MICAT

Multiple Impacts Calculation Tool

The Multiple Impacts of Energy Efficiency:

Environmental Indicators

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Why MICAT? – The project idea

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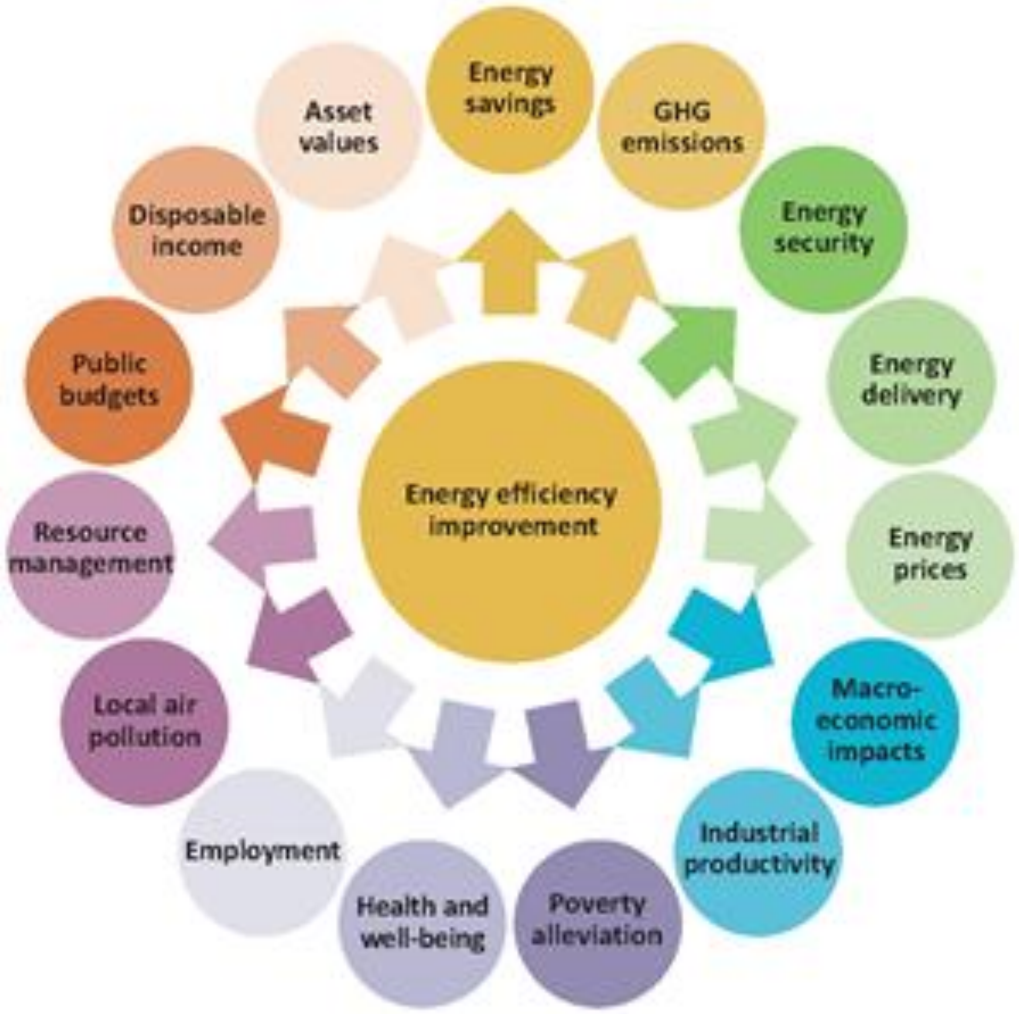
- Relevance of energy efficiency to mitigate climate change
  - „Energy efficiency gap“ ~ is efficiency not enough?

  → Additional benefits? Do they pay off?

- „Multiple Impacts“: Co-benefits, non-energy benefits (NEBs),
  multiple benefits (MBs), or impacts (MIs)
  - accompany energy efficiency projects and provide additional arguments to
    implement EE measures, but are rarely reported
  - explicitly mentioned in EC's policy-making (e.g. EPBD, EED) and reporting (NECPs)

→ show the full set of advantages of energy efficiency policy measures
through monetization of impacts and cost-benefit analyses



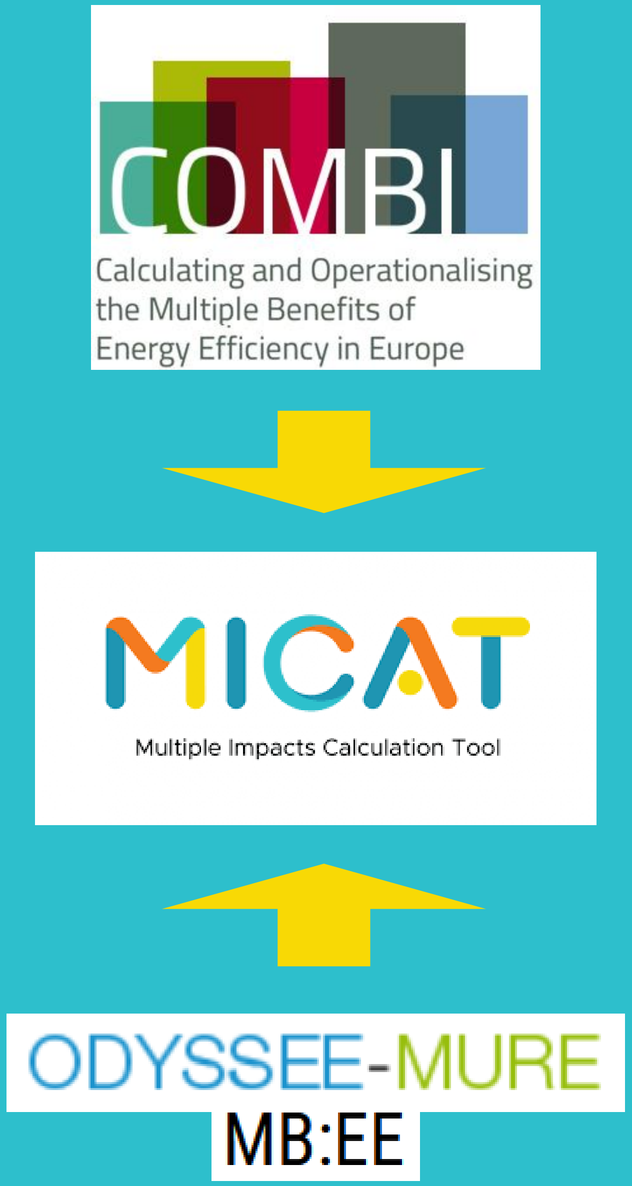
Source: IEA

The MICAT Approach

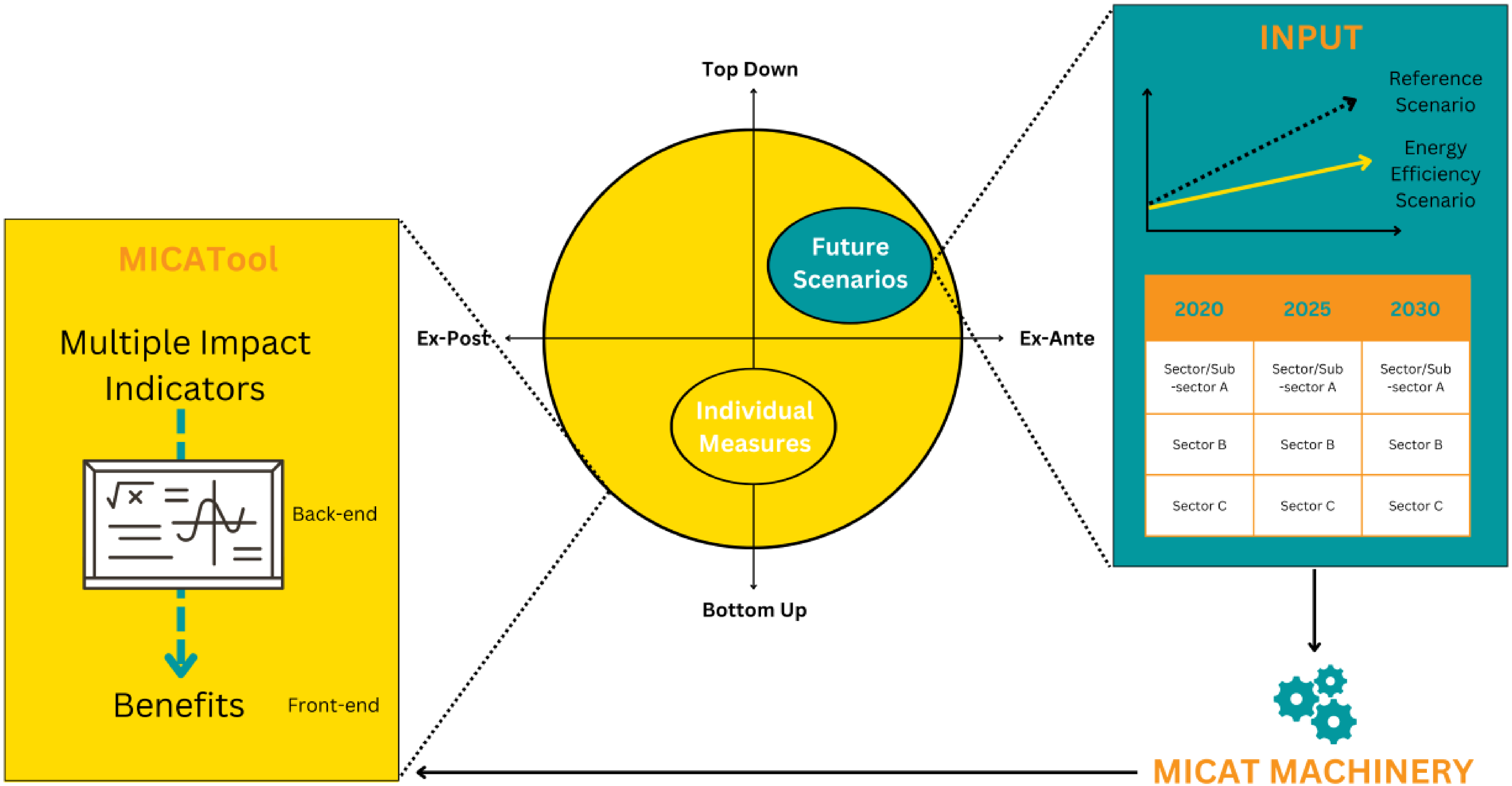
Development of a comprehensive approach to estimate Multiple Impacts of Energy Efficiency by providing a publicly available and easily usable online tool.

- **Improve scientific knowledge** and methods to quantify Multiple Impacts
- Underline the **importance of MIs** in policy evaluations
- **Facilitate assessment of MI** of policies at EU, national and local levels
    - **Quantification and monetisation** of different categories of multiple impacts
    - **Go beyond the approaches** of earlier MB-Tools like in ODYSSEE-MURE and COMBI
    - Cover several **key scenarios (EU, DE, IT, PL),** allow evaluation of customised scenarios and policy measures
    - **Maximise usefulness** for a large target group and cover a wide range of use-cases

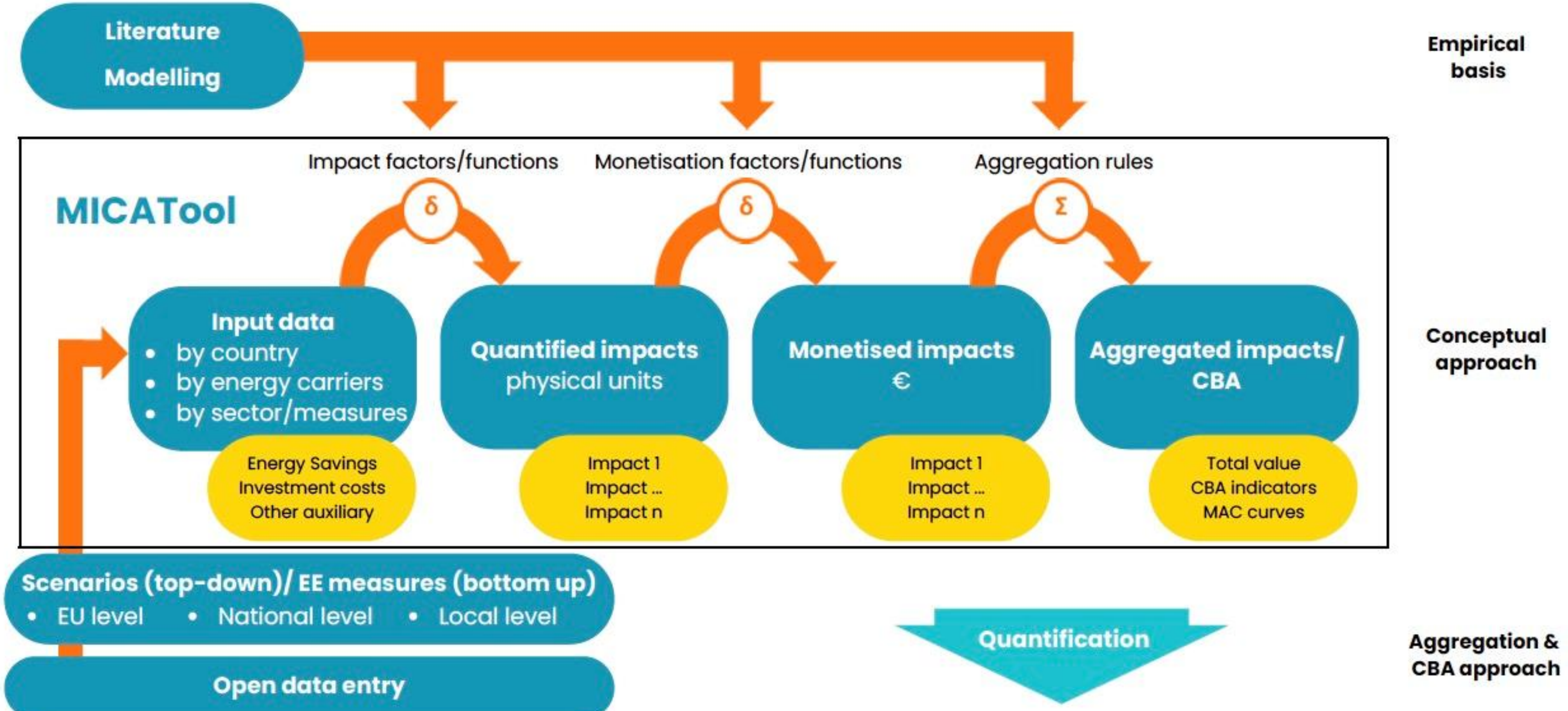
MICAT: **M**ultiple **I**mpacts **Ca**lculation **T**ool



General Approach of MICAT



Conceptual quantification framework of MICAT



Scope of environmental indicators in MICAT

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MICAT systems boundary

Air

Natural
Material
Resources

EnI	Environmental impact indicators	Lead	Quantification methodology / unit
		Energy & Resource Management	
EnI-1	Energy (cost) savings	Fraunhofer, E3M	Energy savings derived from scenario ana evaluation of policies Partly based on PRIMES Unit: MWh, ktoe
EnI-2	Savings on material resources	WI	Material Flow Accounting: Bottom-up moc gate) of material and energy flows; charac intensity of primary materials Unit: tons, tons/GDP
EnI-2.1	*Reduction in overall material footprint*	WI	Sum of extracted abiotic (fossil fuels, meta and biotic raw materials from nature, inclu economic unused materials. Unit: tons, tons/GDP
EnI-2.2	*Life-Cycle wide fossil fuel consumption*	WI	Accounting of all raw materials from natur classified as fossil fuels and are put to an Unit: tons
EnI-2.3	*Metal ores*	WI	Accounting of all raw materials from nature that can be classified as metal ores and are put to an economic use. Unit: tons
EnI-2.4	*Minerals*	WI	Accounting of all raw materials from nature that can be classified as minerals and are put to an economic use. Unit: tons
EnI-2.5	*Biotic raw materials*	WI	Accounting of all raw materials from nature that can be classified as biotic raw materials and are put to an economic use. Unit: tons
EnI-2.6	*Unused extraction*	WI	Accounting of materials that are extracted from nature that are not translocated from site or put to an economic use. This includes overburden and by-catch as well as waste on site. Unit: tons
		Global & Local Pollutants	
EnI-3	Impacts on RES targets	Fraunhofer	Partial achievement of RES targets due to the reduction of gross final energy consumption; replacement of RES capacity; reduced need for interconnectors Unit: %
EnI-4	GHG savings (savings of direct carbon emissions)	Fraunhofer	Direct carbon emissions are based on emission factors for different fuel types. Values are listed in CO_2 equivalents per unit of energy. Unit: Mt CO2eq
EnI-5	Reduction in air pollution emissions	IIASA	GAINS model Outdoor air pollutants emissions from fuel combustion, transportation and other economic activities (SO2, PM2.5, NOx, NH3, NMVOC) Unit: tons

Reduction in emissions of air pollutants

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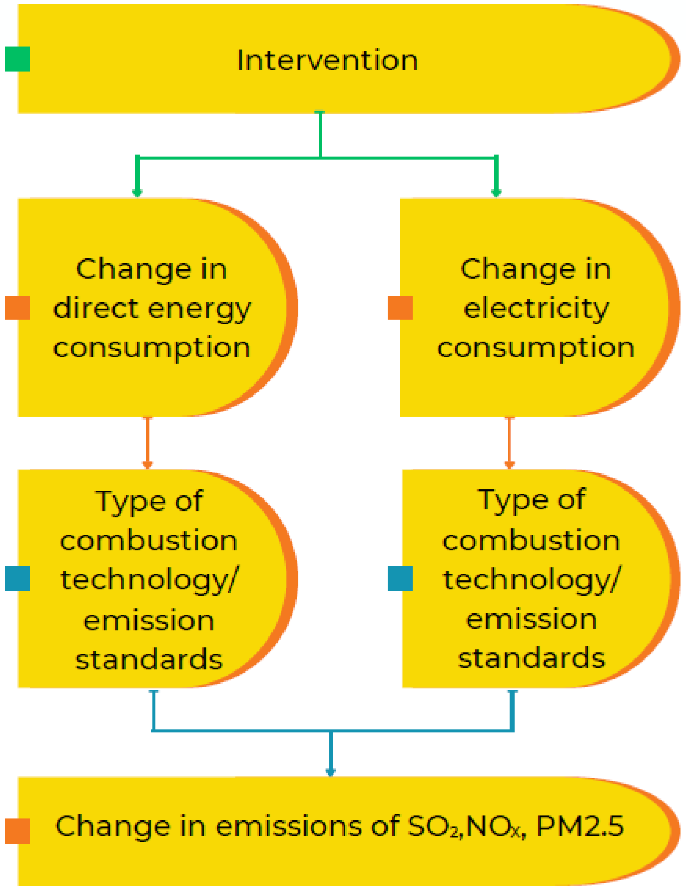
Impact pathway



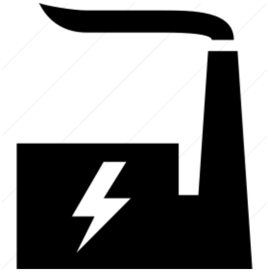
GAINS model

- Supports EC air quality policy development & reflects current policies
- Hundreds of sectors and technologies
- Interfaces with PRIMES
- Covers both air pollutants and GHGs
- Includes a reduced form chemical transport model derived by EMEP
- Here: focus on SO2, NOx, primary PM2.5

How emissions are calculated in GAINS

Emissions = (activity data) x (emission factor)

Example: coal-fired power plants, SO_2

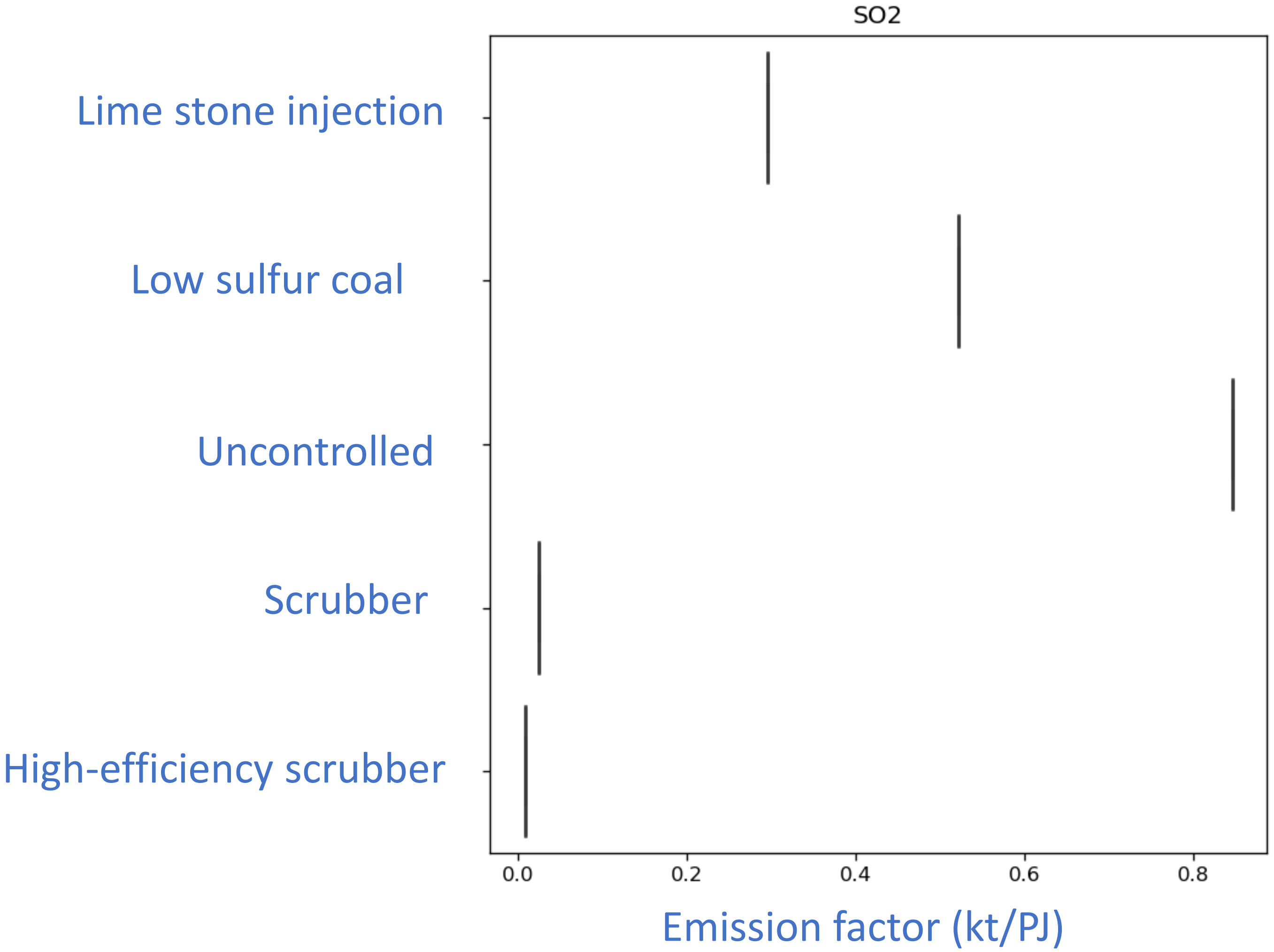


Emissions = (activity data) x (emission factor)
= 100 PJ x ???

The value of the emission factor depends on the control technology in place, if any.

Let's look at some SO2 emission factors for power plant emission control technologies

SO2 emission factors for power plants



Which one should we use?

Answer: It depends on which emission control technology is actually being applied in the real world to coal-fired power plants

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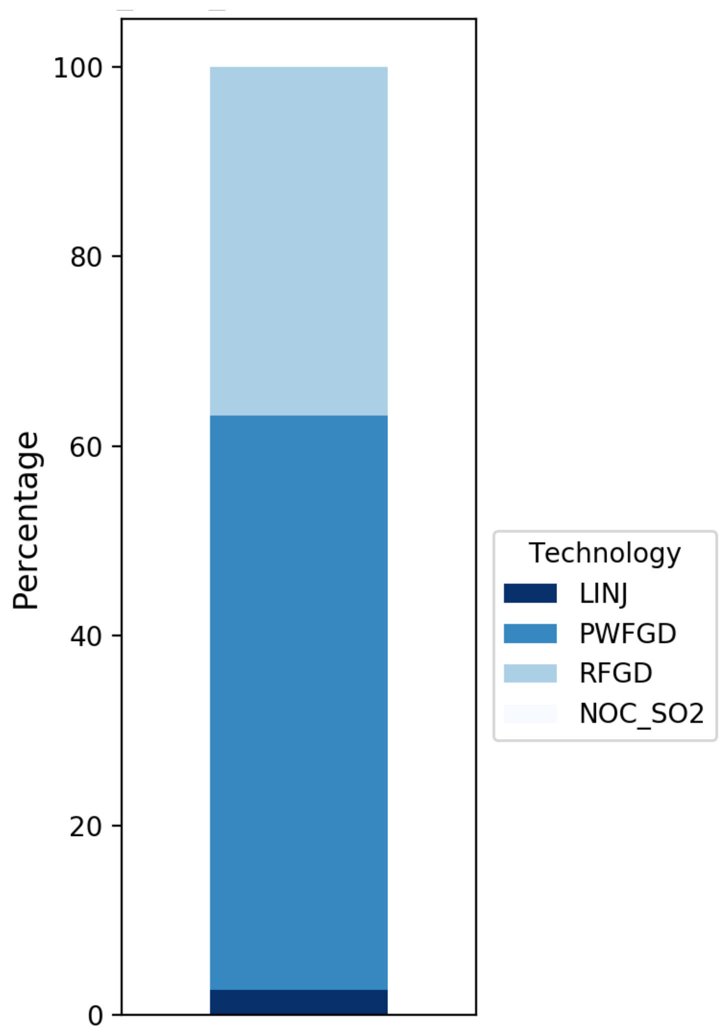
Share of each technology applied (the 'control strategy'):



Background: the policy context

- Zero Pollution Action Plan
- EU Clean Air policy package [National Emission Ceilings Directive; Directives on Large and Medium combustion plants]
- Industrial Emissions Directive (IED)
- Gothenburg Protocol under the UNECE LRTAP convention

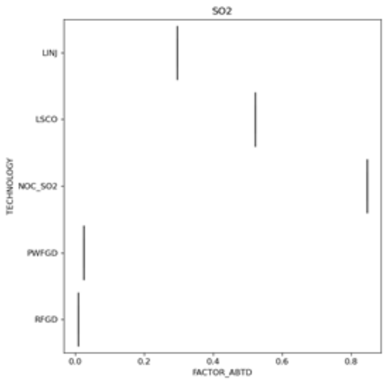
The average emission factor

The average emission factor is the weighted sum of the emission factors of the available control technologies and their relative application rates (‘control strategy’):

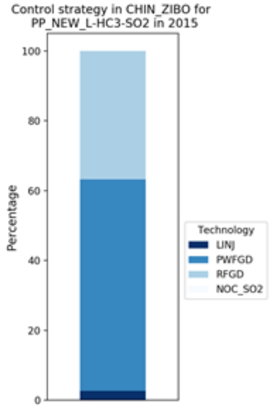
$$EF_{average} = \sum_{t} EF_t \times (share)_t$$

Example: coal-fired power plants

$$EF_{average} = \sum_{t}$$



$\times$

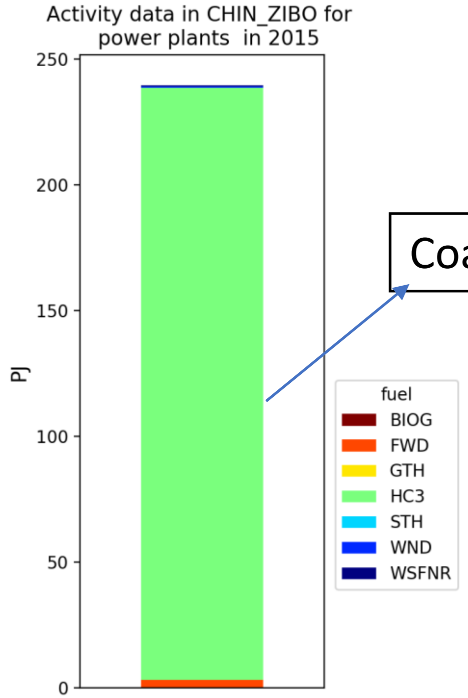


We can do this for every sector-activity-pollutant combination!

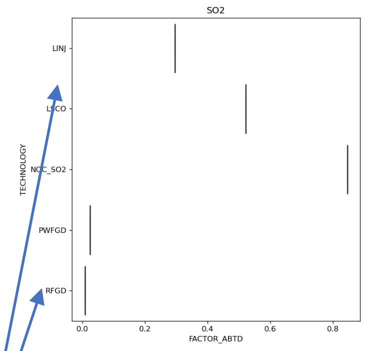
Revisiting the emissions calculation

- E.g. power plants

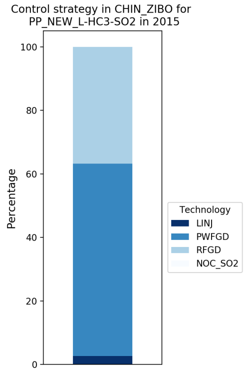
Emissions = (activity data) x (emission factor)



Coal (“HC3”) use $\times \sum_{t}$



$\times$



Different SO2 removal technologies

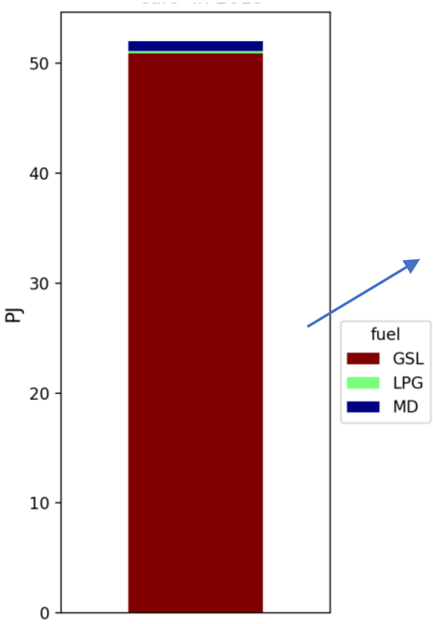
We can do this for every sector-activity-pollutant combination!

How emissions are calculated in GAINS

Emissions = (activity data) x (emission factor)

Example 2: NOx emissions from gasoline cars

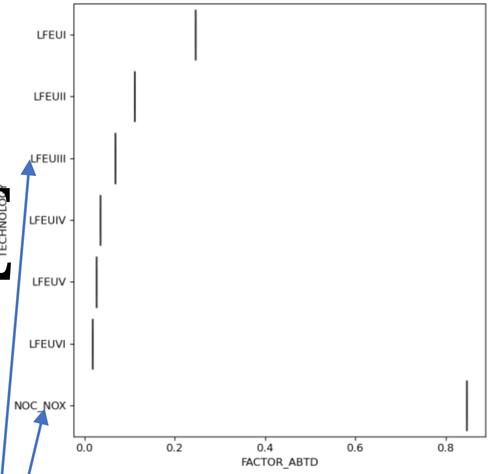
Fuel use in 2015



gasoline consumption

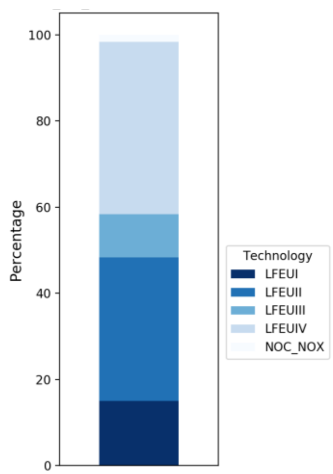
$$\times \sum_{t}$$

NOx emission factors



$$\times$$

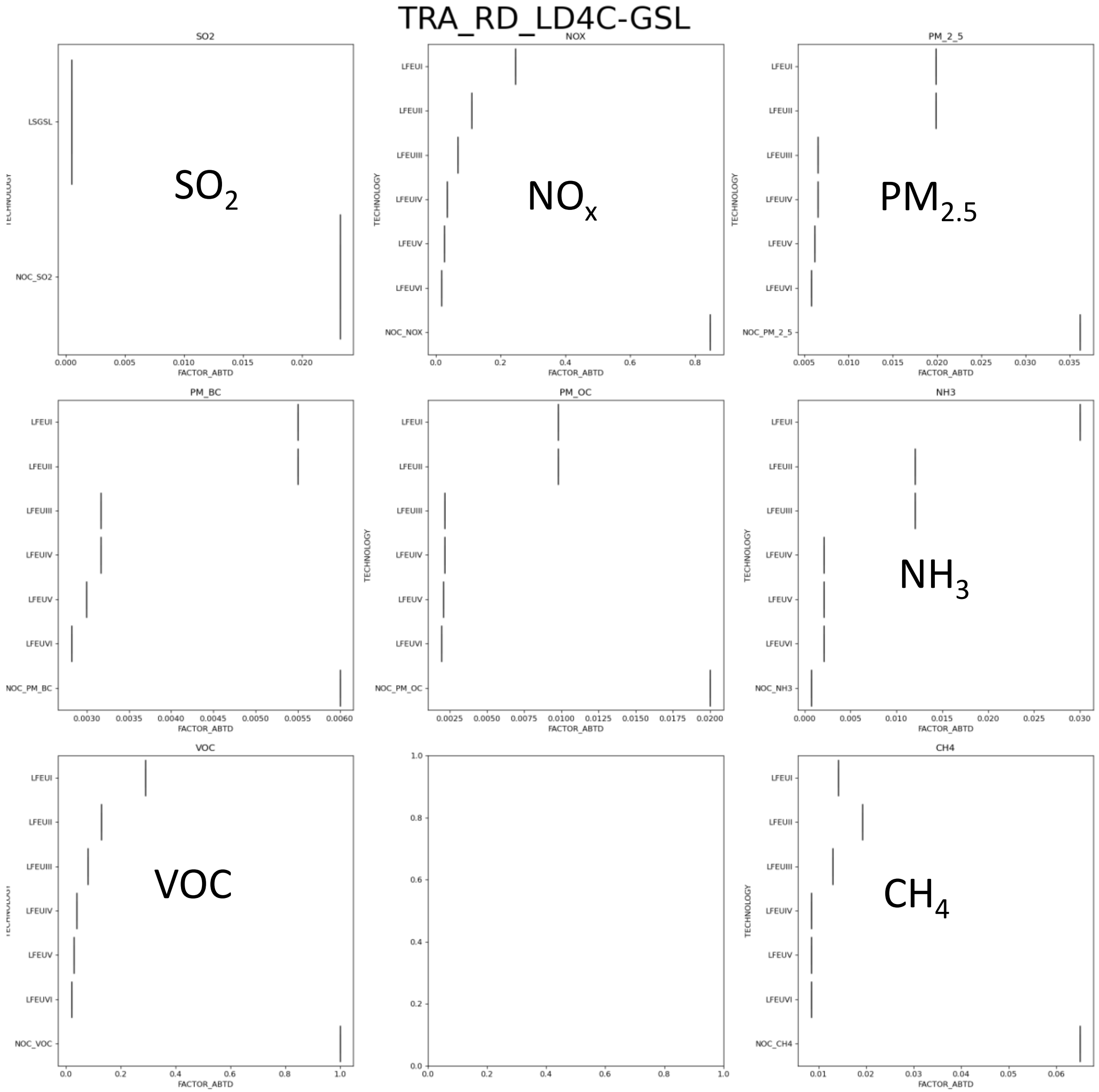
Share of technologies



Different EURO standards

GAINS calculates this for all pollutants

Emission factors used



Future emission factors scenarios

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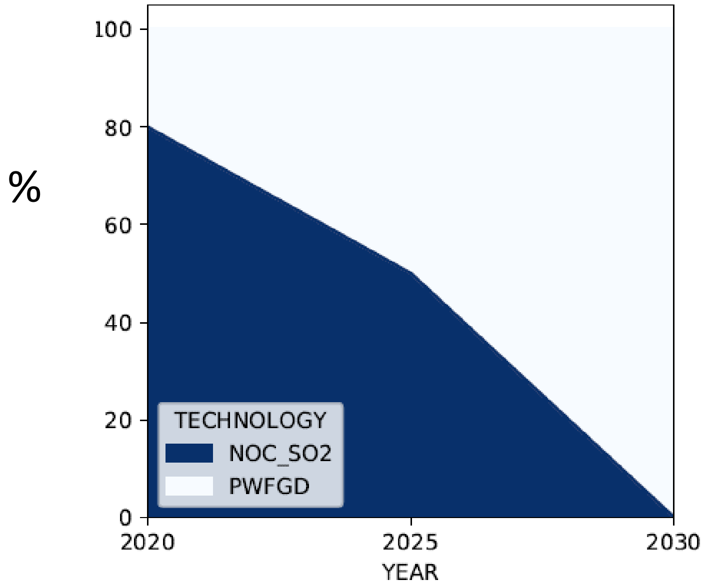
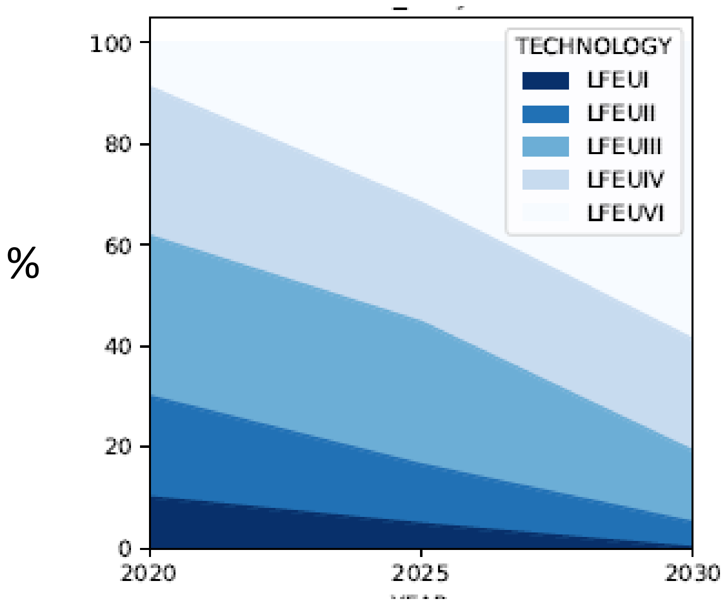
Challenge: Translate future emission control policies into ‘control strategies’

e.g. SO_2 controls in coal-fired power plants



e.g. NO_x controls for gasoline cars



Respect fleet turnover rates!

Human health (air pollution) - Motivation

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Health impacts of air pollution in Europe, 2022

Air pollution is the largest environmental health risk in Europe. It is a major cause of adverse health effects: for instance, air pollution causes and aggravates respiratory and cardiovascular diseases. Heart disease and stroke are the most common causes of premature deaths attributable to air pollution, followed by lung diseases and lung cancer. This chapter presents the latest estimates of the health impacts of exposure to fine particulate matter, nitrogen dioxide and ozone in terms of morbidity and premature deaths. It also assesses progress towards the EU's zero pollution action plan target to reduce mortality attributable to air pollution.

Published 24 Nov 2022 — Last modified 13 Mar 2023 — 15 min read — Photo: © Elia Lazzari, Well with Nature /EEA.

Key messages

- In 2020, air pollution led to a significant number of premature deaths in the 27 EU Member States (EU-27). Exposure to concentrations of fine particulate matter above the 2021 World Health Organization guideline level resulted in 238,000 premature deaths; exposure to nitrogen dioxide above the respective guideline level led to 49,000 premature deaths. Acute exposure to ozone caused 24,000 premature deaths.
- The zero pollution action plan aims to reduce the number of premature deaths due to exposure to fine particulate matter by 55% by 2030, compared to 2005. In 2020, the number of premature deaths attributable to exposure to fine particulate matter above the WHO guideline level fell by 45% in the EU-27, compared to 2005. If this rate of decline is maintained, the EU will reach the aforementioned zero pollution action plan target before 2030.

Source: EEA

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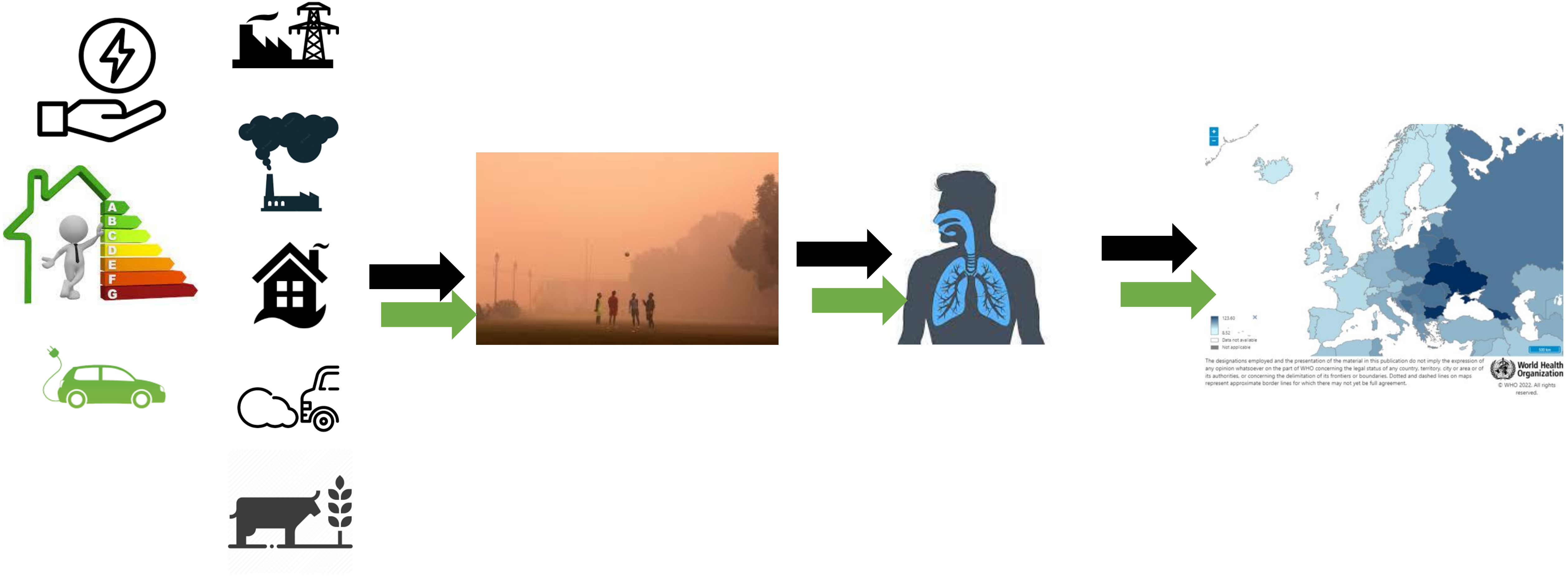

Emissions

Ambient air quality

Exposure and vulnerability

Impact

Human health (air pollution) - Methodology

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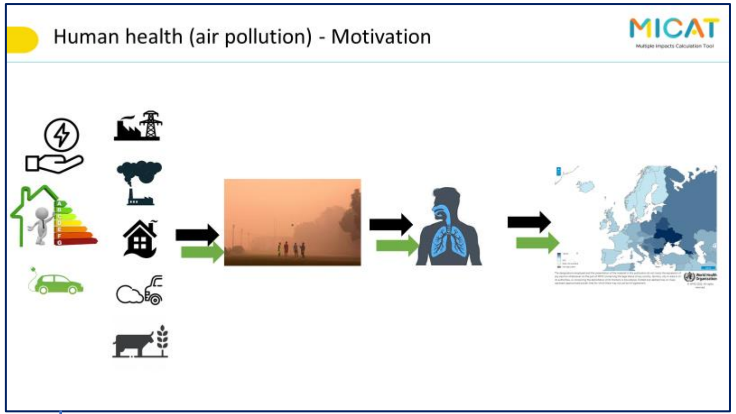

GAINS model

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- Hundreds of sectors and technologies
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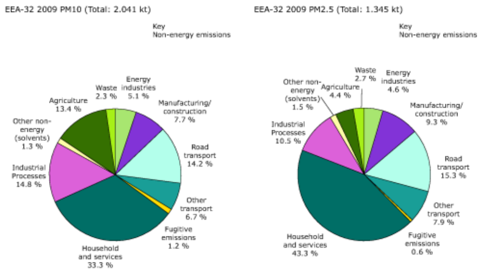
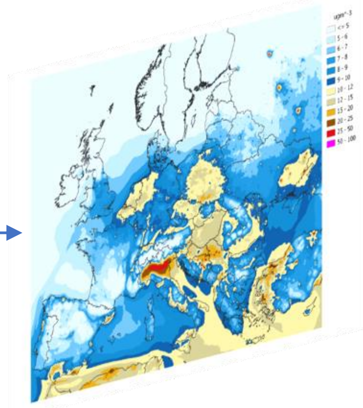
- Here: focus on health impact of fine particles (PM2.5)

How many tons of emissions are reduced?



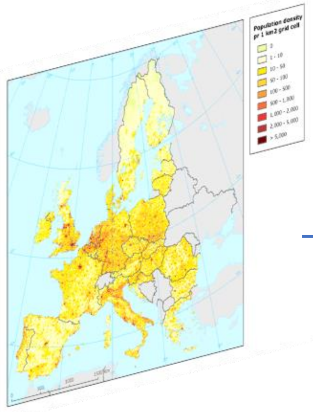
Reflect use of technologies, sector specific emission factors and regulations

Where is the ambient pollution being reduced?



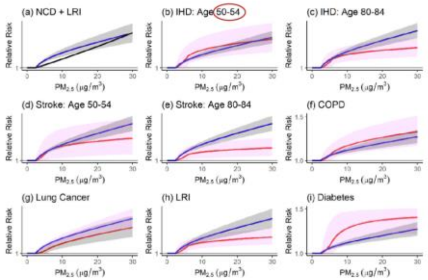
Reduced form chemical transport model

Where do people live?



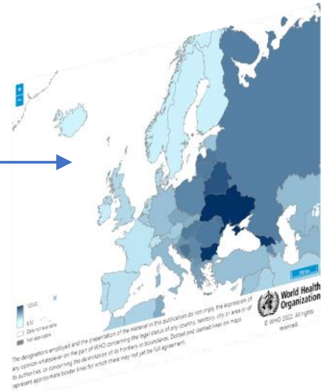
Population density map

How vulnerable are the populations?



Relative risks

How many people are affected?



Impact coefficients per unit of energy saved

Human health (air pollution) - Monetization

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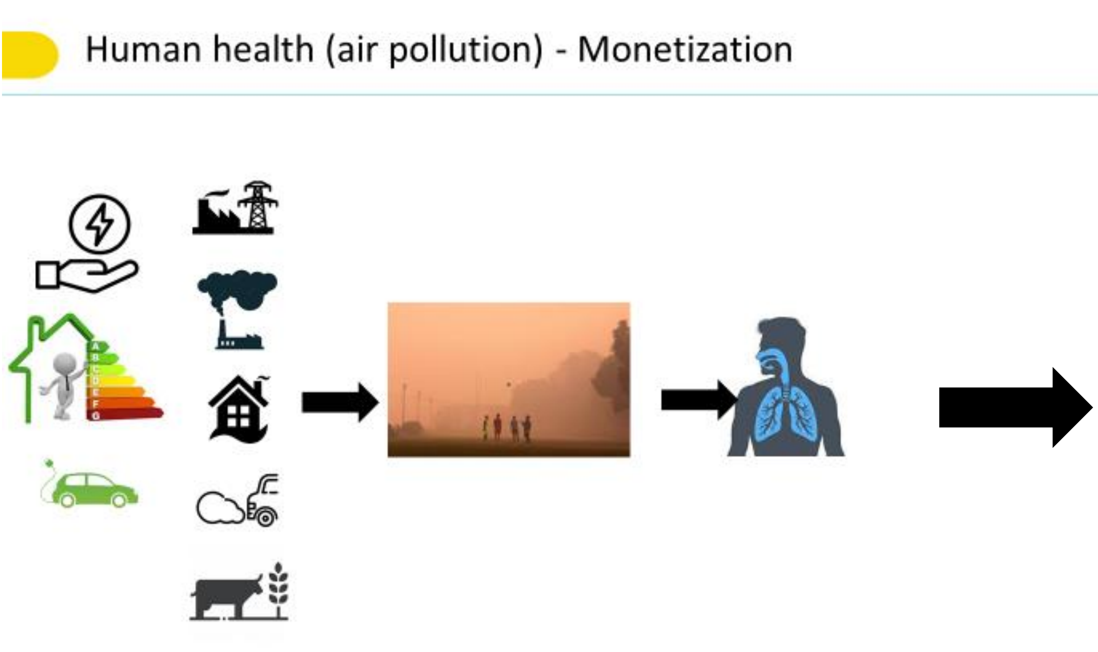


Related hospitalizations

(Costs per day) x days

Work days lost

(Costs per day) x days

Premature deaths

Value of statistical life

Human health (air pollution) – Main assumptions/limitations

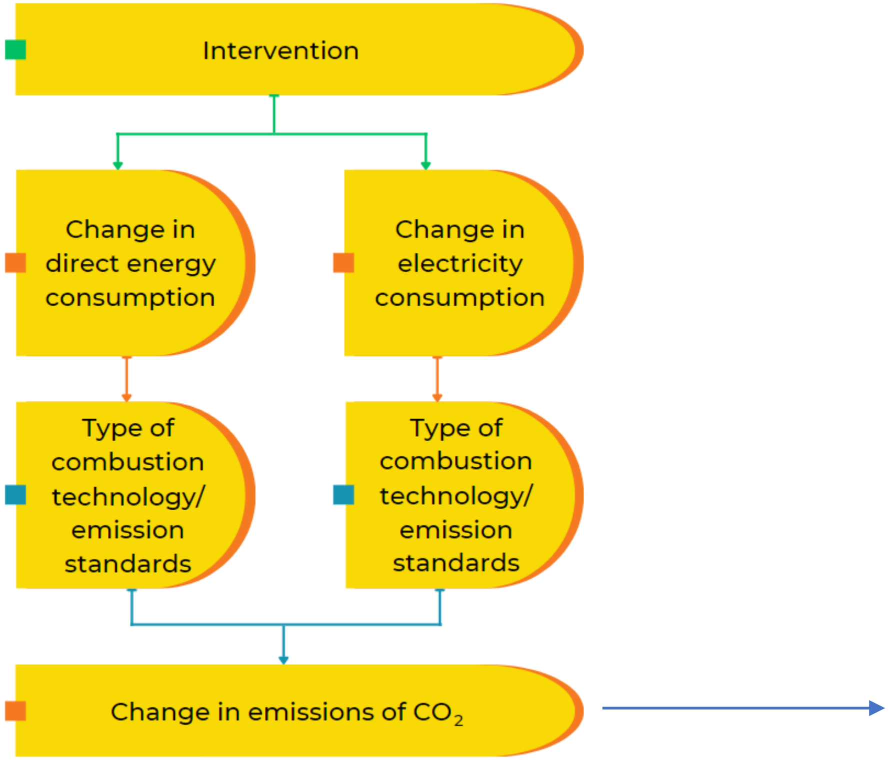
Central assumptions

- PM2.5 has the most significant air pollution related health impact → focus on PM2.5 and precursors
- The GAINS model methodology for calculating PM2.5 concentrations is well-established, peer-reviewed and consistent across member states
- The dataset used in MICATool is consistent with the assumptions made for recent EC work on the Ambient Air Quality Directive (AAQD) and the Clean Air Outlook (CAO3) → future scenarios reflect current policies

Methodological limitations/uncertainties

- Energy efficient measures in MICATool are often not fuel-specific
- Spatial distribution of sources are constant (within a sector) in GAINS
- Linear dose-response functions at the national level → not straightforward to scale down to city level

Impacts on emissions of GHGs/CO_2



Monetization (options):
- Carbon price
- Social Costs of Carbon

GHGs: CO_2 – Main assumptions/limitations

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Central assumptions

- IPCC Tier 1 emission factors
- Biomass is not considered carbon neutral

Methodological limitations/uncertainties

- Non-CO2 gases not covered in MICAT

Savings of natural material resources

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Definition of Material Footprint in MICAT: *Savings of abiotic and biotic raw materials from nature including raw materials without economic use (unused extraction)*

Sub-indicators of Material Footprint:

- Savings of fossil fuels
- Savings of metal ores
- Savings of minerals
- Savings of biotic raw materials
- Unused extraction savings

Application in MICAT:

- Quantification of the differences (usually savings) in removing material resources from nature before and after energy efficiency improvement actions are implemented.
- **Use phase:** account for the reduced demand of material resources from energy provision (cradle-to-gate)
- **Production phase:** account for changes in product types and product stocks

Quantification approach:

1. All indicators expressed in form of intensities (gram of material per functional unit) that are derived from the input data (e.g. electricity mix defines upstream material demand per kWh) and models (e.g. material demand for producing an electric vehicle).
2. Intensities are multiplied with the marginal changes in the system (e.g., kg of hard coal for heat) and summed up.

Impact pathway for savings of natural material resources

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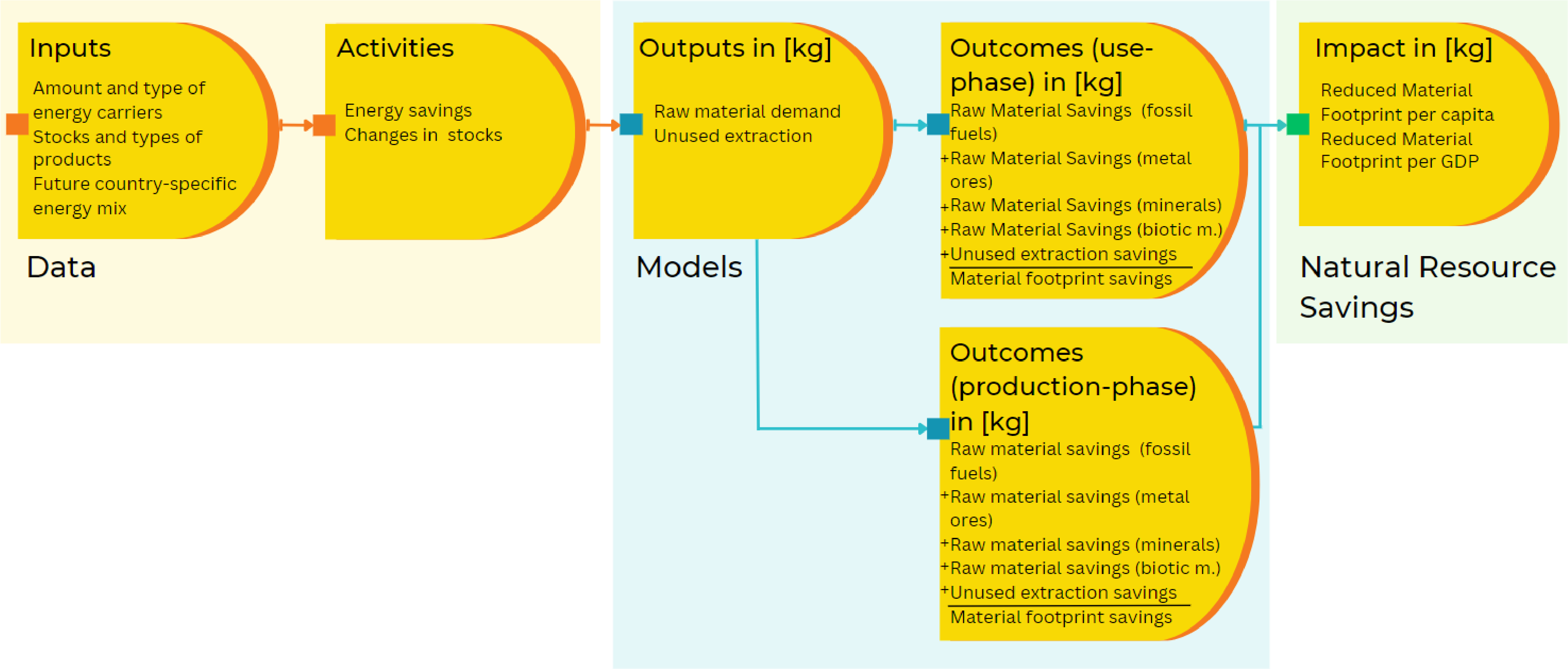
LOGIC MODEL (THEORY OF CHANGE) FOR MATERIAL FOOTPRINT



Quantification of natural material resource savings

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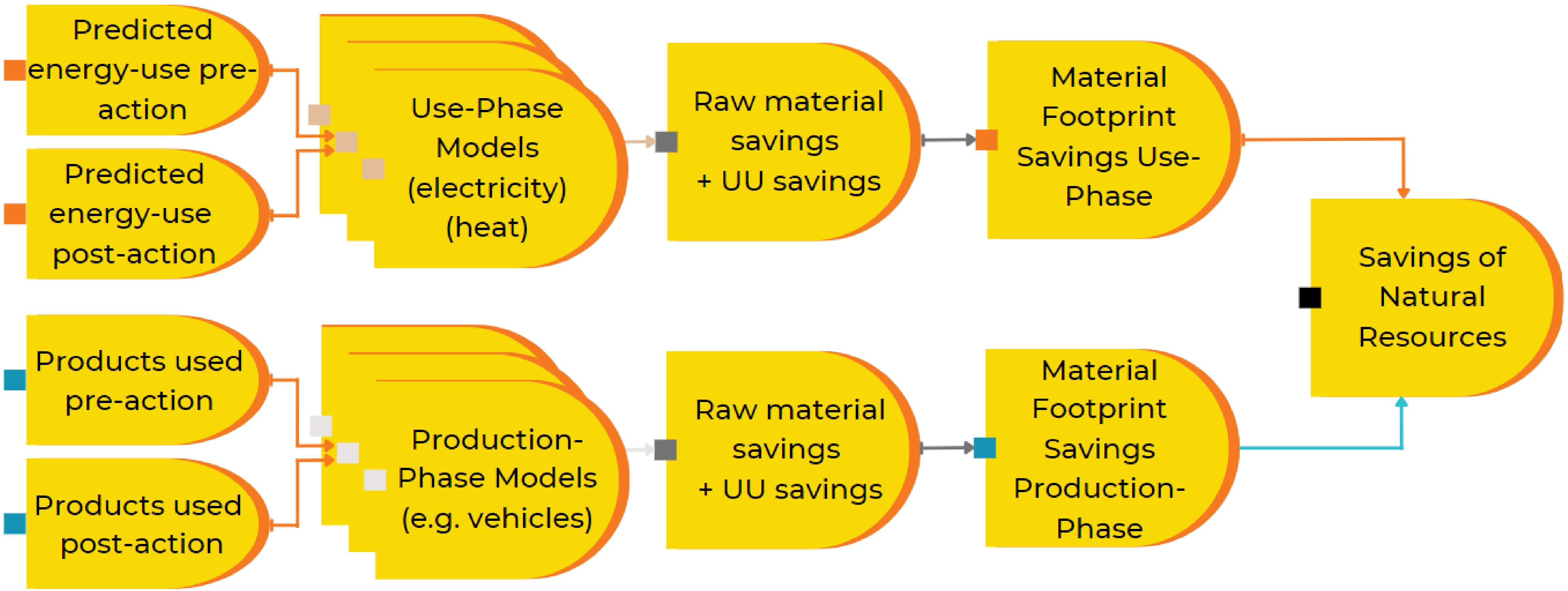
CALCULATION STEPS



Limitations and challenges

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- Definition of average/representative energy efficiency improvement actions necessary to quantify the production phase

  → production phase only quantified for a limited number of energy efficiency actions in MICAT (e.g. lighting)

- Resource savings not included in CBA due to double counting with investments (production phase) and energy cost savings (use-phase). However, avoided external (often future) environmental costs of use phase (e.g. due to resource extraction) can be considered in CBA.

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THANK YOU

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