ENV 370 (GR A332 – GRB001)
Environmental system analysis and assessment – Evaluation et analyse environnementale systémique

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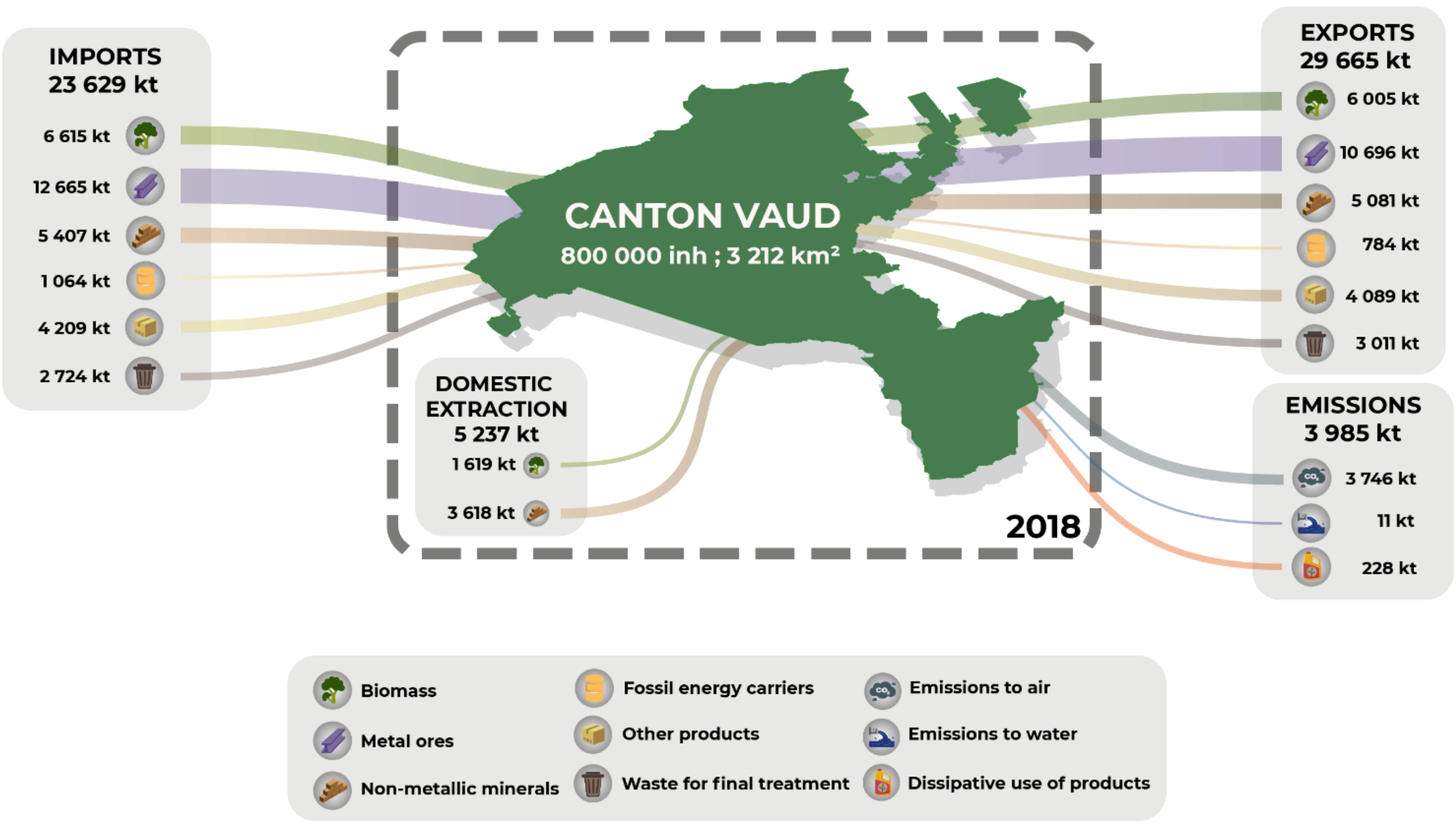
EPFL - Spring 2025

Merci pour votre participation

Aim of the course

Enable you to carry out environmental system analyses and assessments (through using different assessment methods for different scales)

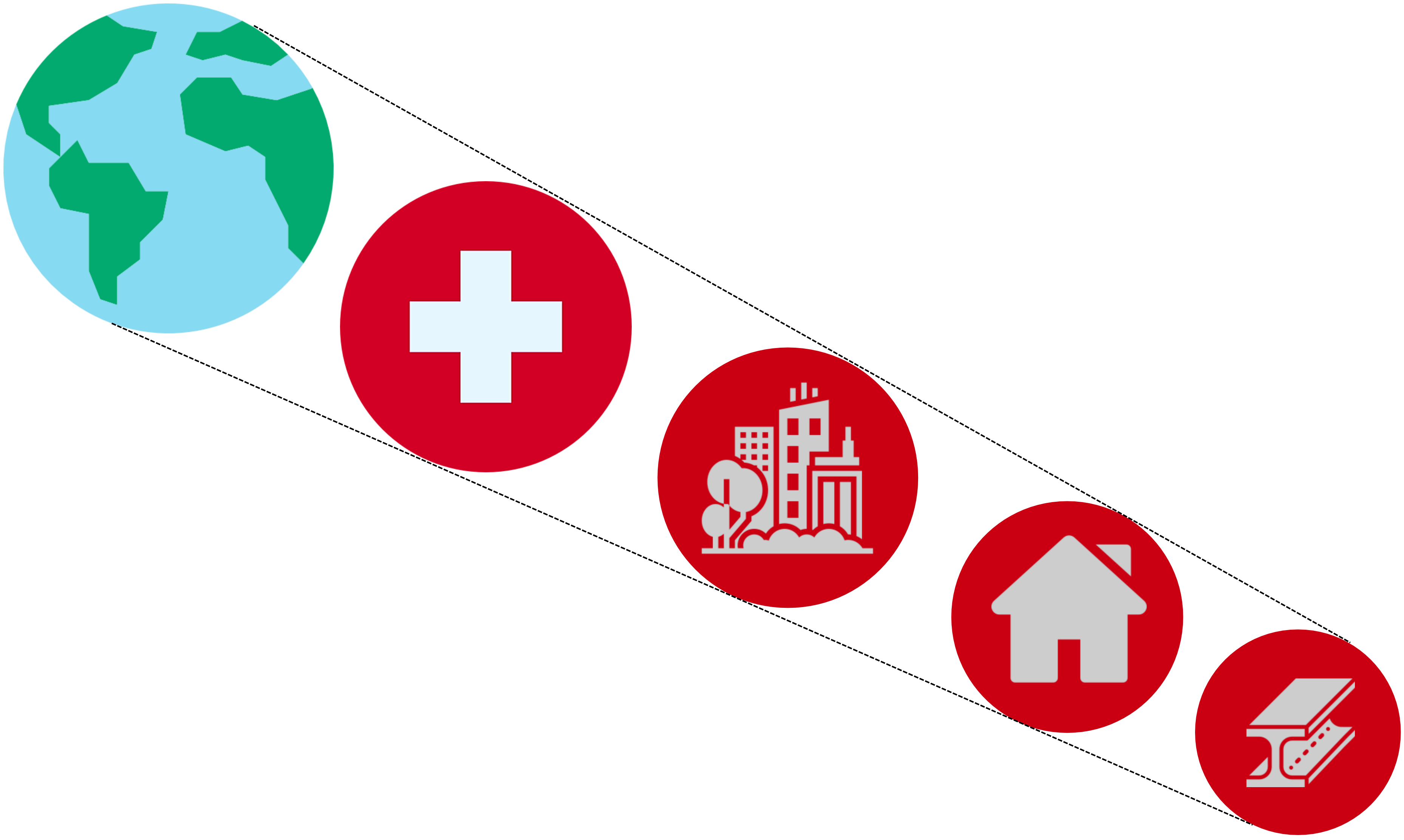


Questions ?

Question ?

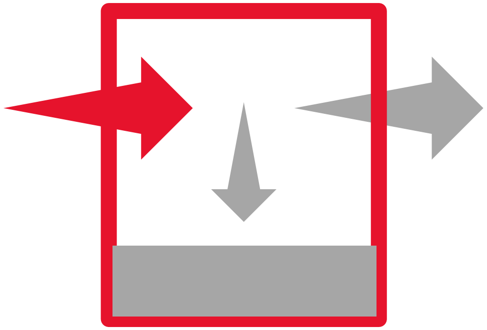
1. Par rapport au contenu de la semaine passé?
2. Par rapport à l'organisation du cours?
3. Vous avez digéré les chiffres?

RECAP



Recap – what number surprised you the most?

From 1900-2015



- Population: 4.6x
- Rural Population: 2.6x
- Urban Population: 14x
- Global primary energy consumption: 15x/year
- Global freshwater use: 6x/year
- Global material extraction: 12x/year
- Material stocks: 27x
- Waste/Outflows: 11x/year
- CO_2 emissions: 15x/year
- GDP : 27x

RECAP – Stocks vs Flows

Elhacham, E., Ben-Uri, L., Grozovski, J., Bar-On, Y. M., & Milo, R. (2020). Global human-made mass exceeds all living biomass. *Nature*, *588*(7838), 442-444.

Krausmann, F., Lauk, C., Haas, W., & Wiedenhofer, D. (2018). From resource extraction to outflows of wastes and emissions: The socioeconomic metabolism of the global economy, 1900–2015. *Global Environmental Change*, *52*, 131-140.

RECAP - Global inequalities over use

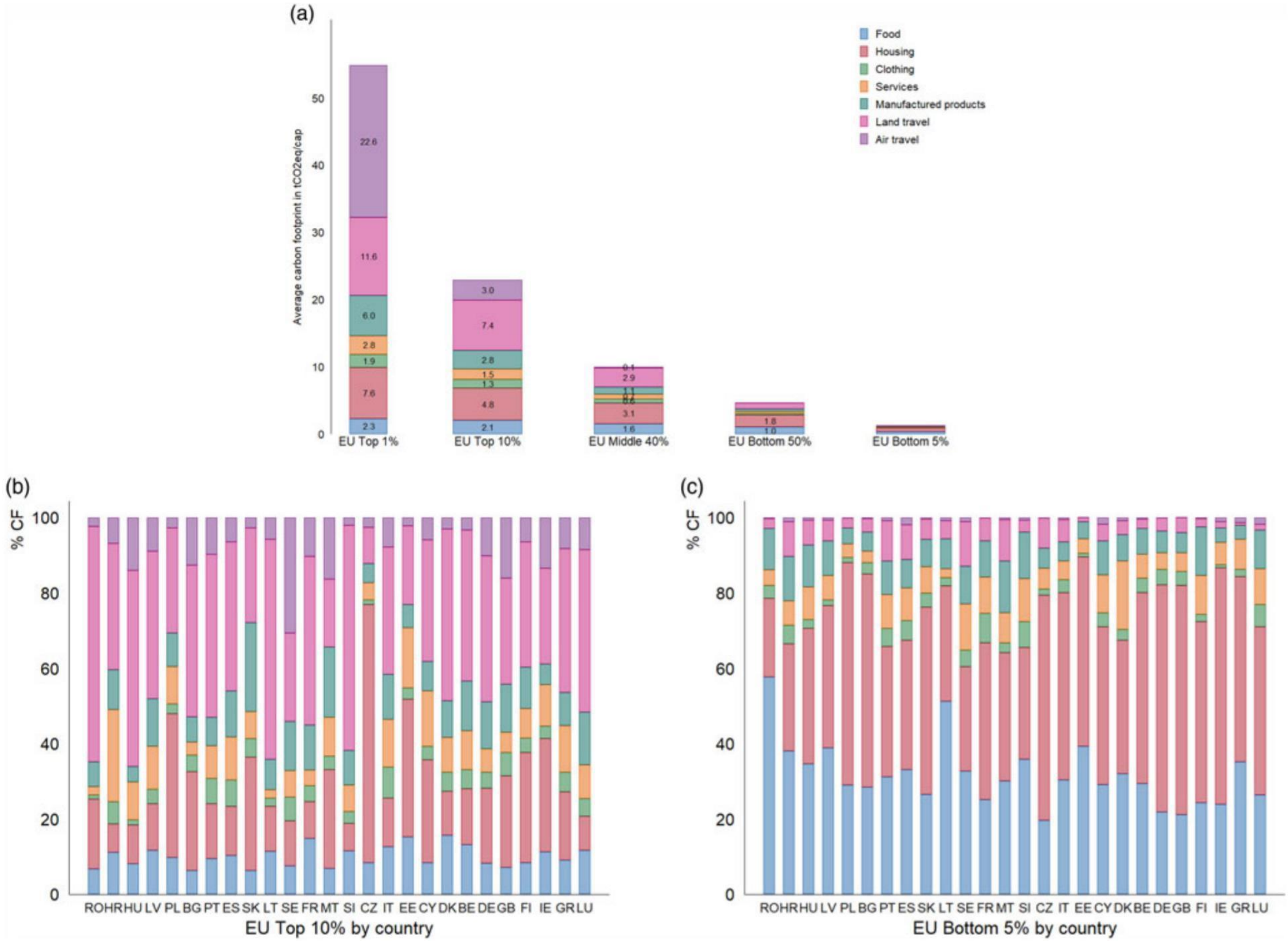


Fig. 3. Average carbon footprint (CF) distribution by consumption category in the European Union (EU) (top). The bottom graph depicts the average CF shares by consumption category and countries of EU top 10% emitters on the left (with CF >15 tCO_2eq/cap) and EU bottom 5% of emitters on the right (with CF <2.5 tCO_2eq/cap). See SI4 for country averages. EU household weights applied. See Section 2 for country codes.

Source: : Ivanova D, Wood R (2020). The unequal distribution of household carbon footprints in Europe and its link to sustainability. Global Sustainability 3, e18, 1–12. https://doi.org/10.1017/sus.2020.12

What about Energy Transition ?

National **4+ categories** material flows | National **13+ categories** material flows | National material **totals and ratios**

Filter countries — Clear filter: World ×

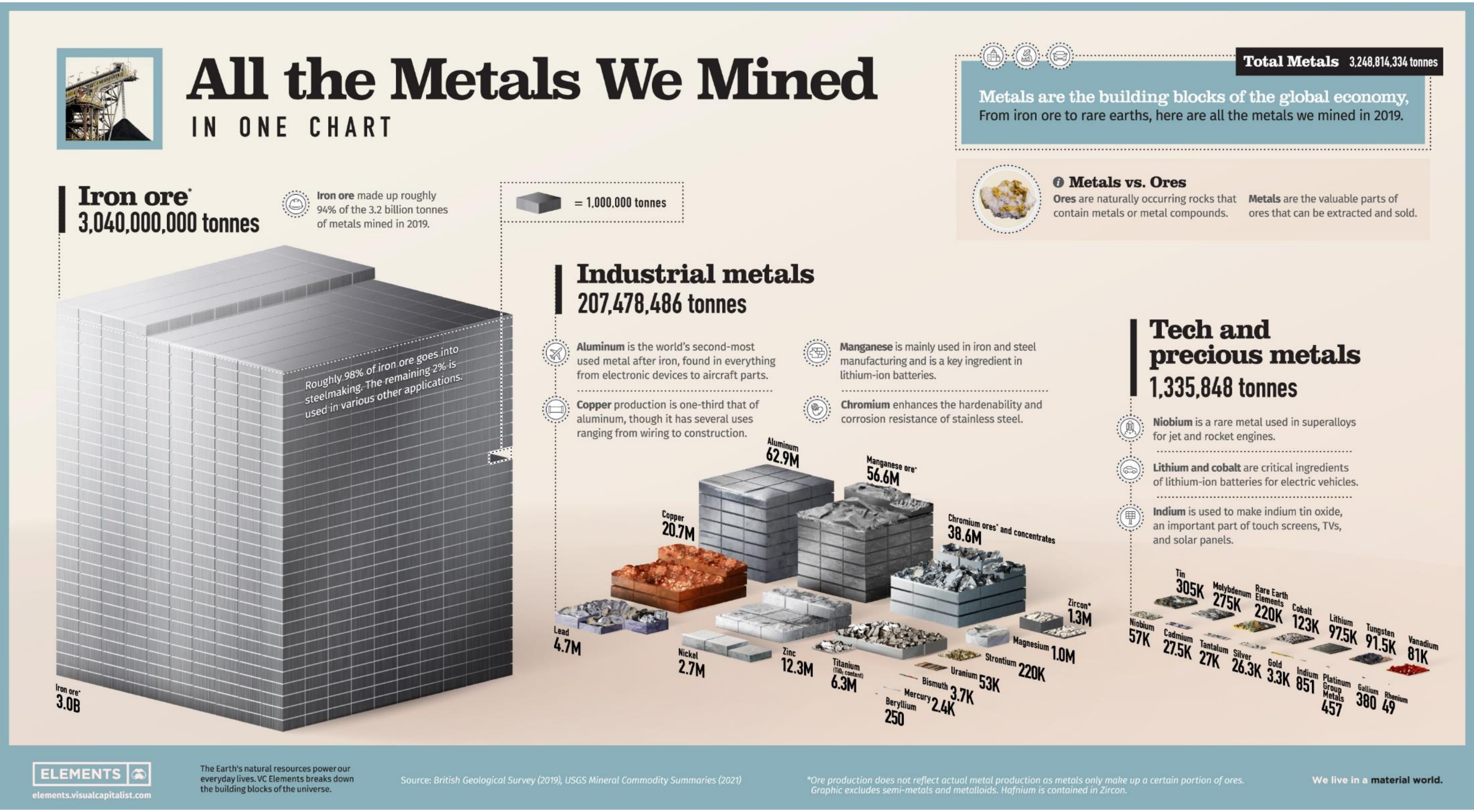
Filter categories — Clear filter: Fossil fuels ×, Metal ores ×

Filter flow types — Clear filter: DE (Domestic Extraction,... ×

Country	Category	Flow	2020	2021	2022	2023	2024
World	Fossil fuels	DE	362,033,658	15,823,307,613	15,915,740,174	15,998,218,386	16,102,490,158
World	Metal ores	DE	405,077,100	9,830,519,158	10,070,051,181	10,321,586,529	10,619,770,397

https://www.resourcepanel.org/global-material-flows-database

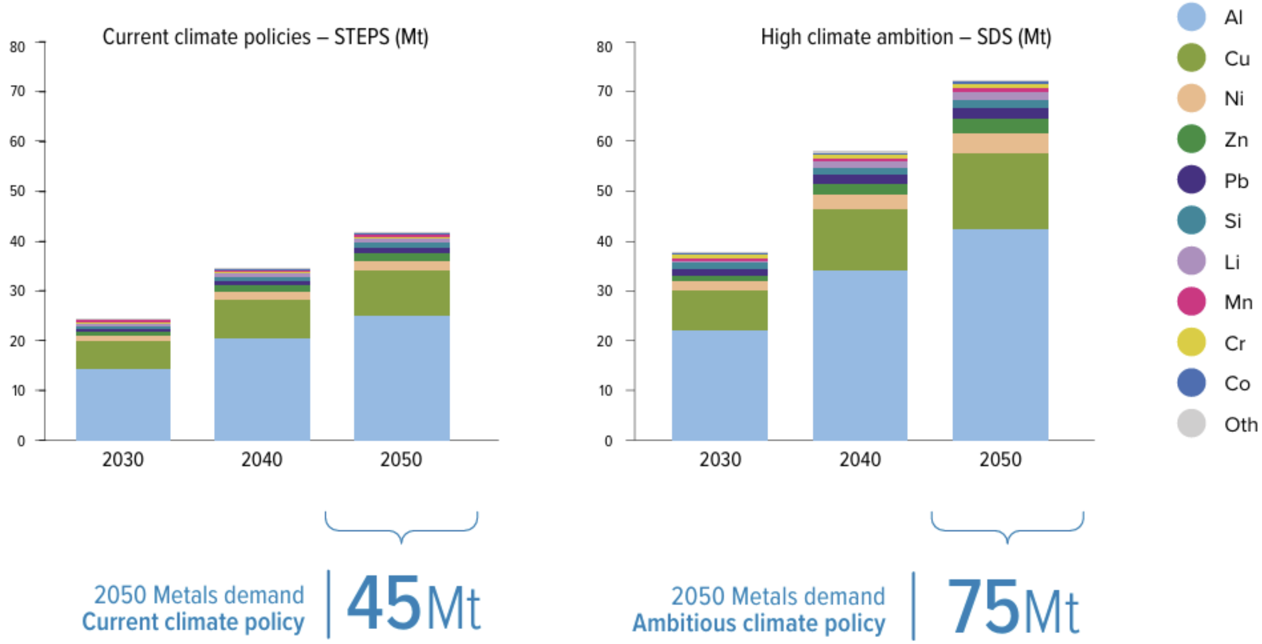
What about Energy Transition ?



https://www.visualcapitalist.com/all-the-metals-we-mined-in-one-visualization/

What about Energy Transition ? Metal needs

Global metal demand by commodity for clean energy technologies in a STEPS and SDS scenario respectively (Mt*)



% metal required in 2050 for clean energy technologies vs. 2020 overall use (Global SDS ambitious climate scenario).** †

Lithium	2,109%	Silicon	62%
Dysprosium	433%	Terbium	62%
Cobalt	403%	Copper	51%
Tellurium	277%	Aluminium	43%
Scandium	204%	Tin	28%
Nickel	168%	Germanium	24%
Praseodymium	110%	Molybdenum	22%
Gallium	77%	Lead	22%
Neodymium	66%	Indium	17%
Platinum	64%	Zinc	14%
Iridium	63%	Silver	10%

**Mt = million tonnes, annual (including lithium expressed as metal equivalent)*

https://www.eurometaux.eu/media/hr2ftbp3/2022-policymaker-summary-report-final-13-5-22.pdf

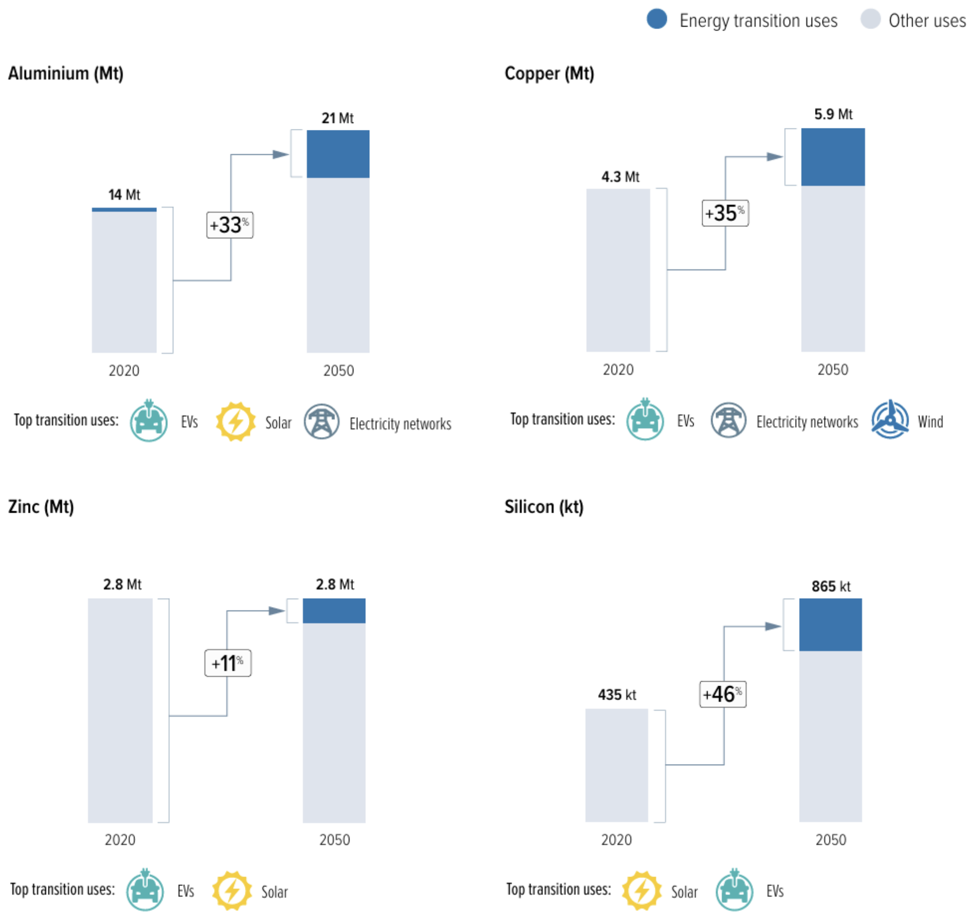
What about Energy Transition ? (Lithium need in EU x35)

World Mine Production and Reserves: Reserves for Argentina, Australia, Brazil, China, the United States, and "Other countries" were revised based on company and Government reports.

	Mine production 2022	Mine production 2023[e]	Reserves[4]
United States	W	W	1,100,000
Argentina	6,590	9,600	3,600,000
Australia	74,700	86,000	[5]6,200,000
Brazil	[e]2,630	4,900	390,000
Canada	[e]520	3,400	930,000
Chile	38,000	44,000	9,300,000
China	[e]22,600	33,000	3,000,000
Portugal	[e]380	380	60,000
Zimbabwe	[e]1,030	3,400	310,000
Other countries[6]	—	—	2,800,000
World total (rounded)	[7]146,000	[7]180,000	28,000,000

https://www.usgs.gov/centers/national-minerals-information-center/lithium-statistics-and-information

What about Energy Transition ? In Eu ? Opening of new Mines ?

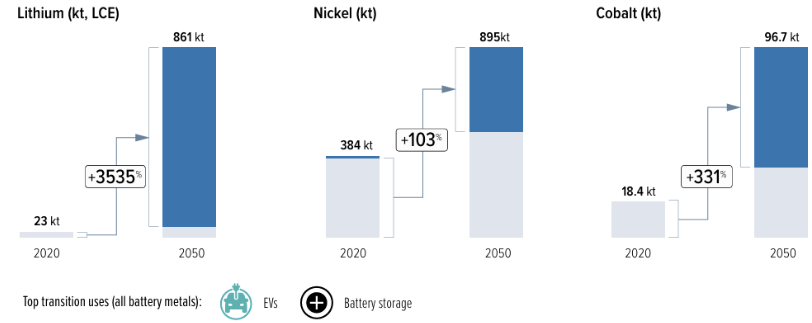


BATTERY METALS

Europe will require significant new supplies of nickel, lithium, and cobalt for its domestic battery cathode manufacturing plans. Of these metals, Europe only has a significant existing market for nickel, which is mainly used in stainless steel.

By 2050, batteries will be Europe's major use for lithium, nickel, and cobalt under all the study's scenarios, with new demand reaching up to 3500% of Europe's lithium consumption today, 330% of cobalt, and more than 100% of nickel.

Uncertain technology developments after 2030 will likely impact these long-term projections. Regular attention is required to the battery market and potential breakthrough technologies.

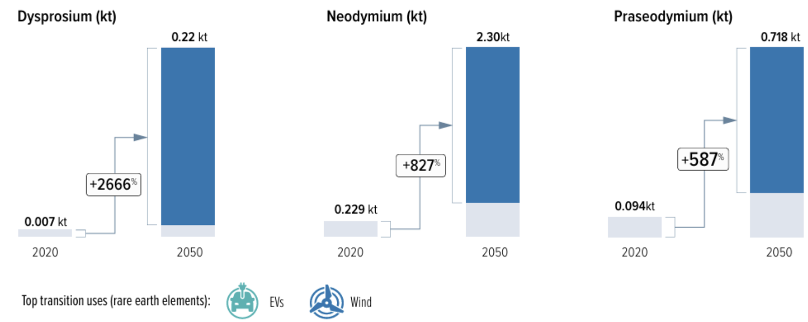


RARE EARTH METALS

Significant volumes of rare earth elements in permanent magnets will be required in Europe's electric vehicles and wind turbines.

But Europe will only require new supplies of rare earth metals if it is successful in building up domestic permanent magnets production – competing against China's near monopoly of the rare earths/permanent magnets market.

Even a moderate level of European domestic magnets production would transform the European rare earths market, requiring between 600% and 2700% extra compared with Europe's consumption today.



https://www.eurometaux.eu/media/hr2ftbp3/2022-policymaker-summary-report-final-13-5-22.pdf

Opening of new Mines ? What to consider ?

Actualités Économie Vidéos Débats Culture Le Goût du Monde Services

ÉCONOMIE · INDUSTRIE

Une première mine de lithium va être exploitée en France, avec l'ambition d'équiper 700 000 véhicules en batteries par an

Le leader mondial des spécialités minérales pour l'industrie Imerys a annoncé, lundi, le lancement d'un important projet d'exploitation à Echassières, dans l'Allier.

Par Jean-Yves Vif (Moulins, correspondant)
Publié le 24 octobre 2022 à 08h01, modifié le 25 octobre 2022 à 06h01 · Lecture 3 min. · Read in English

Lire plus tard

Article réservé aux abonnés

Les études et carottages prévoient la présence en profondeur de fortes concentrations d'hydroxyde de lithium, au total un million de tonnes d'une teneur entre 0,9 % et 1 % d'oxyde, confirmant les estimations du Bureau de recherches géologiques et minières (BRGM). Ce gisement permettra l'extraction de 34 000 tonnes pendant vingt-cinq ans. Imerys deviendra ainsi un fournisseur de premier plan du marché européen, avec une capacité d'équipement de 700 000 véhicules en batteries lithium-ion par an.

Lire aussi : Réindustrialisation : « Le gouvernement a lancé la machine, mais il reste le plus dur, changer les esprits »

Outre les études déjà réalisées pour 30 millions d'euros, le projet nécessitera un investissement minimum d'un milliard d'euros, sur la base d'un coût de production du lithium estimé entre 7 euros et 9 euros le kilo. Imerys le juge *« très compétitif, en particulier sur le*

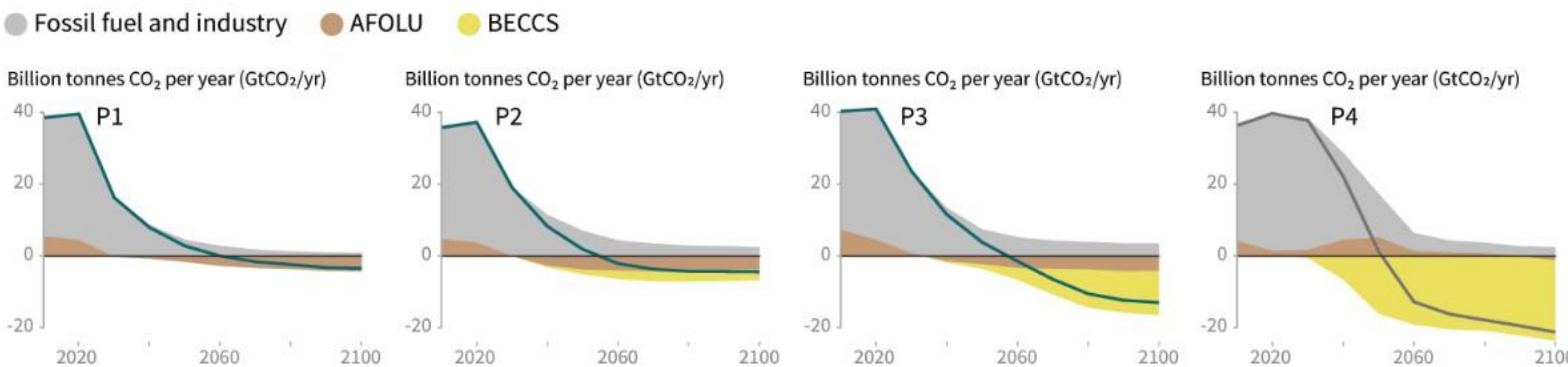
https://www.lemonde.fr/economie/article/2022/10/24/imerys-annonce-l-ouverture-de-la-premiere-production-de-lithium-en-france-qui-fera-de-l-entreprise-un-acteur-de-poids-du-marche-europeen_6147060_3234.html

IPCC Pathways that stay under 1,5 C

Characteristics of four illustrative model pathways

Different mitigation strategies can achieve the net emissions reductions that would be required to follow a pathway that limits global warming to 1.5°C with no or limited overshoot. All pathways use Carbon Dioxide Removal (CDR), but the amount varies across pathways, as do the relative contributions of Bioenergy with Carbon Capture and Storage (BECCS) and removals in the Agriculture, Forestry and Other Land Use (AFOLU) sector. This has implications for emissions and several other pathway characteristics.

Breakdown of contributions to global net CO_2 emissions in four illustrative model pathways



P1: A scenario in which social, business and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A downsized energy system enables rapid decarbonization of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

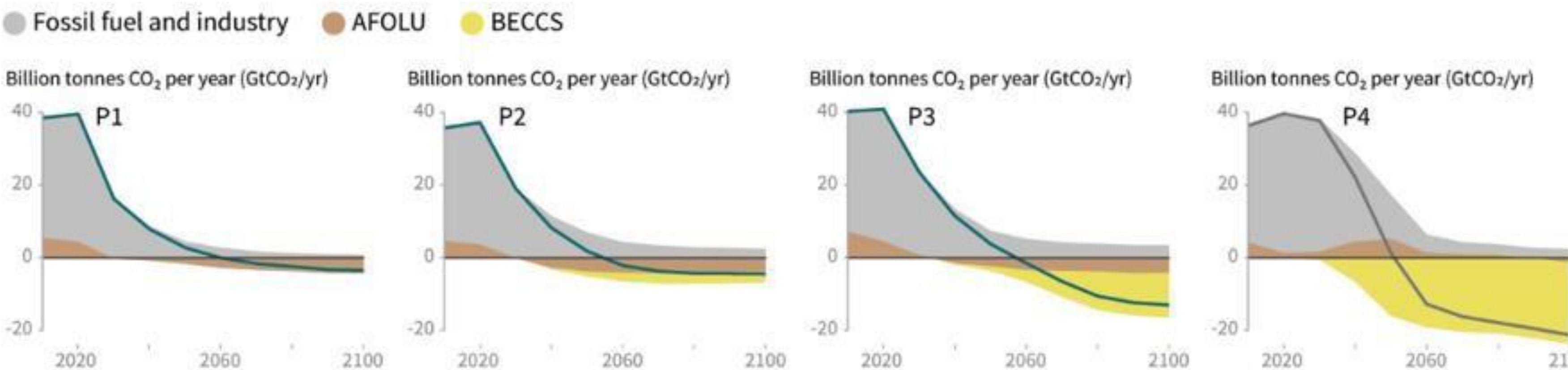
P2: A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

P3: A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

P4: A resource- and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas-intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

Source: IPCC, 2018: Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-24, doi:10.1017/9781009157940.001.

What Scenario is most desirable ?



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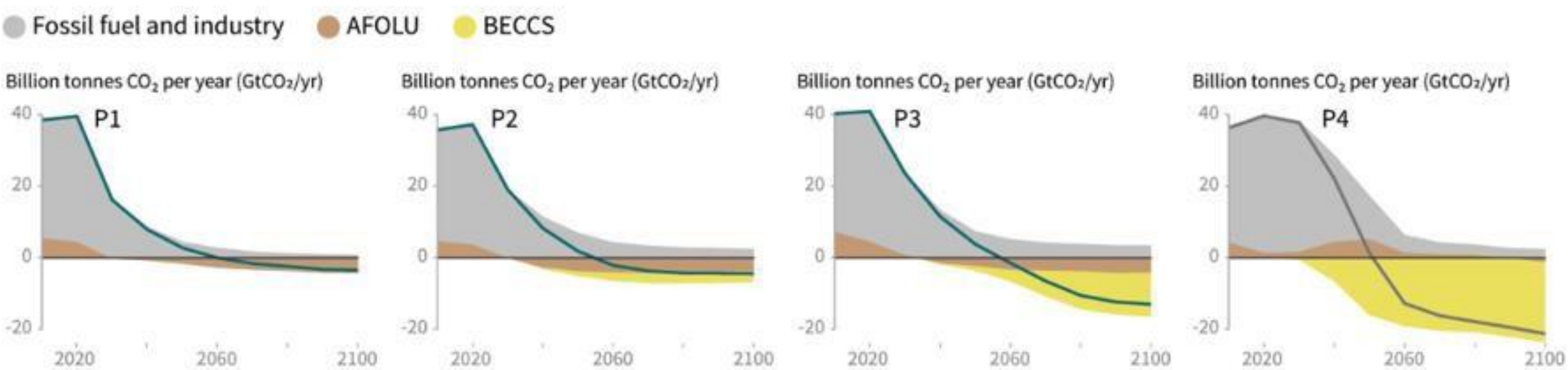
What Scenario is most likely ?



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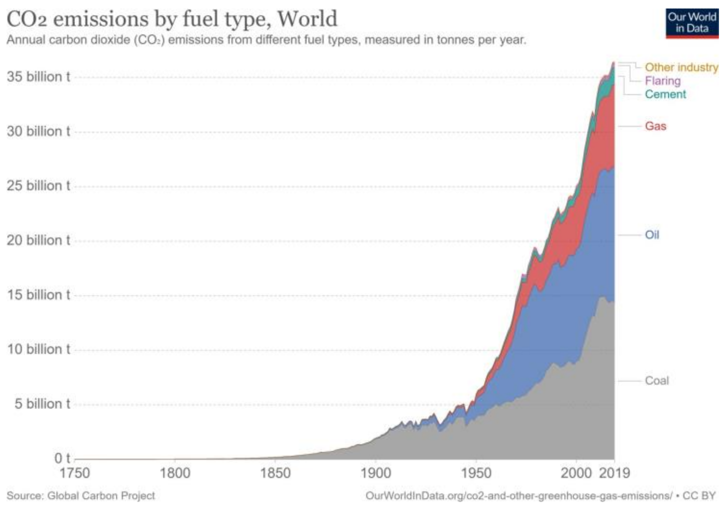
What solutions do we have ? Technologies



Many options available now in all sectors are estimated to offer substantial potential to reduce net emissions by 2030. Relative potentials and costs will vary across countries and in the longer term compared to 2030.

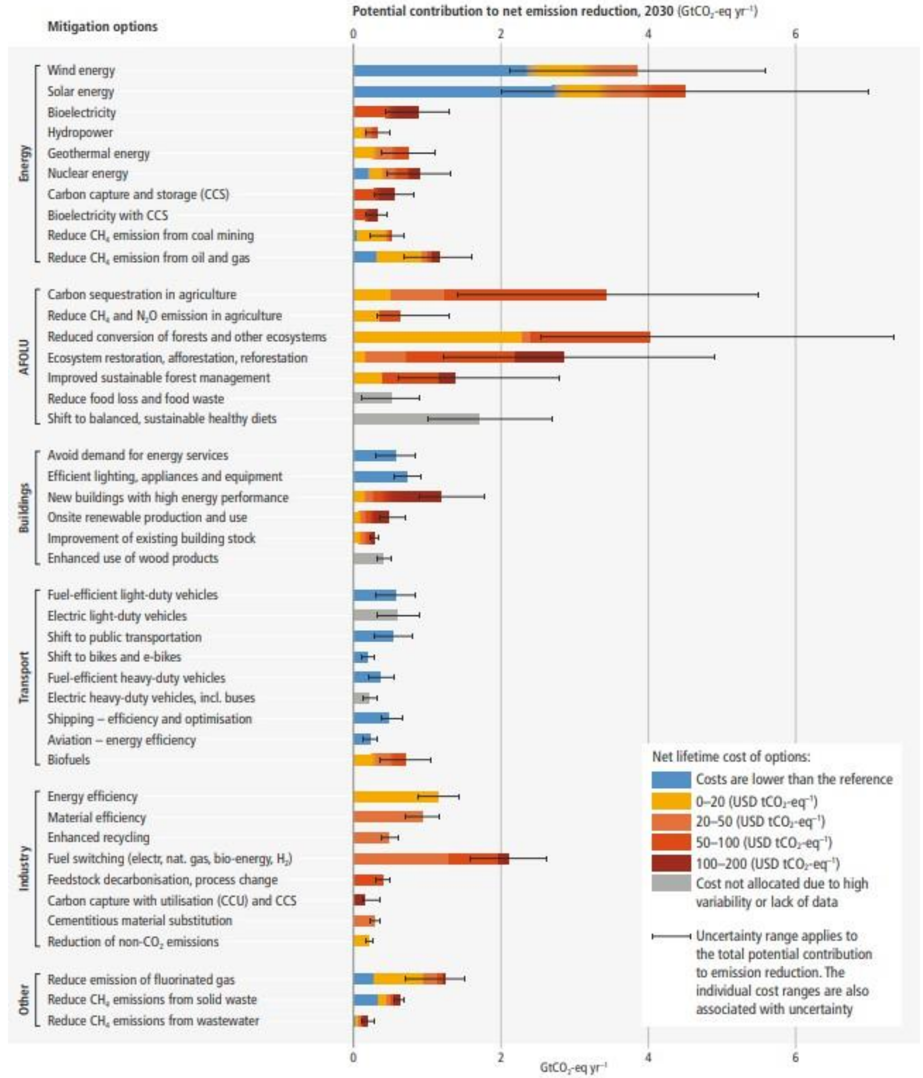
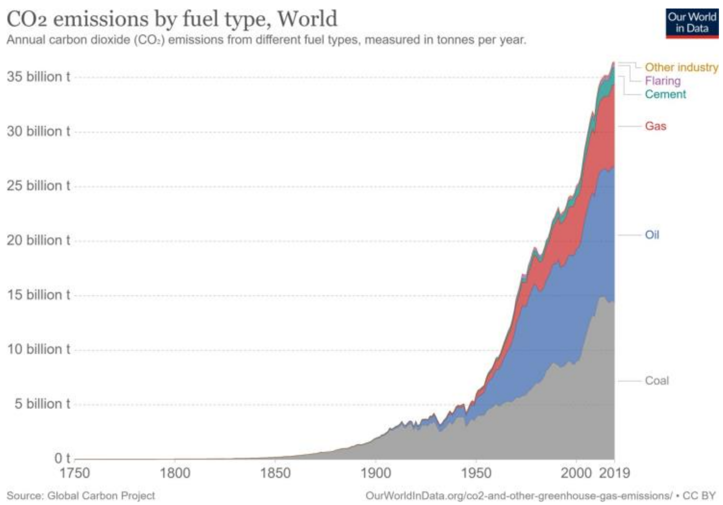
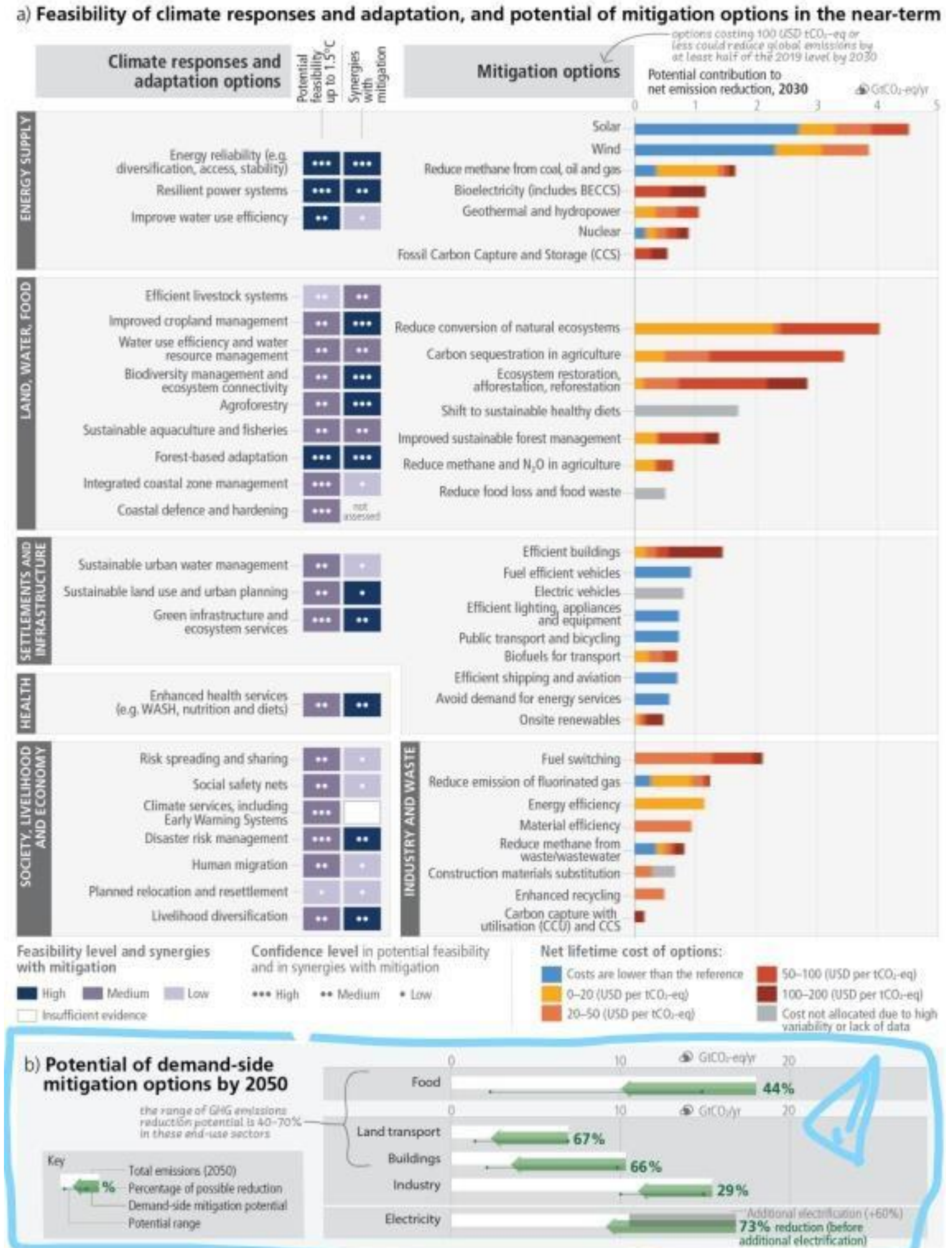


Figure SPM.7 | Overview of mitigation options and their estimated ranges of costs and potentials in 2030.

Source: IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.001.

What solutions do we have ?
Technologies





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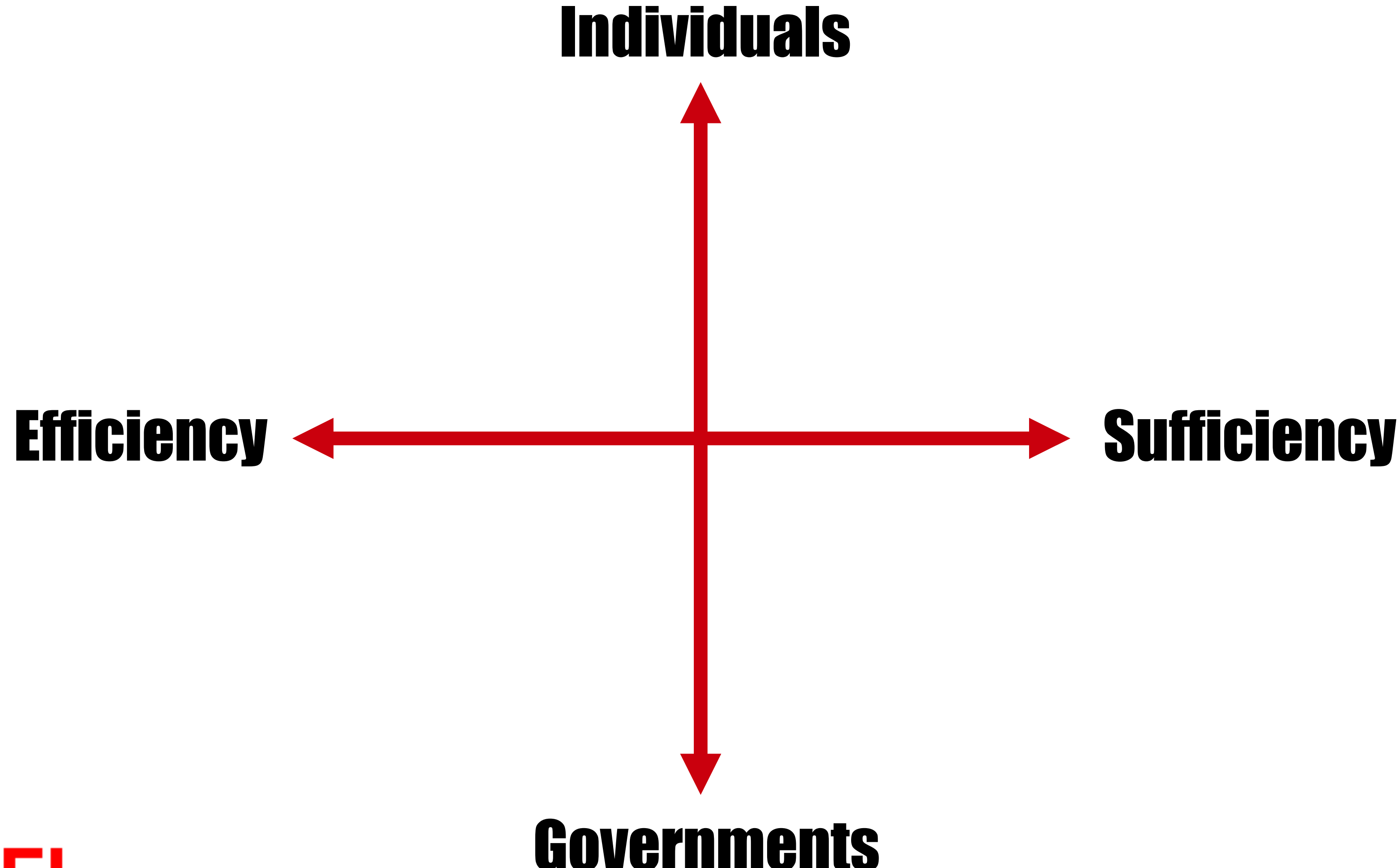
Who has to do something about it ?
How to do it ?
Give me some solutions ?



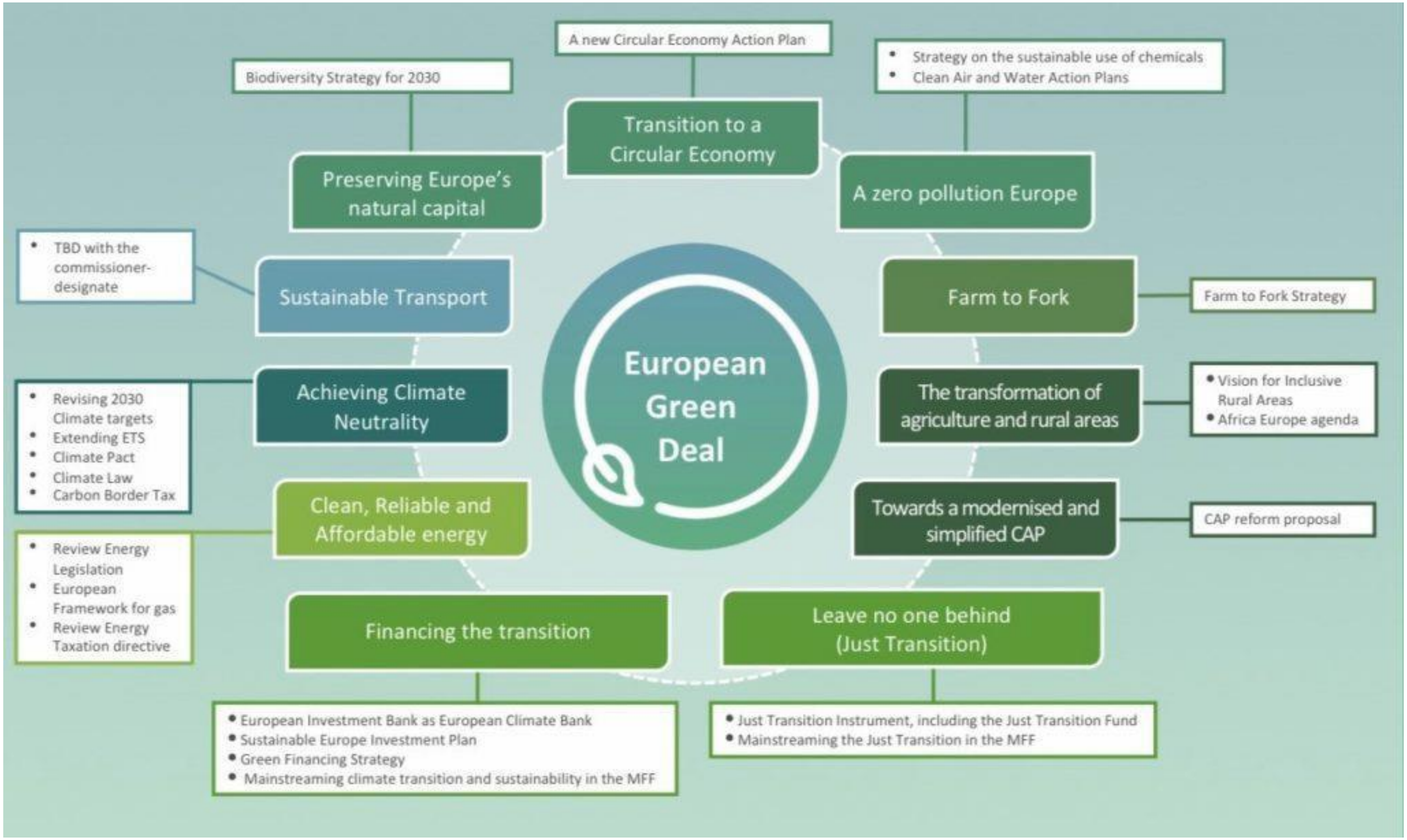
What is happening ? Paris agreement (2015)

SDGs (2030)


1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
THE GLOBAL GOALS
For Sustainable Development

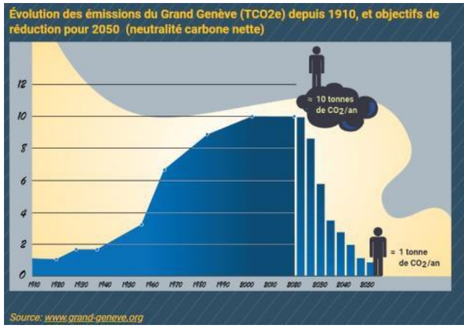
Green New Deal

EU Green New Deal



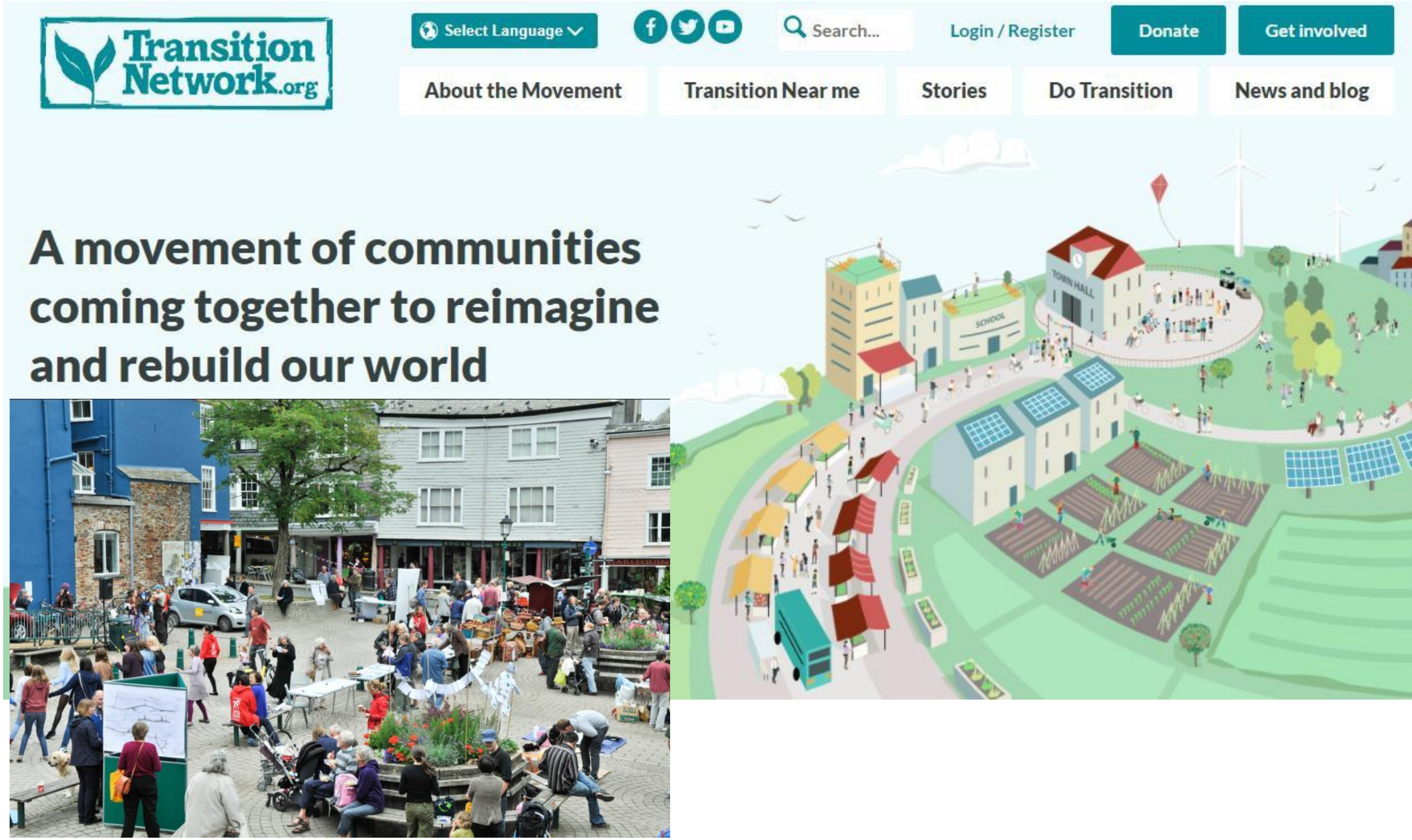
Examples at a city level (Lausanne climat)

Source: https://www.ge.ch/document/24973/telecharger



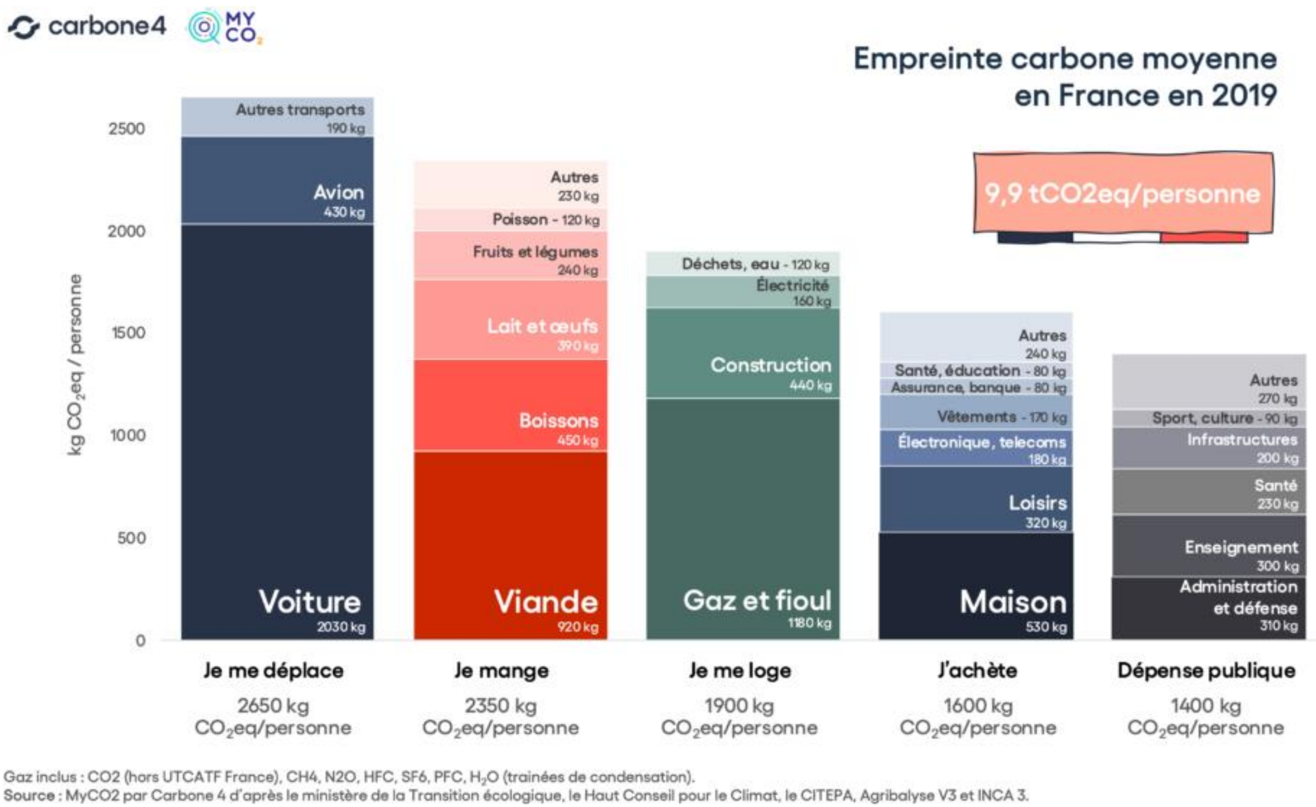
Source: https://www.ge.ch/teaser/plan-climat-cantonal-geneve-2030/plan-climat

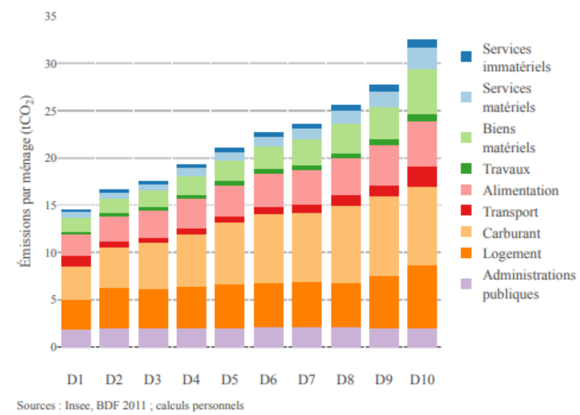
Examples at a city level (Transition Towns)



https://transitionnetwork.org/

Everyday choices – what can you cut off?





Source: https://bonpote.com/comment-calculer-son-empreinte-carbone/

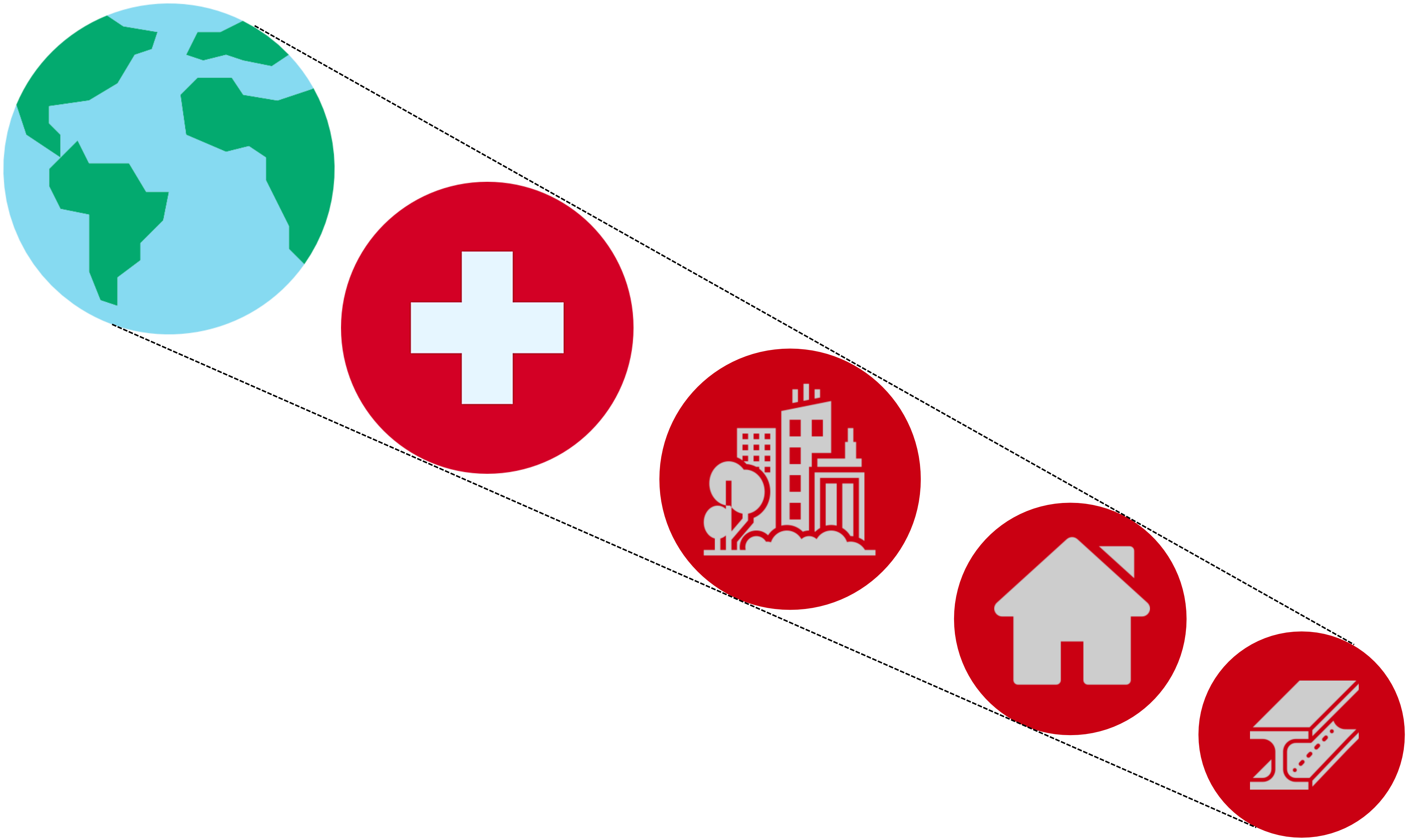
Source: Pottier, A., Combet, E., Cayla, J. M., de Lauretis, S., & Nadaud, F. (2020). Qui émet du CO2? Panorama critique des inégalités écologiques en France. *Revue de l'OFCE*, *169*(5), 73-132.

Where to now? Let's vote

- Degrowth
- Technological fix
- Policy vs everyday choices

	Degrowth	Technofix
Individual	A	B
Policy	C	D

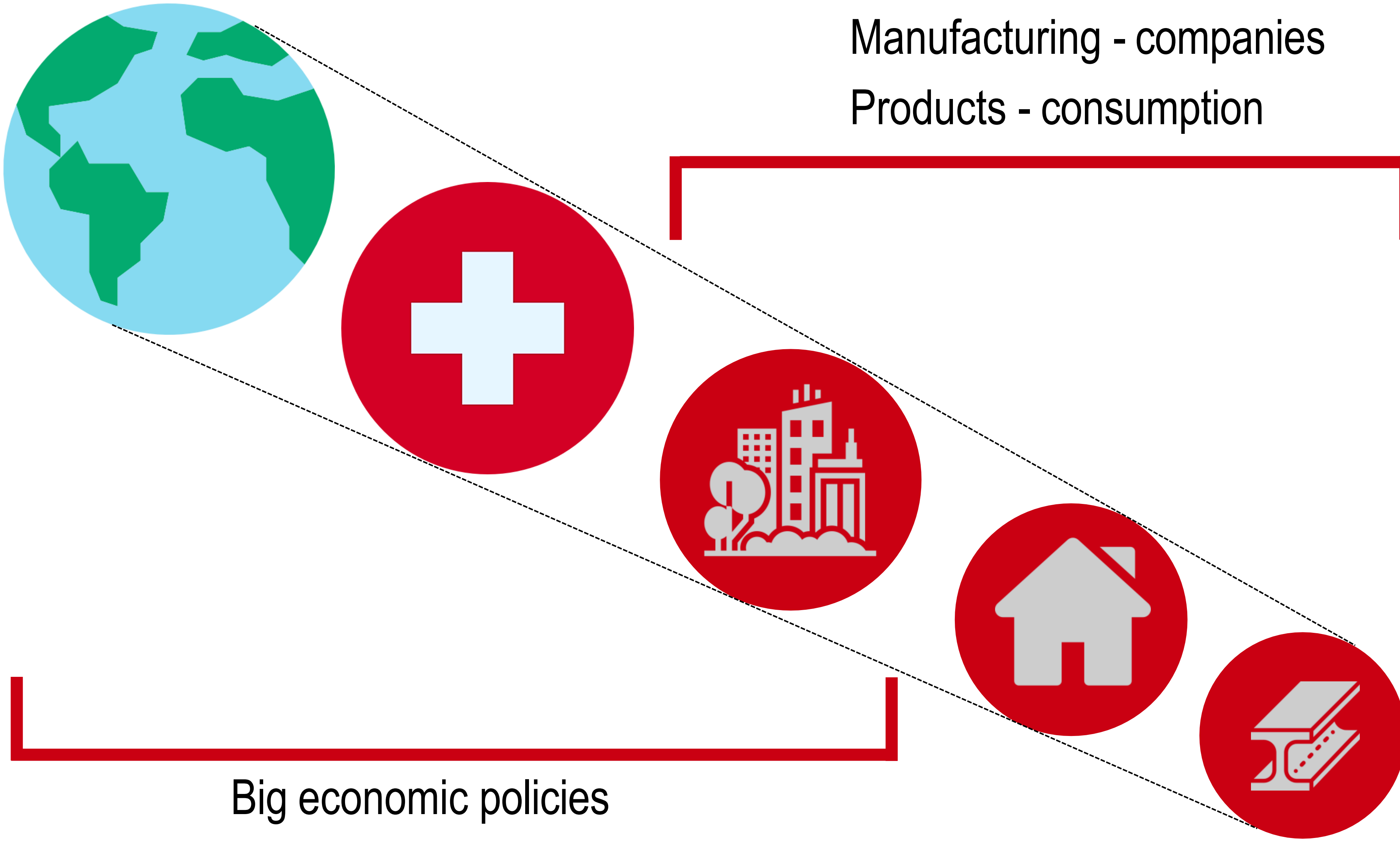
Link from Planet to Product



Link from Planet to Product – what systemic vantage point?

Manufacturing - companies

Products - consumption

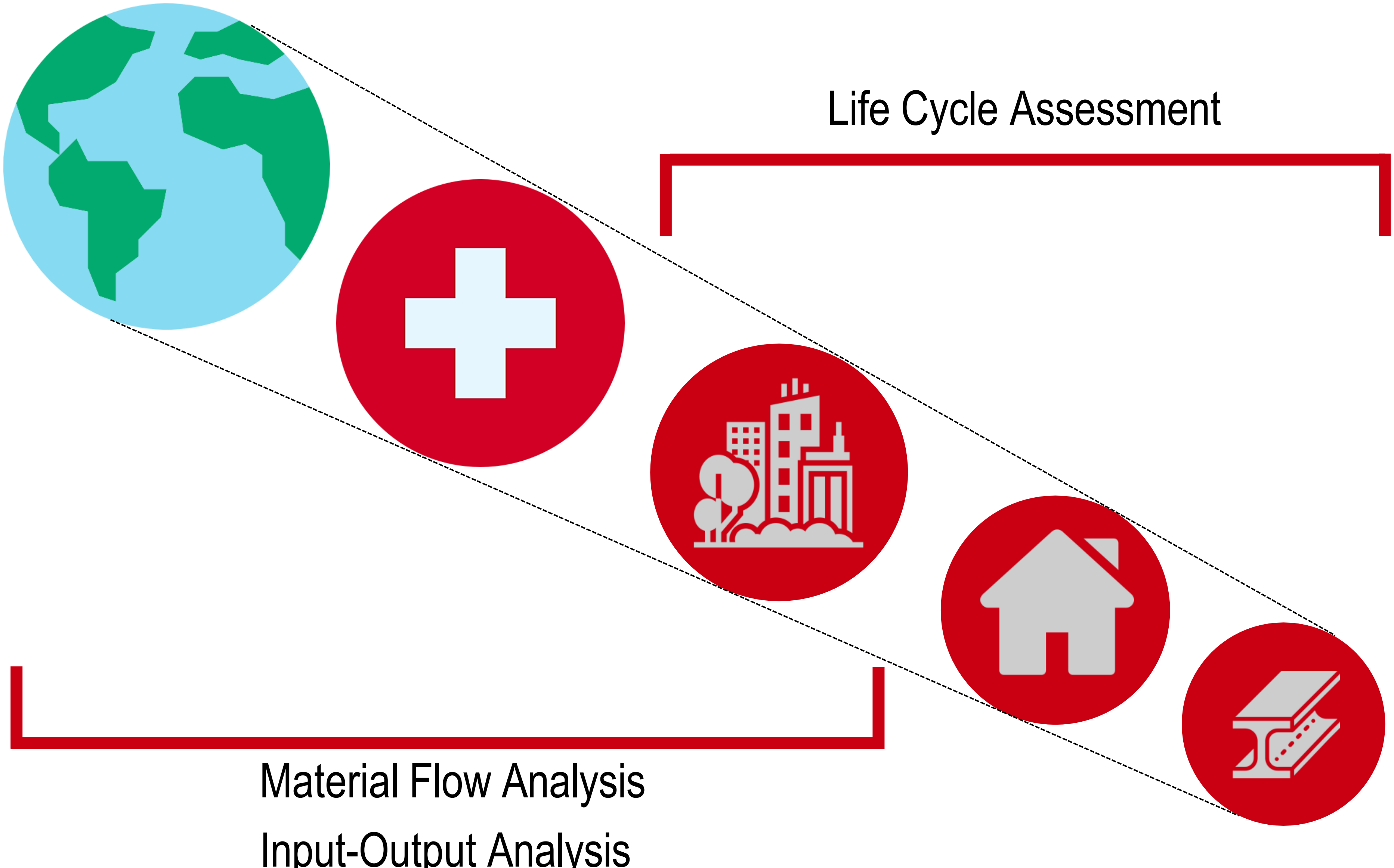


Big economic policies

Global challenges

EPFL

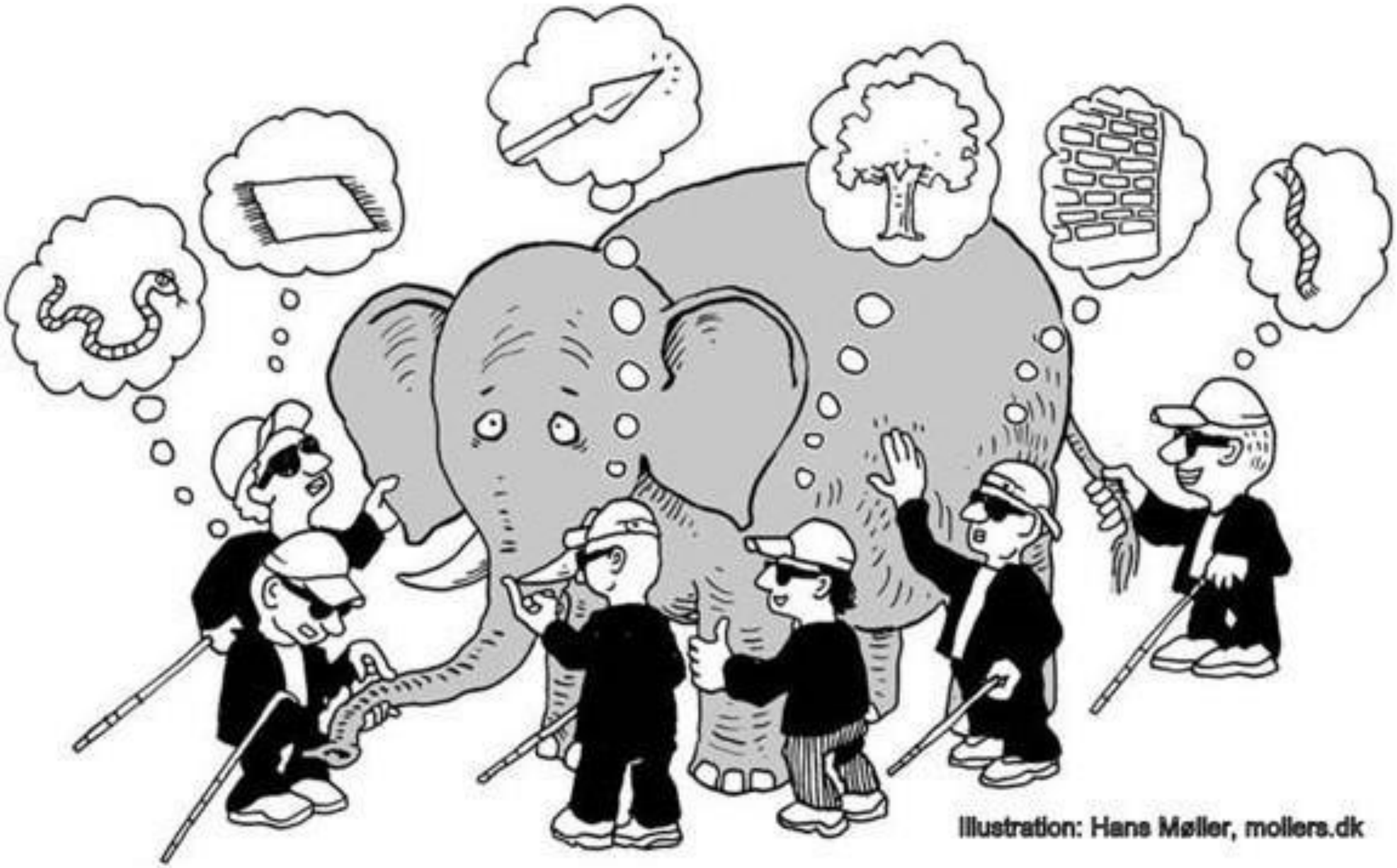
Link from Planet to Product – accounting methods



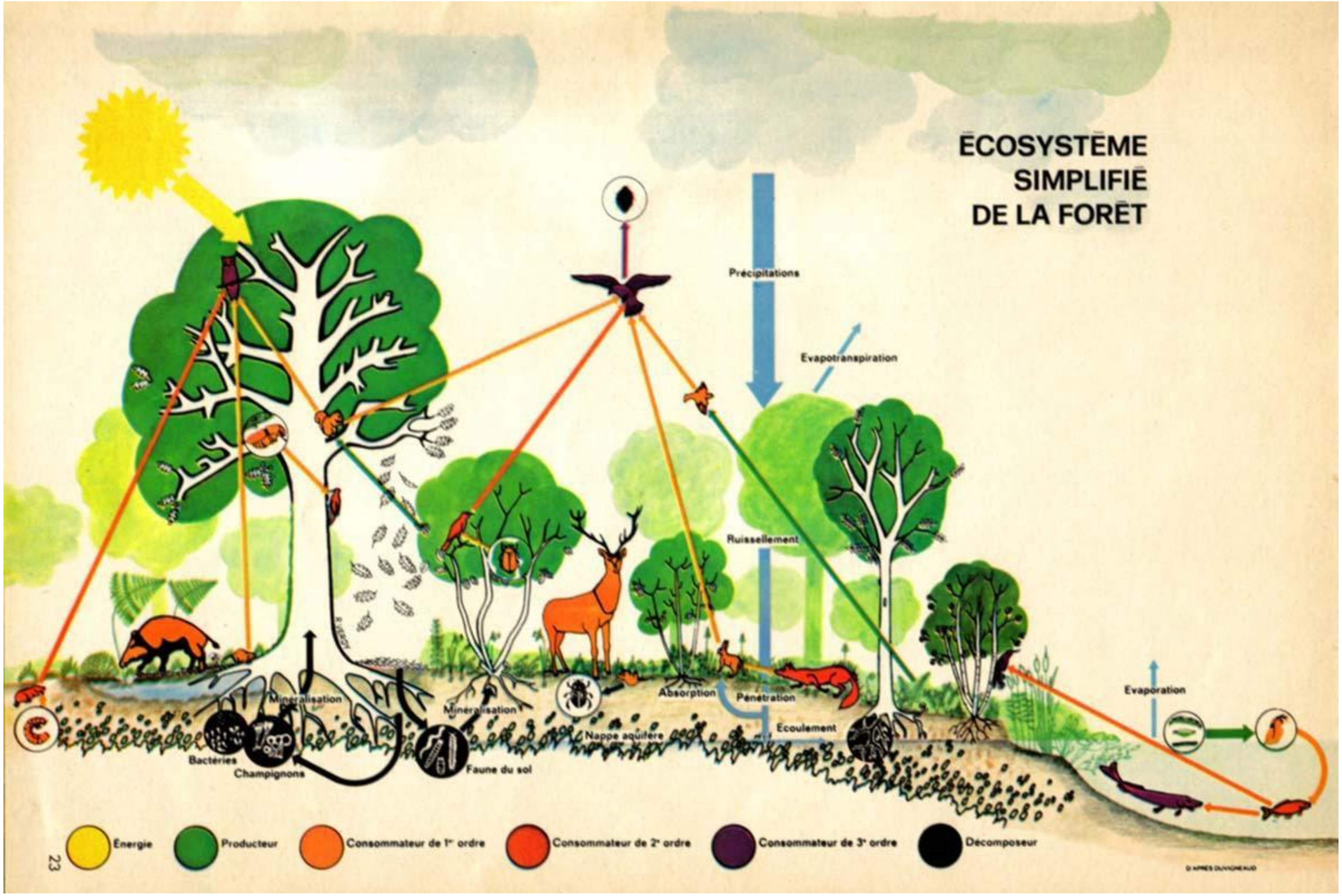
Systems thinking

What is a system?

The elephant and the blind men – what is a system?



What is a system?



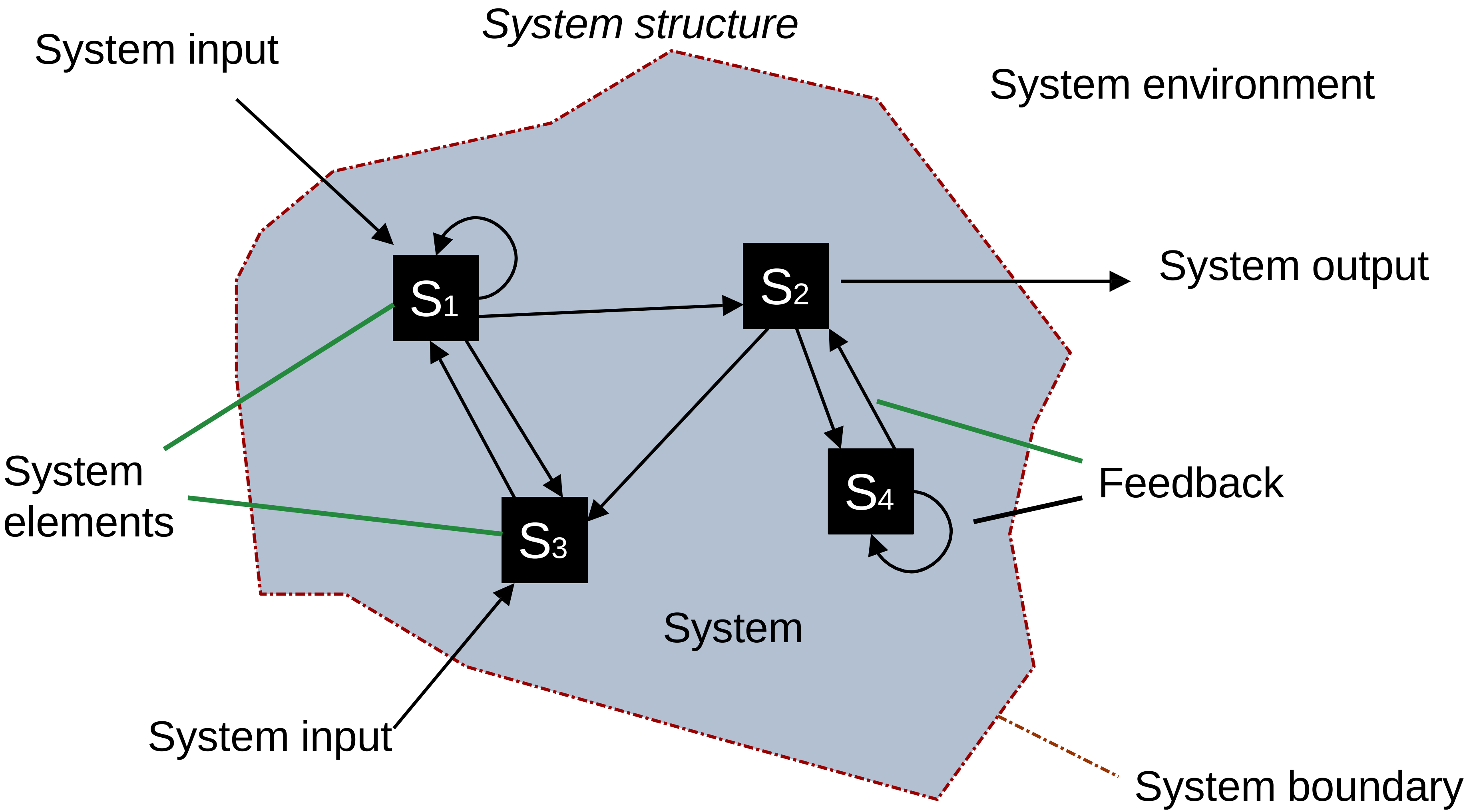
Duvigneaud, P. (1974). *A synthesis of ecology: populations, communities, ecosystems, biosphere and noosphere*. Doin, editeurs..

What is a system?

A ***system*** is anything that is composed of system ***elements*** connected in a characteristic system ***structure***. This configuration of system elements allows it to perform specific system ***functions*** in its system ***environment***.

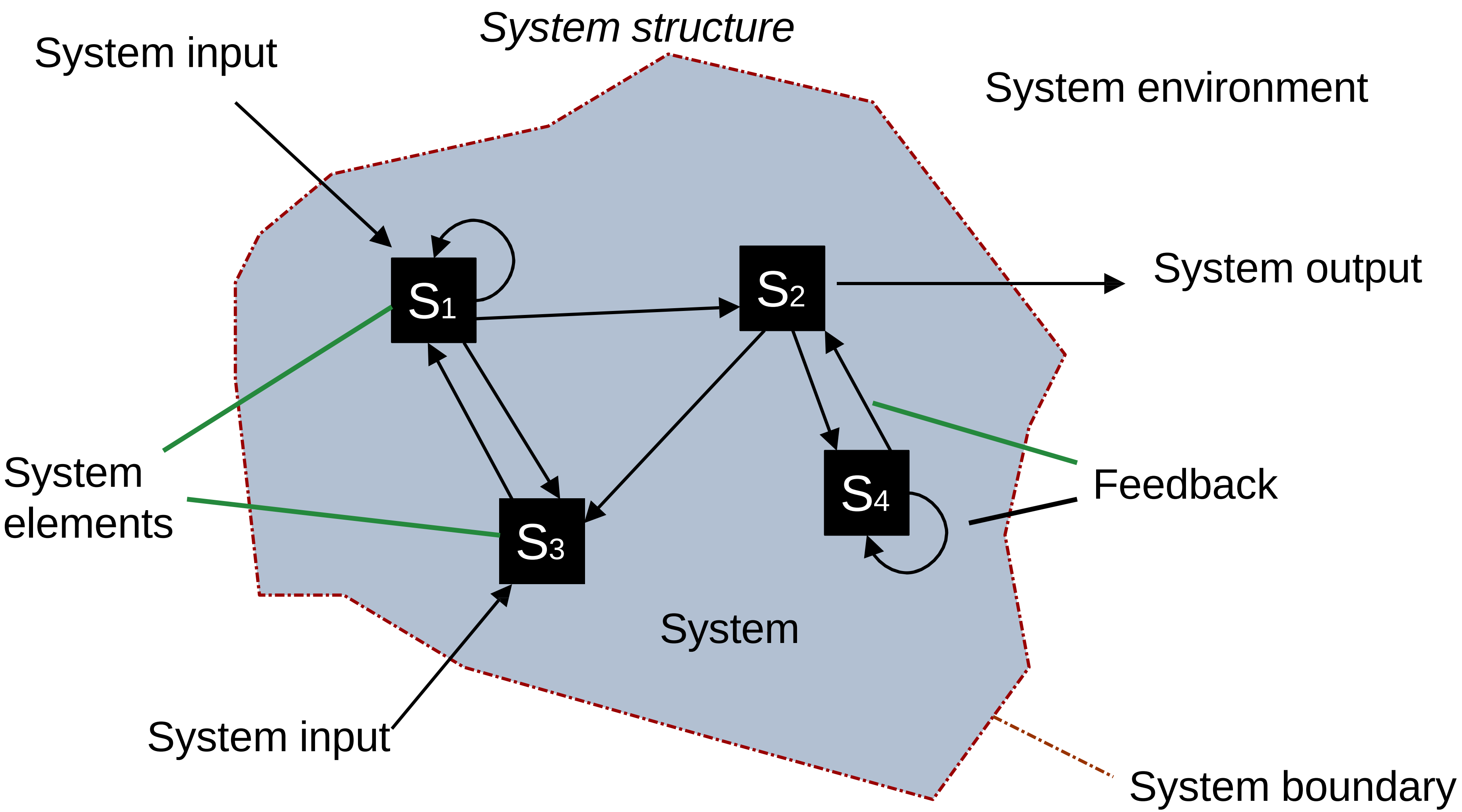
These functions can be interpreted as serving a distinct system ***purpose***. The system ***boundary*** is permeable for ***inputs*** from and ***outputs*** to the environment. It defines the system's ***identity*** and ***autonomy***. (Bossel, 1999)

What is a system? Elements, interrelations, system boundaries



After Bossel, 2004; Mrotzek, 2009

Let's say this is a city: what are the functions ? what are elements ? What are the feedbacks ? What are the boundaries ?

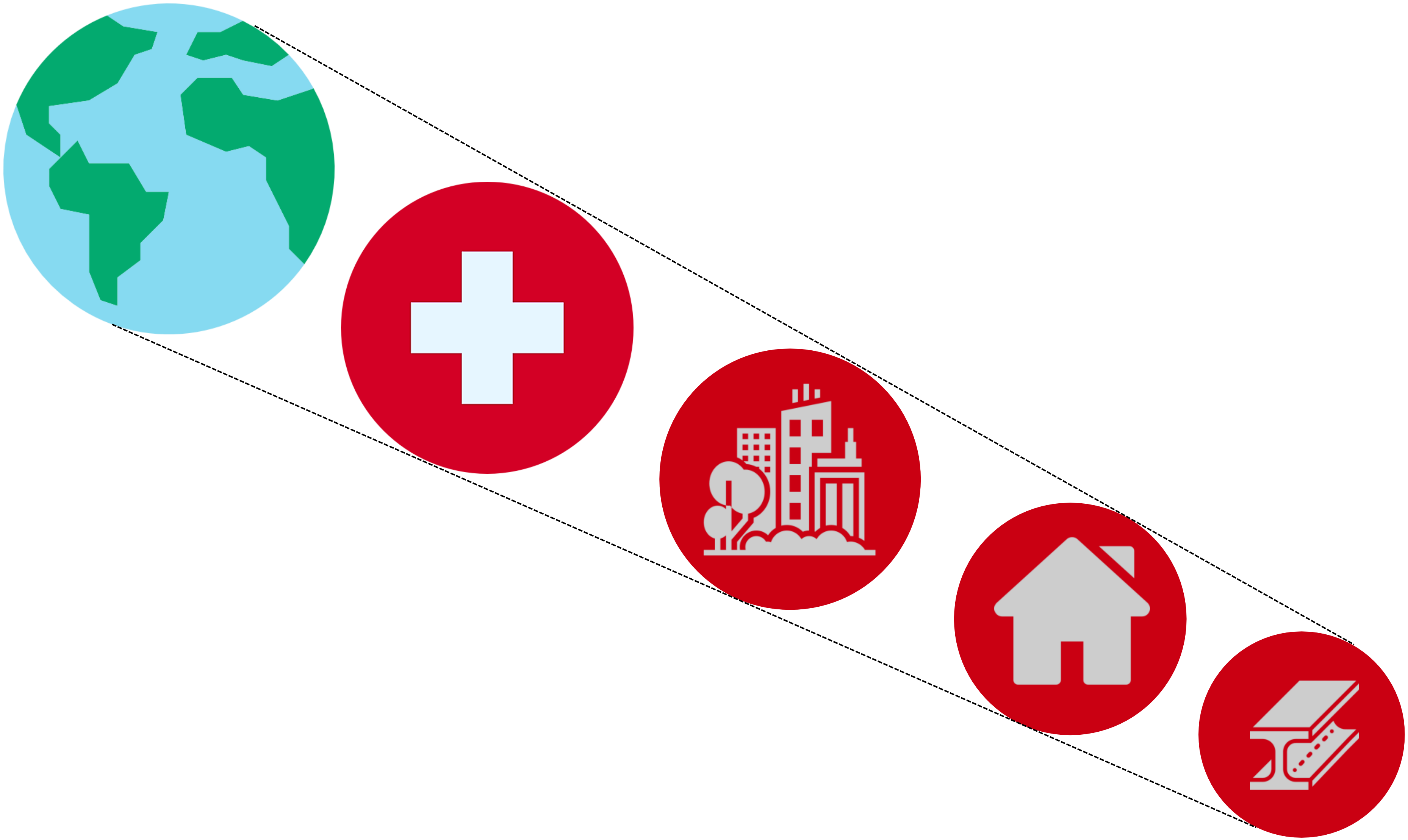


After Bossel, 2004; Mrotzek, 2009

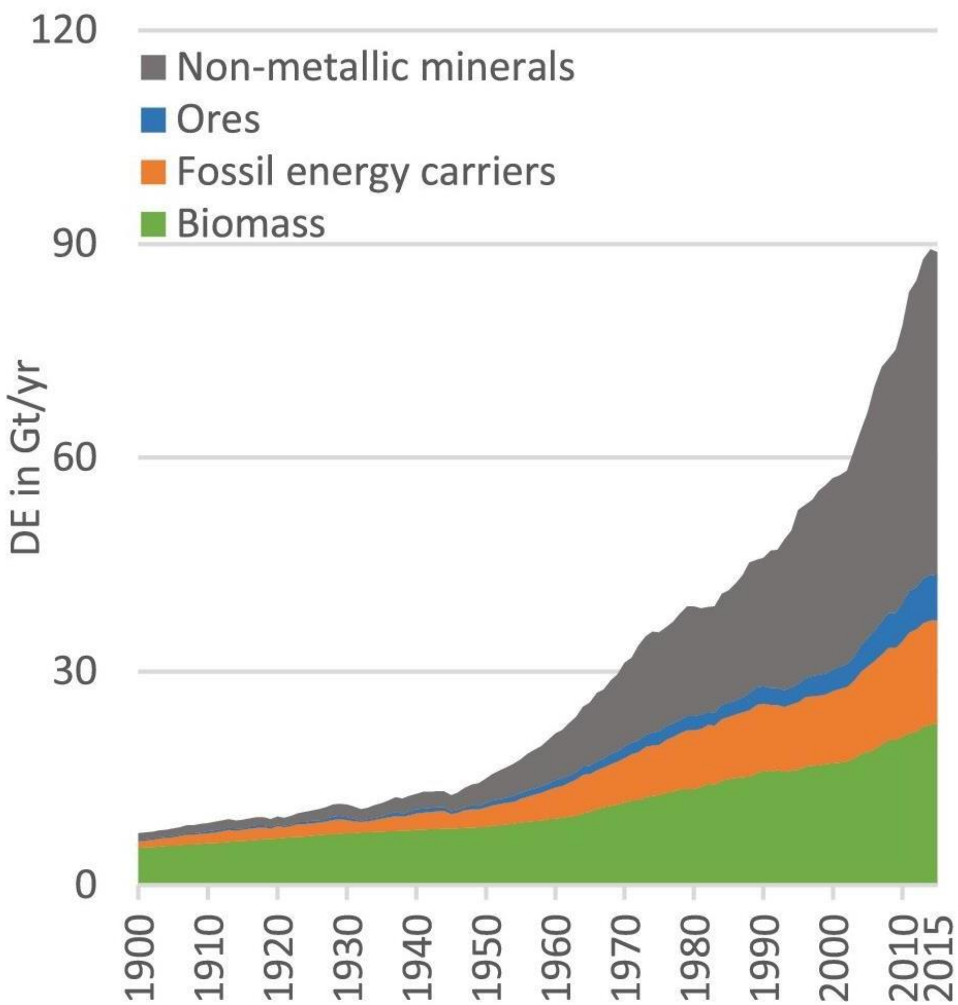
What is a system? System boundary

- Defines what is inside of the system to be analysed and what belongs to the system context
- Defines inputs and outputs of the system
- Elements of a system boundary: space and time.

1. System boundary – importance of space

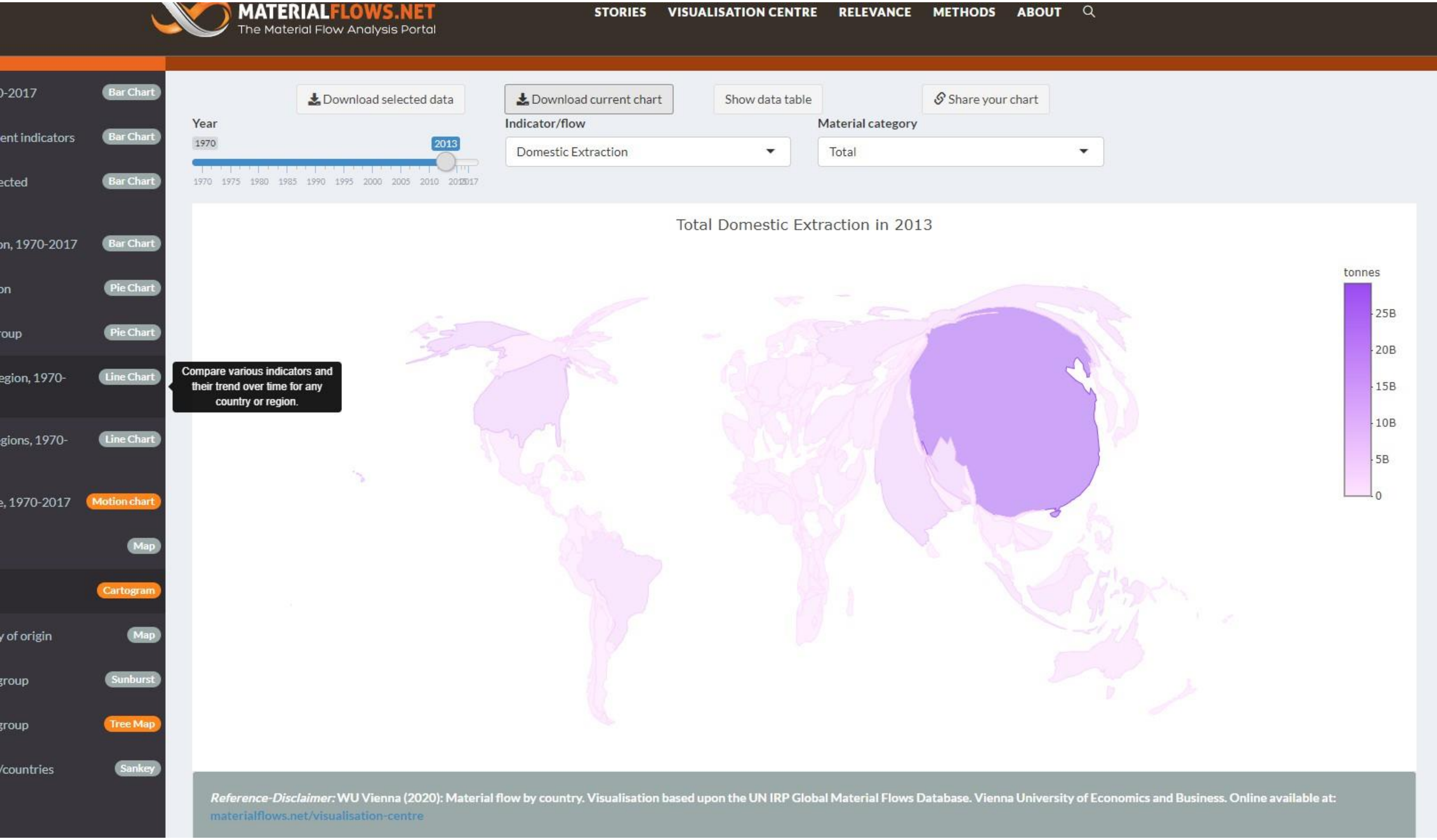


1. System boundary – importance of space



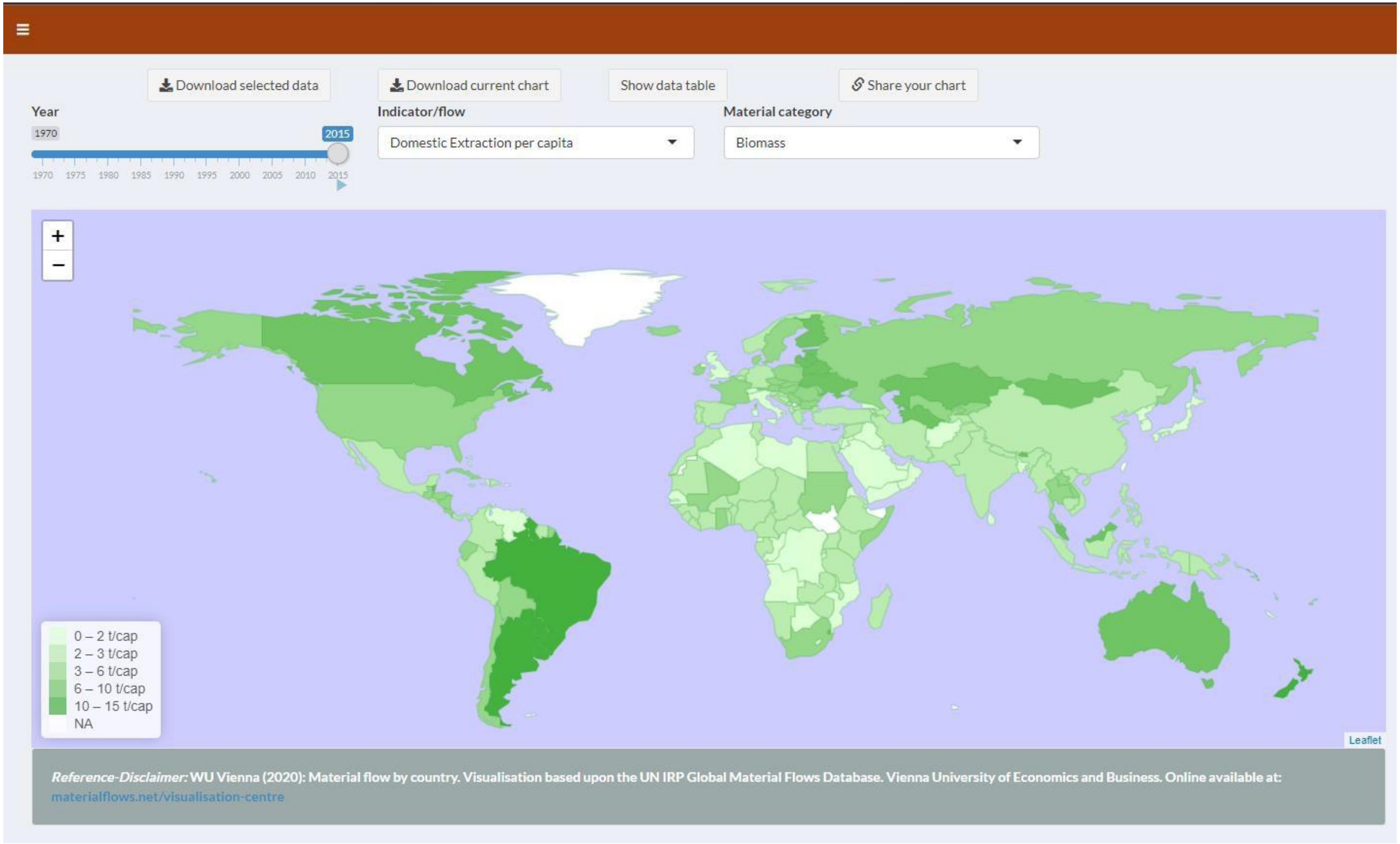
Krausmann, F., Lauk, C., Haas, W., & Wiedenhofer, D. (2018). From resource extraction to outflows of wastes and emissions: The socioeconomic metabolism of the global economy, 1900–2015. *Global Environmental Change*, *52*, 131-140.

From world to countries



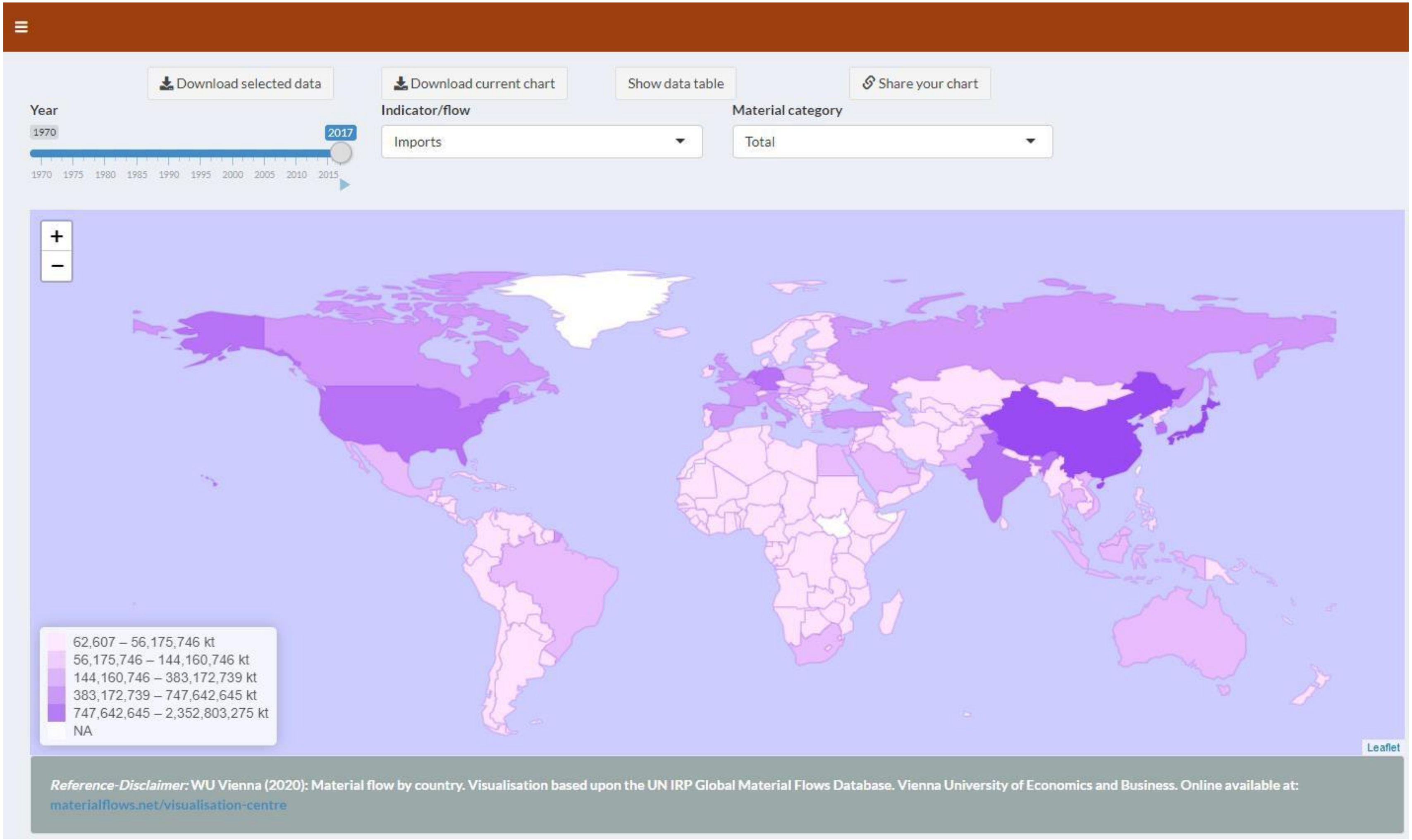
Source: http://www.materialflows.net/visualisation-centre/data-visualisations

From world to countries (why some countries extract more?)



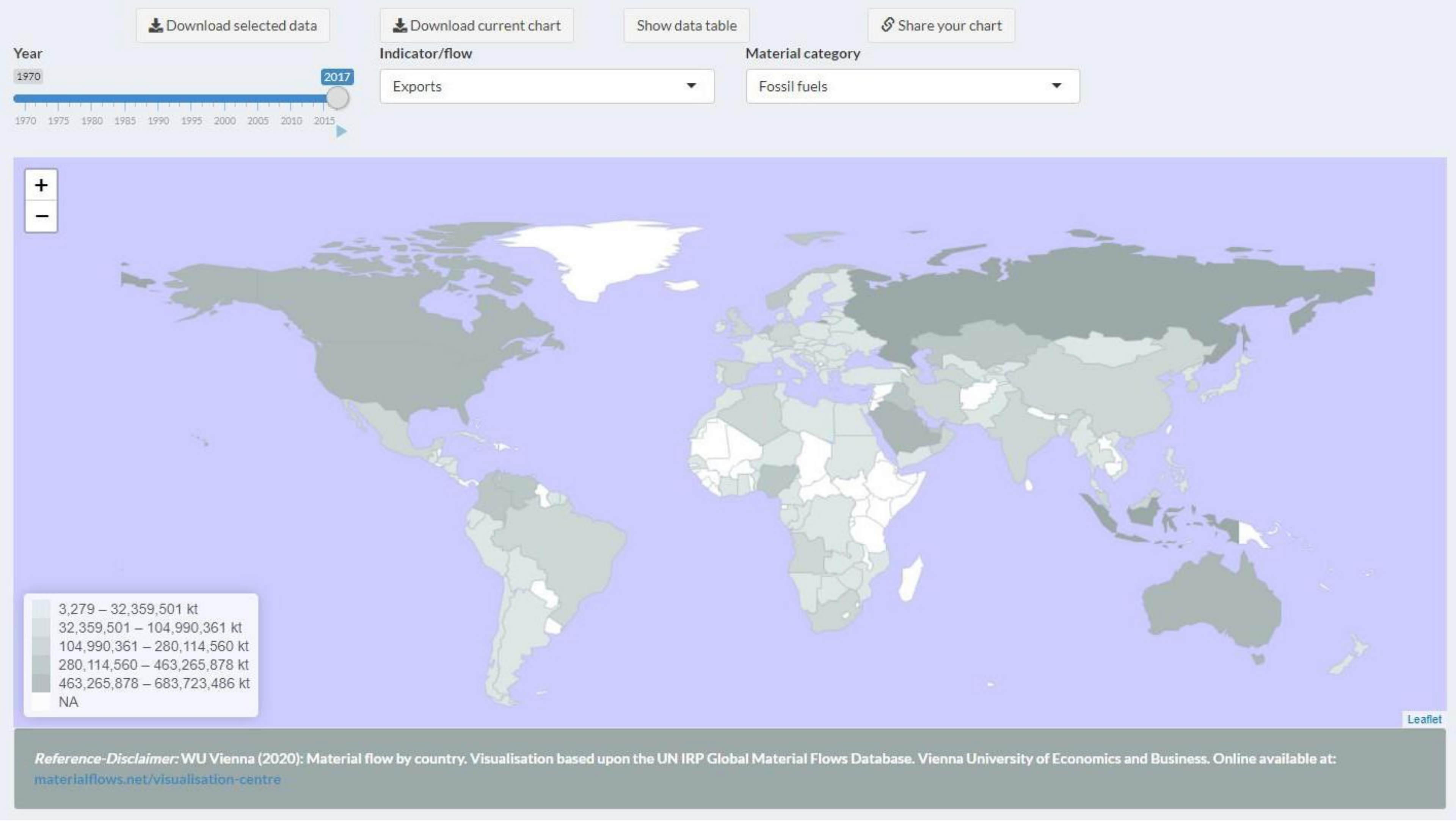
[Source: http://www.materialflows.net/visualisation-centre/data-visualisations](http://www.materialflows.net/visualisation-centre/data-visualisations)

From world to countries (internal flows)



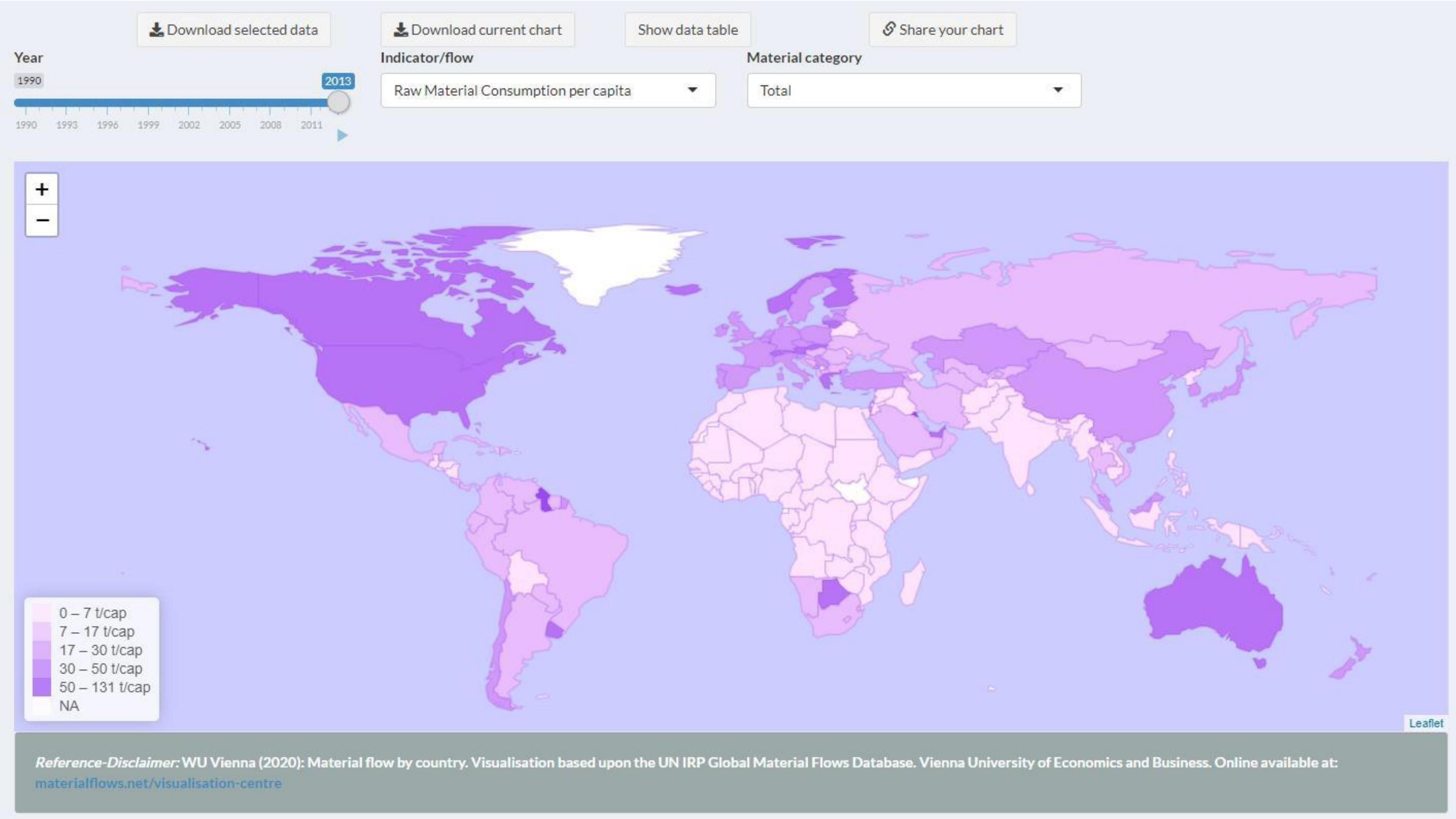
[Source: http://www.materialflows.net/visualisation-centre/data-visualisations](http://www.materialflows.net/visualisation-centre/data-visualisations)

From world to countries (internal flows)



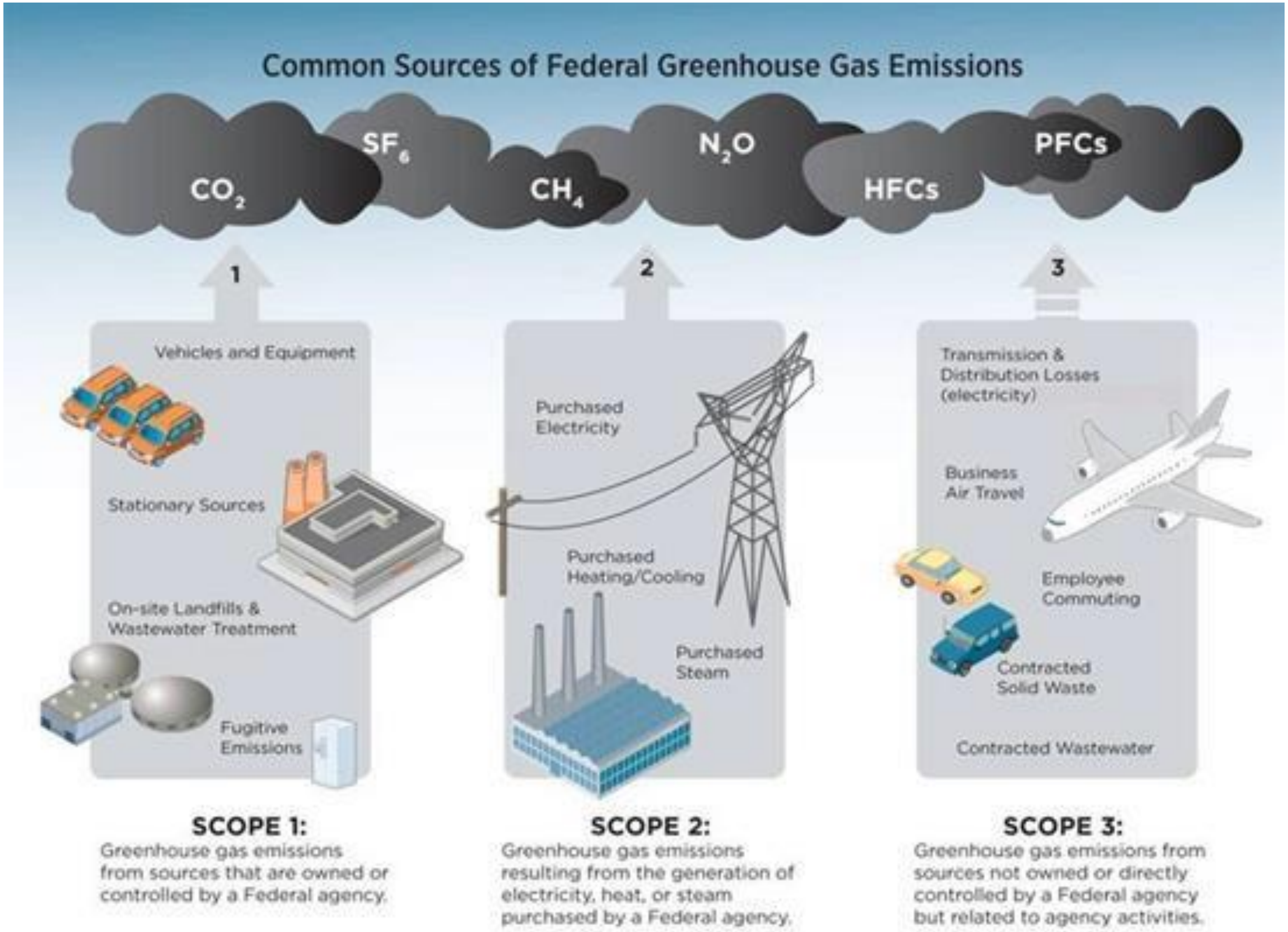
Source: http://www.materialflows.net/visualisation-centre/data-visualisations

From world to countries (indirect flows)



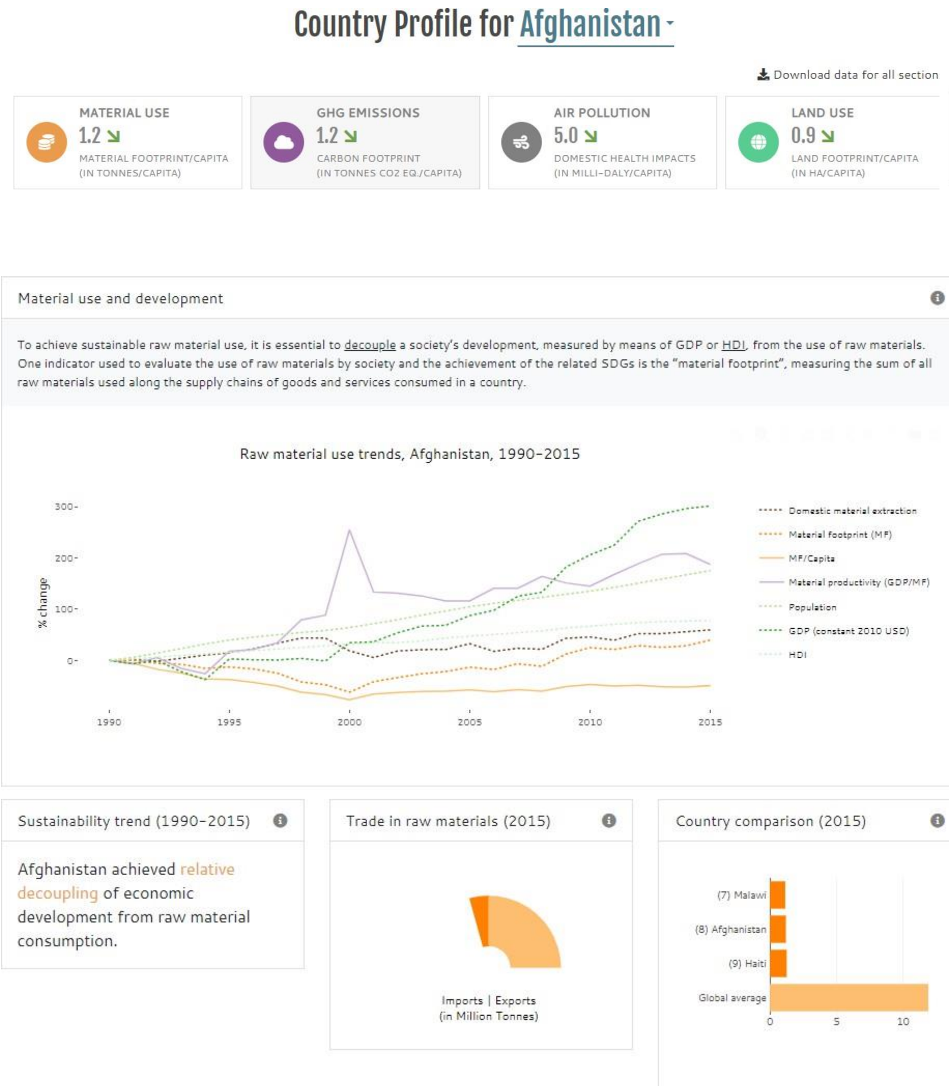
Source: http://www.materialflows.net/visualisation-centre/data-visualisations

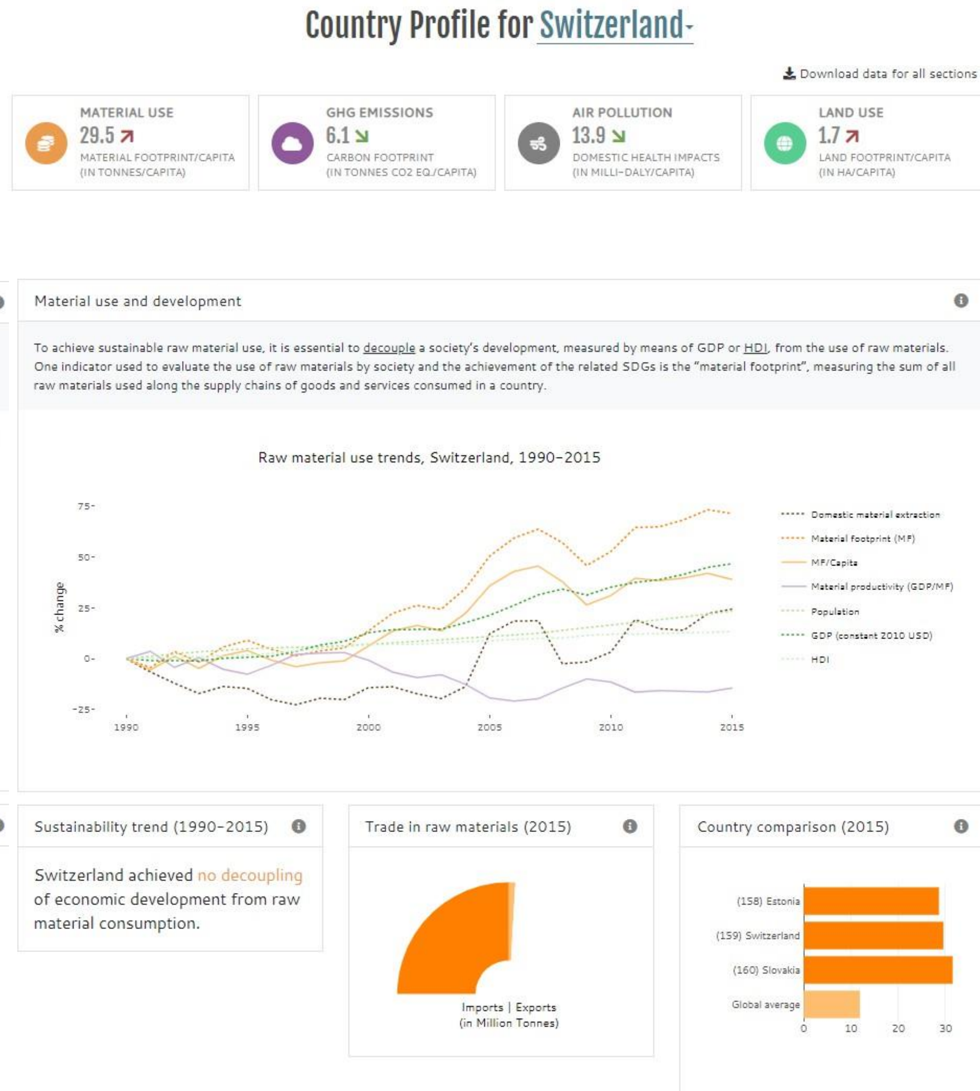
From world to countries (indirect flows)



https://www.wbdg.org/images/greenhousegas_fb_03.jpg

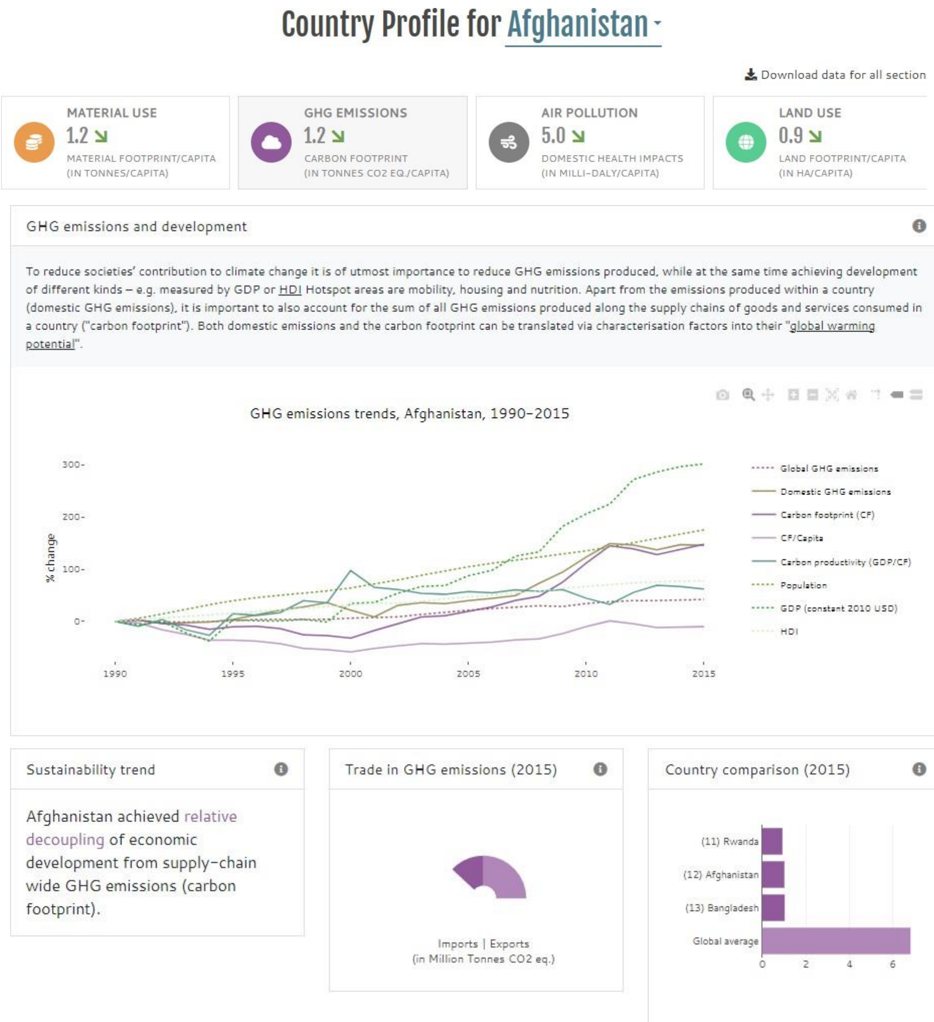
Individual countries

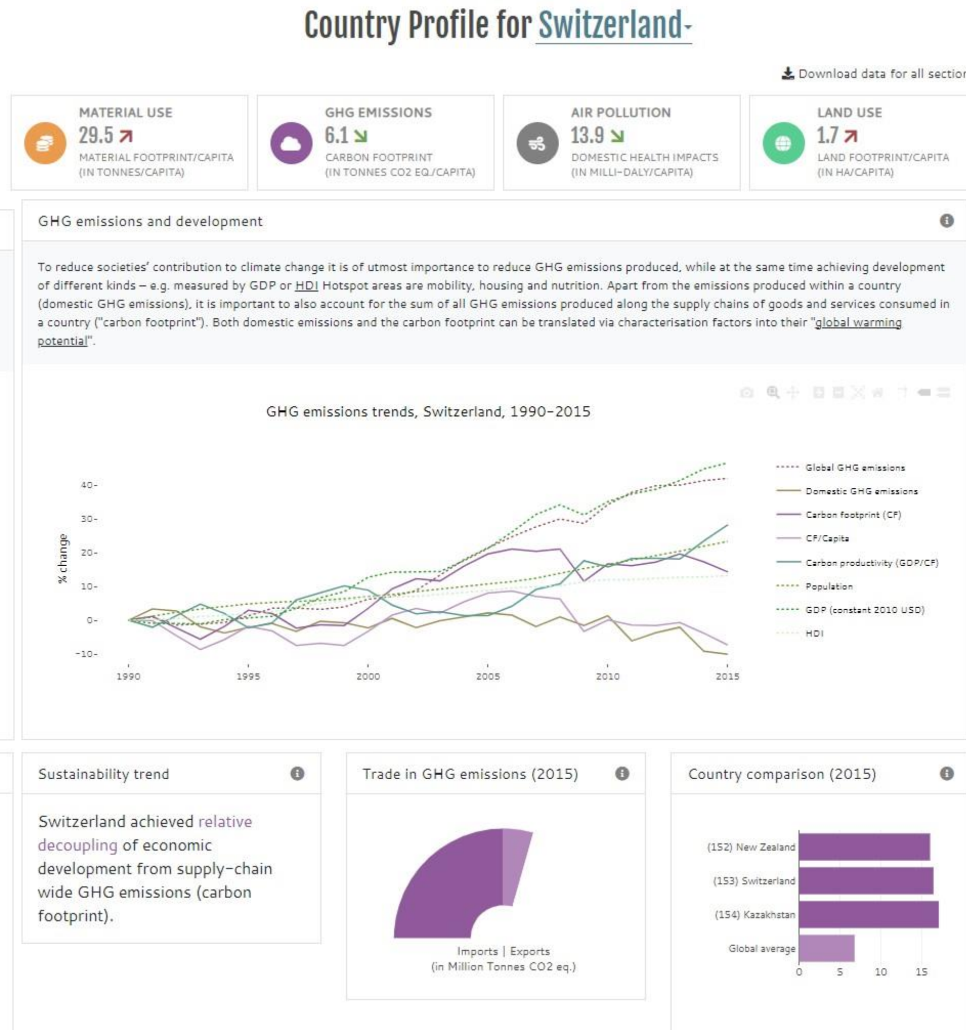




Source: http://scp-hat.lifecycleinitiative.org/module-1-country-profile/

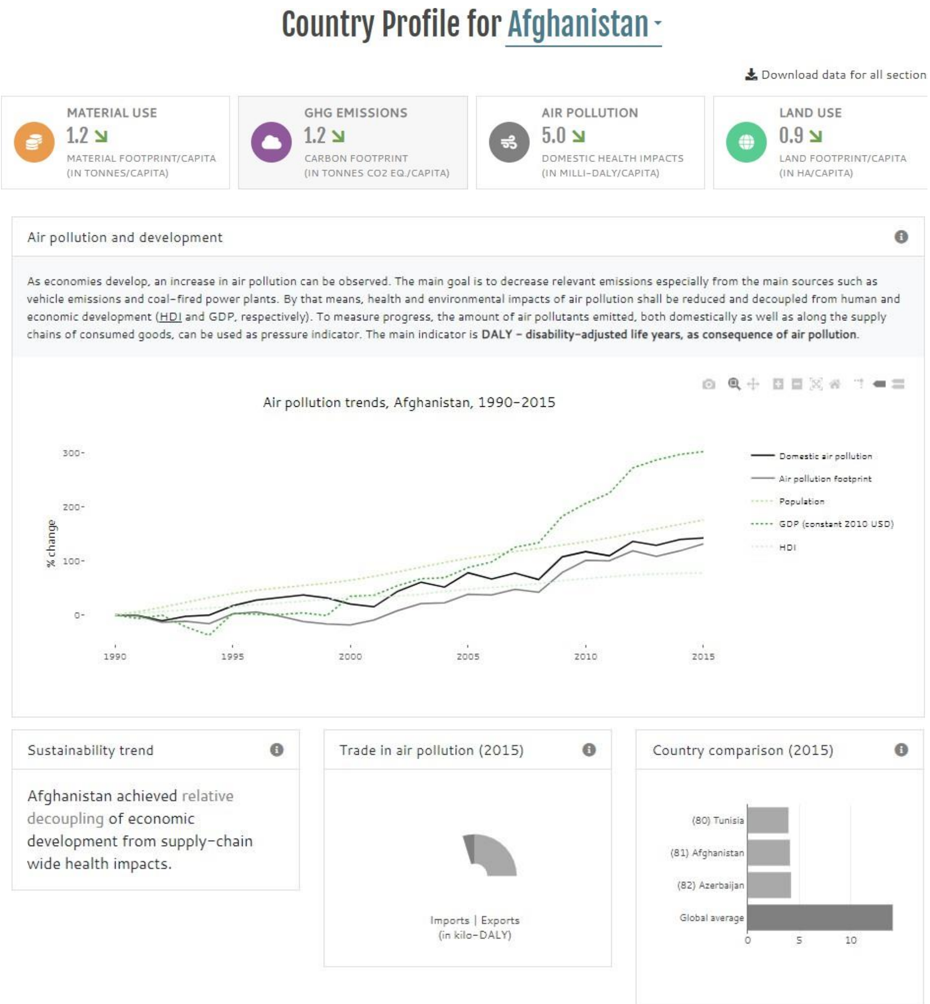
Individual countries

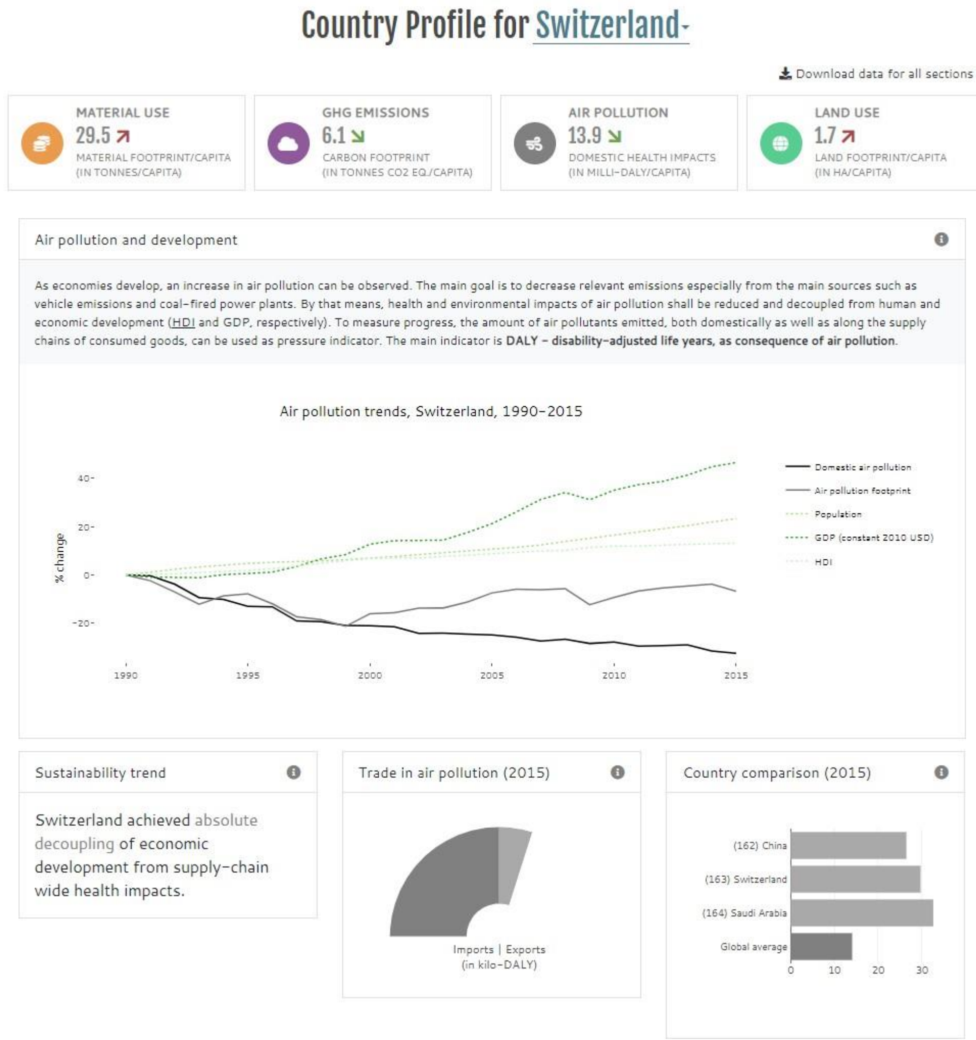




Source: http://scp-hat.lifecycleinitiative.org/module-1-country-profile/

Individual countries

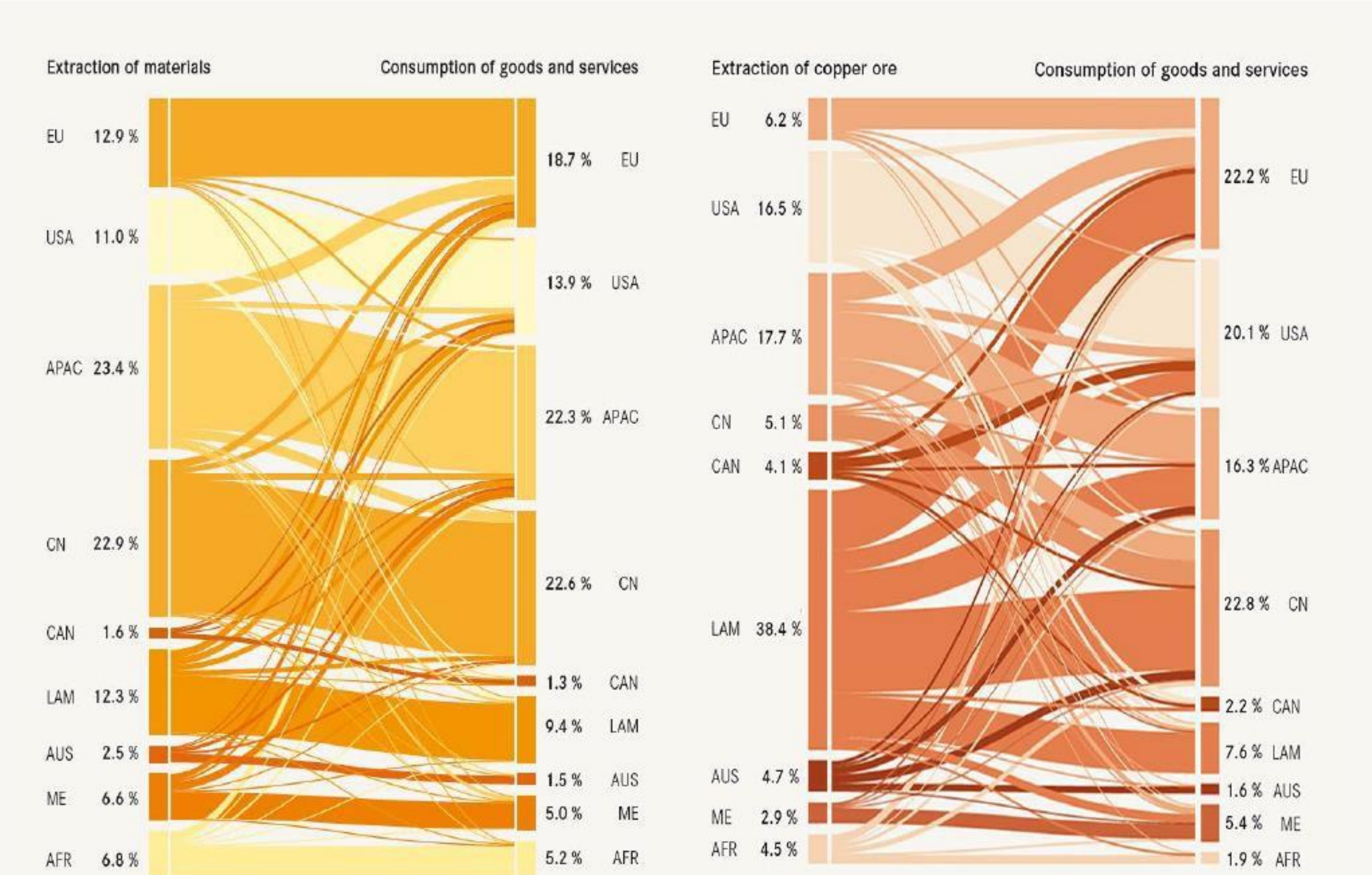




Source: http://scp-hat.lifecycleinitiative.org/module-1-country-profile/

What are some additional insights that you can see at country level? (which were invisible at global level)

Production (extraction) vs. Consumption

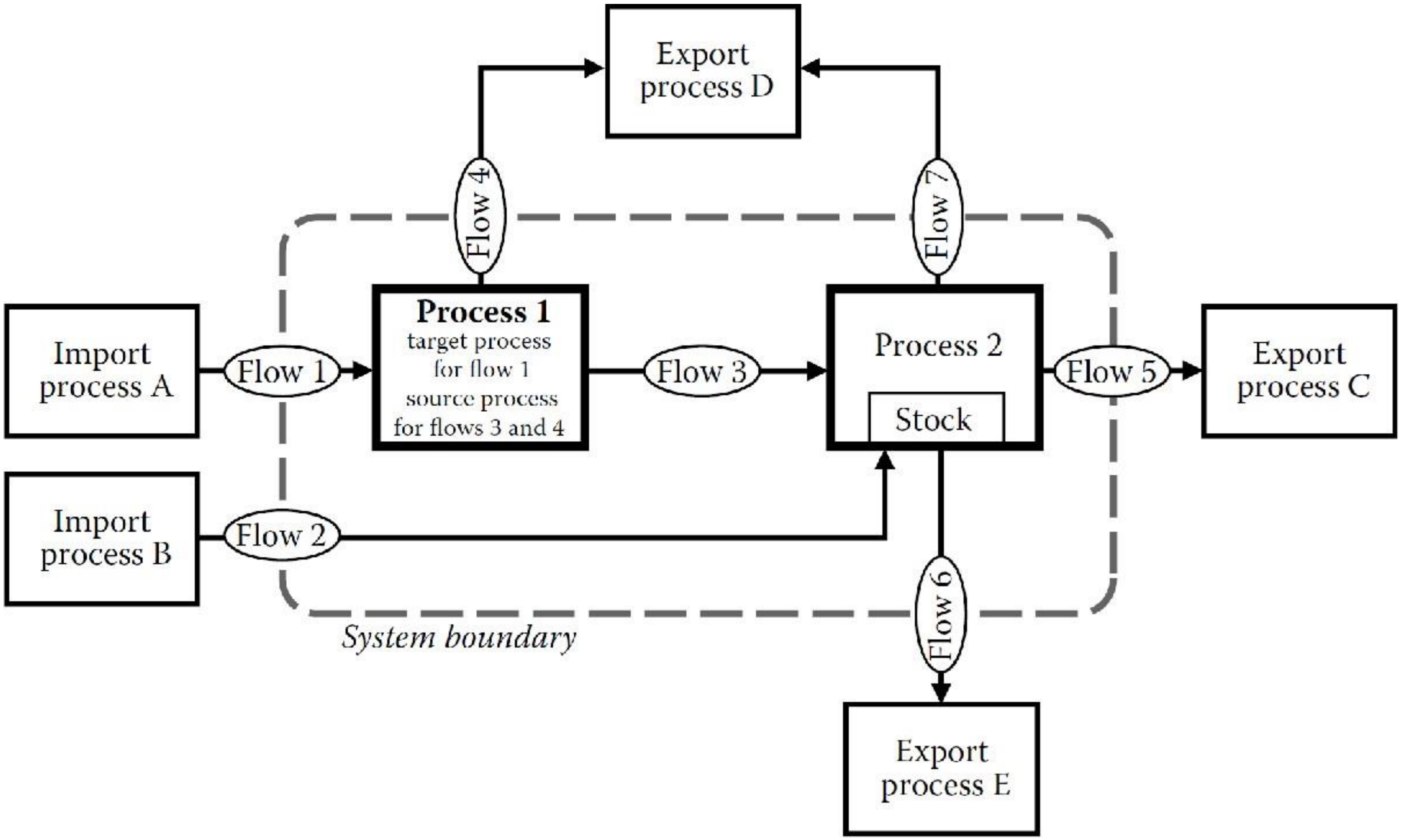


Tukker, A., T. Bulavskaya, S. Giljum, A. de Koning, S. Lutter, M. Simas, K. Stadler, and R. Wood. 2014. *The Global Resource Footprint of Nations. Carbon, water, land and materials embodied in trade and final consumption calculated with EXIOBASE 2.1.* Leiden/Delft/Vienna/Trondheim:

So who is responsible ?

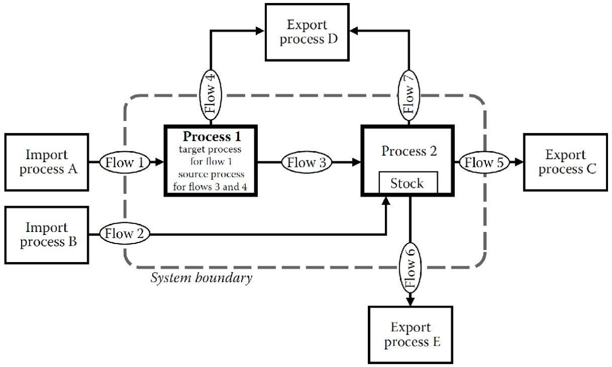
Material Flow Analysis

First method to include in your arsenal: MFA



Brunner & Rechberger, 2016

Definition of MFA

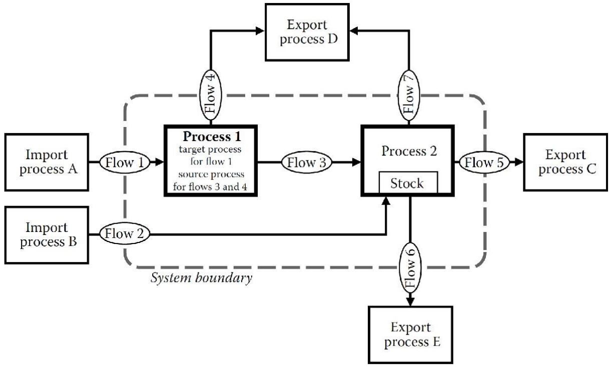


Material Flow Analysis (MFA) is a systematic assessment of the **flows and stocks of materials** within a system defined in **space** and **time** .

- MFA connects the **sources, pathways and sinks** of a material.
- MFA results can be controlled by a **mass balance** comparing all inputs, stocks, and outputs of a process/system measured in kg (principle of mass conservation).

Brunner & Rechberger, 2016

History of MFA



- **Santorio Santorio (1561–1636)**
  Human metabolism
- **Antoine Lavoisier (1743–1794)**
  Law of mass conservation in chemical processes
- **Wassily W. Leontief (1906–1999)**
  Economic input-output tables
- **Abel Wolman (1965), Duvigneaud & Denayeyer-De Smet (1975), Newcombe, Kalma & Aston (1978)**
  Metabolism of cities: hypothetical American city, Brussels, Hong Kong

Brunner & Rechberger, 2016

Santorio's analysis of the human metabolism

Brunner & Rechberger, 2016

Inputs: food, beverages
Outputs: excretions

Santorio's analysis of the human metabolism

Brunner & Rechberger, 2016

Inputs: food, beverages
Outputs: excretions

Mass balance: input ≠ output ???

Santorio's analysis of the human metabolism

Brunner & Rechberger, 2016

Inputs: food, beverages
Outputs: excretions

Mass balance: input ≠ output

Air in and out was not measured!

What is the purpose of MFA ??

Purpose of MFA

- **Early detection** of harmful/useful material accumulation or depletion in anthropogenic/natural subsystems (e.g. metal enrichment in landfills due to the deposition of slag).
- **Prediction** of future quantities in anthropogenic/natural subsystems.
- **Identification of the need for action** in the areas of environmental, resource, waste and policy management.
- **Evaluation** of the effectiveness of current/planned measures.
- **Design** of ecologically-optimized products, processes and systems
(e.g. green design, eco-design).

Steps of MFA

Step I: System definition
Problem definition, definition of system boundaries, selection of processes and flows of materials/substances (qualitative model)

Step II: Measurement
Data collection of flows and stocks of materials/substances and characterization of uncertainties (measurements, literature data, estimations)

Step III: Calculation
Calculation of unknown quantities by balancing of materials based on the principle of mass conservation (MFA software)

Step IV: Illustration and interpretation
Sources, stocks, flows and sinks

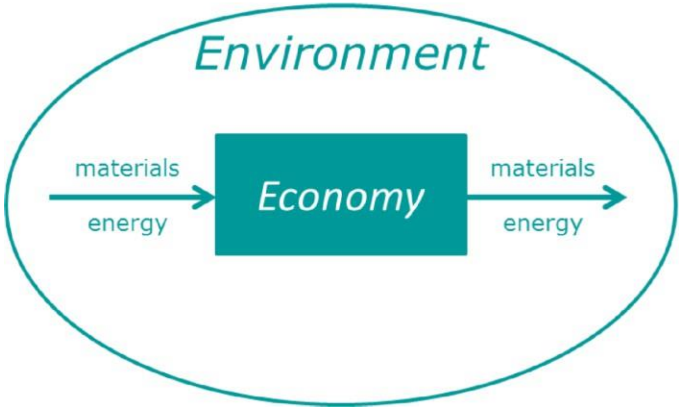
Step V: Recommendations
How can the system be optimized?

Method 1: EUROSTAT Economy –Wide Material Flow Analysis

First way to perform a MFA: EW-MFA Definition

- **Economy-wide material flow accounting and analysis (EW-MFA)**
  is the quantification of the material flows into and out of an economy (socio-economic metabolism).

- **EW-MFA** describes the interaction of the domestic economy with the natural environment and the rest of the world economy.

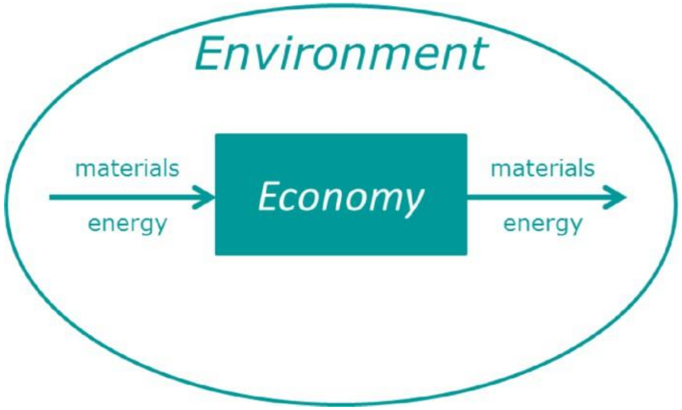


Eurostat, 2018

First way to perform a MFA: EW-MFA Definition

- **EW-MFA** represents national accounts in physical instead of monetary terms.

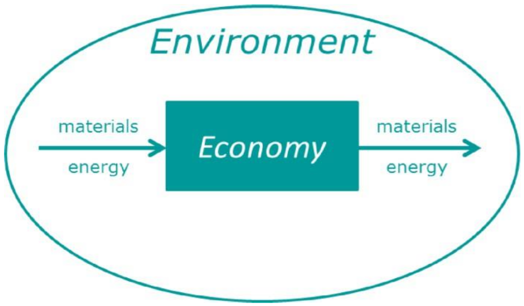
- **EW-MFA** are compatible with other national accounts, enabling integrated analyses of environmental and economic aspects.



Eurostat, 2018

History of EW-MFA (in Europe)

- **1990s:** European Statistical System (ESS) started its work on the integration of environmental and economic information systems.
- **2000:** Eurostat task force developed a methodological framework to record material flows and defined material flow indicators.
- **2004-2006:** Eurostat task force developed a classification of materials, standard tables and harmonized compilation procedures.
- **2011:** EU Regulation No. 691/2011 for member states to report the EW-MFA data to Eurostat.
- **2013:** First mandatory annual data collection.
- **2018:** Latest methodology out

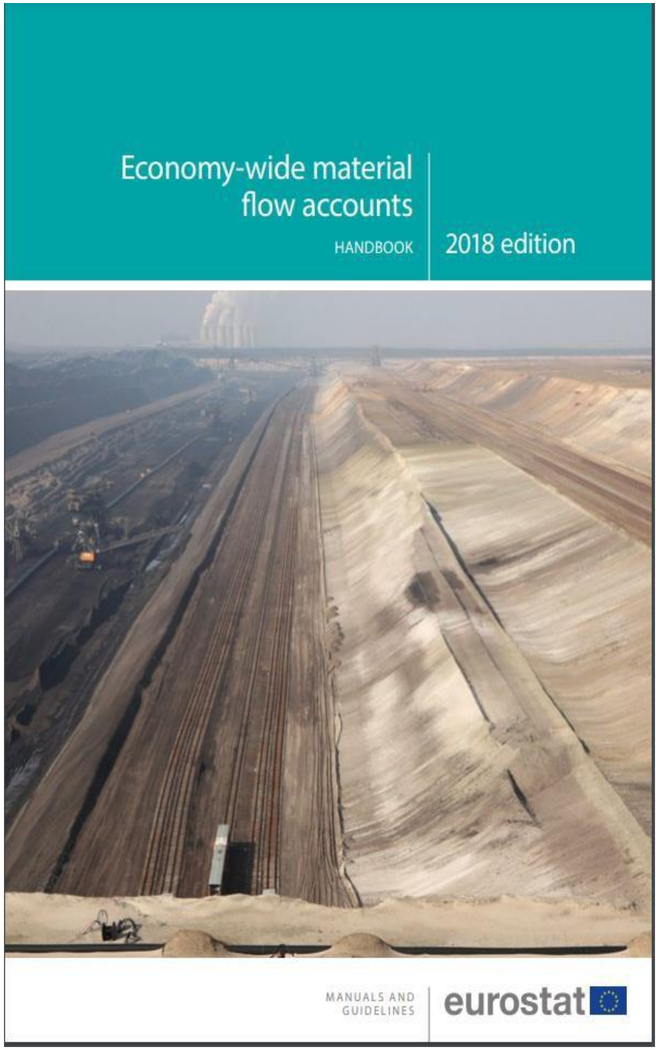


Eurostat, 2018

EW-MFA (globally -2021)

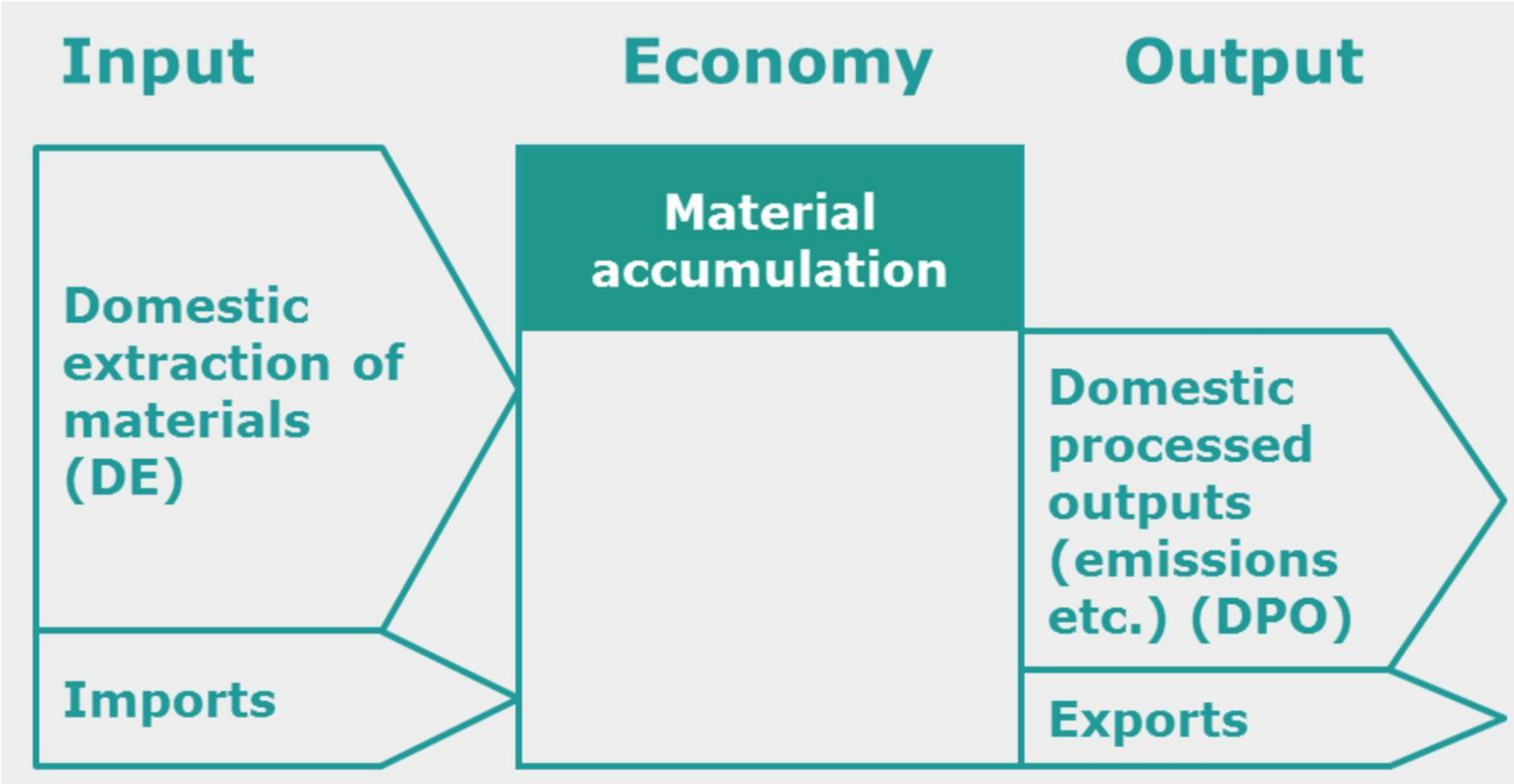
https://www.resourcepanel.org/reports/global-manual-economy-wide-material-flow-accounting

EW-MFA (in Europe): detailed method



Source: https://ec.europa.eu/eurostat/documents/3859598/9117556/KS-GQ-18-006-EN-N.pdf/b621b8ce-2792-47ff-9d10-067d2b8aac4b?t=1537260841000

EW-MFA (in Europe): detailed method



Material flows within the economy, Water flows and electricity flows are not represented in EW-MFA

EW-MFA (in Europe): detailed method

eurostat

☐ Enable automatic checks when closing workbook

Check the whole questionnaire

Economy-wide material flow accounts (EW-MFA)

2020 EW-MFA questionnaire

INTRODUCTION

version 25 August 2020

This is Eurostat's electronic questionnaire for the 2020 data collection on **economy-wide material flow accounts** (EW-MFA). It includes a number of sheets – an overview is provided in sheet '***structure***'. Reporting Tables A, B, and D are based on Regulation (EU) No. 691/2011.

Please specify your country by selecting from the drop-down list:

Deadline for returning back the 2020 EW-MFA questionnaire is: **31 December 2020**

The sheet '***instructions***' provides you with detailed information on filling in the questionnaire. Please address any questions to the following e-mail address:

ESTAT-MFA@ec.europa.eu

This electronic questionnaire shall be submitted to Eurostat using the **EDAMIS** reporting system (Electronic **D**ata files **A**dministration and **M**anagement **I**nformation **S**ystem). Please ensure that the following EDAMIS parameters are entered:

Domain: **ENVPFLAC**

Data set: **ENVPFLAC_MFA_A**

Year: **2018** (which is the most recent legally mandatory reference year). Eurostat greatly appreciates receiving EW-MFA data starting from 2000 ranging up to 2019.

The eDAMIS system has been installed in all National Statistical Institutes and your local eDAMIS coordinator will give you a user-id and password.

Should you have any questions regarding data transmission, please contact your local eDAMIS coordinator or the Eurostat eDAMIS helpdesk at:

estat-support-edamis@ec.europa.eu

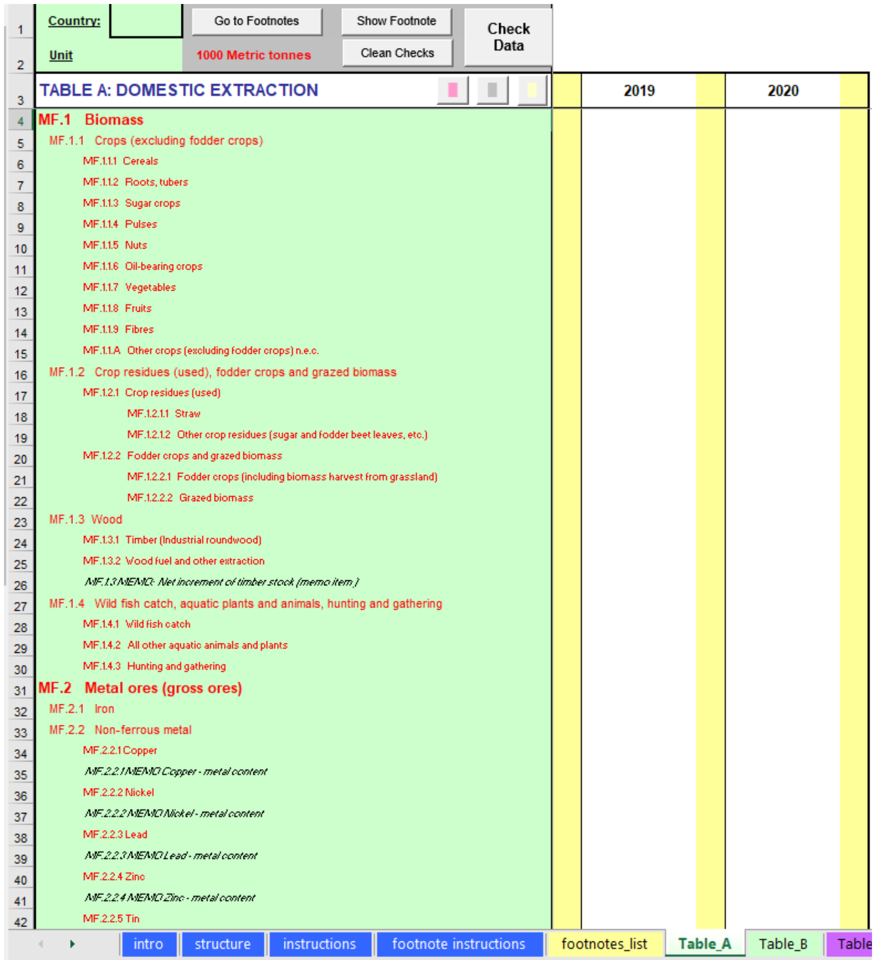
or call +352 4301 33213.

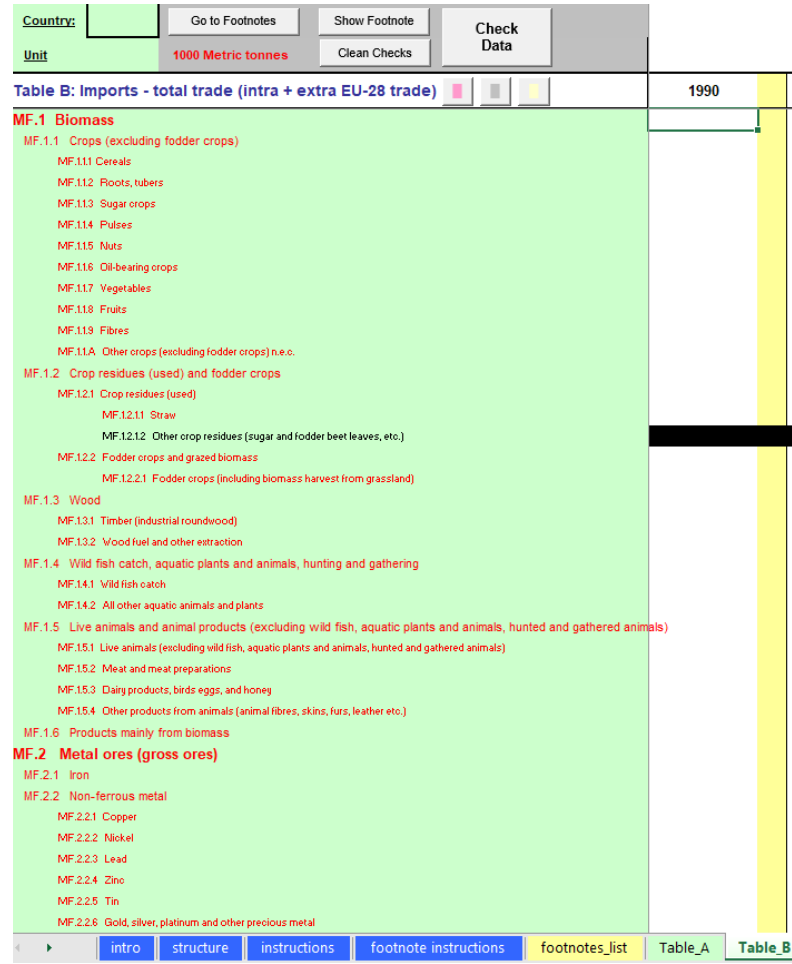
Please provide the **primary contact person for EW-MFA in your country** (*institution, unit, name, email, telephone*):

intro | structure | instructions | footnote instructions | footnotes_list | Table_A | Table_B | Table_C | Table_D | Table_E | Table_F | Table_G | Table_H | Table_I

Source: https://ec.europa.eu/eurostat/documents/1798247/6191533/Economy-wide+material+flow+accounts+%28EW-MFA%29+questionnaire

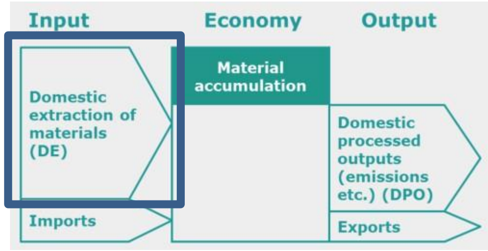
EW-MFA (in Europe): detailed method





Source: https://ec.europa.eu/eurostat/documents/1798247/6191533/Economy-wide+material+flow+accounts+%28EW-MFA%29+questionnaire

EW-MFA: Domestic Extraction



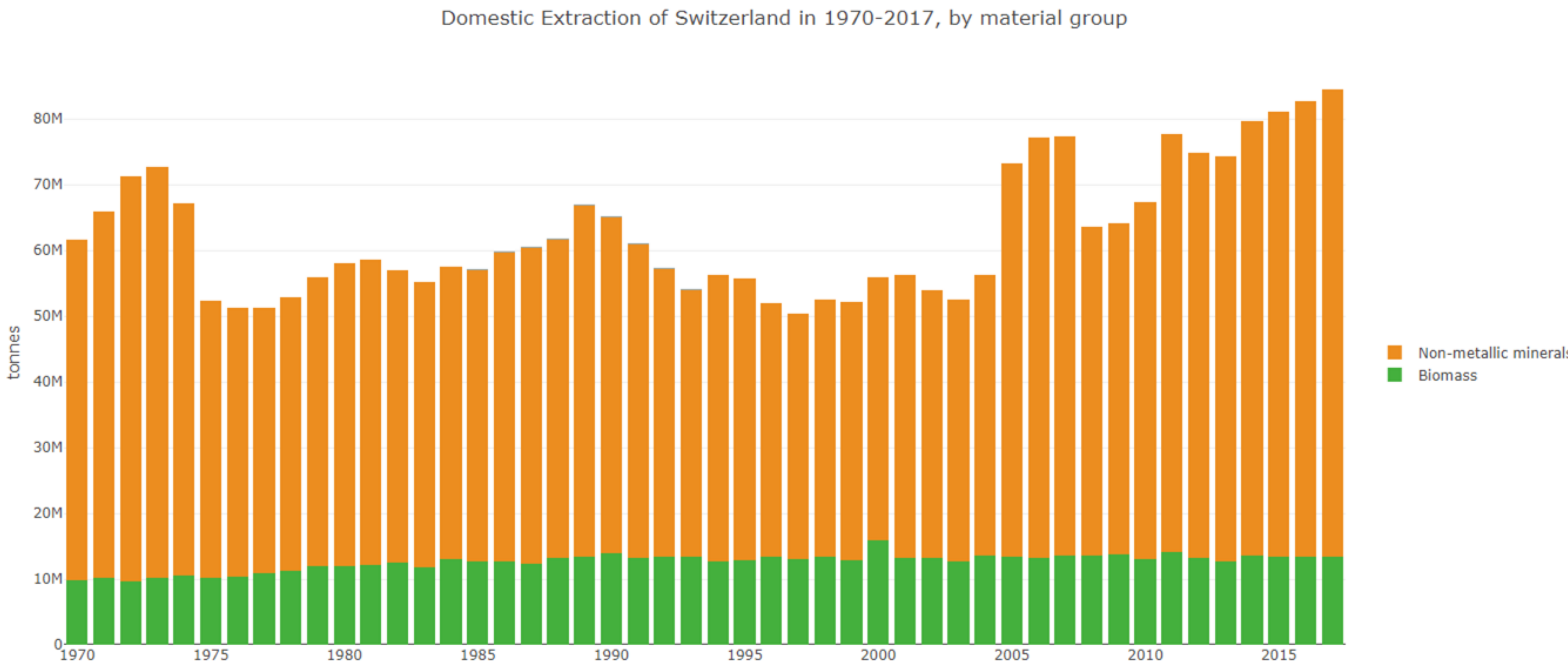
- **Domestic extraction (DE):** all raw materials that are extracted from the domestic environment and further used in production processes (excluding air and water).

- **Raw material classification**
  Biomass (crops, wood, animals, etc.)
  Metal ores (iron, copper, zinc, etc.)
  Fossil energy materials/carriers (coal, oil, natural gas etc.)
  Non-metallic minerals (limestone, sand, salt etc.)

- **Data sources:** national extraction/mining statistics, e.g. crop, forestry or mining statistics. (for instance FAO, USGS, …)

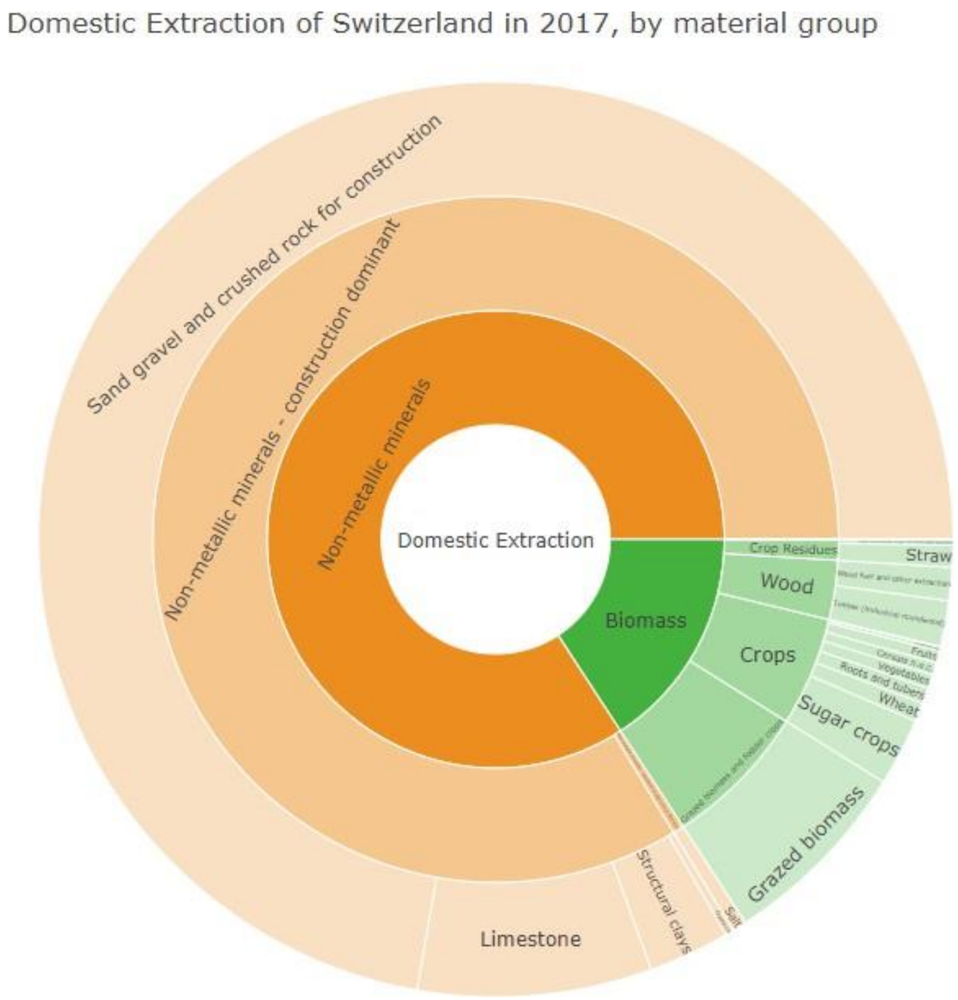
Domestic extraction in CH

What quantities of raw materials are domestically extracted to sustain economic activities?
Which raw material groups contribute most to the domestic extraction and how has this changed over time?



http://www.materialflows.net/

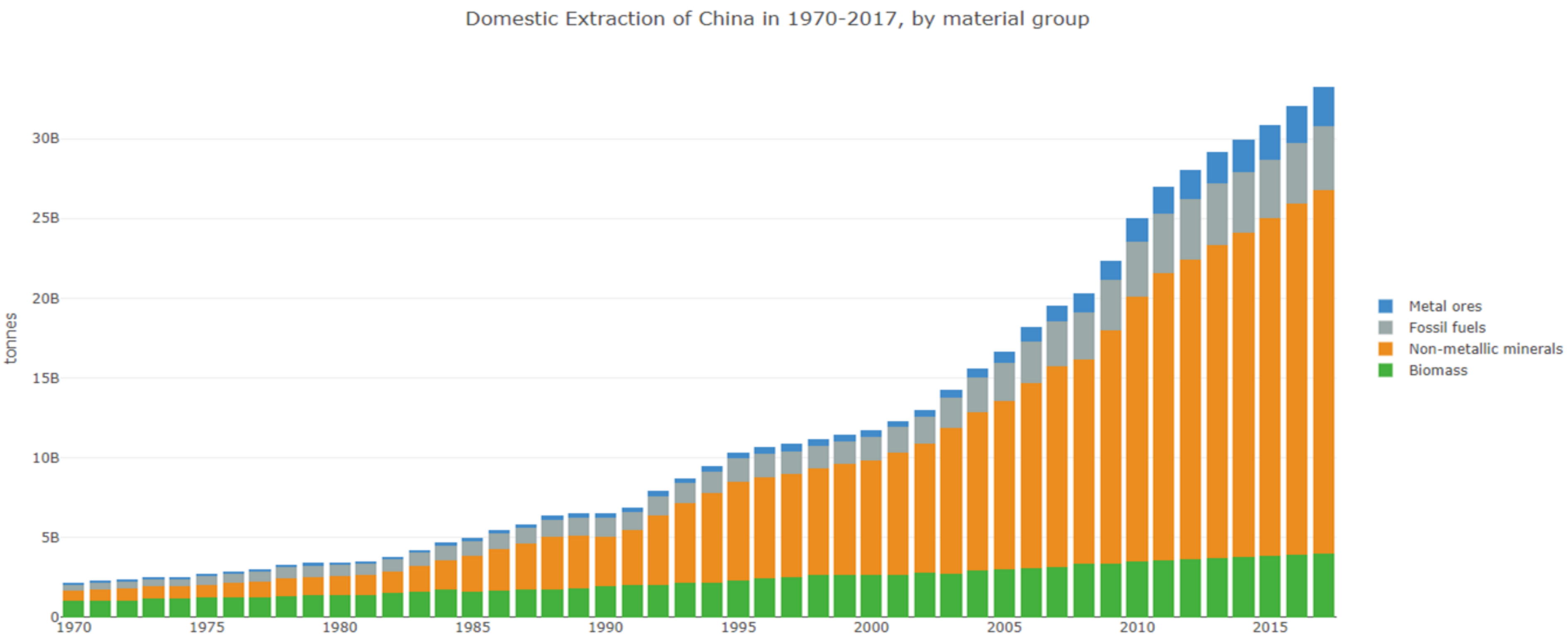
Domestic extraction in CH



http://www.materialflows.net/

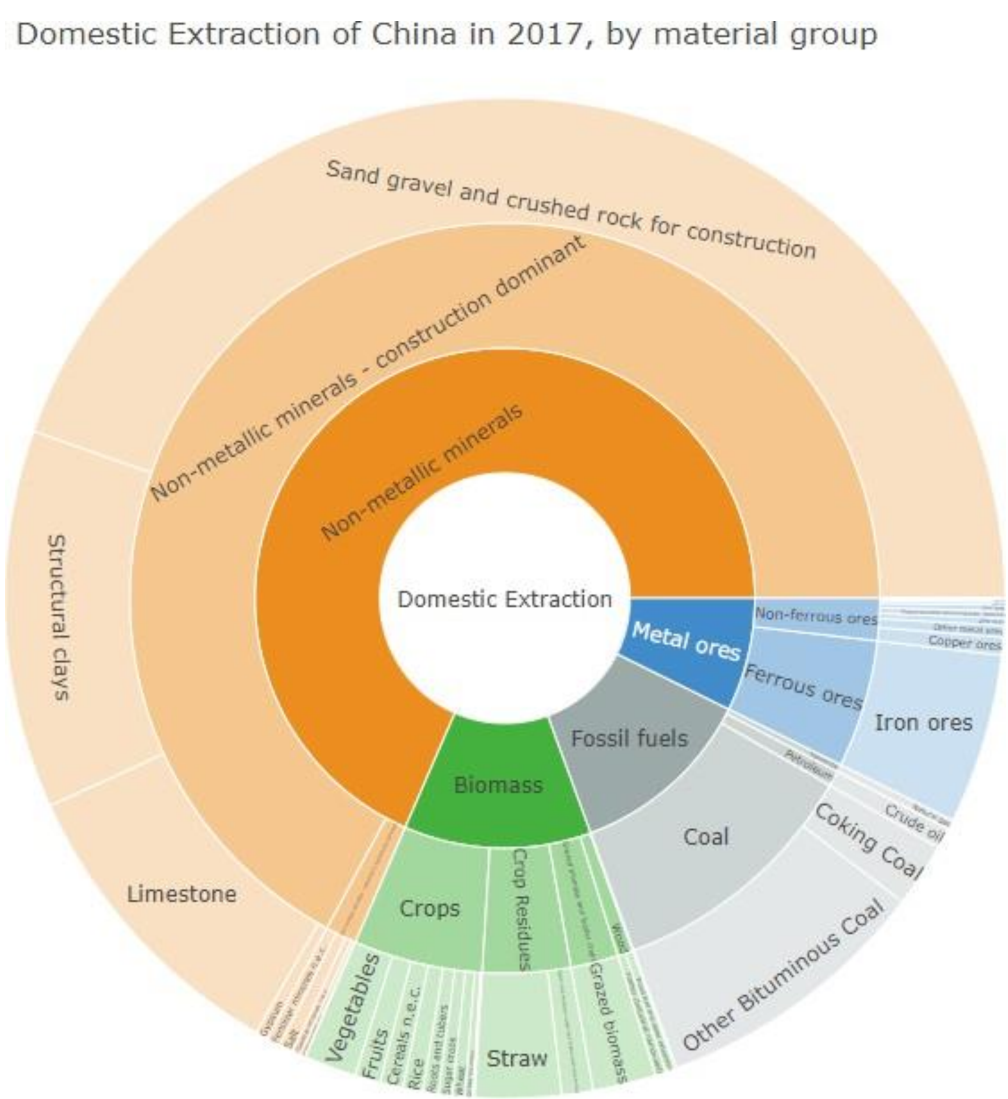
EPFL

Domestic extraction in China



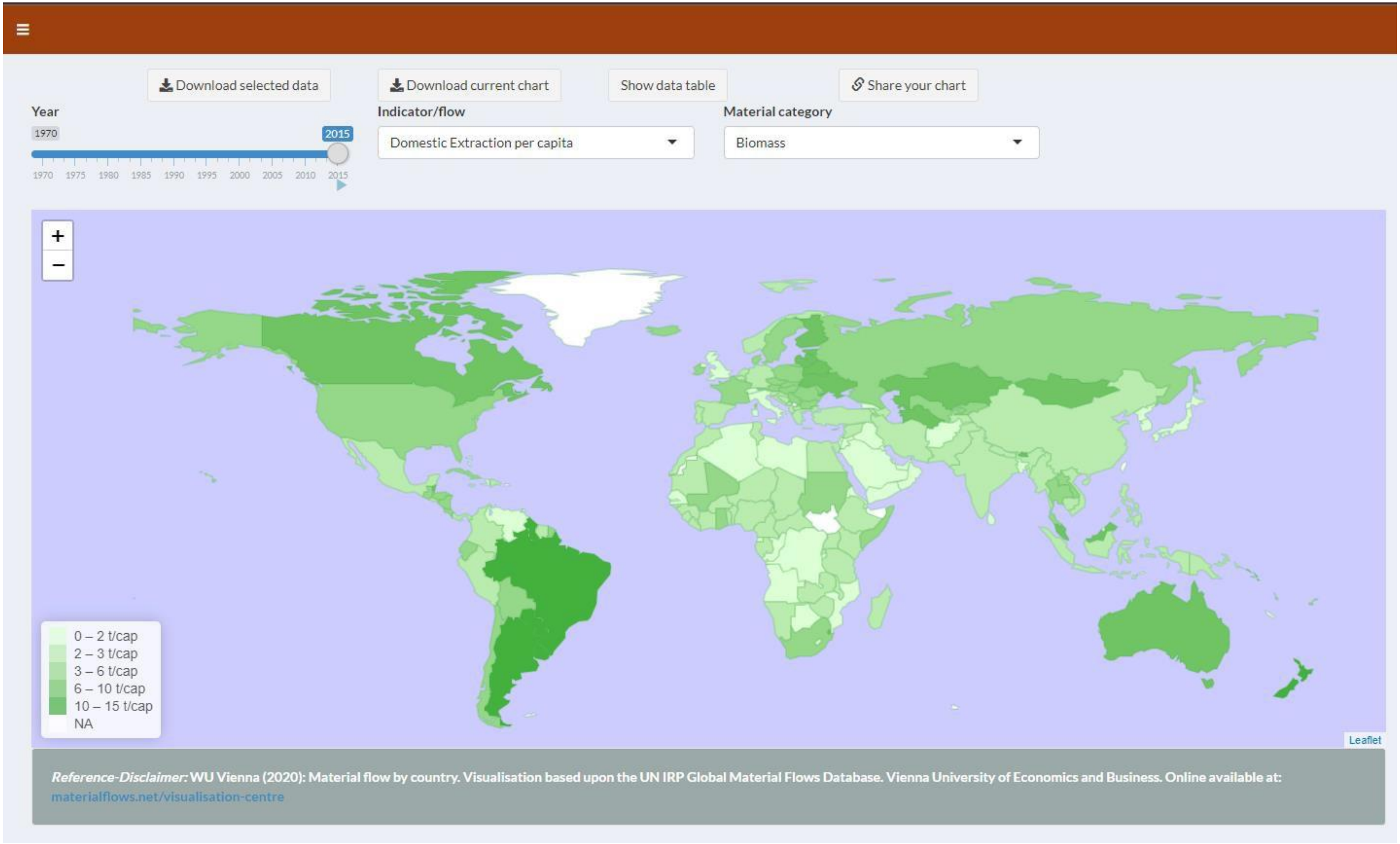
http://www.materialflows.net/

Domestic extraction in China



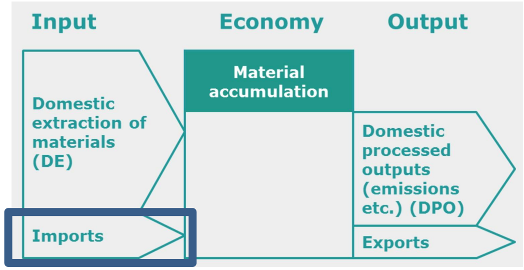
http://www.materialflows.net/

Domestic extraction in countries



http://www.materialflows.net/

MFA (Eurostat): imports



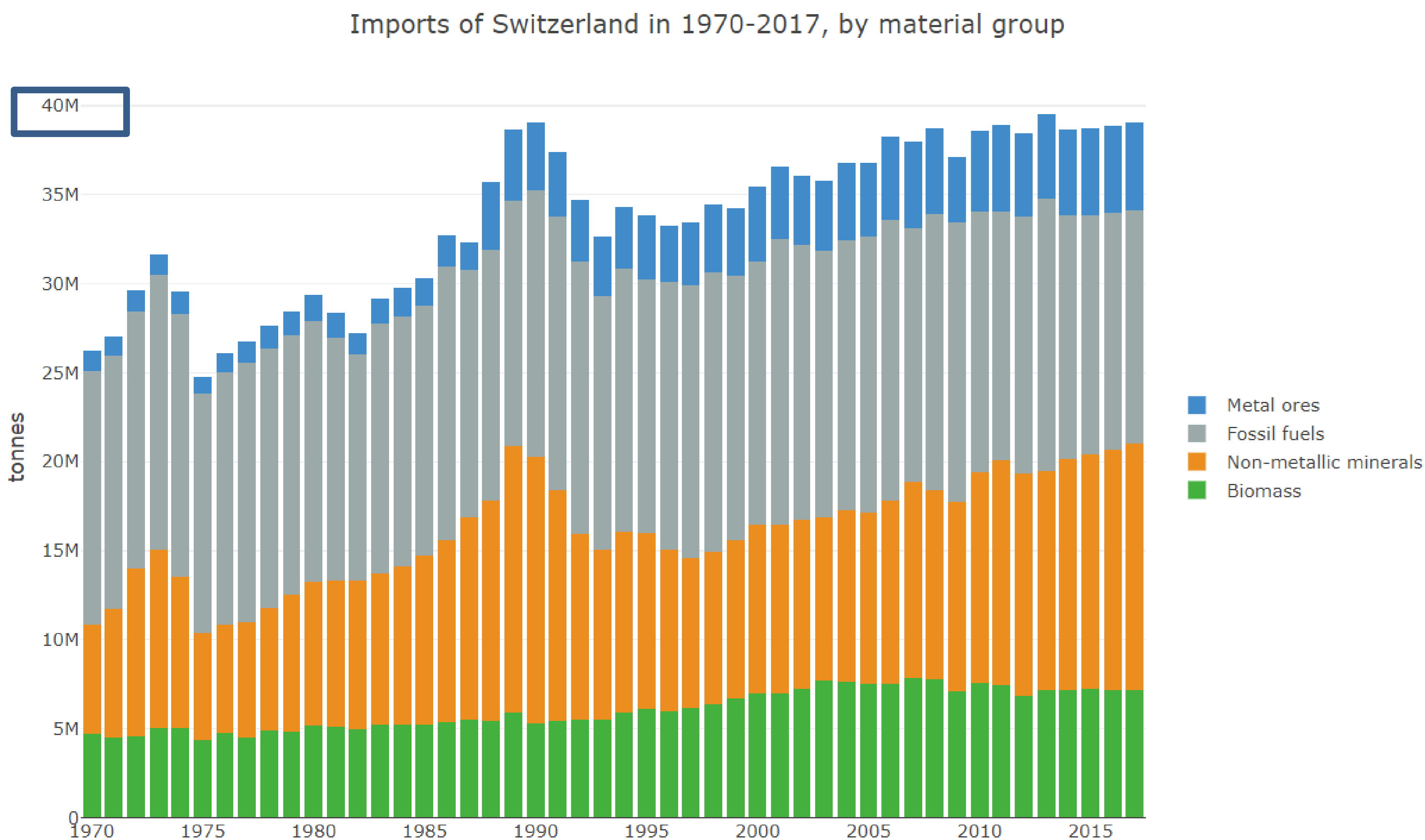
- **Imports (IMP):** imported and traded goods at all stages of processing, from raw materials to highly processed products.

- **Methods:** products are allocated to specific material categories, e.g. imported car produced from steel as the main component is allocated to iron ore.

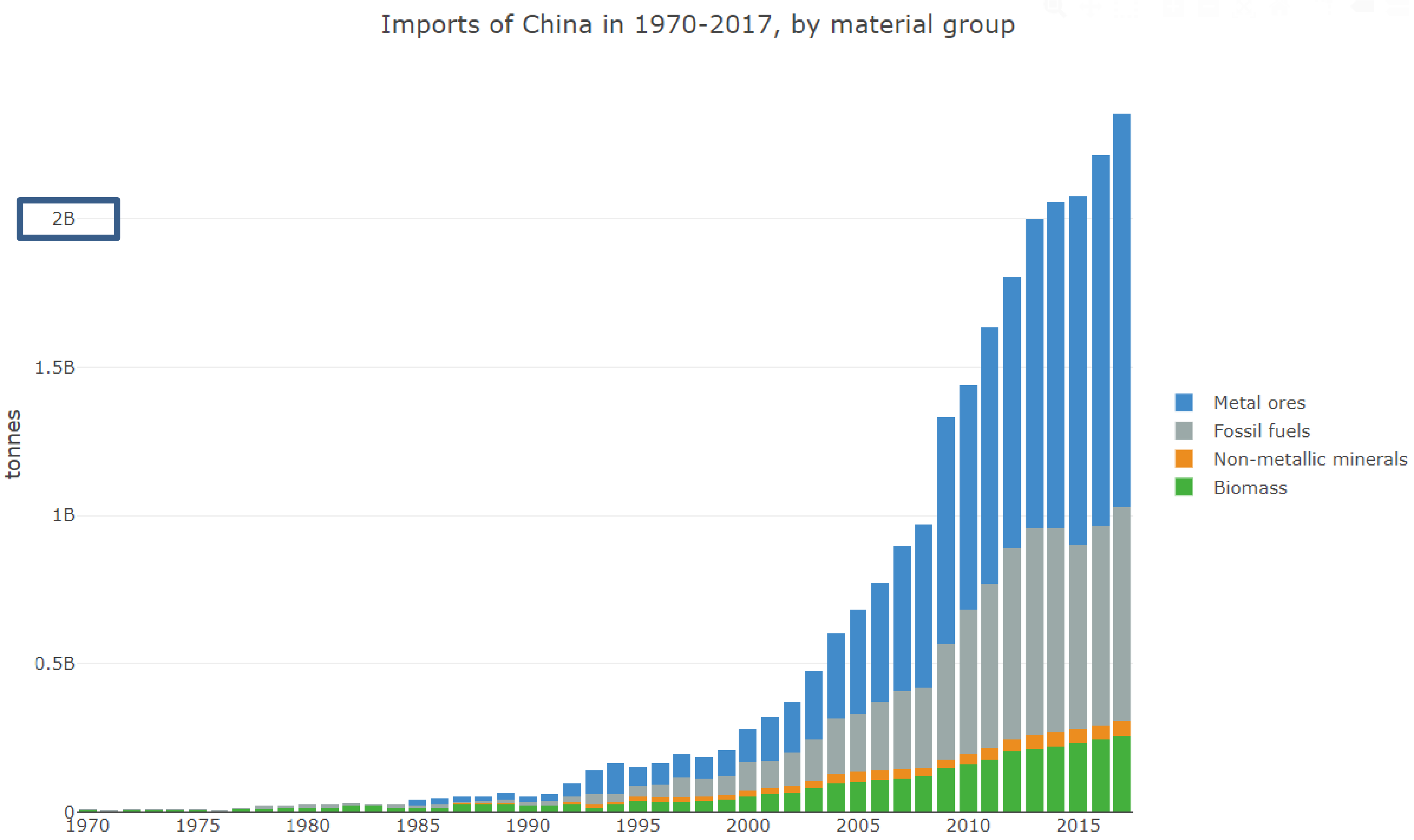
- **Data sources**: foreign trade statistics, either from national or international (EU, UN) statistical sources. (see COMEXT, CN, NST)

Imports in CH

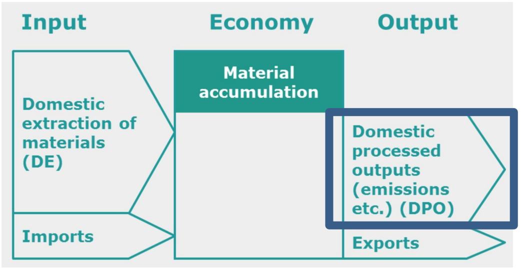
How many goods is a country importing in addition to domestic extraction?
How dependent is the productive sector of an economy on raw material imports?



Imports in China



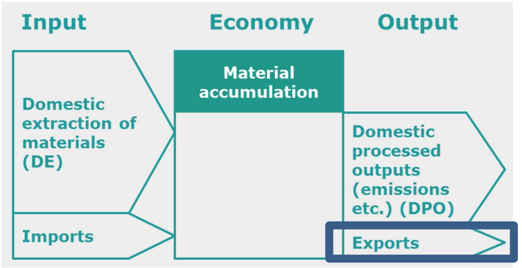
MFA (Eurostat): domestic processed output



- **Domestic processed output (DPO):** total mass of waste materials generated along the value added chain, including resource extraction, processing, manufacturing use, and waste management.

- DPO includes emissions to air, water, and landfill.

MFA (Eurostat): exports



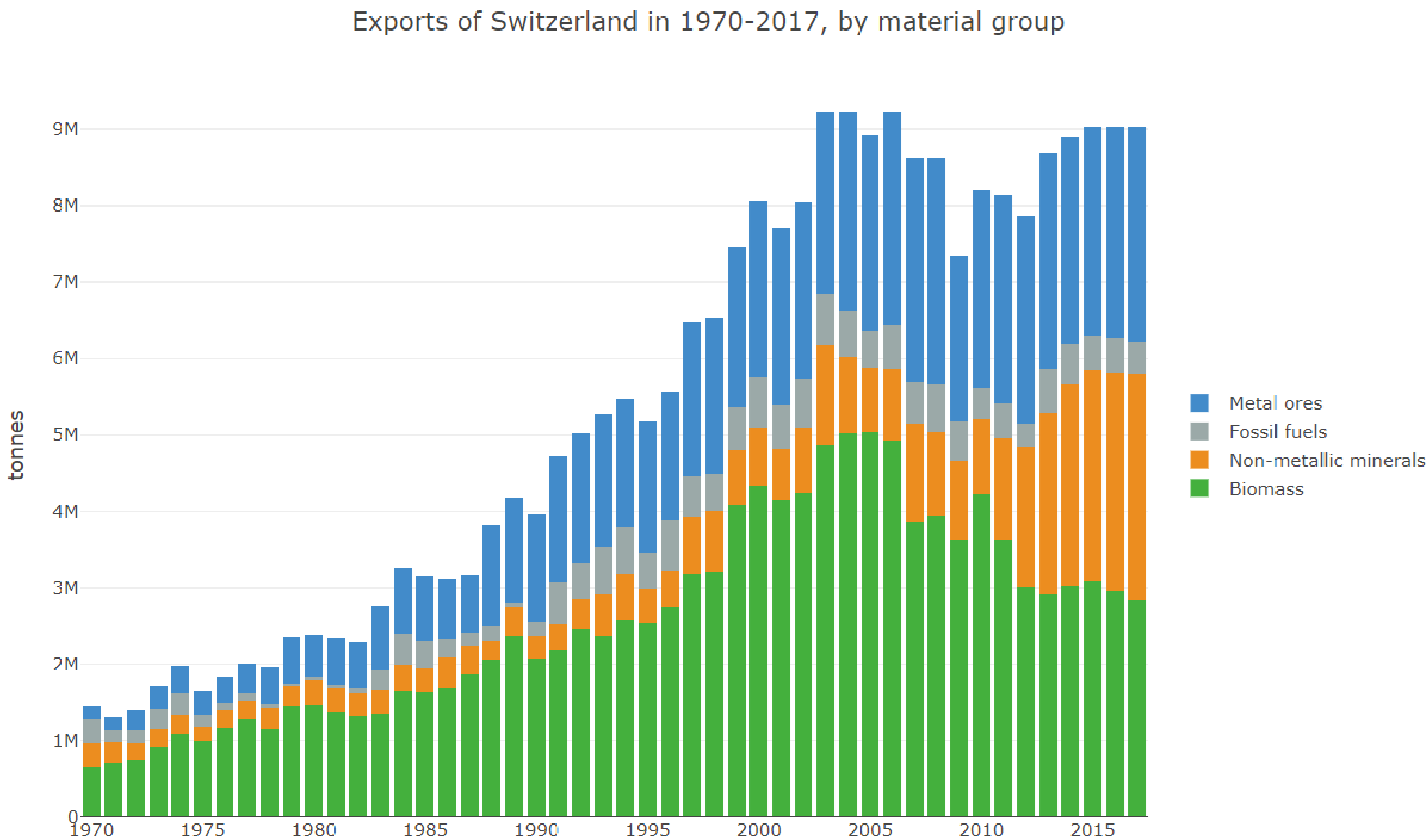
- **Exports (EXP):** exported and traded goods at all stages of processing, from raw materials to highly processed products.

- **Methods:** products are allocated to specific material categories, e.g. exported car produced from steel as the main component is allocated to iron ore.

- **Data sources:** foreign trade statistics, either from national or international (EU, UN) statistical sources.

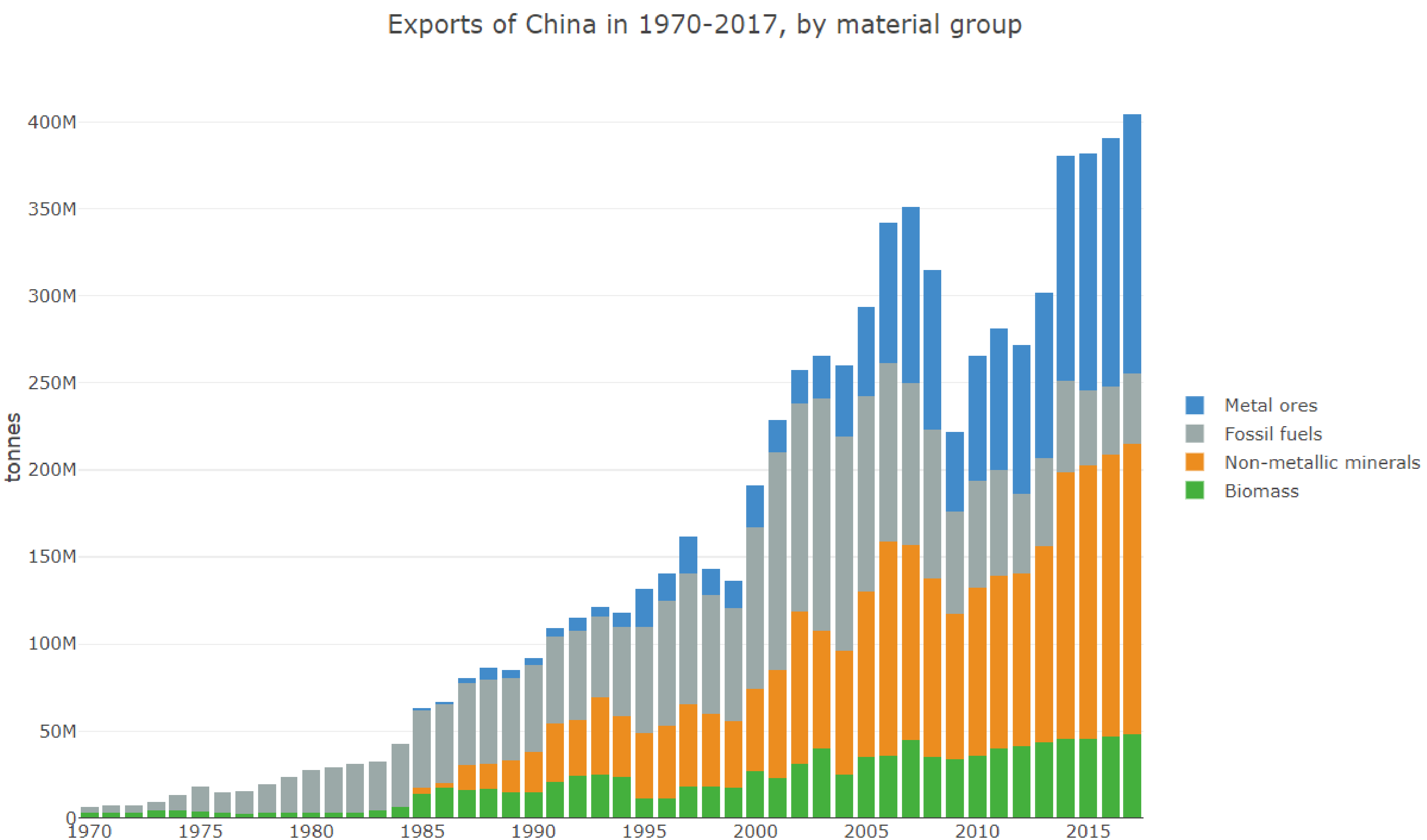
Exports in CH

How many goods is a country exporting?
40M vs 9M



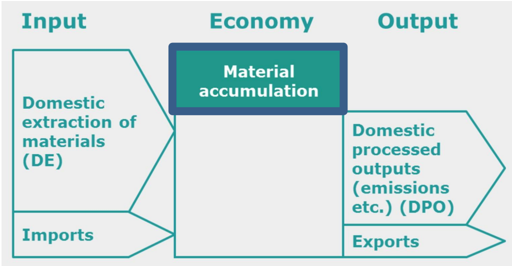
Exports in China

2,5B vs 400M



EPFL

MFA (Eurostat): material accumulation



- **Material accumulation or net additions to stock (NAS):** measure of physical growth in an economy.
- New materials in form of **buildings, infrastructures, durable goods** such as e.g. cars, industry machinery, or household appliances are added to the economy's material stock each year **(gross additions).**
- Old materials are removed from stock as buildings are demolished, and durable goods disposed of **(removals).**

MFA (Eurostat): indicators

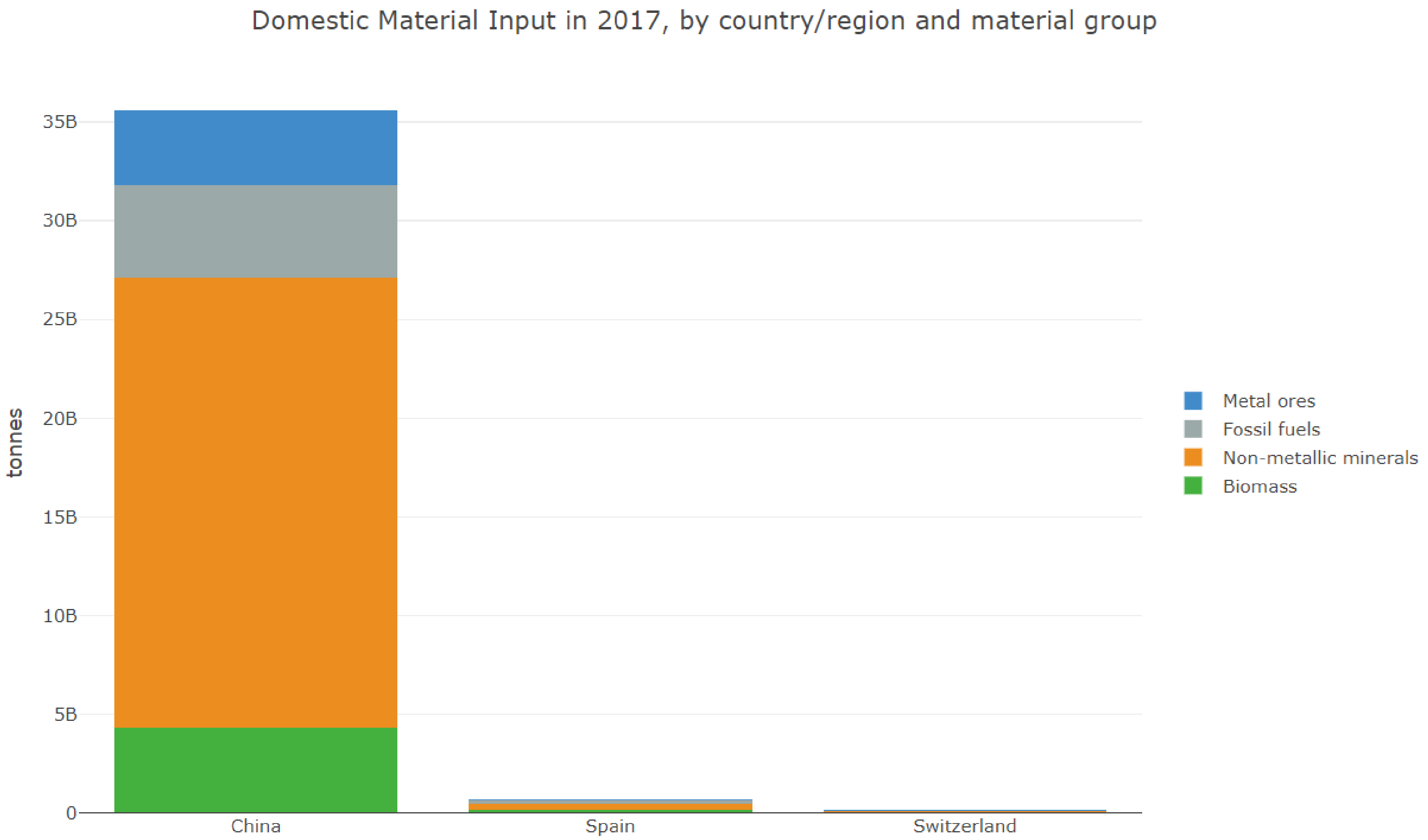
Basic flow types

- Domestic extraction (DE)
- Domestic processed output (DPO)
- Imports (IMP)
- Exports (EXP)

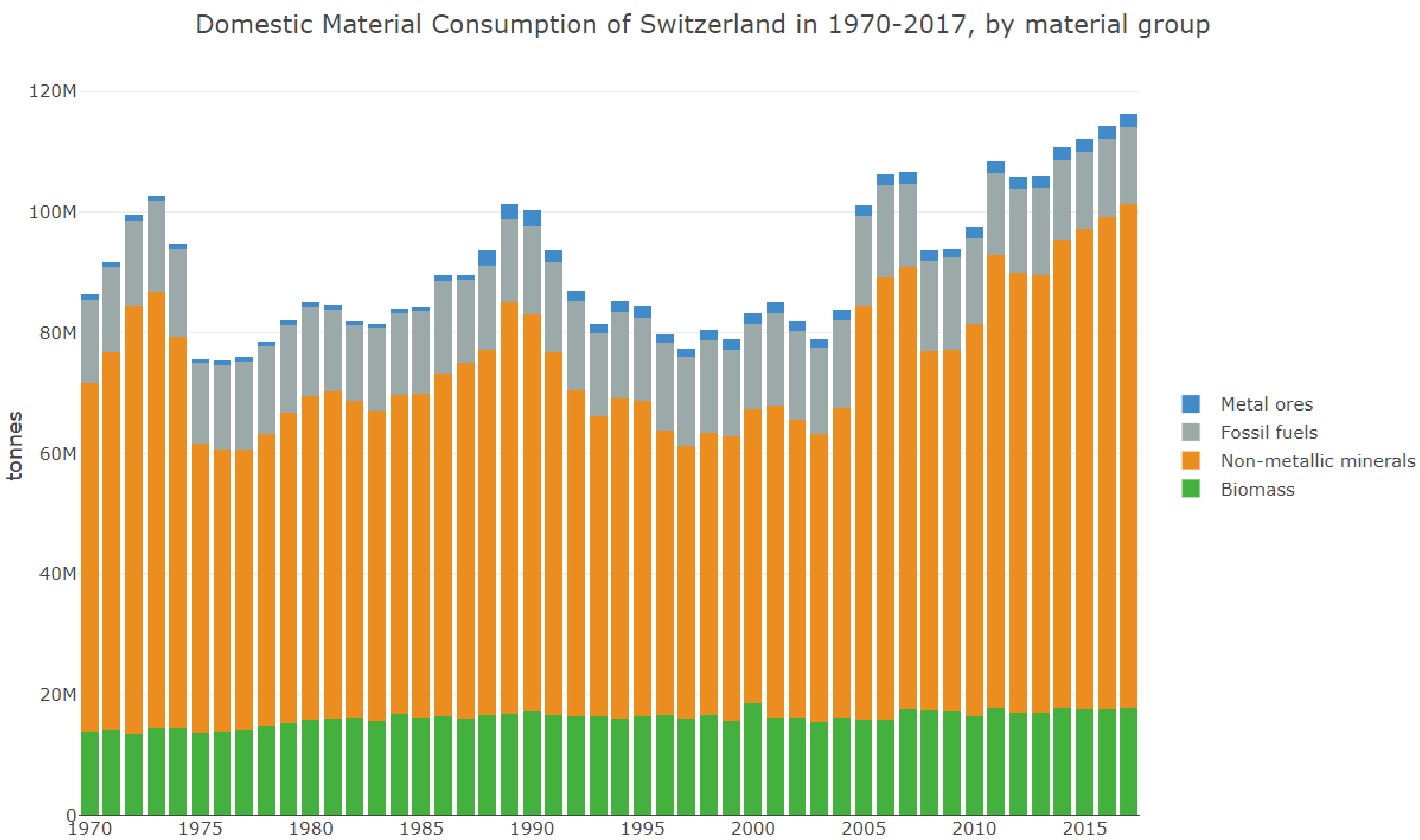
Flows types are basis for indicators

- Domestic material input (DMI) = DE + IMP
- Domestic material consumption (DMC) = DE + IMP – EXP
- Physical trade balance (PTB) = IMP – EXP
- Net additions to stock = DMI – DPO – EXP

MFA (Eurostat): indicators DMI

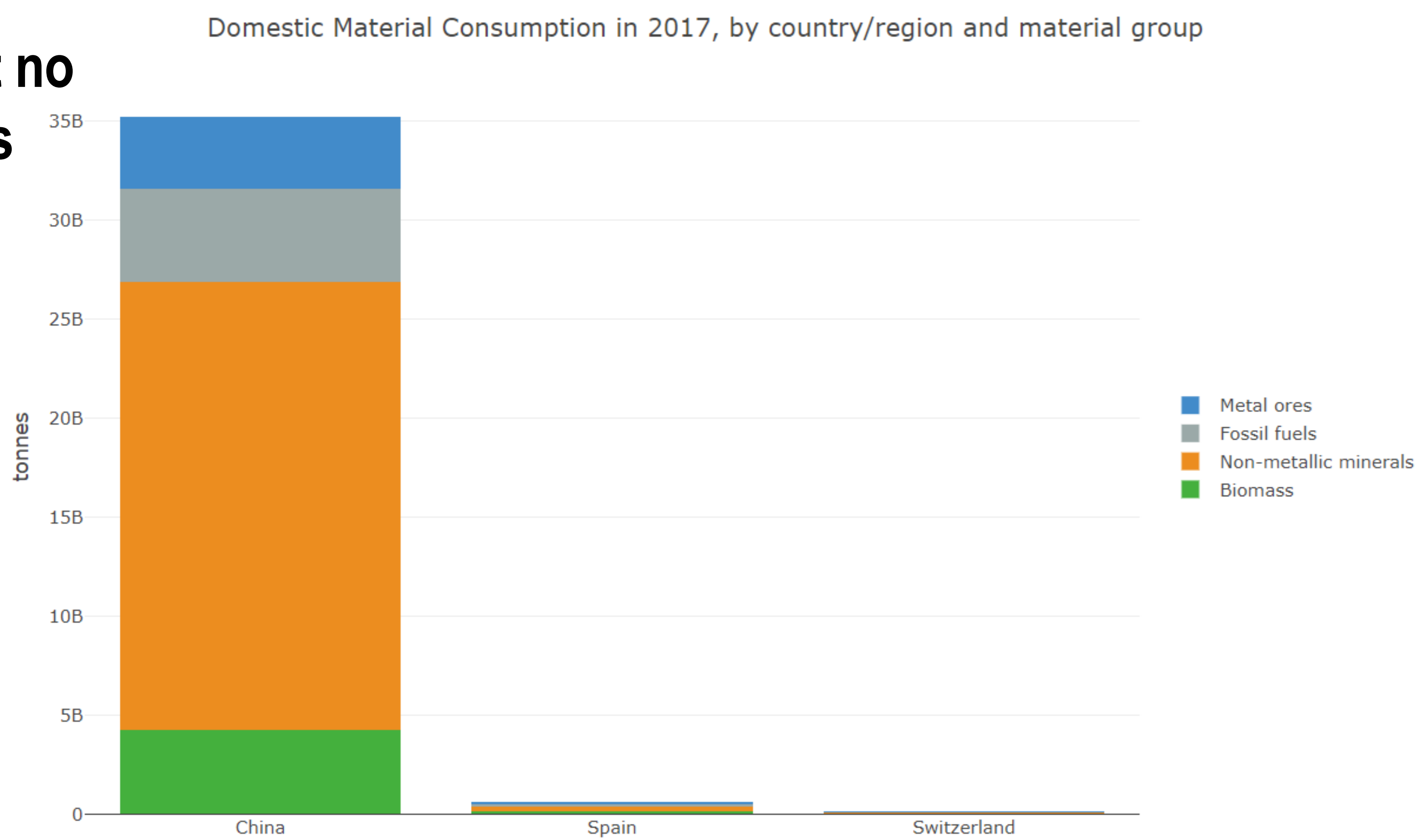


Domestic material consumption in CH



Domestic material consumption

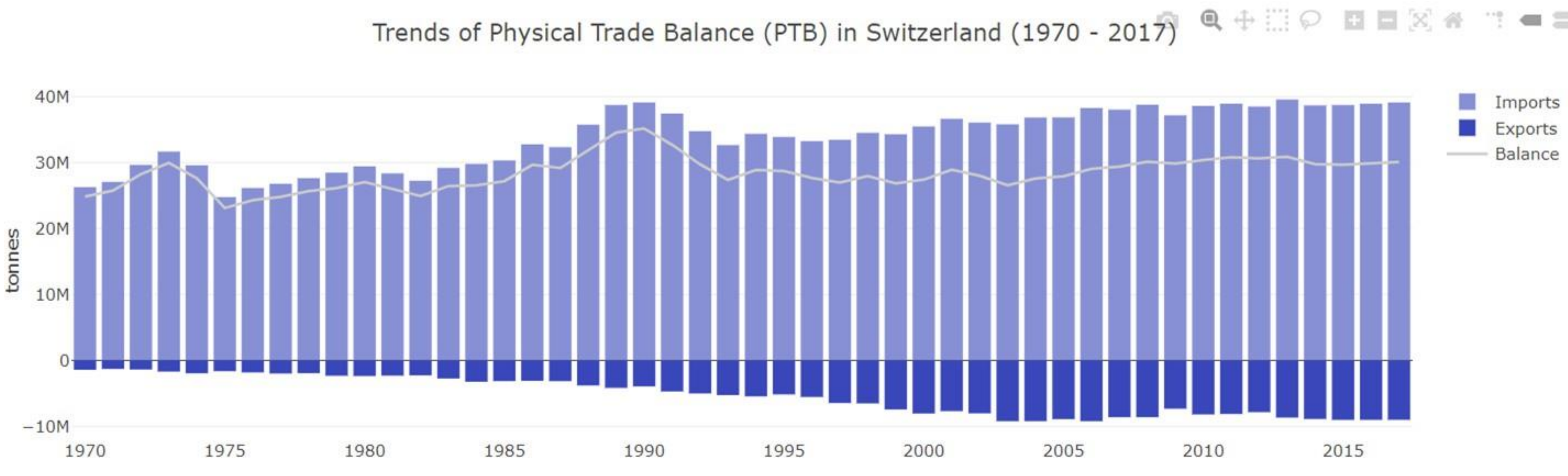
Almost no imports



EPFL

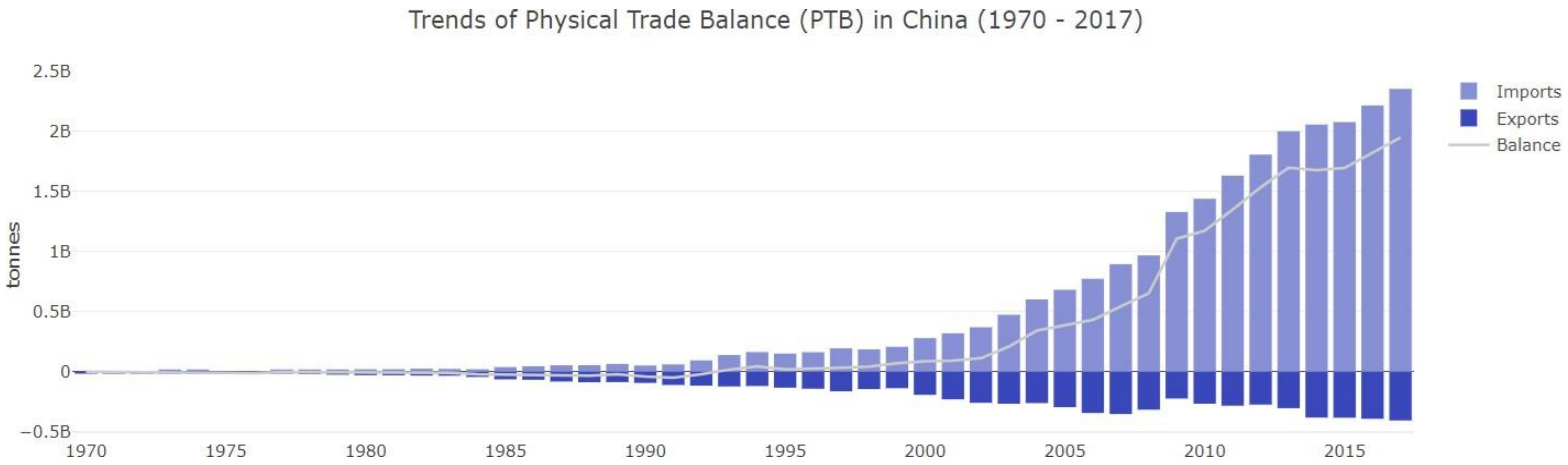
PTB in CH

Is a country a physical net-importer or net-exporter of raw materials?



PTB in China

Is a country a physical net-importer or net-exporter of raw materials?



MFA (Eurostat): additional “monetary” indicators

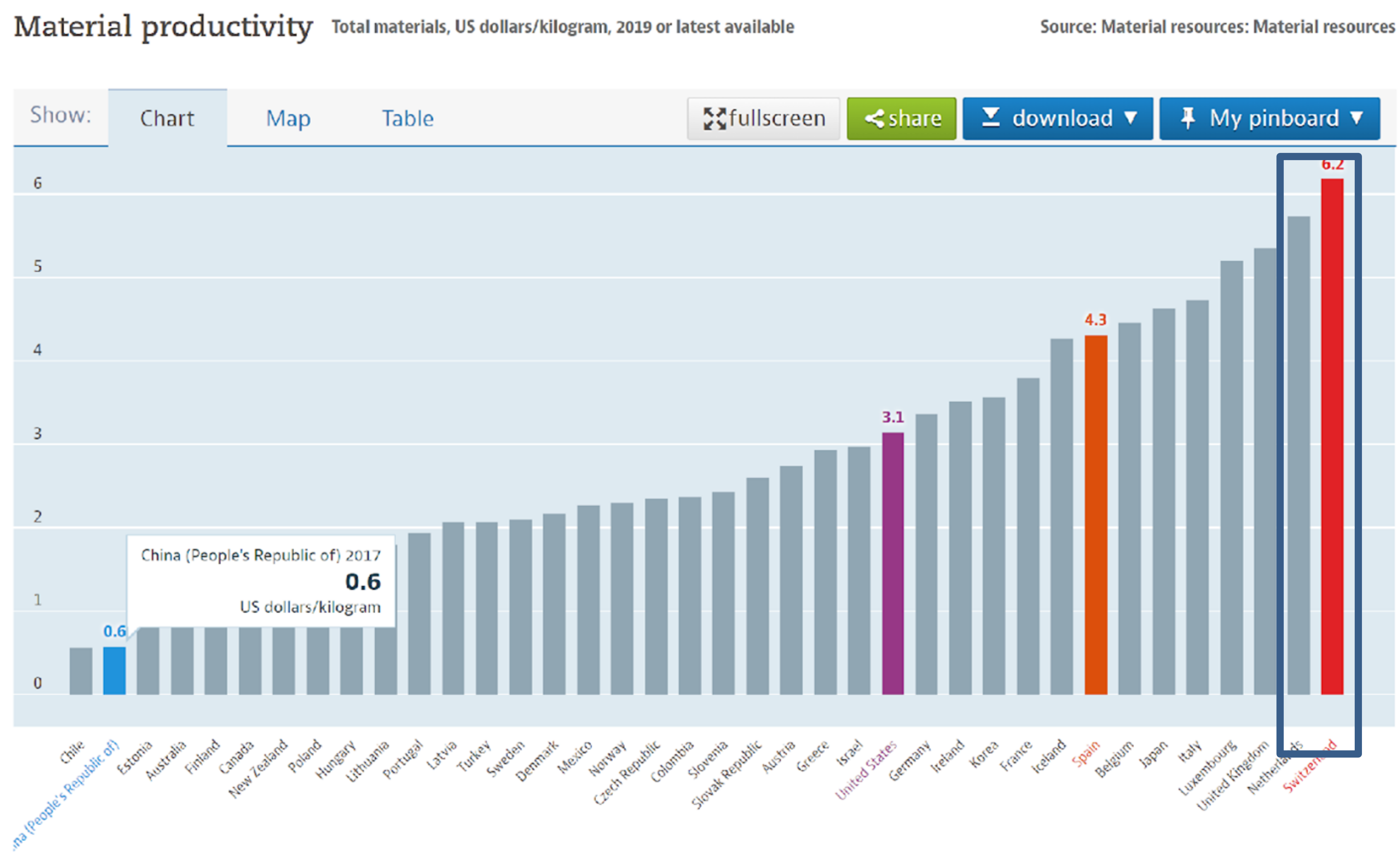
Material productivity = GDP $_{\text{[€ of added value]}}$ **/ DMC** $_{\text{[t of material input]}}$

- **Material productivity:** measure of economic output (goods or services) per unit of material input.
- Increase in material productivity = decoupling material use and economic performance.

Material intensity = DMC $_{\text{[t of material input]}}$ **/ GDP** $_{\text{[€ of added value]}}$

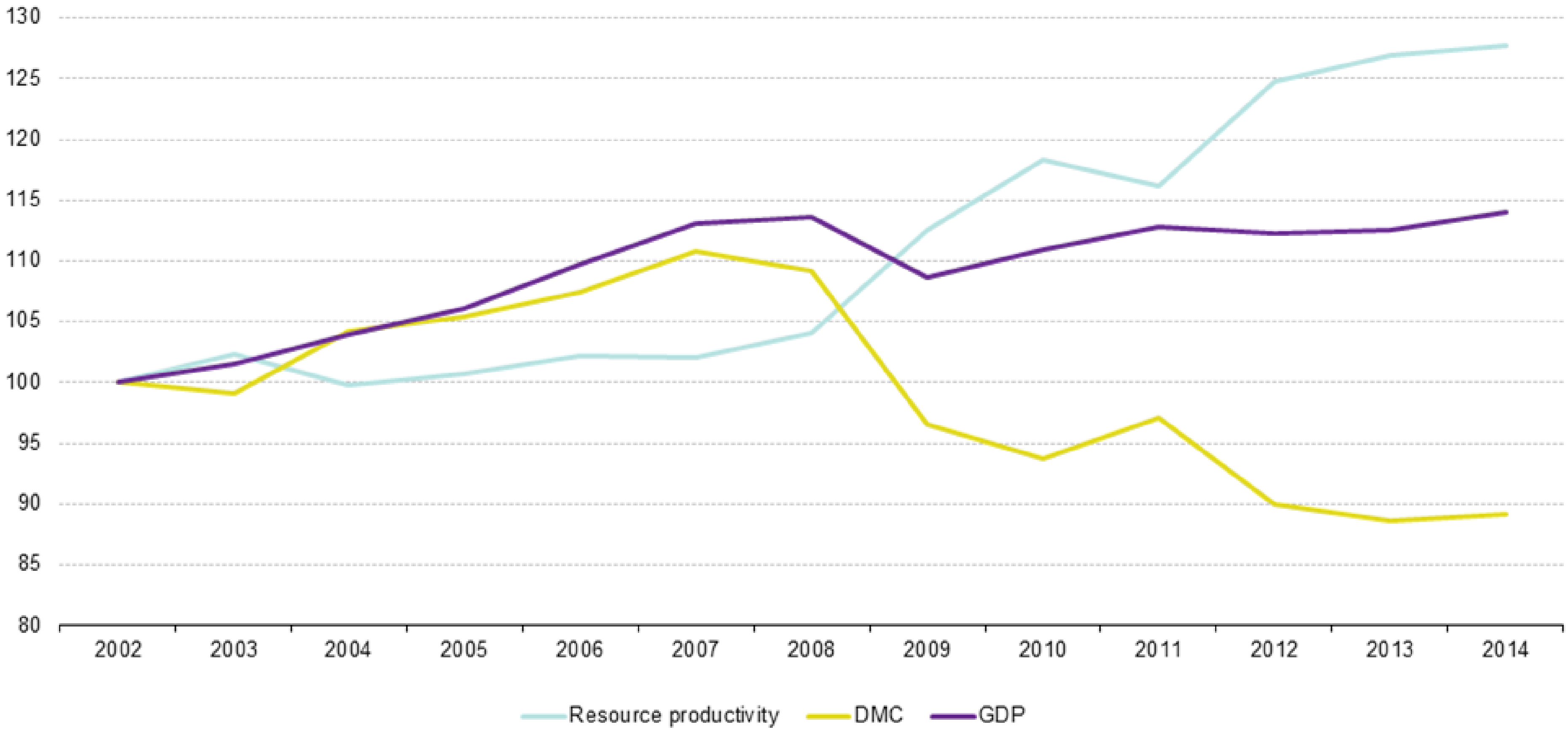
- **Material intensity:** measure of material input used per economic output (good or service)
- Decrease in material intensity = more efficient material use.

Material productivity OECD-37



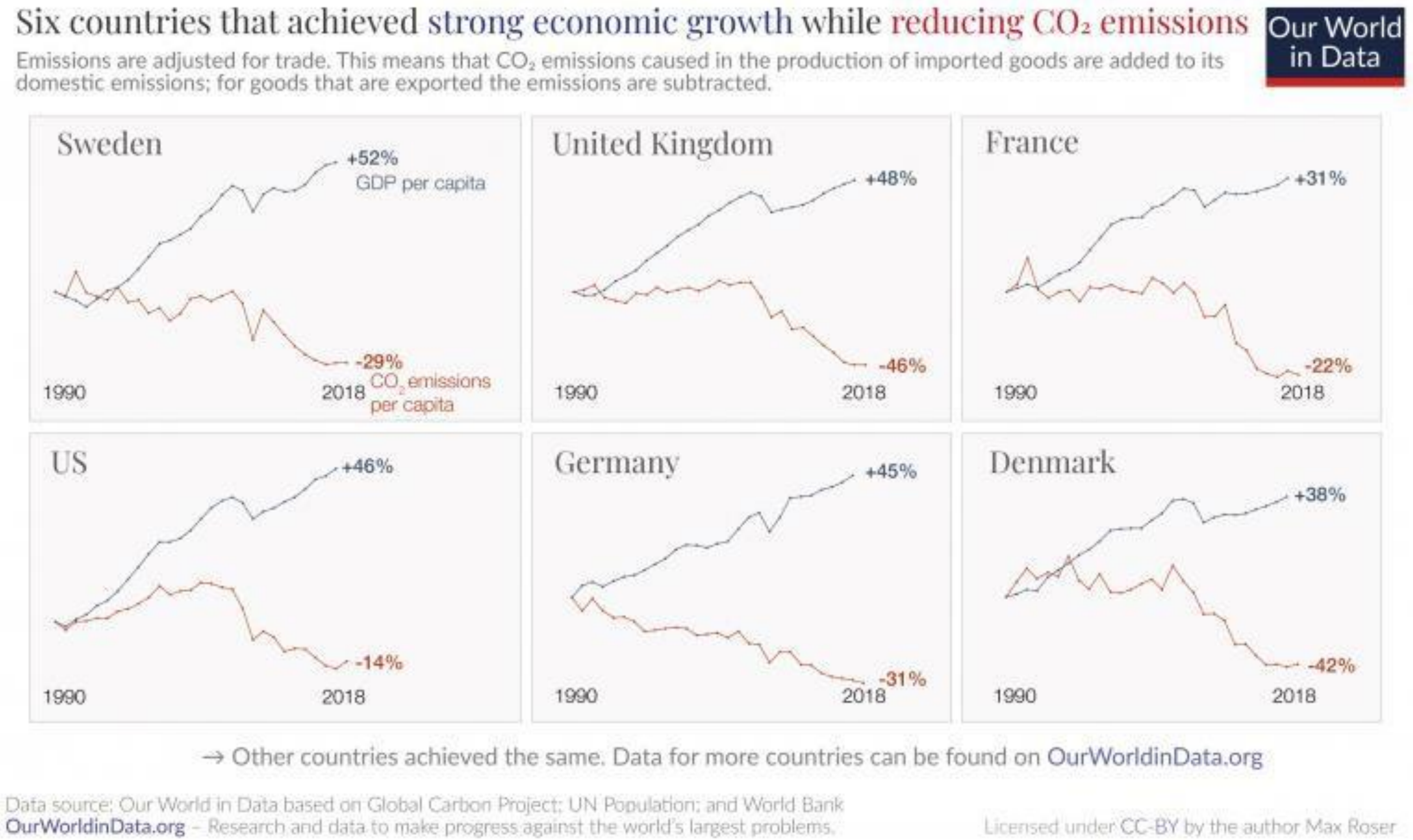
Why?

Let's talk about decoupling (absolute, relative, sufficient)



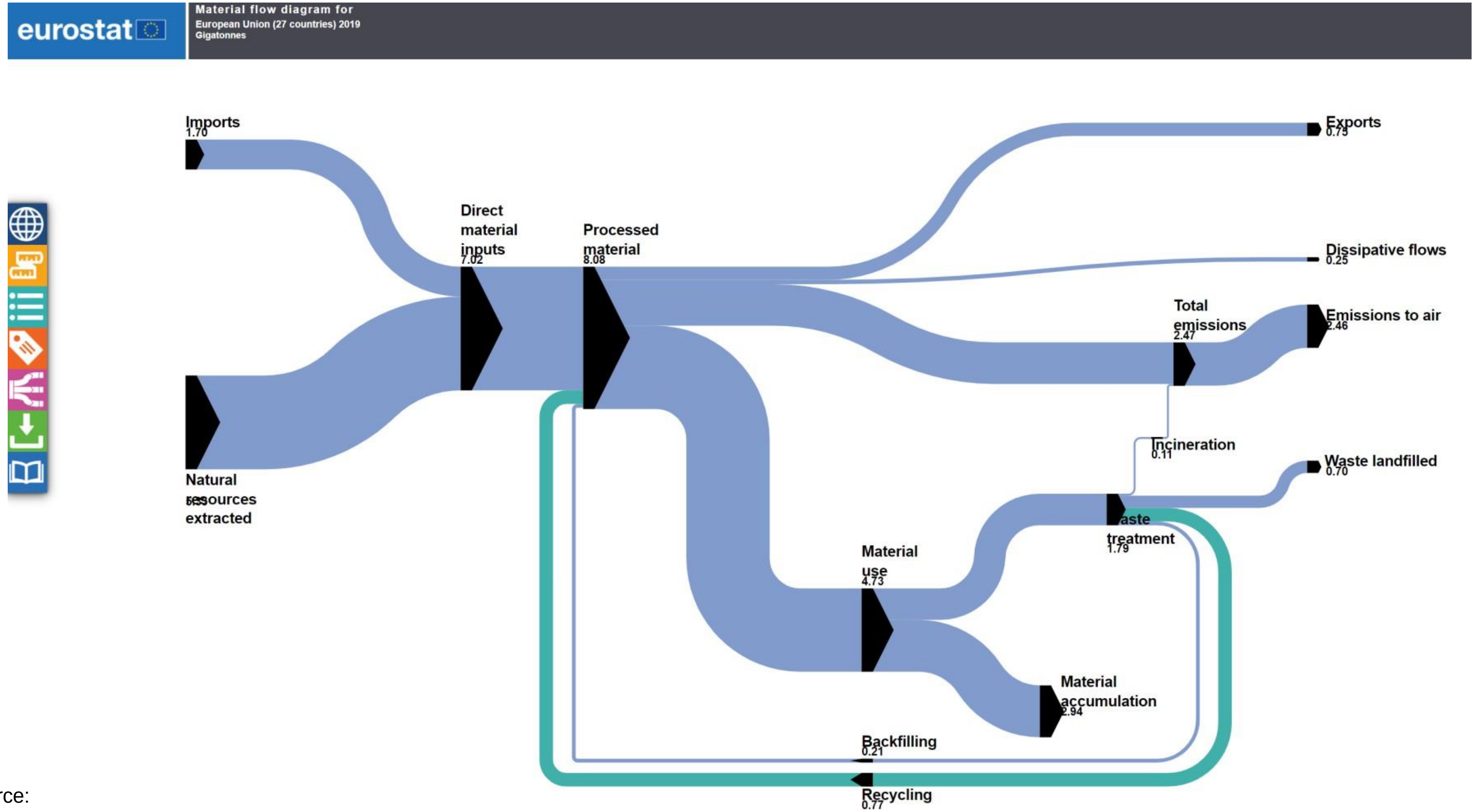
https://data.oecd.org/materials/material-productivity.htm#indicator-chart

Let's talk about decoupling (absolute, relative, sufficient)



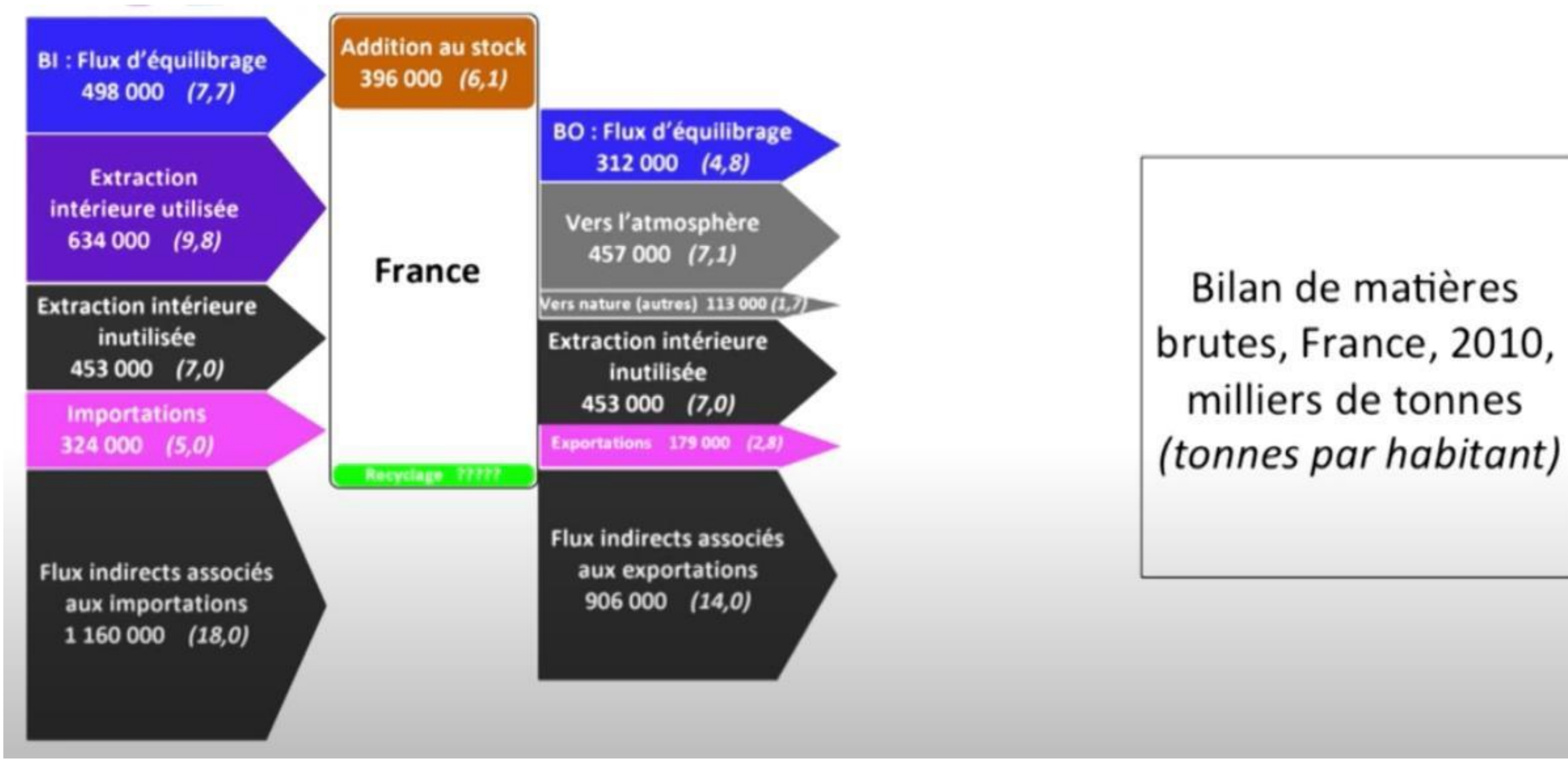
https://ourworldindata.org/carbon-price

Circular Economy at a EU level



Source:
https://ec.europa.eu/eurostat/cache/sankey/circular_economy/sankey.html?geos=EU27&year=2019&unit=G_T&materials=TOTAL&highlight=0&nodeDisagg=0101100100&flowDisagg=false&translateX=200&translateY=70&scale=0.6&language=EN&xyz=89&material=TOTAL

EW-MFA: Use at a territorial level (French case study)



Source: https://www.youtube.com/watch?v=W1Fgqh1xlaM&list=PLeU78T5dtVW6wH7xsbDc2KdU3QmnlT8RC

EW-MFA: Use at a territorial level (French case study)

Figure 3.3 : AFM de la région Île-de-France en 2003

Figure 3.4 : AFM de la région Midi-Pyrénées en 2006

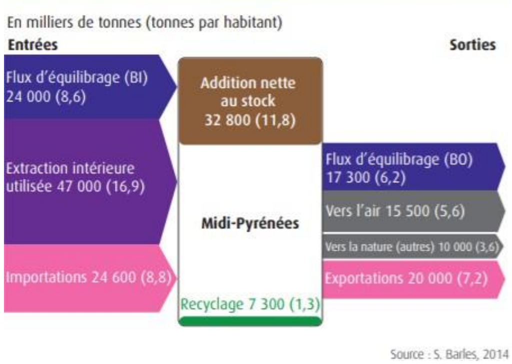
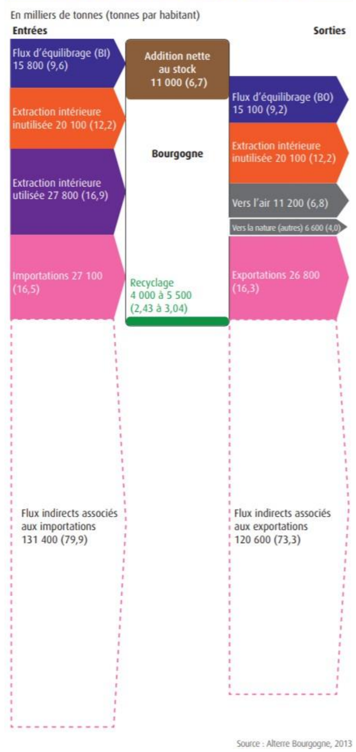


Figure 3.5 : AFM de la région Bourgogne en 2010



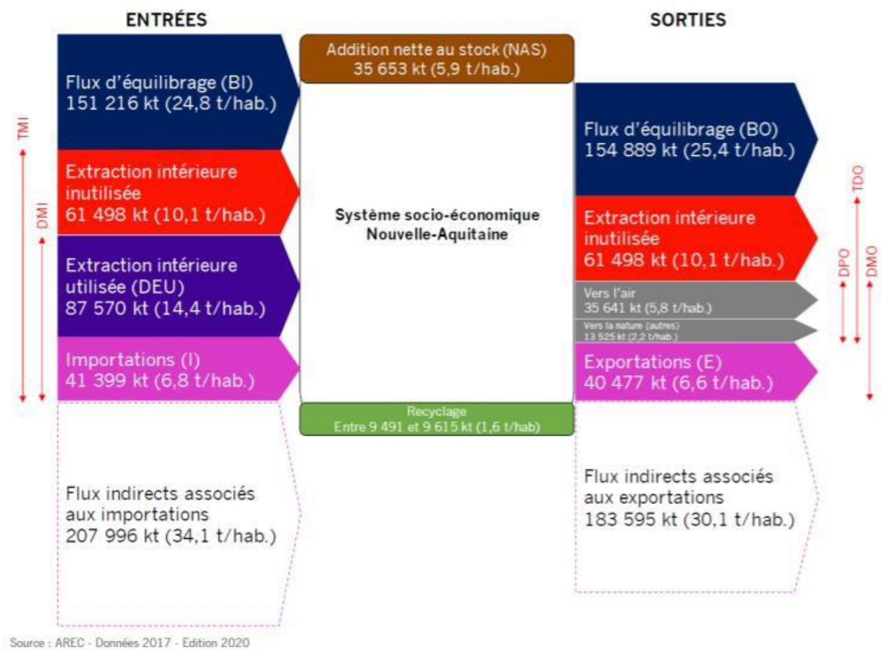
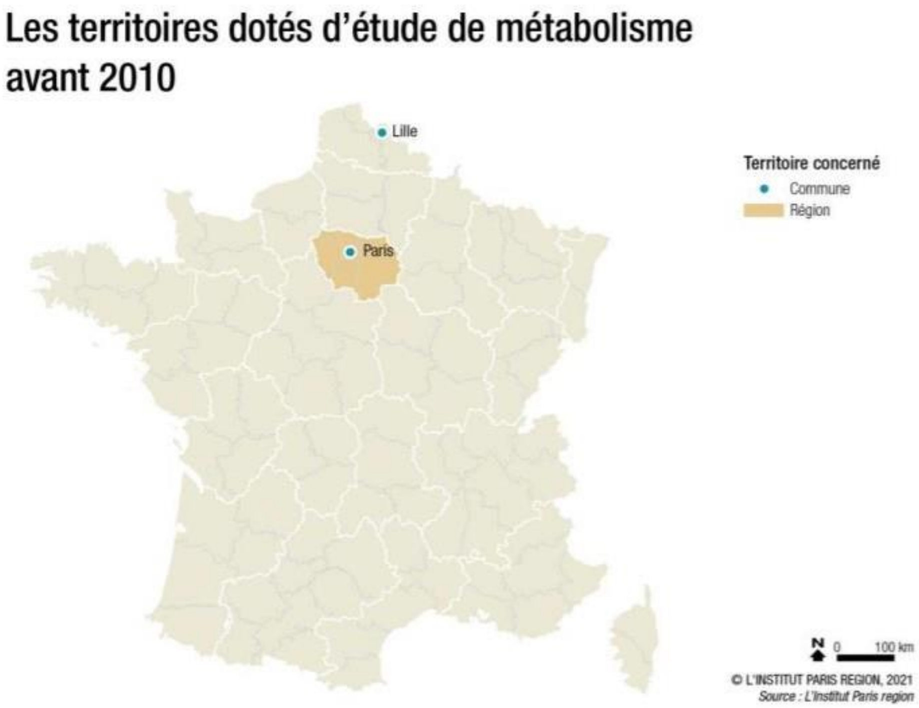
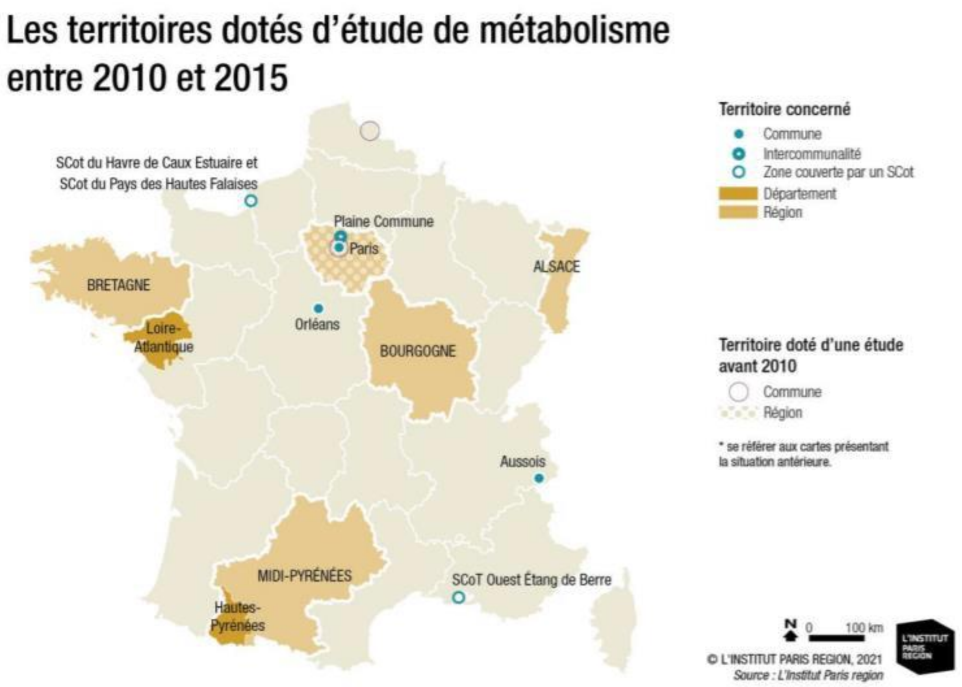


Figure 6. Schéma de principe et principaux indicateurs de l'analyse de flux de matières de la Nouvelle-Aquitaine en 2017. Sources : « Analyse de flux de matières de la Nouvelle-Aquitaine ». Les synthèses de l'AREC - ORDEC Edition 2020 – année 2017.

Source: https://www.ecologie.gouv.fr/sites/default/files/EIT%20-%20comptabilite%20des%20flux%20de%20matieres.pdf / https://www.institutparisregion.fr/fileadmin/NewEtudes/000pack2/Etude_2625/EtudesMetabolisme_Recensement_VF.pdf

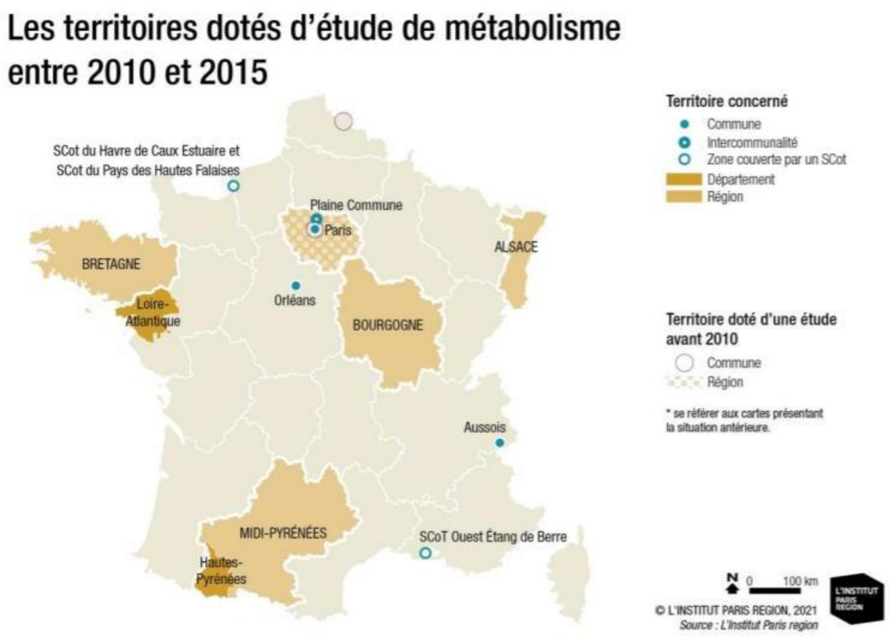
EW-MFA: Use at a territorial level (French case study)

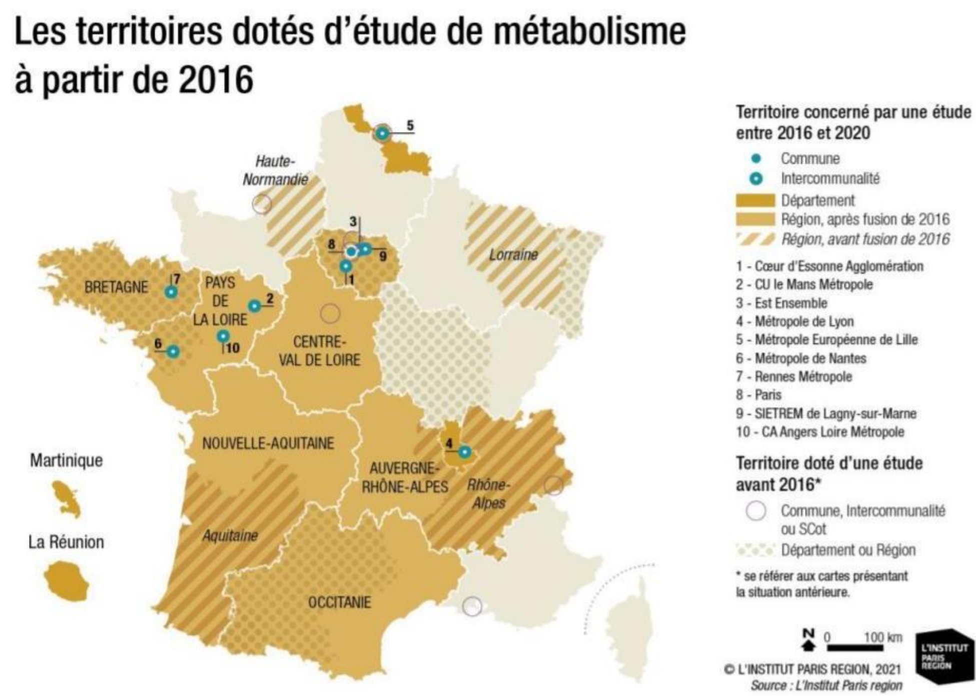




Source:https://www.institutparisregion.fr/fileadmin/NewEtudes/000pack2/Etude_2625/EtudesMetabolisme_Recensement_VF.pdf

EW-MFA: Use at a territorial level (French case study)





Carte n°3 : Etudes de métabolisme territorial en France métropolitaine en 2020

Source:https://www.institutparisregion.fr/fileadmin/NewEtudes/000pack2/Etude_2625/EtudesMetabolisme_Recensement_VF.pdf

EW-MFA: advantages vs. disadvantages

Advantages

- Trend representation within countries
- Identification of proportions and hotpots
- Comparative analysis across countries/regions
- Development of physical indicators which can be set in relation to economic indicators
- Monitoring and assessment of overarching policy goals (e.g. SDGs)
- Circular Economy monitoring

Disadvantages

- Black-box approach
- Difficulties in explaining trends
- Difficulties in deriving causalities
- None of the indicators show the full picture

EW-MFA: source

- **Eurostat**
  https://ec.europa.eu/eurostat/web/environment/material-flows-and-resource-productivity
- **International Resource Panel (IRP)**
  https://www.resourcepanel.org/global-material-flows-database
- **OECD Statistics**
  https://stats.oecd.org/
- **World Resource Institute**
  http://www.wri.org/
- **WU Vienna / CSIRO**
  http://www.materialflows.net/
- **Material flows of Switzerland**
  https://www.bfs.admin.ch

Course organisation

Aim of the course (I)

- Analyser un produit ou nu service avec l'ACV
- Calculer les impacts environnementaux d'un produit
- Anticiper les évolutions réglementaires en environnement
- Optimiser les performances environnementales des produits
- Critiquer une étude existante
- Elaborer des stratégies holistiques pour boucler les flux de matière
- Critiquer les stratégies et plans environnementaux des villes et pays
- Analyser les flux de ressources et de déchets

Aim of the course (II)

- Planifier des actions et les mener à bien de façon à faire un usage optimal du temps et des ressources à disposition.
- Recevoir du feedback (une critique) et y répondre de manière appropriée.
- Ecrire un rapport scientifique ou technique.
- Utiliser les outils informatiques courants ainsi que ceux spécifiques à leur discipline.
- Etre responsable des impacts environnementaux de ses actions et décisions.