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Odyssee MUREII

Decomposition analysis of the energy demand Methodology and ODYSSEE tool

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Session 1 : reporting

The decomposition analysis can answer to the MS yearly requirement reporting

(Annex XIV, part 1) EED: *“In sectors where energy consumption remains stable or is growing, Member States shall analyse the reasons for it and attach their appraisal to the estimates.)*.

1. **Methodology of the decomposition analysis: general principle and example of calculation**
2. ODYSSEE : current application at sectorial and end-use levels
3. ODYSSEE : The decomposition facility
4. Conclusion

Enerdata

Decomposition of the final energy consumption variation Methodology (general principle)

- A decomposition of the energy demand variation is carried out for each sector (industry, transport, household, services) to show what are the drivers behind the changes observed.

- For each sector, the decomposition is calculated as the sum of decomposition by main end-uses or sub-sector.

- Since we are dealing with volumes in ktoe the factors can be added.

- Changes in the final energy consumption between 2 years is decomposed in the following explanatory factors or technico-economic effects:
  - An activity effect, to assess the impact of an variation of the production in industry, variation on number of dwellings in households, changes in traffic of passengers and goods, change in number of employees in services etc on the energy demand.
  - Energy savings , to assess the impact of unit consumption changes measured at end-use or sub-sector level;
  - Structural changes, to assess the change in industry structures, change in transport mode distribution
  - A climatic effect,   to show the impact of climate difference between the 2 years;
  - Other effects, such as lifestyle effects , demography effect etc

This methodology is coherent with the methodologies used in EU recommendations on energy saving calculations, in CEN-CENELEC and the ISO 17742

- Energy savings per indicator are calculated from the change in indicator value between two year (t and t-1) combined with the driver at year t:

$$ESPI = [(IND_{(t-1)} - IND_{(t)})] \times DV_{(t)}$$

Where ESPI: energy savings per indicator;
IND is indicator (for instance unit consumption of cement)
DV is the driver (e.g physical production of cement for instance

- For example, the energy savings for cement production at year *t* are derived from the change in energy consumption per tonne of cement between year t and the previous year t-1. This quantity in GJ/tonne is multiplied by the total production of cement in year *t*.

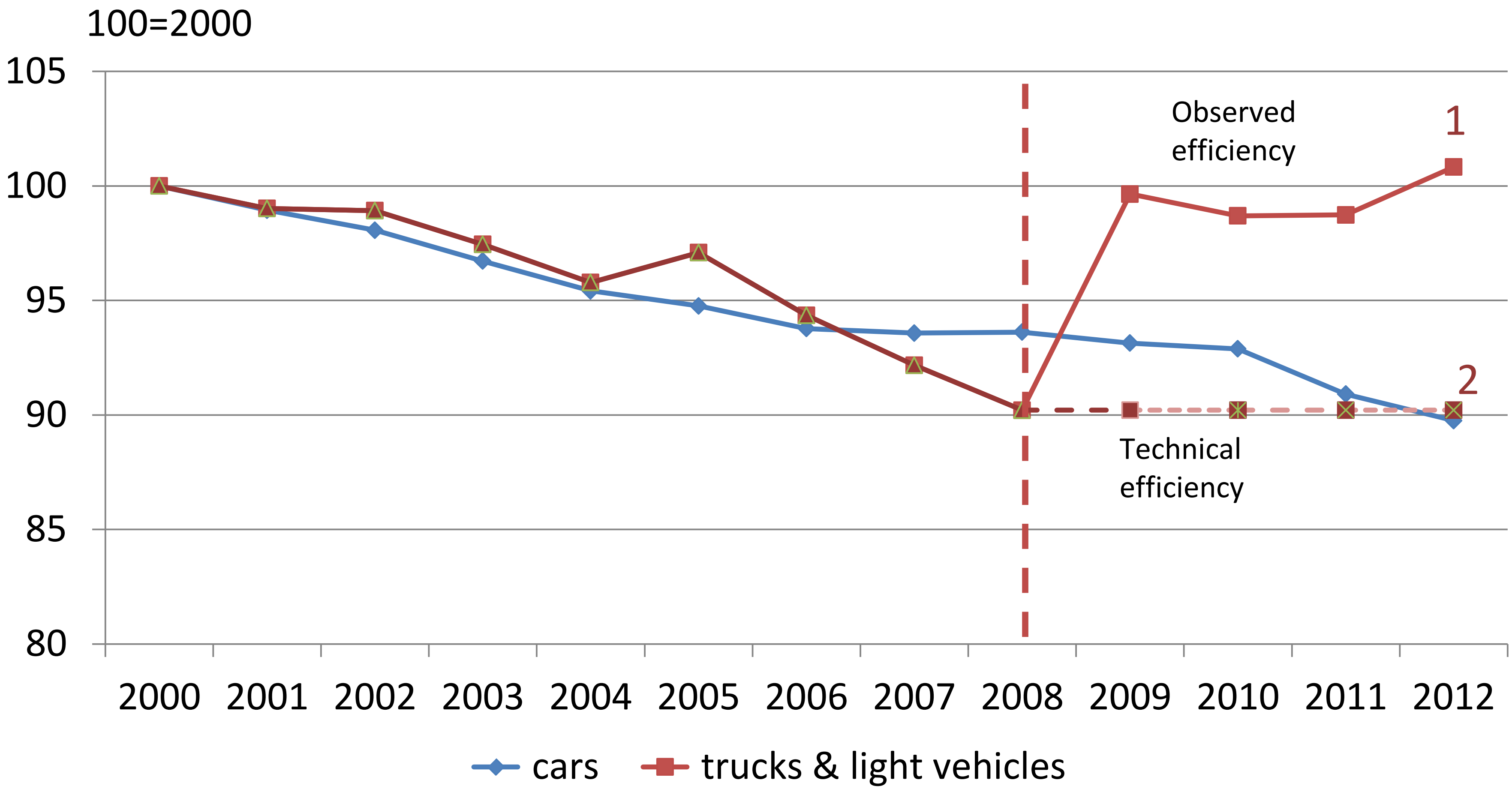
Observed energy savings versus technical savings

- As explained above, energy savings are on the basis of the observed variation in the specific consumption.

- In some countries, these specific consumption in industry and road transport of goods are increasing because of the low utilisation rate of capacities or trucks during the recent economic crisis etc), implying a deterioration of energy efficiency, which is not well understood.

- Therefore, in ODYSSEE we have introduced the concept of **"technical savings"** , which assume that energy efficiency, and hence savings cannot reverse.

Technical versus observed efficiency/savings: case of transport



1. Methodology of the decomposition analysis: general principle and example of calculation
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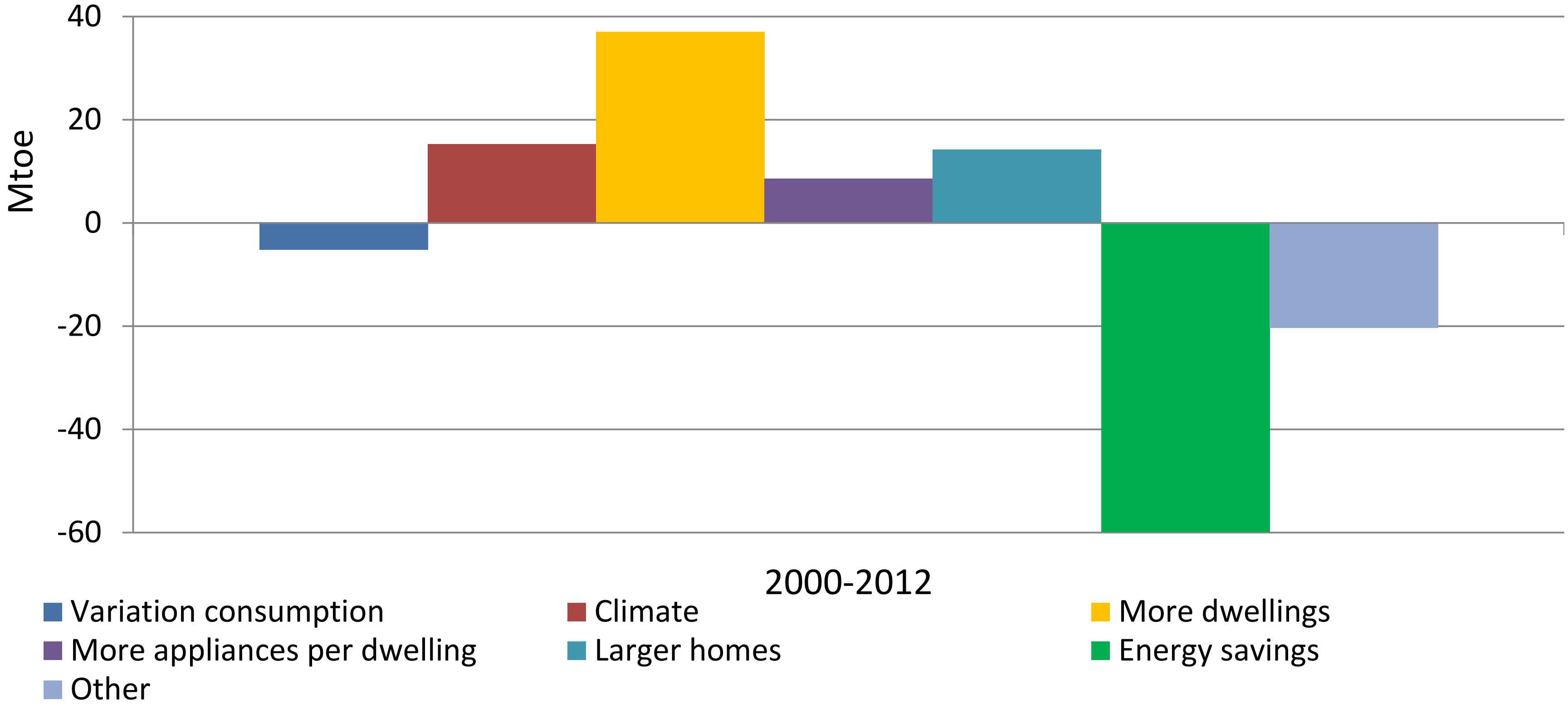
Energy consumption of households between 2 years is changing under the influence of :

- Climatic effect (due to climatic difference between years t and t-1)
- Change in number of occupied dwelling (more dwellings")
- Evolution of lifestyles:
  - Average floor area of dwelling for space heating ("larger homes")
  - More appliances (electrical appliances, central heating)
- Energy savings
- Change in heating behaviors

Decomposition of energy consumtion changes for households (EU)



Decomposition of the energy demand in transport

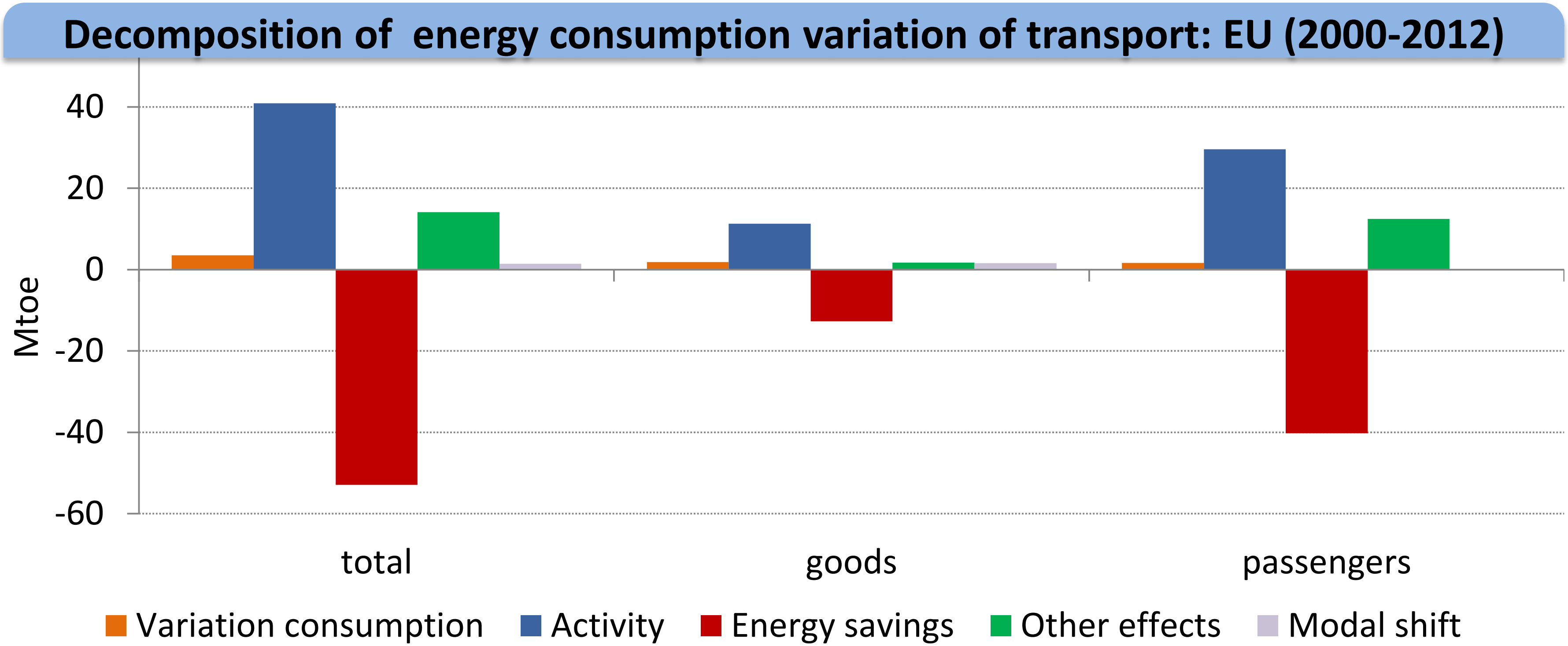
Transport energy consumption is changing under the influence of various factors

- Change in traffic (“activity effect”) measured in pkm or tkm
- Energy savings (i.e. change in the efficiency of cars, trucks etc)
- Modal shift, ie change in the share of each transport modes in the total traffic
- Other effects, i.e behavioral effects and "negative savings" in freight transport due to low capacity utilization.

The calculation is done for passengers, freight and air transport separately.

Two opposite trends may explain the variation of the energy consumption in transport :

- Change in passenger and goods traffic (40 Mtoe)
- Other effects, i.e. i.e behavioral effects and "negative savings" in freight transport due to low capacity utilization.
- On the opposite , energy savings (mainly for passengers) (around 50 Mtoe)



Source : ODYSSEE

Air transport included

Decomposition of the energy consumption in services

Energy consumption in services is changing under the influence of various factors :

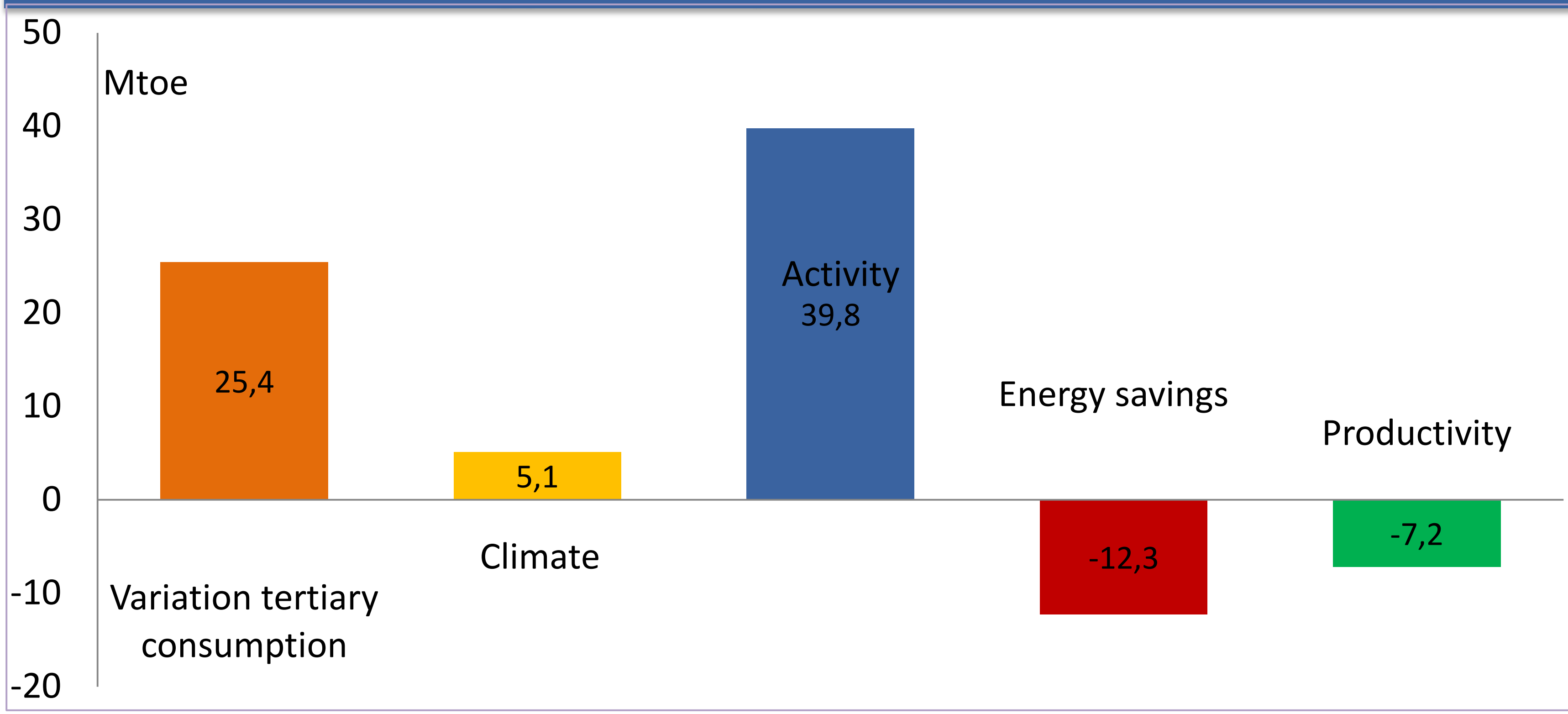
- Climatic effect (due to climatic difference between years t and 0)
- Change in activity (in terms of employee)
- Energy savings (based on toe/employee)

The quantity effect can be further split between 3

- **An activity effect as** measured by the changes in value added
- **Structural changes** : Assess the impact of the VA structure changes ie the fact that individual branches with different energy intensities are not growing at the same rate (“structural effect”)
- **A productivity effect** which assess the impact of the change of the ratio VA/employee

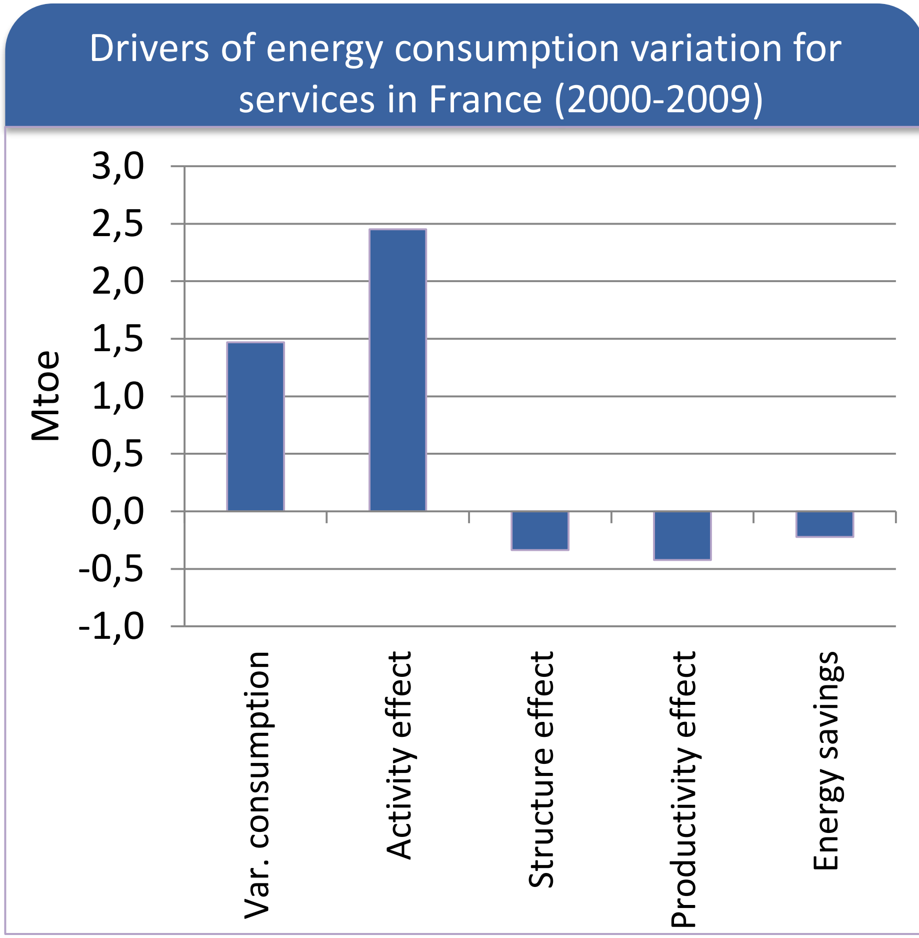
- The energy consumption of services increased by 25 Mtoe from 2000 to 2012
- Increase of the value added contributed to raise consumption by almost 40 Mtoe .
- Energy savings and labour productivity gains (VA/employee) decreased the consumption by 12 and 7 Mtoe respectively.

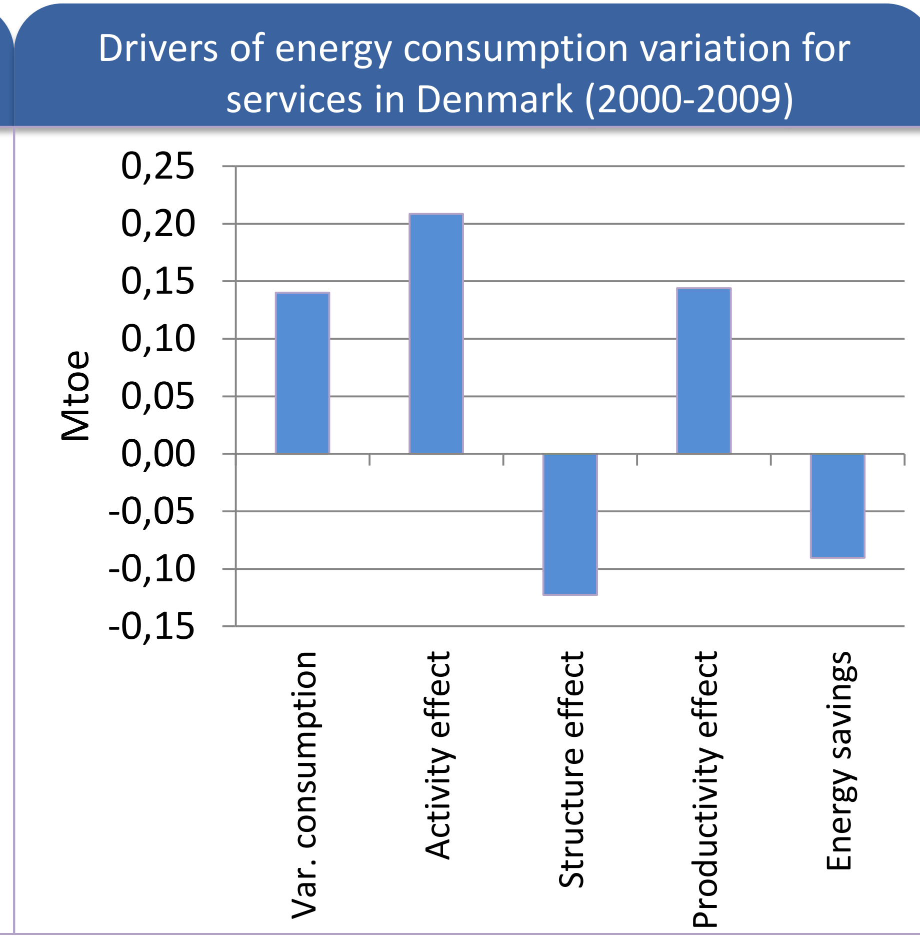
Drivers of the energy consumption in services (2000-2012): EU



Energy savings based on change in energy consumption per employee

- Activity is the main driver of energy demand in the tertiary sector
- Changes in the economic structure of services as well as changes in labour productivity also contribute to change in energy use although no clear pattern can be established





Decomposition of the final energy consumption in industry

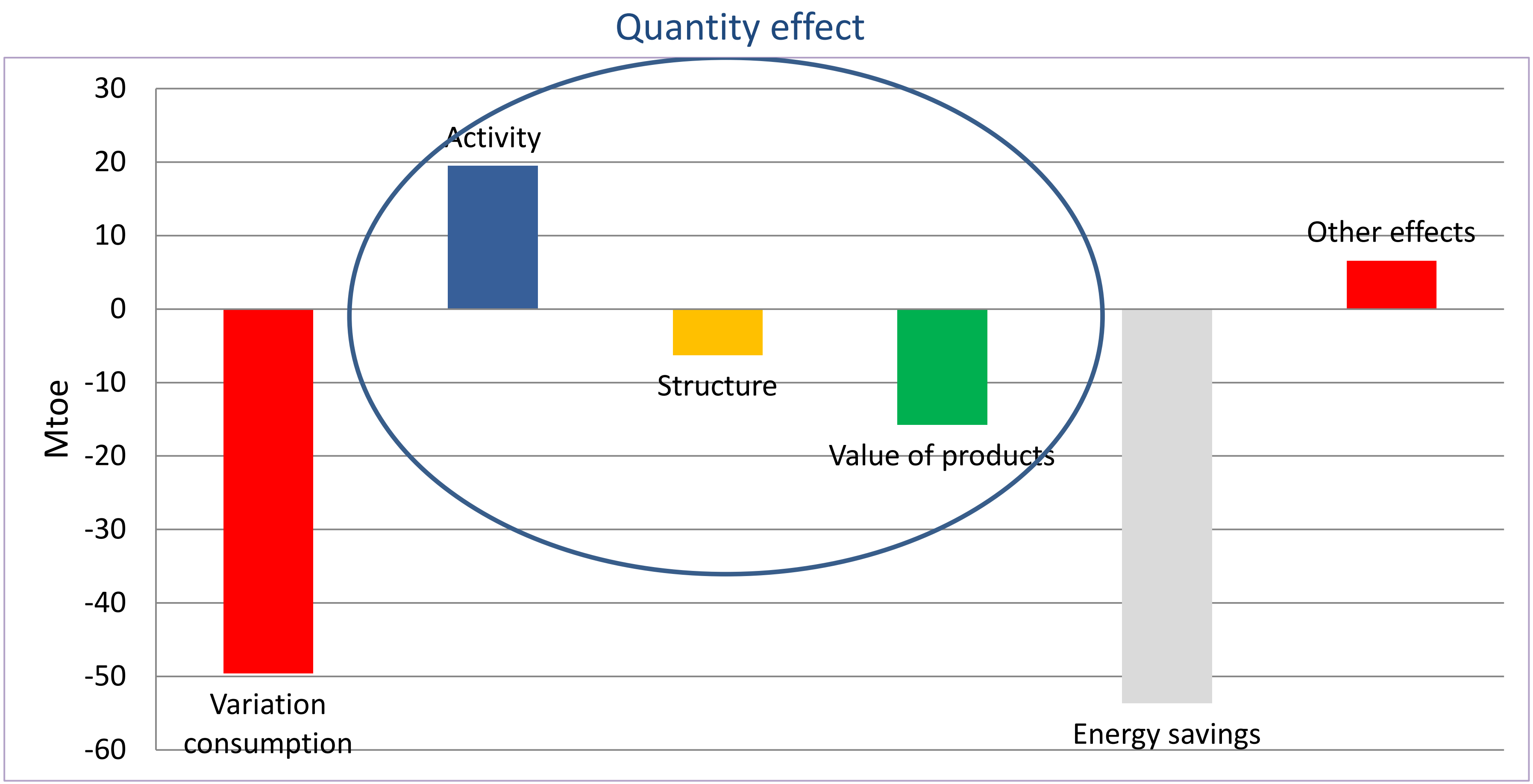
The variation of the industrial energy consumption is influenced by the following factors :

- Change in industrial activity (measured with the value added) ("activity effect");
- Structural changes ("structural effect)", i.e. the fact that individual branches with different energy intensities are not growing at the same rate;
- Changes in the value of production, i.e. in the ratio value added over physical production (for steel, cement and paper) or production index (for the other branch);
- Energy savings calculated from changes in energy consumption per unit of production at branch level;
- Other effects: mainly "negative" savings due to inefficient operations in industry.

The effect of change in physical production at branch level is actually the sum of three effects: activity, structural changes and value of products.

The sum of "energy savings" and "other effects" show the impact of changes in specific energy consumption at branch level.

Decomposition of the energy consumption in industry (2000-2012): EU



* Activity and structural effects based on value added; value of product: change in ratio value added over index of production

Decomposition of the total final energy consumption

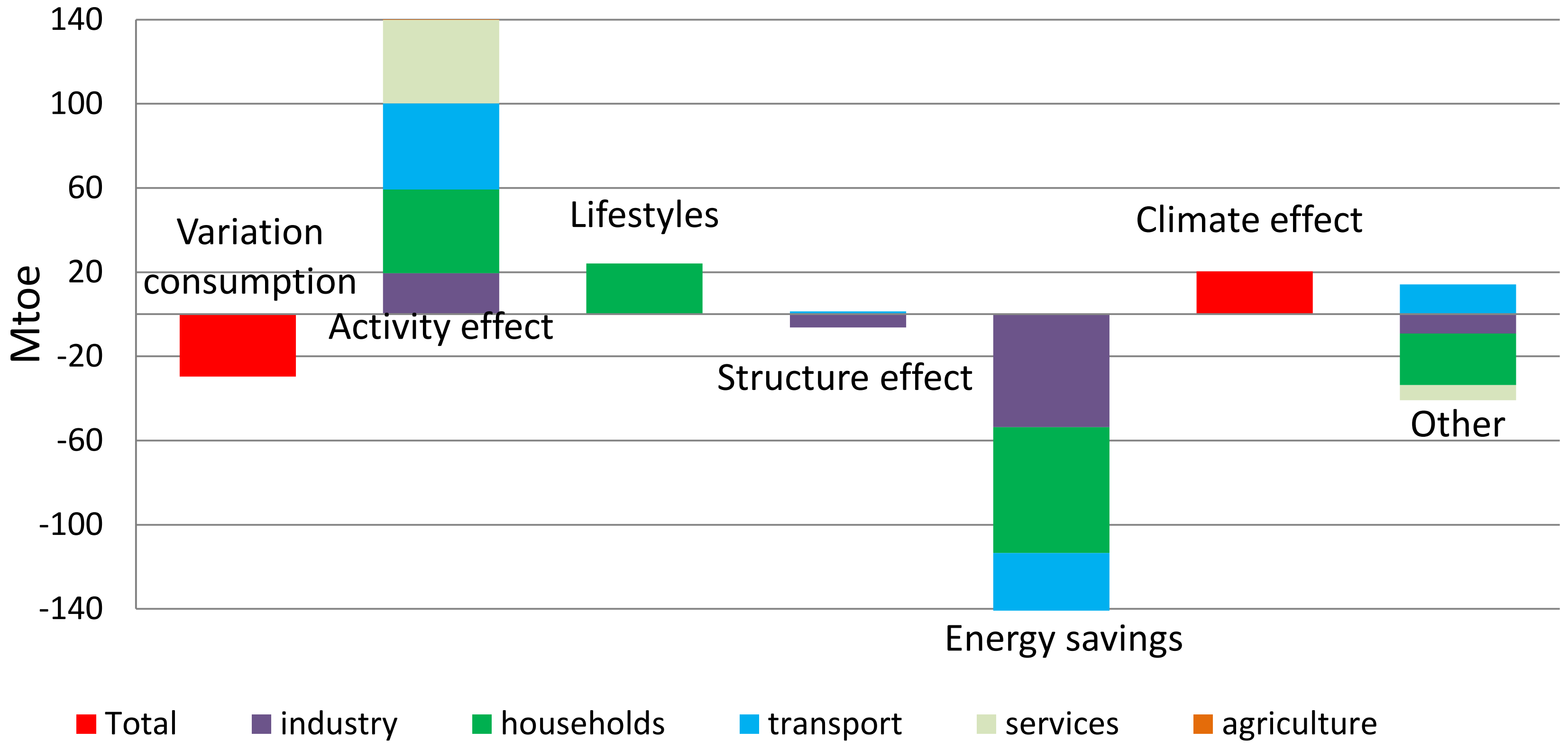
The decomposition of the final energy consumption is done by adding the effects in the different end-use sectors :

- Industry
- Households
- Transport
- Services
- Agriculture

Decomposition of the final energy consumption variation

- Consumption decreased by 30 Mtoe between 2000 and 2012
- Economic activity contributed to an increase of 140 Mtoe (of which 40 Mtoe each due to traffic increase in transport and more dwellings in households), the effect of which was offset by energy savings (140 Mtoe).
- Other drivers were: structural changes (-5 Mtoe), lifestyles (24 Mtoe), climate variation (20 Mtoe) and other factors (mainly behavioural changes).

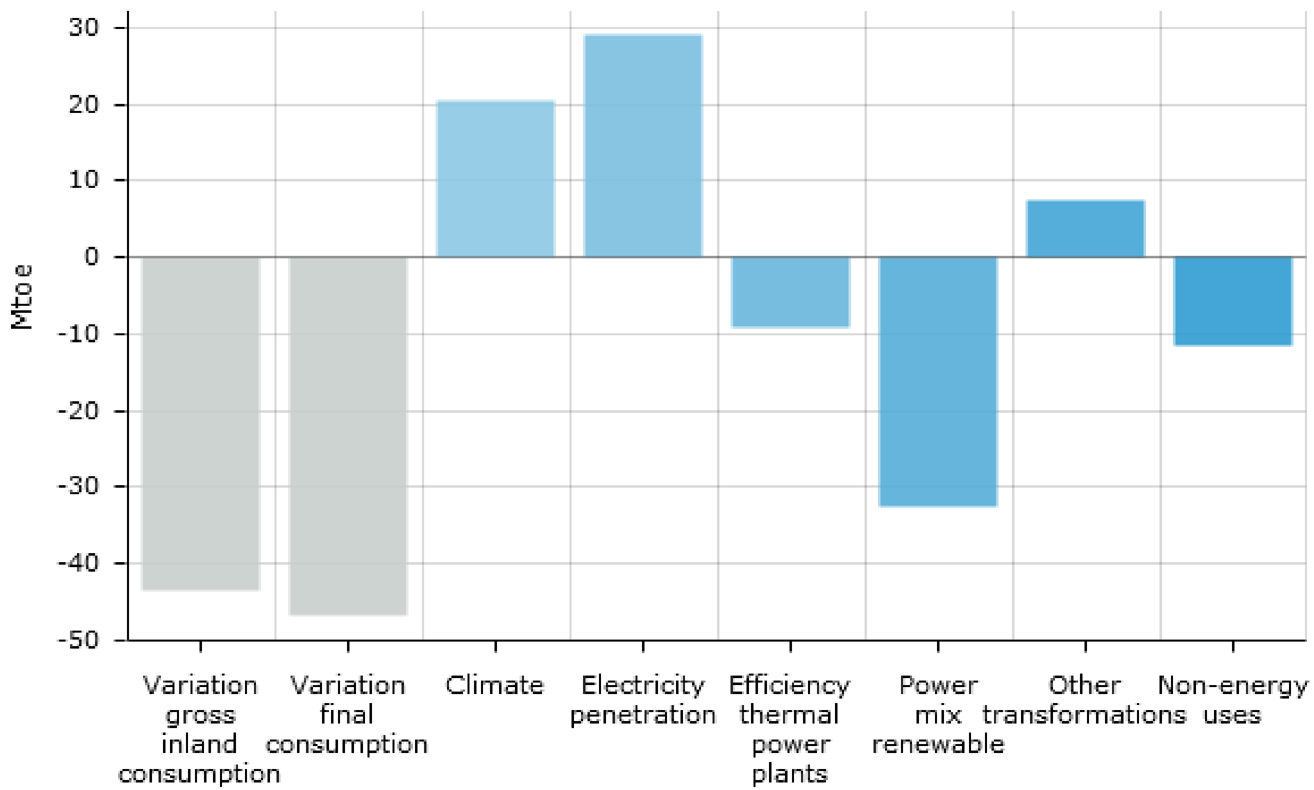
Drivers of the variation of the final energy consumption in the EU between 2000 and 2010



Decomposition of primary energy consumption variation

- The variation of the gross inland energy consumption (non-energy included) is explained by :
- the variation of the final energy consumption for energy uses;
- the decomposition of the variation of the net consumption of the power sector in three effects (changes in electricity consumption, in thermal power efficiency and in the power mix between thermal, renewables and nuclear);
- the variation of the consumption of the other energy transformations and vi) change in climate".

Drivers of the variation of the primary energy consumption in the EU between 2000 and 2012



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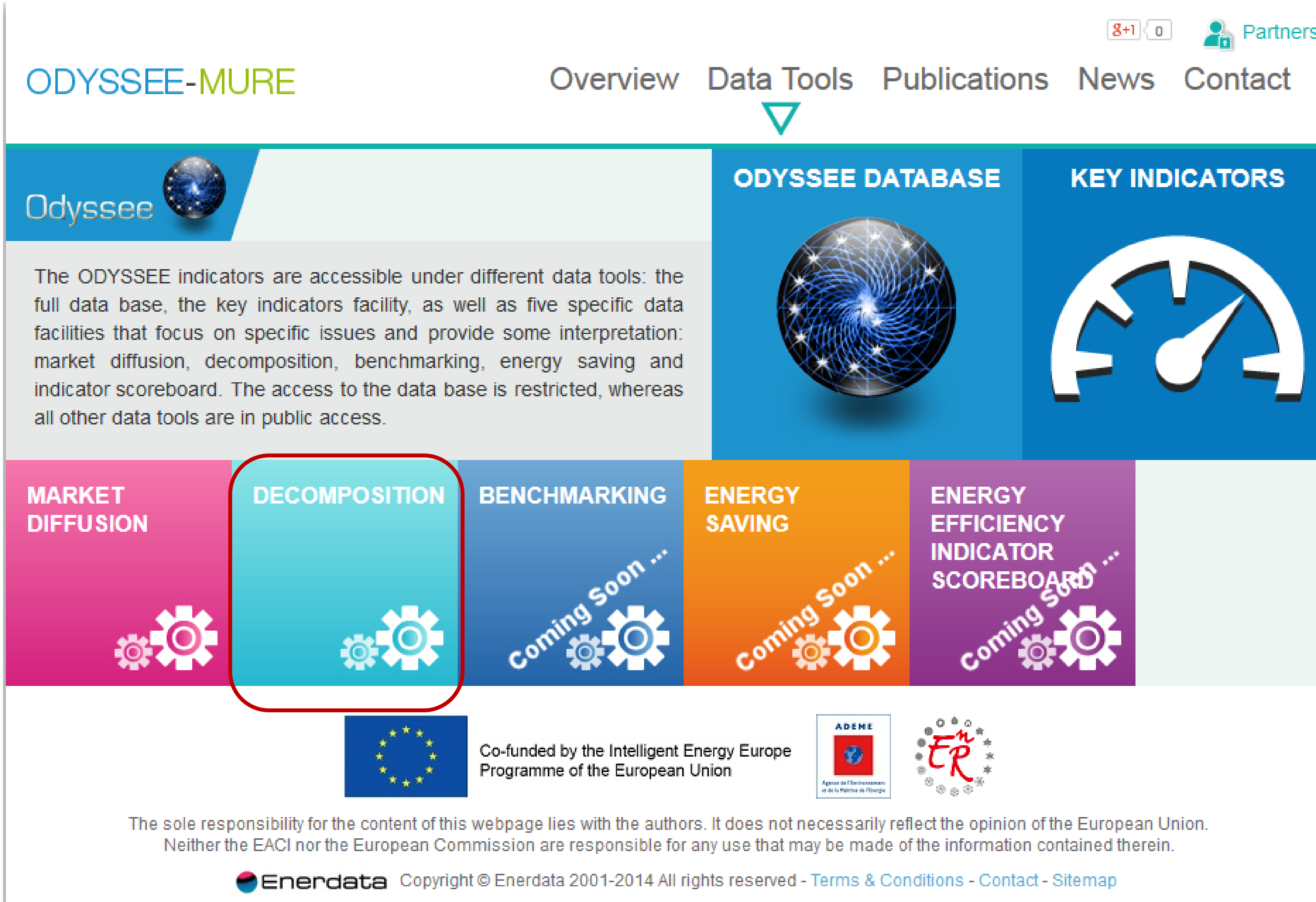
The five ODYSSEE facilities on indicators

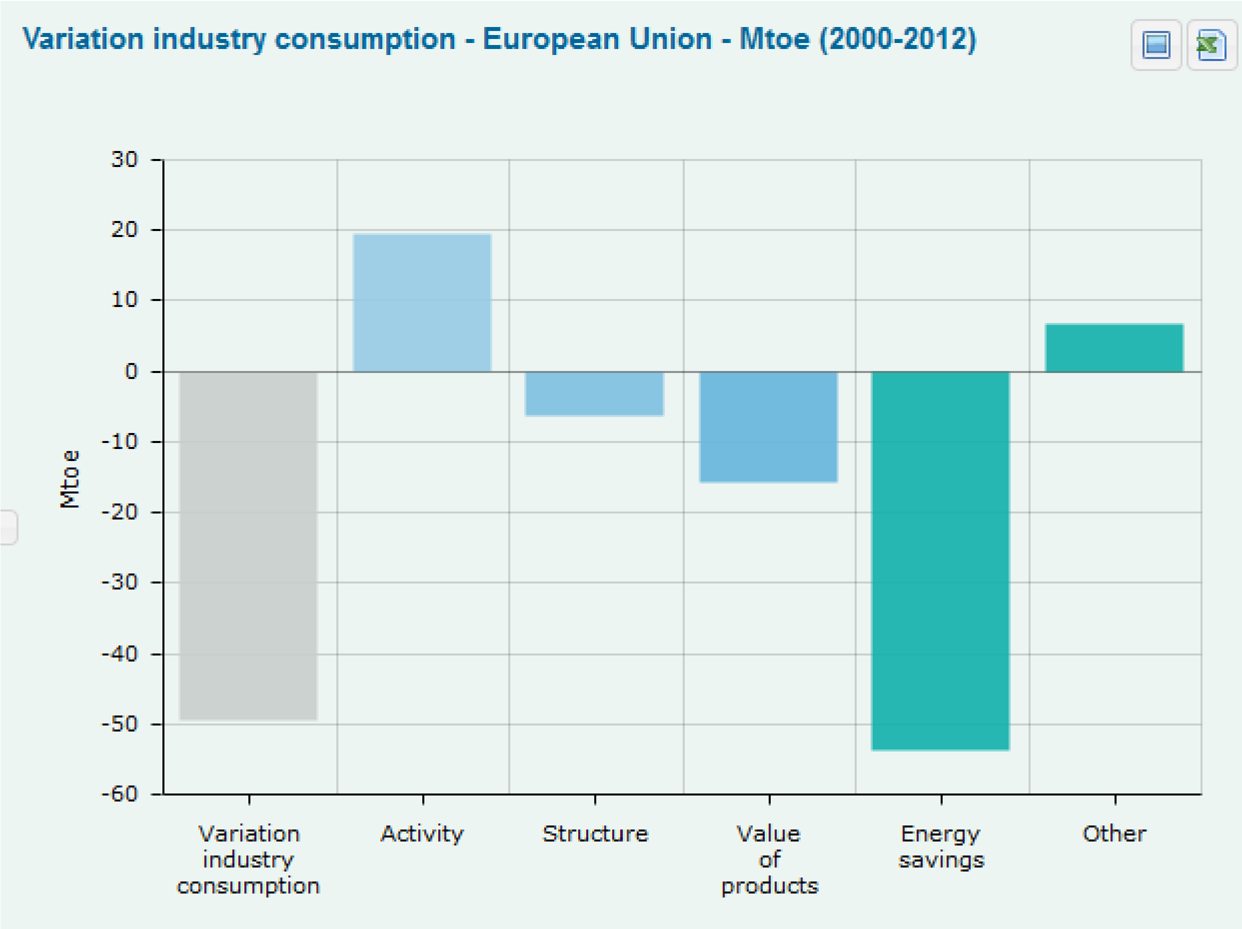


Decomposition facility

This facility enables to display the different effects (i.e. the drivers for energy consumption) :

- by country;
- by sector (primary, power, total final or end-use sector);
- for a selected period (since 2000);
- in various units (ktoe, TJ, GWh and %)

already available for 19 countries



http://www.indicators.odyssee-mure.eu/decomposition.html

A text will appear below to explain the meaning of the drivers shown

Decomposition facility

Decomposition of the variation of energy consumption proposed at different levels: 11 sectors/end-use + options ➔ around 20 consumption segments:

- Total primary energy consumption with several options (actual and at normal climate; with/without non-energy uses)
- Total final energy consumption (actual and at normal climate);
- Power and heat sector
- Industry
- Transport (with and without air)
  - Passenger (with and without air)
  - Cars
  - Freight
- Households (actual and at normal climate)
- Heating (actual and at normal climate)
- Services (actual and at normal climate)
- Agriculture

Decomposition facility: adaptation to country data availability

- For each sector a reference approach is proposed, corresponding to the level of calculation of energy savings using the “preferred indicators” recommended for ESD TD ;

- For countries with limited data a simplified alternative is proposed (even two for households).

- For industry only a reference approach is proposed as countries have all data;

- The reference decomposition for household and transport is available for **12 countries and the EU;** if services is include this is only available for 7 countries.

Decomposition facility: adaptation to country data availability: households

- For **households,** three options are considered to adapt to the data available :
    1. Calculation **by end-use and major appliance** (14 countries +EU) ;
    2. Simplification if some end-uses are missing (12 countries);
    3. Aggregate calculation if no data by end-use available (3 countries);

- Variation of consumption decomposed into 3 or 4 effects:
    - ✓Climate effect;
    - ✓A demographic effect, due to the increasing number of dwellings,
    - ✓A lifestyle effect, due to the increase in the number of households equipment and to larger homes;
    - ✓Energy savings (as measured from ODEX).

Energy savings are based on ODEX which combines energy efficiency improvement for thermal uses (space heating, water heating, cooking) and for 5 large electrical appliances

Decomposition facility: adaptation to country data availability Services

- **For services** two alternative cases have been considered for all countries to fit to the data available by branch or by end use :
  1. Calculation by branch (11 countries);
  2. Calculation for fuels and electricity separately (simplified) (11 countries+ EU);
- Variation of consumption decomposed in 3 or 4 effects:

  - ✓Climate effect (if actual variation, i.e. at real climate);
  - ✓Activity effect, based on variation of value added;
  - ✓Energy savings, based on change in energy consumption per employee;
  - ✓Productivity linked to changes in the value added peer employee;

Conclusion (1/2)

The decomposition analysis methodology is broadly applied at international (IEA, EU-ODYSSEE, UN-CEPAL etc.) and national levels.

This methodology enables MS to fulfil the yearly reporting requirement in particular in providing quantitative assessment of the explanatory factors.

- This methodology allows to put in coherence energy savings changes (as reported in the NEEAP3 for instance) and the energy demand variations .
- Due to methodological issues, transparency and sourcing is important.
- ODYSSEE, through a user-friendly facility, provides an automatic application of the decomposition analysis as well as all the definitions used.

Conclusion (2/2)

- Using the “shared ODYSSEE decomposition methodology” allows a certain homogeneity and comparison among countries;
- ODYSSEE is finalising the facility with pending and new developments in the coming weeks;
- ODYSSEE experts encourages MS to use the decomposition analysis for the NEEAP reporting in general and the ODYSSEE facility tool in particular.
- ODYSSEE network can help MS for using such methodology

Thank you for your attention

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www.cepal.org/drni/biee/

Definition of technico-economic effect
This is very simple….

CT, Total consumption of an end-use or sub-sector (“module”)

CU, Unit consumption of a module

Q, Driver representing the activity

$$\mathbf{CT = CU * Q}$$

Between two dates t-1 and t, we can write

(1) $CT_{(t)} - CT_{(t-1)} = [CU_{(t)} \times Q_{(t)}] - [CU_{(t-1)} \times Q_{(t-1)}]$

(2) $Var\ CT_{(t,\ t-1)} = [(Q_{(t)} - Q_{(t-1)} \times CU_{(t-1)}] + [(CU_{(t)} - CU_{(t-1)} \times Q_{(t)}]$

= Activity effect + Unit Consumption effect (Energy savings)

A quantitative simple example

- The sum of the two effects mathematically matches with the energy demand variation over the period of observation.

- Total consumption = Q x CU

t-1 : 5000 = 1500 x 3,33

t : 9000 = 3666 x 2,45

EQ = (Qt – Qt-1) X CU t-1 = (3666-1500) X 3,33 = 7212

ECU = (CU t –Cut-1) X Qt = (2,45-3,33) X 3666 = - 3212

Total = 4000 ktoe

Decomposition of the variation of the electricity consumption of appliances : example

Appliance consumption **E= HH*TEQ*SEC**

With:

E consumption of the appliance

HH: number of households

TEQ: equipment ownership ratio (% of households with the appliance)

SEC: average specific consumption of the appliance (kWh/year)

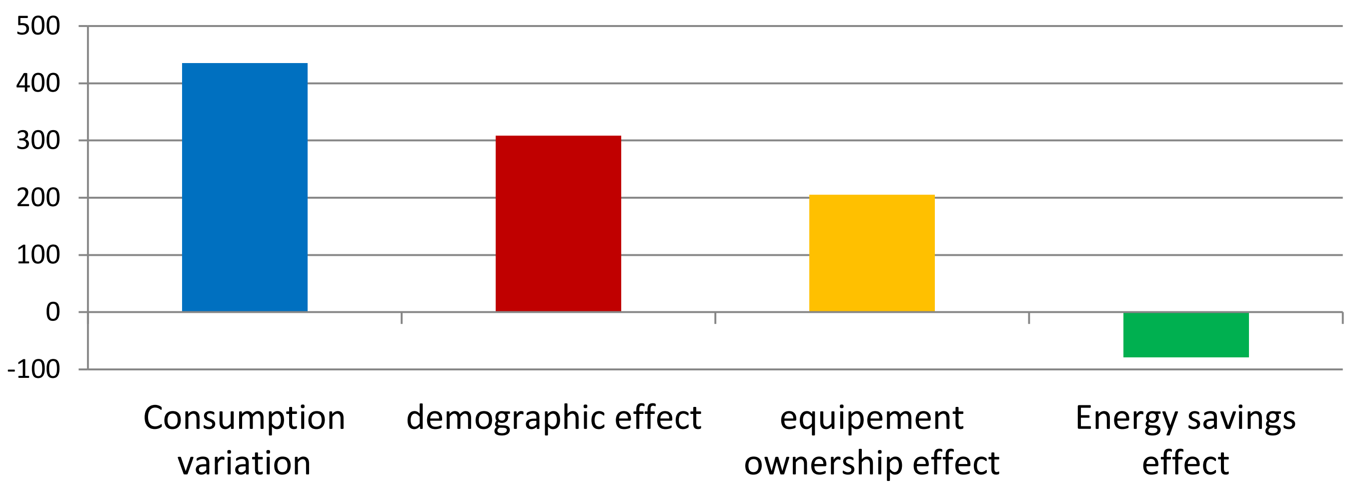
- Calculation of electricity consumption variation between year t-1 and year t:
  - ✓ Demographic effect =$\Delta HH * TEQ_{t-1} * SEC_{t-1}$
  - ✓ Equipment ownership effect: $HH_{t-1} * \Delta TEQ * SEC_{t-1}$
  - ✓ Energy savings effect: $HH_t * TEQ_t * \Delta SEC$

E_t - E_0= sum of 3 effects

Decomposition of the electricity consumption variation : example of TV

	Unite	2000	2010
Number of households	1000	4416	5700
% of households with TV	%	82,3	94,7
Specific consumption of TV	kWh	292	277
Total consumption of TV	GWh	1062	1497
		2000-2010	
Consumption of TV variation	GWh	435	
Effect of TV stock increase	GWh	514	
of which demographic effect		309	
of which equipment ownership effect		205	
Specific consumption effect	GWh	-79	

Drivers of consumption variation for TV (GWh) (2000-2010)



Decomposition analysis of energy demand
Main methodological issues

1. Definition of technico-economic effects (sector dependant)
2. Type of indicators used for each of the effect
3. Calculation method
4. Level of desegregation
5. Order of calculation

Impact of the calculation methods

- The sum of the two effects mathematically matches with the energy demand variation over the period of observation.
- However, there exists two methods of calculation leading to different results according to the weighting system (i.e. reference years).

Total consumption = Q x CU

t-1: 5000 = 1500 X 3,33

t : 9000 = 3666 X 2,45

$EQ = (Q_t - Q_{t-1})$ X CU_{t-1} = (3666-1500) X 3,33 = 7212

$ECU = (CU_t - Cu_{t-1})$ X Q_t = (2,45-3,33) X 3666 = - 3212 Total = 4000

Or

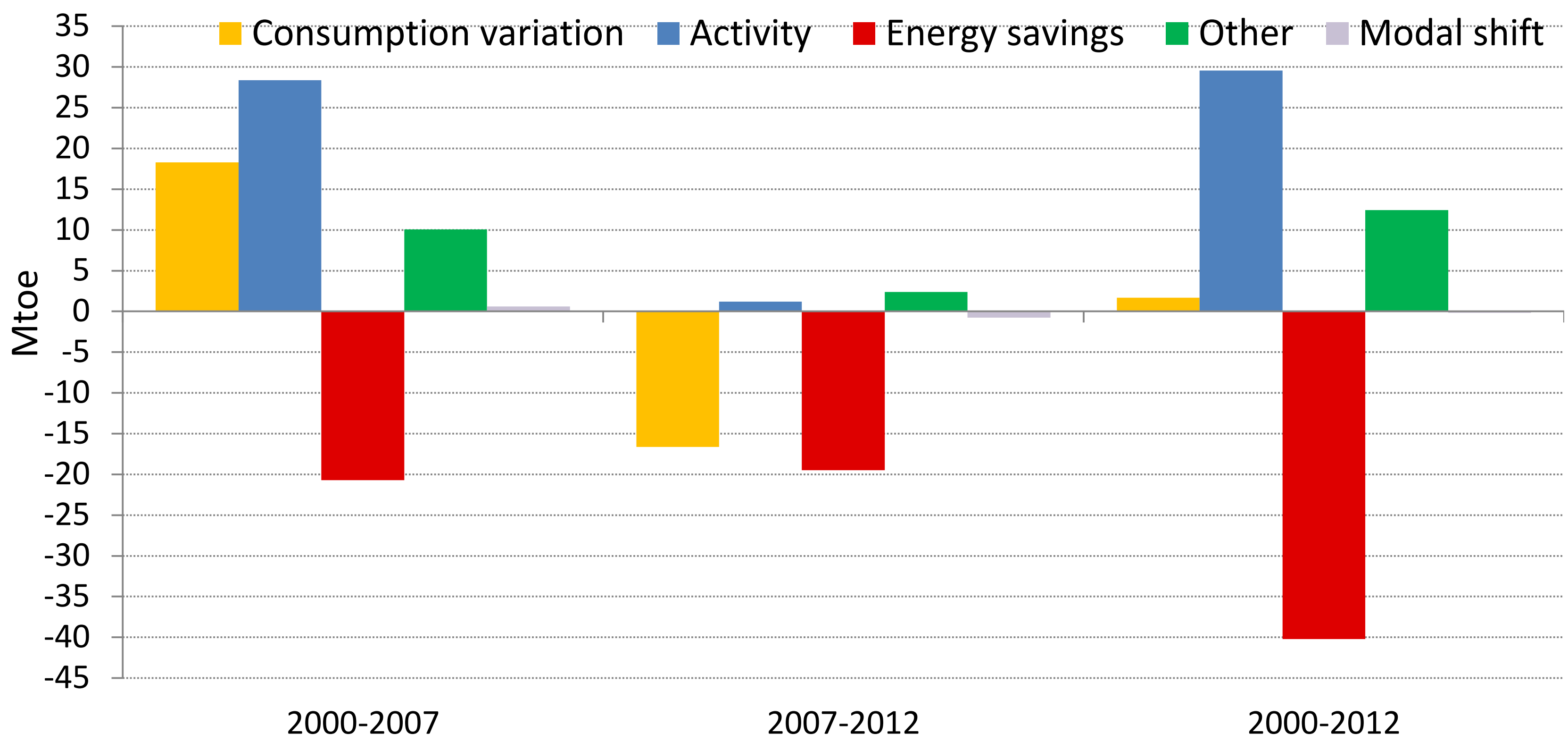
$EQ = (Q_t - Qt_{t-1})$ x CU_t = (3666-1500) x 2,45 = 5310

$ECU = (CU_t - CU_{t-1})$ X Q_{t-1} = (2,45-3,33) X 1500 = - 1310 Total = 4000

➔ Which methodology is more relevant?

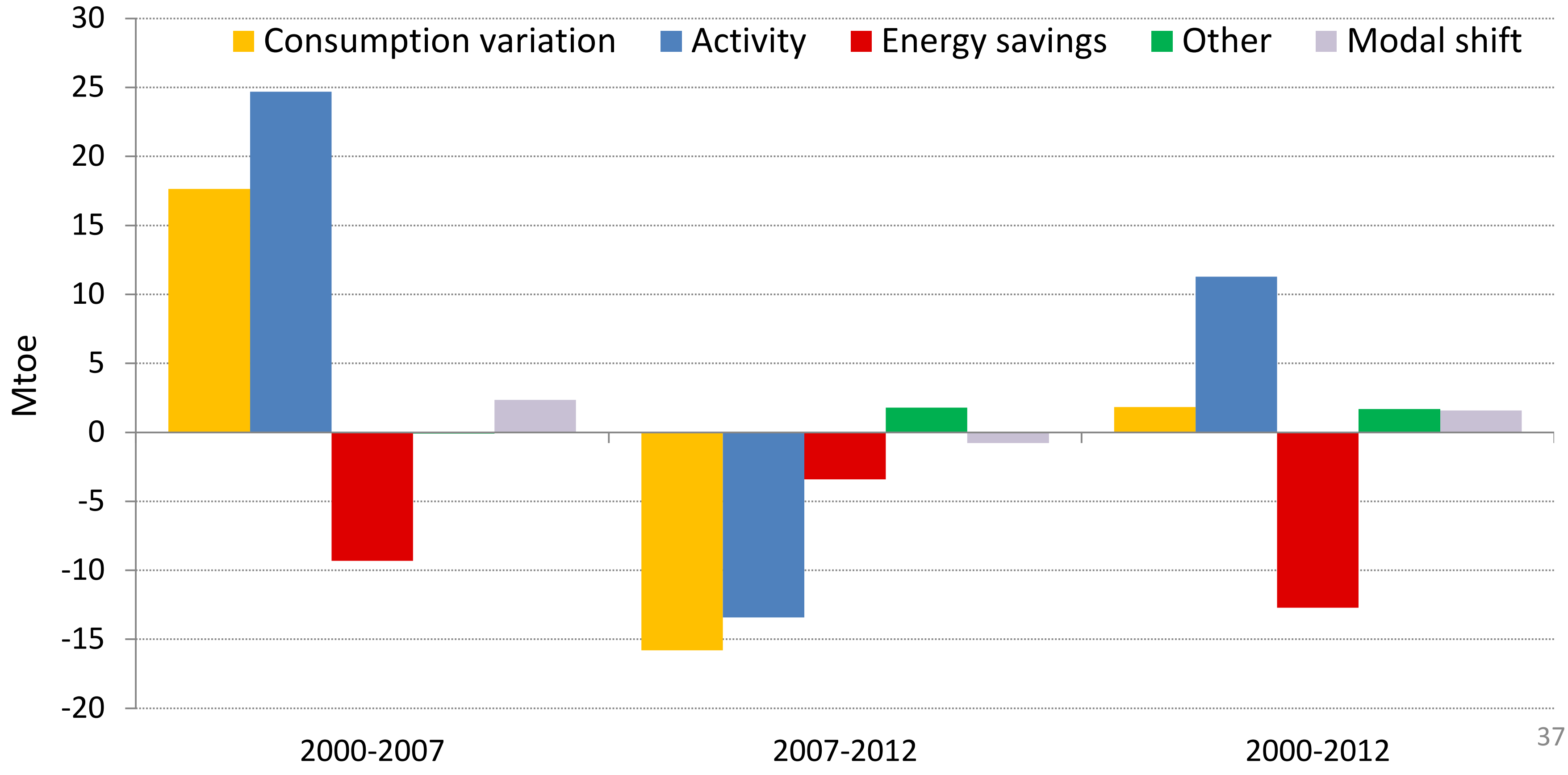
Slight increase in energy consumption for passenger since 2000 driven by 3 main factors; on one side, increase in traffic (30 Mtoe) and behaviour effect (12 Mtoe) but offset by energy savings (40 Mtoe). Negative but marginal impact of modal split due to a decreasing share of public transport in passenger traffic (or a shift from public transport to car).

Decomposition of energy consumption for passengers (EU)

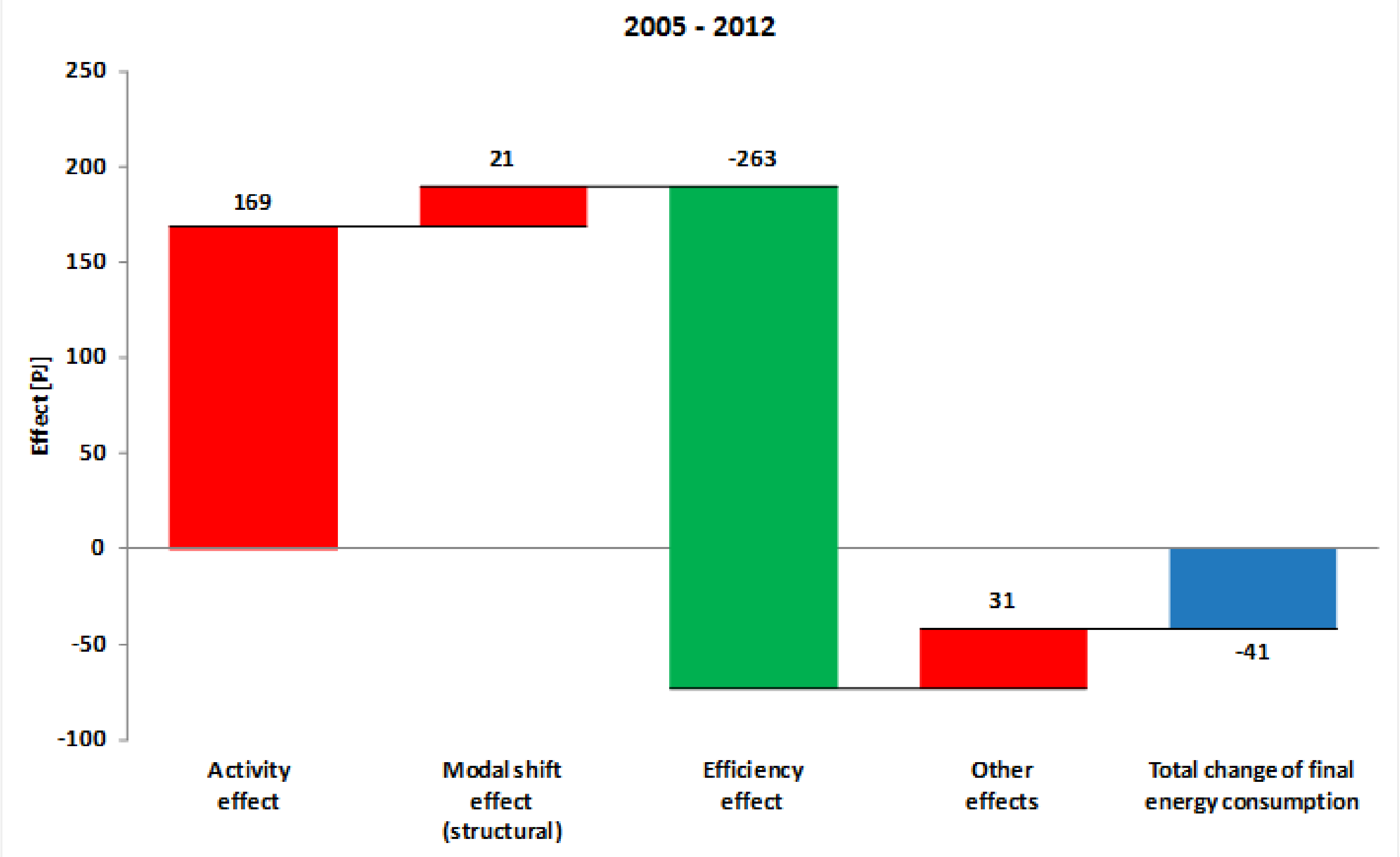


Decreasing energy consumption of freight transport since 2007 (-15 Mtoe) mainly due a decrease in the traffic in ton-km, energy savings and in lesser extend due to modal shift. On the opposite "negative savings" due to low capacity utilization (mainly illustrated by an increase in the energy consumed per tonne –km).

Decomposition of energy consumption variation for freight (EU)



Decomposition of final energy consumption in transport (without air transport) in Germany (2005-2012)



The variation of the energy consumption for cars is influenced by:

- **Change in traffic in passenger-km** and distance travelled ("activity effect")
- A "**technical efficiency effect**", reflecting the change in the efficiency of cars measured in litre per 100km;
- **Other effects**: includes a substitution effect and the effect of changes in the average rate of car occupancy (person/car). The substitution effect reflects the impact of changes in fuel mix, from gasoline to diesel and from oil products to biofuel, both leading to an increase of the average heat content (in toe/litre).

Decomposition of energy consumption variation for cars in EU (2000-2012)