An introduction to decomposition analysis

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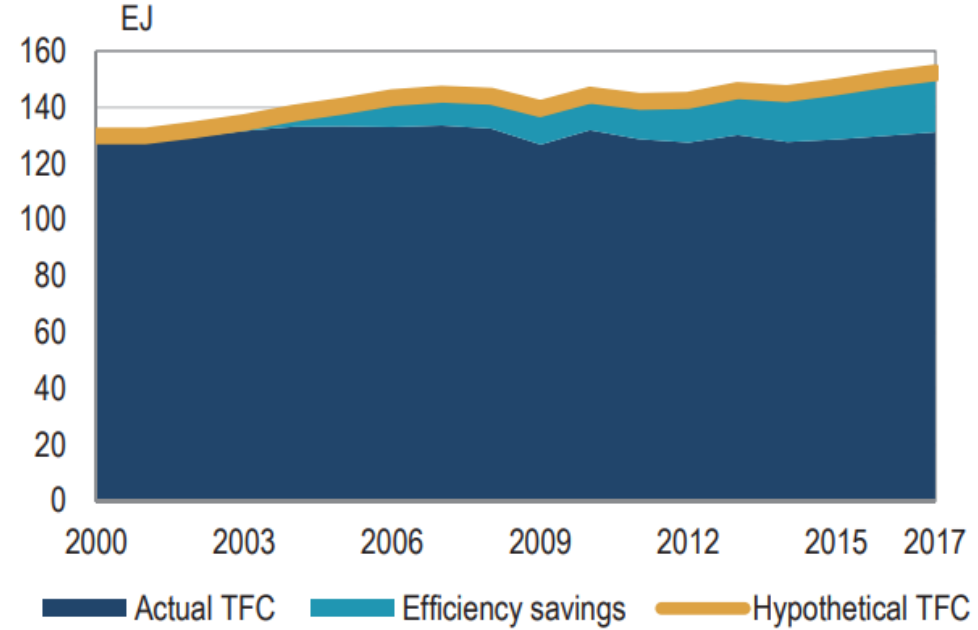
IEA #energyefficientworld

How to estimate energy savings from efficiency over time?



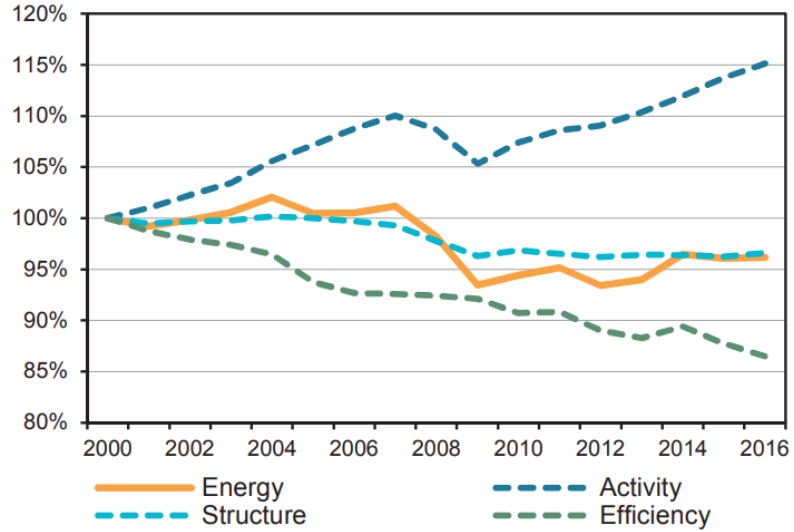
Source: adapted from IEA (2018) *Energy efficiency 2018*, based on the IEA Energy efficiency indicators database, 2018.

Estimated energy savings since 2000 in IEA reached approximately 21EJ, equivalent to energy consumption of Germany, France and UK together.

Need to disentangle different factors: activity, structure and efficiency

Purpose of decomposition analysis:

Quantify **contribution of specific factors** to the change in energy consumption

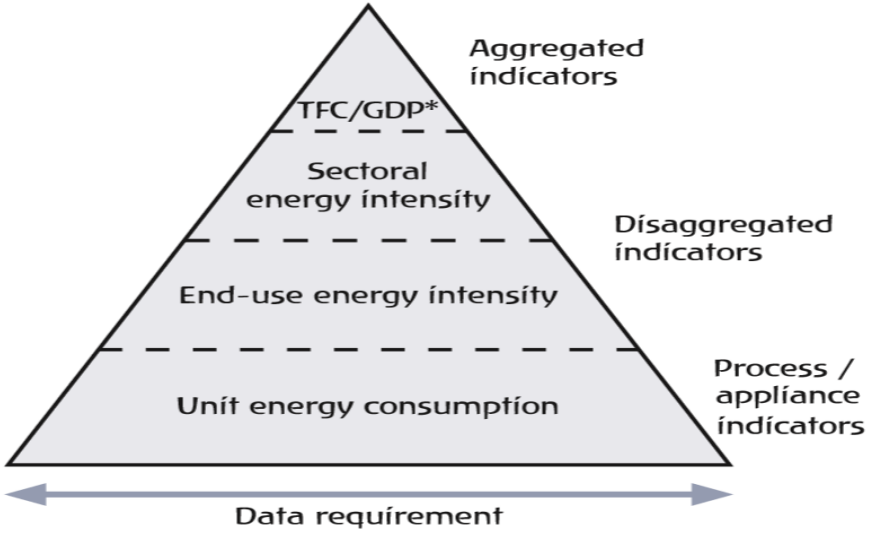


Source: IEA Energy Efficiency Indicators database (2018 edition)

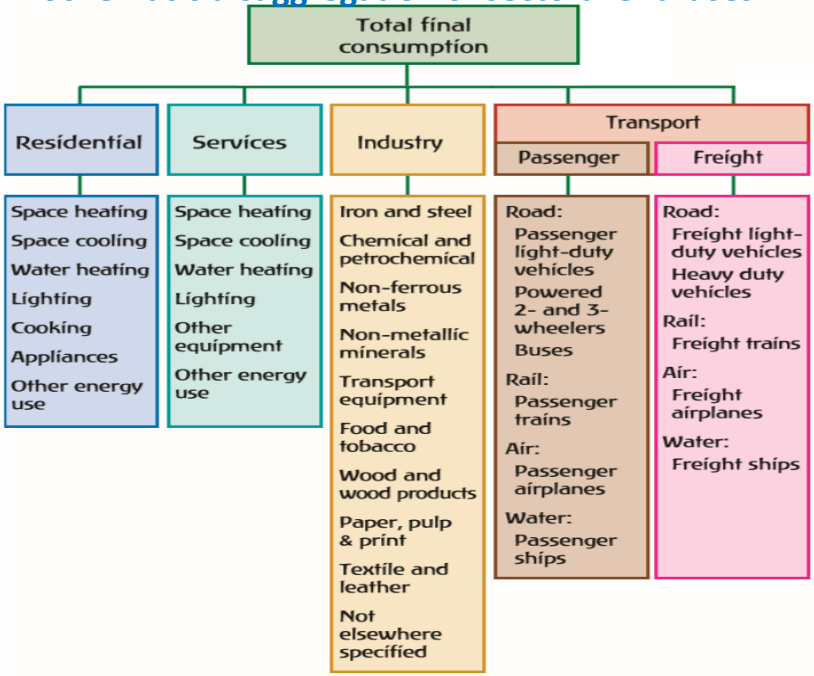
EEI data requirements

- Degree of disaggregation of EEI needed affects the data collection requirements
- Sub-sectoral /end-use energy consumption

Schematic representation of energy indicators



Schematic disaggregation of sectoral end-uses



Decomposition key concepts

Decomposition analysis

- There are **different methods** – the IEA uses the LMDI

LMDI = Logarithmic Mean Divisia Index

- Can be applied to specific subsectors or end uses (e.g. space cooling, cars,…) to estimate the energy savings from efficiency.

Drivers of energy consumption

- **Activity effect**
  - Change in the **overall level** of the activity / level of action that drives energy consumption.

- **Structure effect (Activity mix)**
  - Change in the **mix of activities** within a sector

- **Energy efficiency effect (Intensity)**
  - Changes in **sub-sectoral energy intensities** (i.e. energy used per unit of activity)

There is not a single approach

Additive approach

$$\Delta E = \Delta E_{ACT} + \Delta E_{STR} + \Delta E_{INT} + E_{RSD}$$

where

$$\Delta E = E^{YearT} - E^{Year\ 0}$$

Where : ACT = Activity, STR = Structure, INT = Intensity, RSD = Residual

Additive approach:

Change in energy consumption is a sum of variation due to activity, structure, and intensity

Example of 3-factor LMDI methodology - additive

	Additive
Activity effect (A)	$E_t^A = \sum_i L(E_i^T, E_t^0) \cdot \ln\left(\frac{A^T}{A^0}\right)$
Structural effect (S)	$E_t^S = \sum_i L(E_i^T, E_t^0) \cdot \ln\left(\frac{S_i^T}{S_I^0}\right)$
Intensity effect (I)	$E_t^I = \sum_i L(E_i^T, E_t^0) \cdot \ln\left(\frac{I_i^T}{I_I^0}\right)$
	$E^T = energy\ consumption\ year\ T$ $E^0 = energy\ consumption\ year\ 0$ $i = sub\text{-}sector\ or\ end\ use$

Where, $L(E_i^T, E_t^0)$

is the logarithmic mean of terms above.

$$L\,(E^T, E^0) = (E^T - E^0)\,/(\ln E^T - ln\ E^0)$$

Decomposition: Energy Savings

- After the changes from each effect are calculated:
  - We calculate the **hypothetical energy use (HEU)** if no efficiency improvements happened.

$$E^{T} - \Delta E_{int} \qquad E_{tot} = \Delta E_{act} + \Delta E_{str} + E^{0}$$

  - **We subtract actual energy to obtain the savings** from energy efficiency improvement

Savings = HEU – ACTUAL ENERGY USE

Data and indicators for decomposition analysis

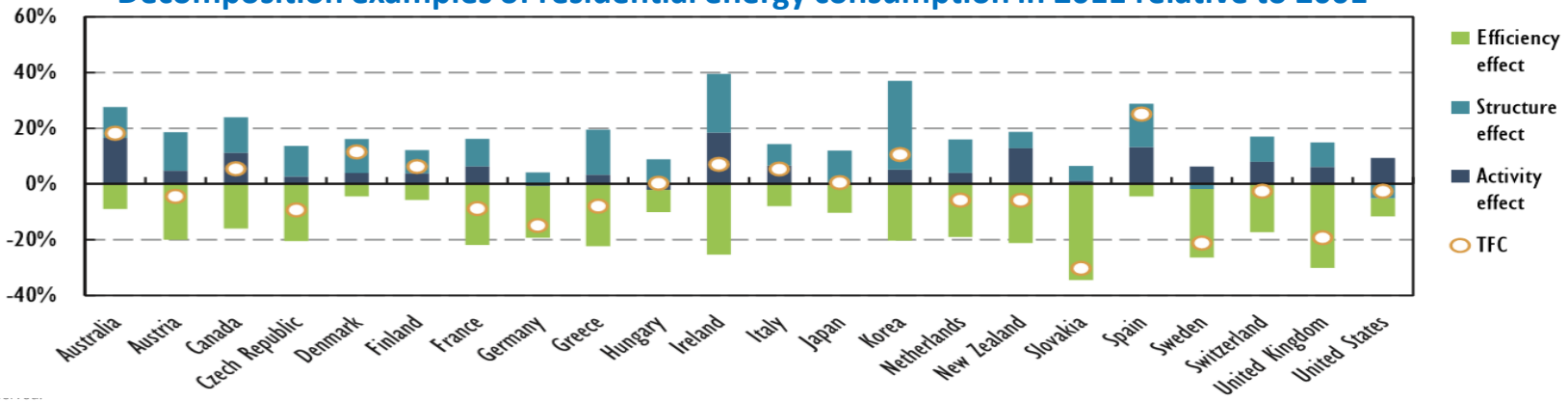
Decomposition Analysis in Residential Sector

- Metric examples for residential energy decomposition

End-use	Activity (A)	Structure (S)	Intensity (I)
Space heating	Population	Floor-area / Person	Space heating energy* / Floor-area
Space cooling	Population	Floor-area / Person	Space cooling energy** / Floor-area
Water heating	Population	Occupied-dwelling / Person	Water heating energy / Occupied-dwelling
Cooking	Population	Occupied-dwelling / Person	Cooking energy / Occupied-dwelling
Lighting	Population	Floor-area / Person	Lighting energy / Floor-area
Appliances	Population	Appliance stocks / Person	Appliance energy / Appliance stocks

* Adjusted energy using HDD compensation, ** Adjusted energy using CDD compensation

Decomposition examples of residential energy consumption in 2011 relative to 2001



Decomposition Analysis in Industry Sector

- Metric examples for industry energy decomposition

Sub-sector	Activity (A)	Structure (S)	Intensity (I)
Food products, beverages, tobacco products (ISIC* 17)	Value-added	Share of Value-added	Energy / Value-added
Paper and paper products (ISIC 17)	Value-added	Share of Value-added, Production / Value-added	Energy / Value-added, Energy / Production
Chemicals and chemical products (ISIC 20-21)	Value-added	Share of Value-added, Production / Value-added	Energy / Value-added, Energy / Production
Non-metallic mineral products (ISIC 23)	Value-added	Share of Value-added, Production / Value-added	Energy / Value-added, Energy / Production
Basic metal (ISIC 24)	Value-added	Share of Value-added, Production / Value-added	Energy / Value-added, Energy / Production
Fabricated metal products, machinery and equipment (ISIC 25-28)	Value-added	Share of Value-added	Energy / Value-added
Other industry (ISIC 10-32, excluding ISIC 19 and those described above)	Value-added	Share of Value-added	Energy / Value-added

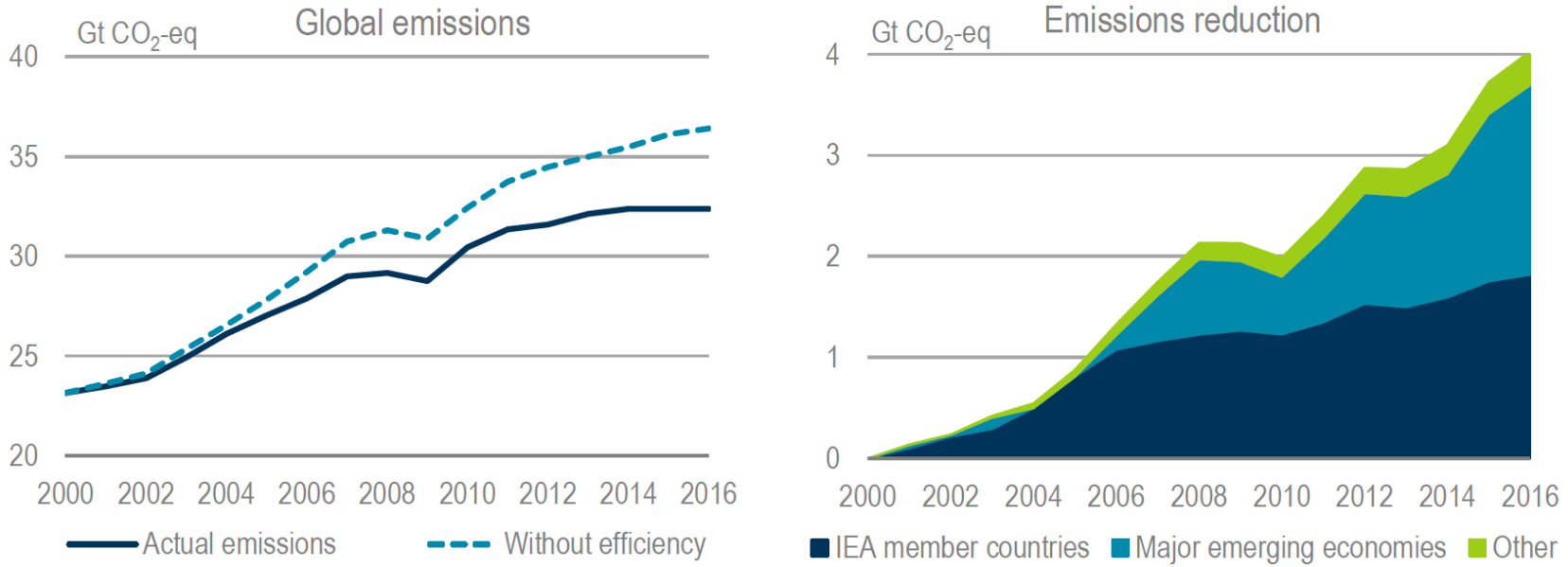
Decomposition Analysis in Transport Sector

- Metrics examples for transport energy decomposition

Mode	Activity (A)	Structure (S)	Intensity (I)
Passenger road (cars, buses…)	Passenger-km	Share of Passenger-km, Registered Vehicle / Passenger-km	Energy / Passenger-km, Energy / Vehicle
Passenger rail	Passenger-km	Share of Passenger-km, Passenger / Passenger-km	Energy / Passenger-km, Energy / Passenger
Passenger domestic air	Passenger-km	Share of Passenger-km, Passenger / Passenger-km	Energy / Passenger-km, Energy / Passenger
Freight road (HDVs)	Tonne-km	Share of Tonne-km, Tonne / Tonne-km	Energy / Tonne-km, Energy / Tonne
Freight rail	Tonne-km	Share of Tonne-km, Tonne / Tonne-km	Energy / Tonne-km, Energy / Tonne
Freight domestic shipping	Tonne-km	Share of Tonne-km, Tonne / Tonne-km	Energy / Tonne-km, Energy / Tonne

Energy efficiency & emissions savings

Avoided global GHG emissions from energy efficiency improvements

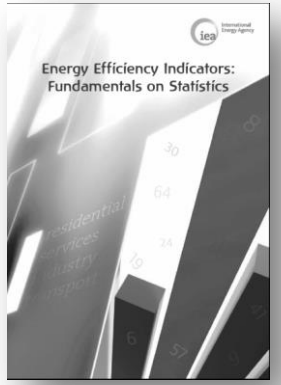


Source: IEA (2017), *Energy Efficiency Market Report*, OECD/IEA, Paris.

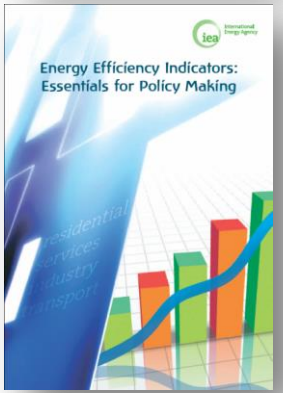
Energy efficiency reduced GHG emissions by 4 $GtCO_2$-eq, or 13% of total CO2 emissions in 2016.

More on decomposition analysis

- Fundamentals on statistics:
  to provide guidance on how to collect the data needed for indicators
  - Includes a compilation of existing practices from across the world
  - https://goo.gl/Y8QD1G



- Essentials for policy makers:
  - to provide guidance to develop and interpret energy efficiency indicators
  - https://goo.gl/agcNg2



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