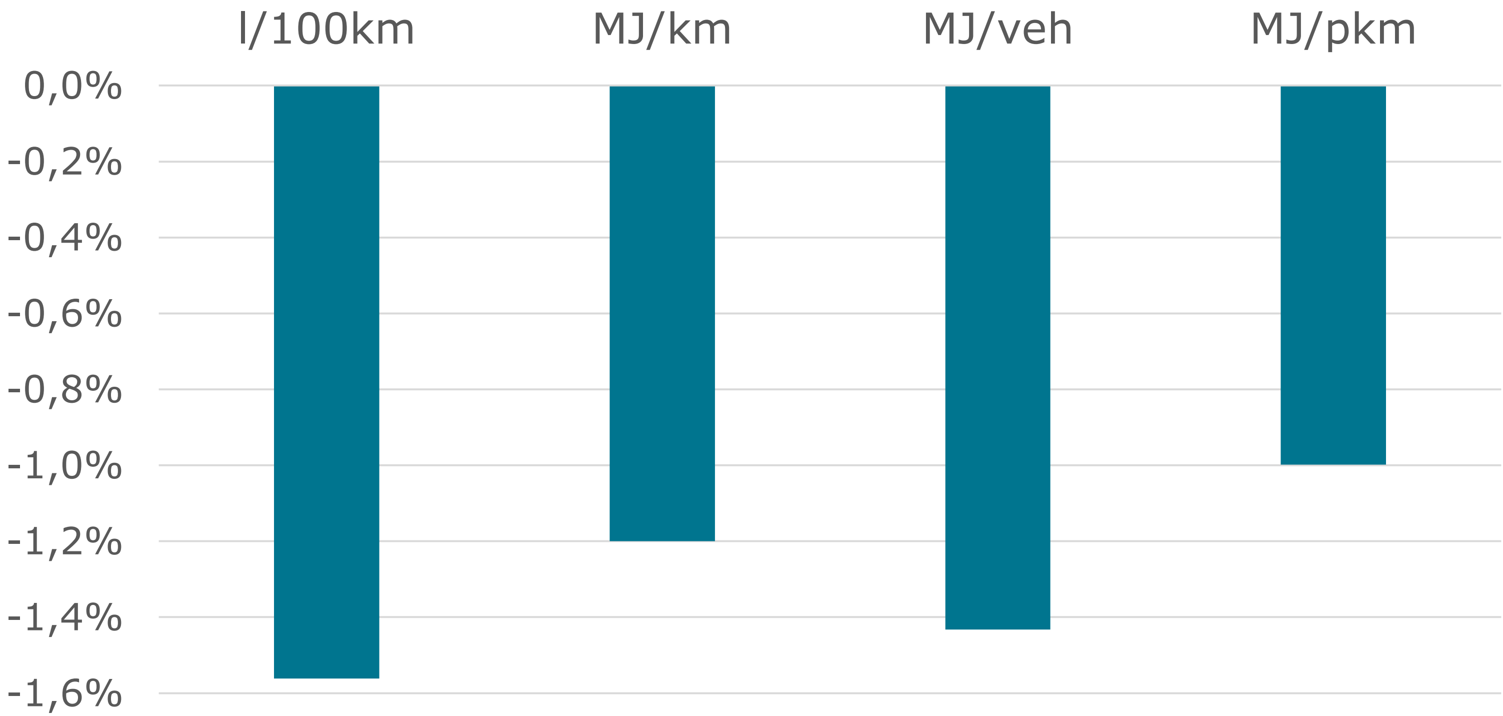
Alternative EEI for cars

	l/100 km or MJ/km	GJ or toe/car	MJ or toe/pkm
Pros	• Gives the closest measure of the technical efficiency of cars • Reflects also the impact of driving behaviour (ecodriving, speed limit) and shift to smaller cars • MJ/km account for change in motor fuel mix (eg biofuels).	• Indicates how efficient is the use of cars (technical, efficiency plus reduced mileage) • Combined with l/100 km enables to separate technical and behavioural savings	• Indicates how efficient is the mobility by car • Reflects the increase in car pooling
Cons	• Excludes part of behavioural savings (reduced use of cars and increased use of public transport)	• Does not separate technical and behavioral savings	• Data on passenger-km uncertain

Alternative EEI for cars: case of Sweden*

- Penetration of biofuels reduce the decrease shown for l/100km;
- MJ/vehicle decreases faster than MJ/km because of reduced mileage (shift to public or non motorized transport);
- MJ/pkm decreases less than MJ/km because of decrease in load factor



*2000-2013

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Interpretation of EEI trends

Interpretation of trends in EEI by combining different indicators

- The interpretation of EEI trends can be enriched by comparing the trends in two different indicators.

Examples for the household sector

End-use	Indicators to be compared	Interpretation of differences
Household heating	kWh per m^2 and per dwelling*	Effect of change in dwelling size
Household heating	kWh/m^2 (or dwelling) in final and useful energy**	Effect of change in fuel mix
Refrigerator	kWh /appliance and kWh/litre	Effect of change in appliance size
Cooking	toe/household in useful** and final energy	Effect of change in fuel mix
Electricity	kWh per household and kWh per electrified household	Effect of electrification

*kWh per m^2 is given as example; it can be toe or GJ per m^2
**useful energy= $\sum$ final energy by fuel * end-use efficiency by fuel

▪ The average dwelling size increased (by 4% since 2000 at EU level reaching.
▪ As a result, energy consumption per dwelling decreased slightly less than consumption per m2 (2% vs 2.4%/year) ➔ almost 20% of the energy efficiency progress for thermal uses has been offset, all things being equal, by the larger size of dwellings.

Consumption per m² VS consumption per dwelling for household heating (2000-2011)

Interpretation of trends: combination of EEI by sub-sector: transport sector

End-use	Indicators to be compared	Interpretation of differences
Cars	litre/100 km and MJ/km	Effect of change in motor fuel mix
Cars	MJ/km and MJ/pkm	Effect of change in car occupancy
Cars	litre/100 km and MJ/pkm	Effect of change in fuel mix and car occupancy

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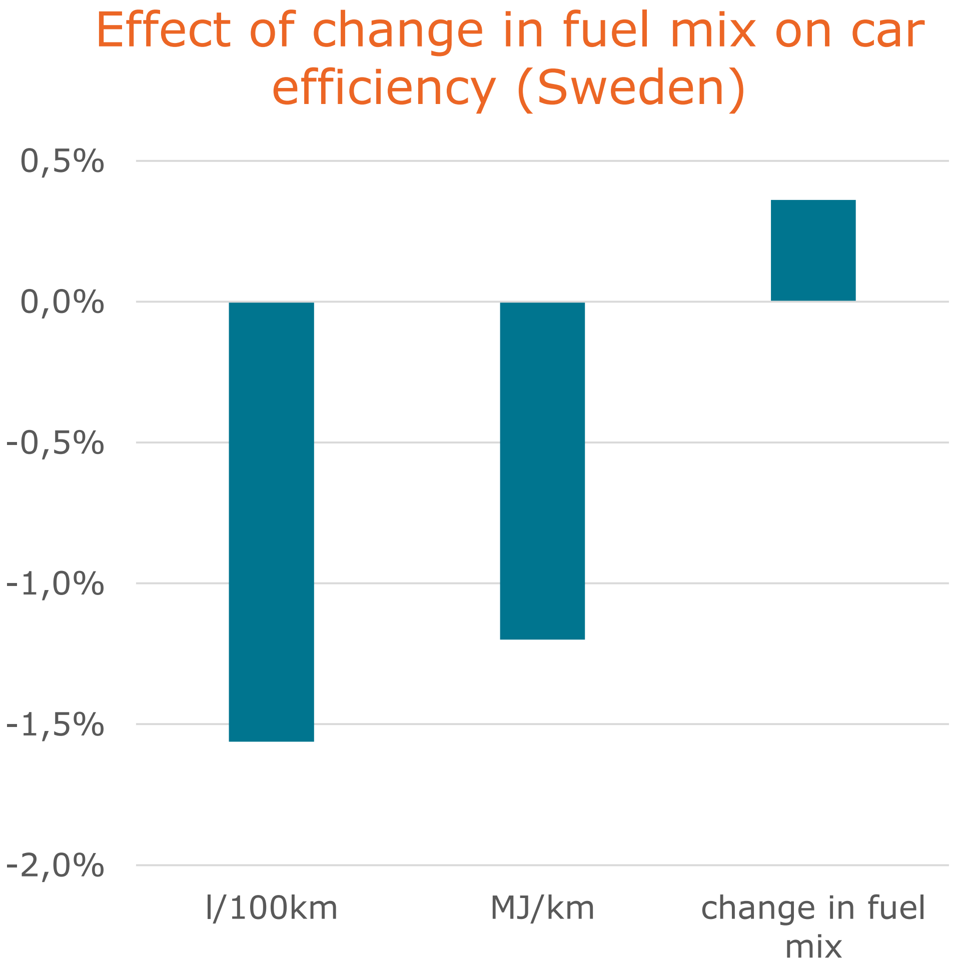
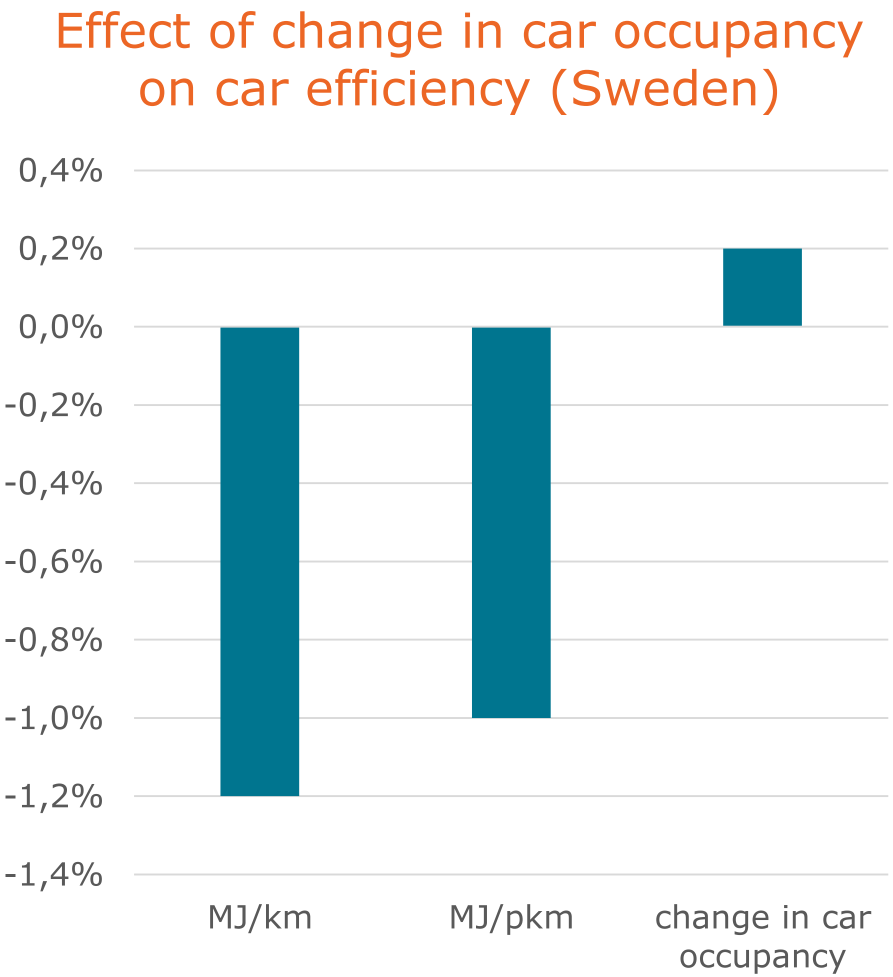
Interpretation of trends: combination of EEI by sub-sector: transport sector





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Link policies and indicators

EEI and policy evaluation

- Can we evaluate the impact of policy measures with indicators?
  - Generally not for a single policy measure
  - Yes for the package of measures that act on the specific indicator.

- Generally a given measure targets a specific end-use or appliance/equipment (case of labels or efficiency standards or targeted financial incentives)… but several measures usually target the same end-use ➔ mapping of measures

- To do this mapping, we have to identify which end-uses are impacted by each measure and select indicator(s) of this end-use(impact or diffusion indicators).
- Then for each end-use we get the package of measures that target it and the related indicators .

EEI and policy evaluation: case of households

- **Heating**: specific consumption per m2/dwelling at normal climate (toe/m2) (stock average and new dwellings) ➔ *shows the impact of building regulations, of policies to promote efficient boilers and to support building refurbishment*
- **Water heating**:
  - unit consumption per dwelling ➔ *shows the impact of policies to promote solar water heaters and efficient boilers*
  - diffusion of solar water heaters (m2 installed) ➔ *shows the impact of policies to promote solar water heaters*
- **Large electrical appliances** (refrigerators, freezers, washing machine , dishwashers, dryers and TV) : specific consumption per appliance (kWh/year) ➔ *shows the impact of labelling, efficiency standards, Voluntary Agreements and other measures to promote efficient appliances*
- **Lighting**:
  - specific consumption per dwelling (kWh/year) ➔ *shows the combined effect of labelling, standards and other measures to promote CFL, as well as behaviours*
  - penetration/sales of CFL ➔ *shows the impact of labelling, of standards and other policies to promote CFL (Compact Fluorescent Lamps)*

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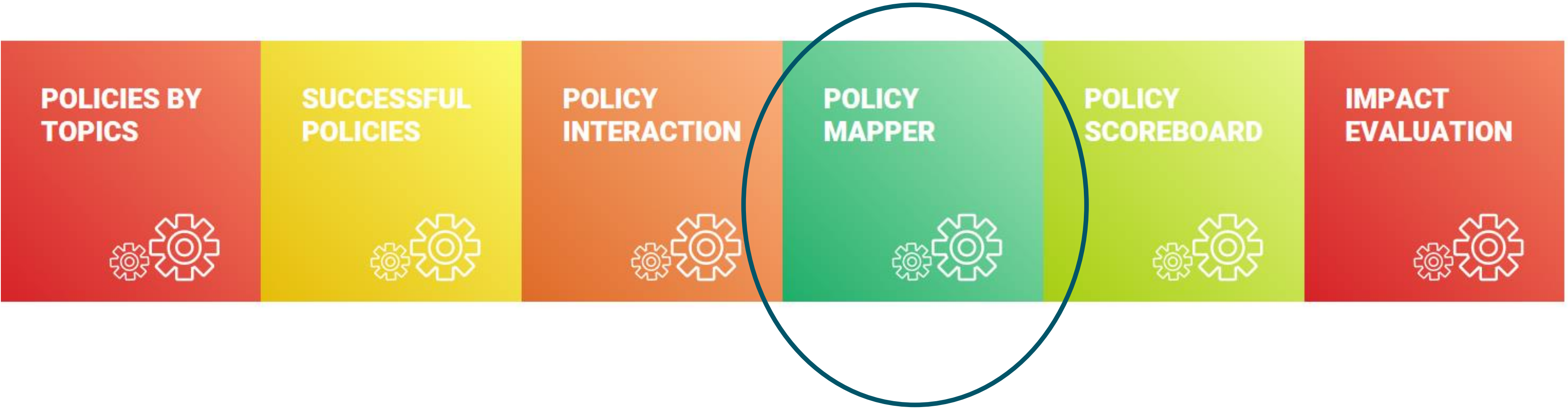
MURE policy mapper

- This tool shows which indicators can be used to monitor the impact of specific policy measures.
- It also shows the trends in the indicators in relation to the implementation of the measure



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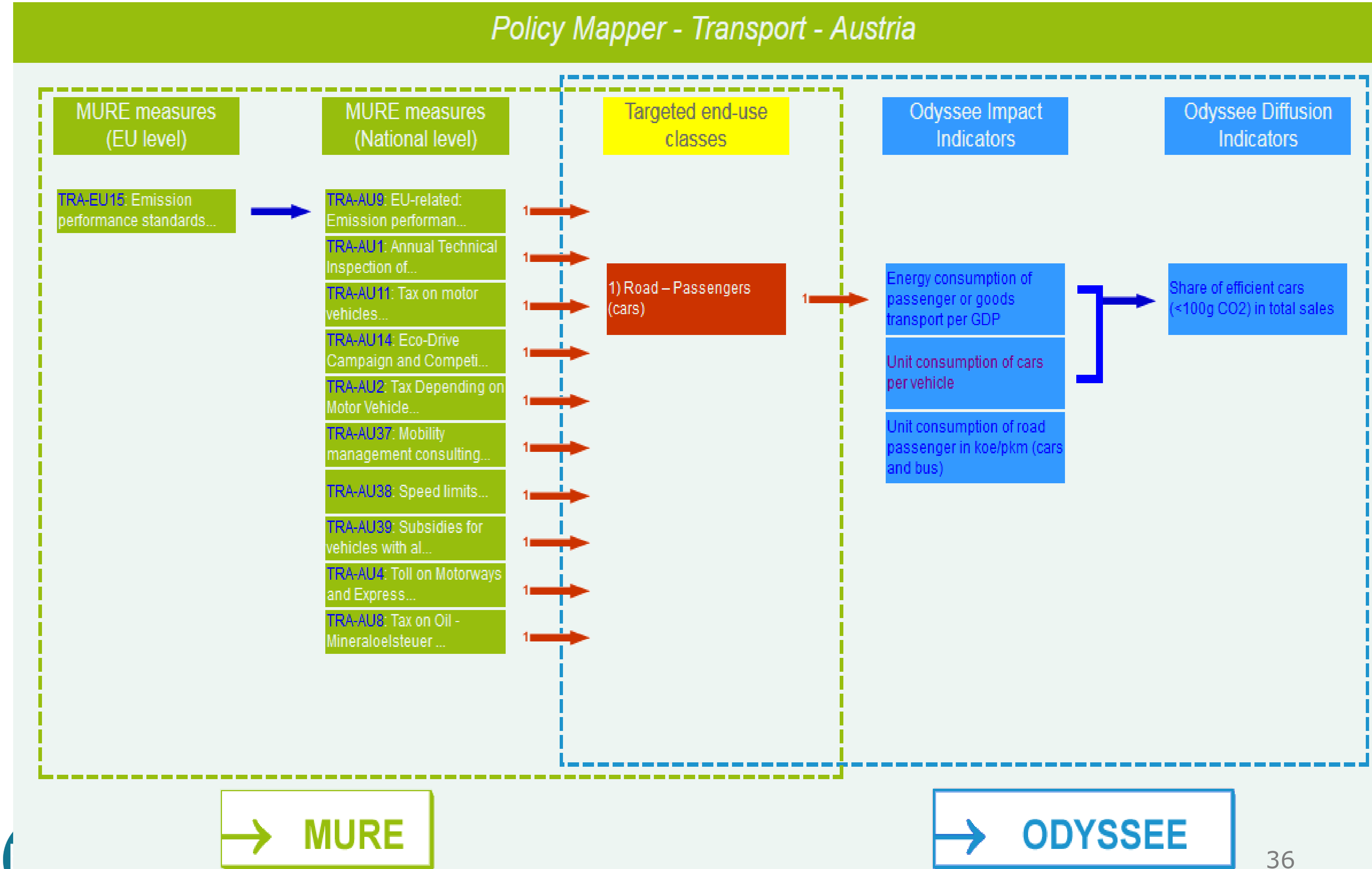
Link policy measures and indicators with MURE policy mapper: case of cars for Austria



Conclusion: the 10 benefits of energy efficiency indicators

10 Benefits of BIEE indicato rs
Organization of information
Understanding trends
Market insight
Benchmarking
Target setting
Target monitoring
Policy monitoring
Long-term impact
Dissemination of results
Multiple benefits of EE