Carsten Nathani

Using input-output analysis for environmental impact analysis

45th LCA Discussion Forum „Environmentally extended IO analysis and LCA“, Ittigen

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sozioökonomische forschung + beratung

Environmental Impacts of Swiss Consumption and Production:

A combination of input-output analysis with life cycle assessment

A project for the Swiss Federal Office of the environment (FOEN)

Project team:

ESU-services Ltd.

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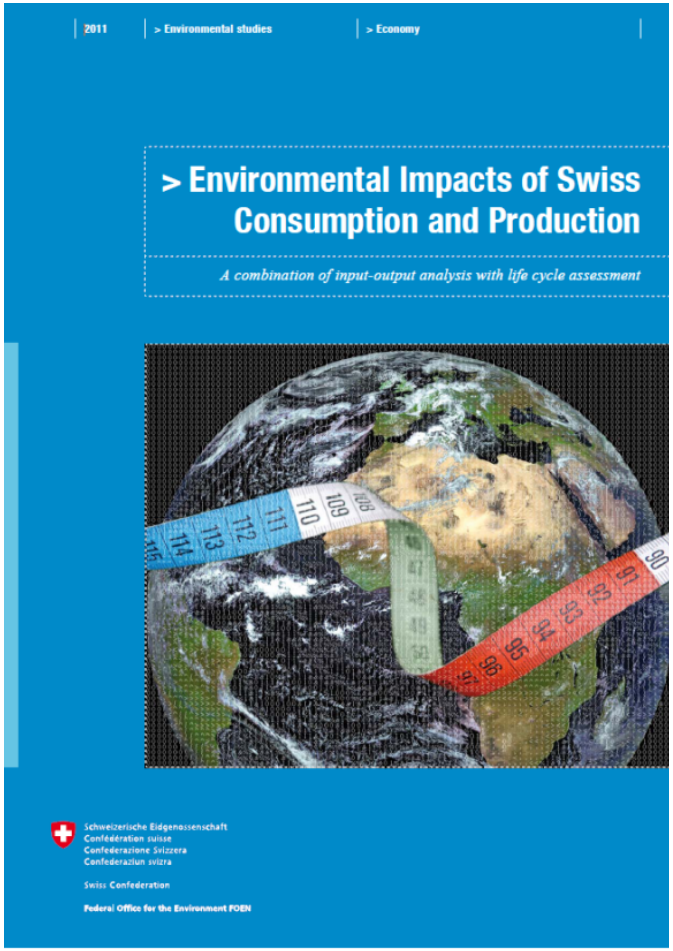

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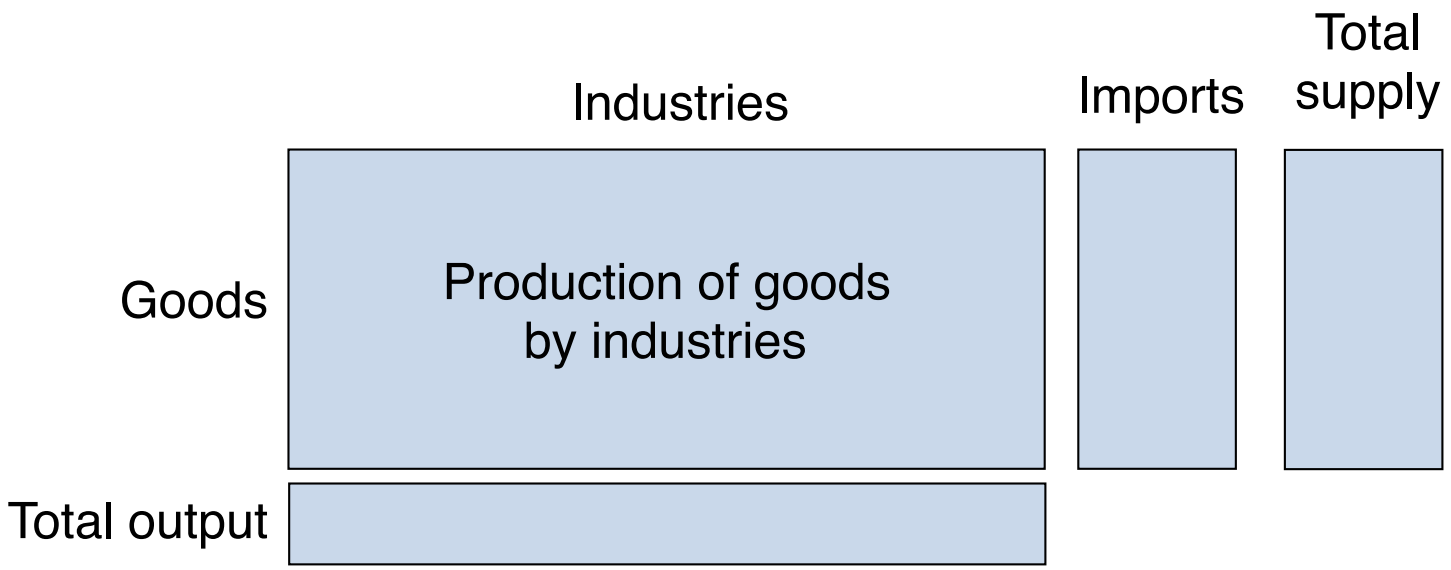
1. Economic input-output analysis (IOA)
2. Environmentally extended IOA
3. Extensions
4. The Swiss IO tables and NAMEA used in EE-IOA

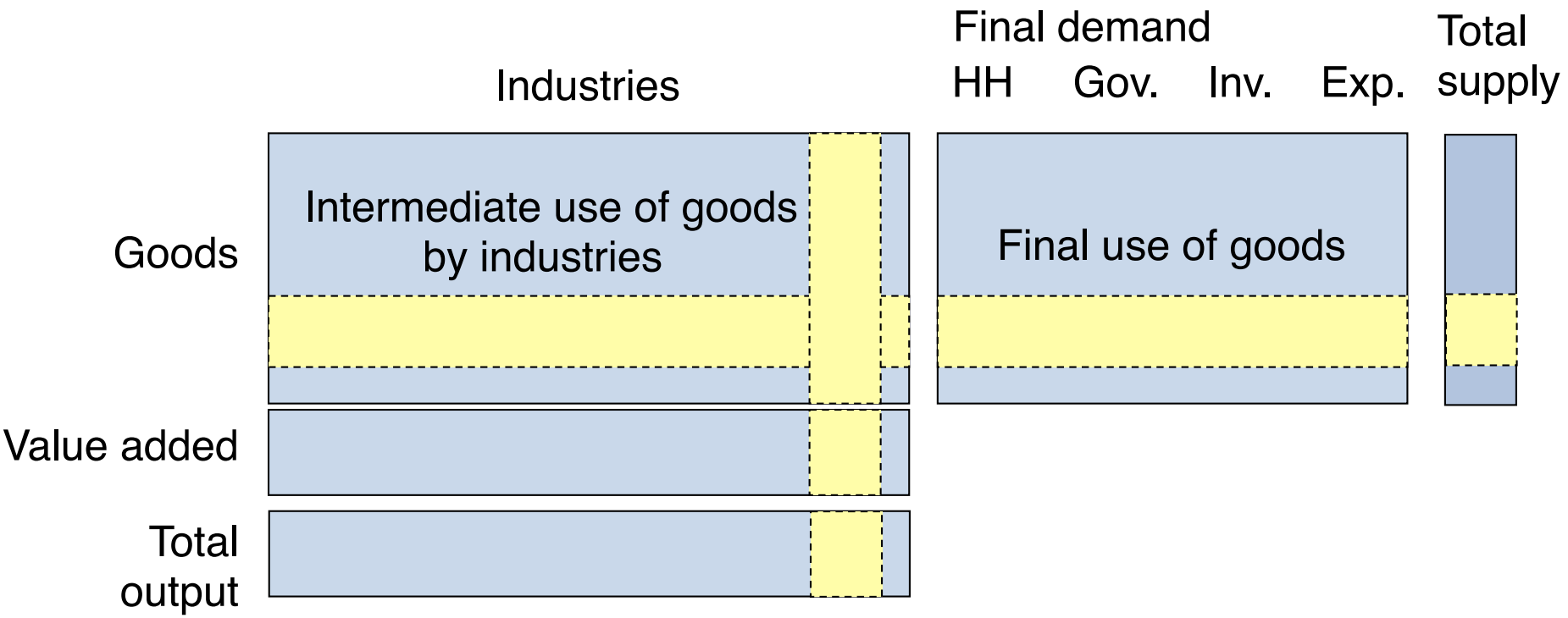
Economic input-output analysis

- **Input-output tables (IOT)** show the supply and use of goods and services in the economy
- Three kinds of tables:
  - Supply table: shows the supply of goods by industries, i.e. domestic production and imports
  - Use table: shows the use of goods by industries and final demand
  - Symmetric IOT: similar to Use table; homogeneous branches instead of industries
- Supply and use of goods are recorded in monetary units
- Number of industries usually equal to number of goods
- Various options to record the use of imported goods

- Scheme of a **SUPPLY table**:
  supply of goods by industries



Scheme of a **USE table**: use of goods by industries and final demand



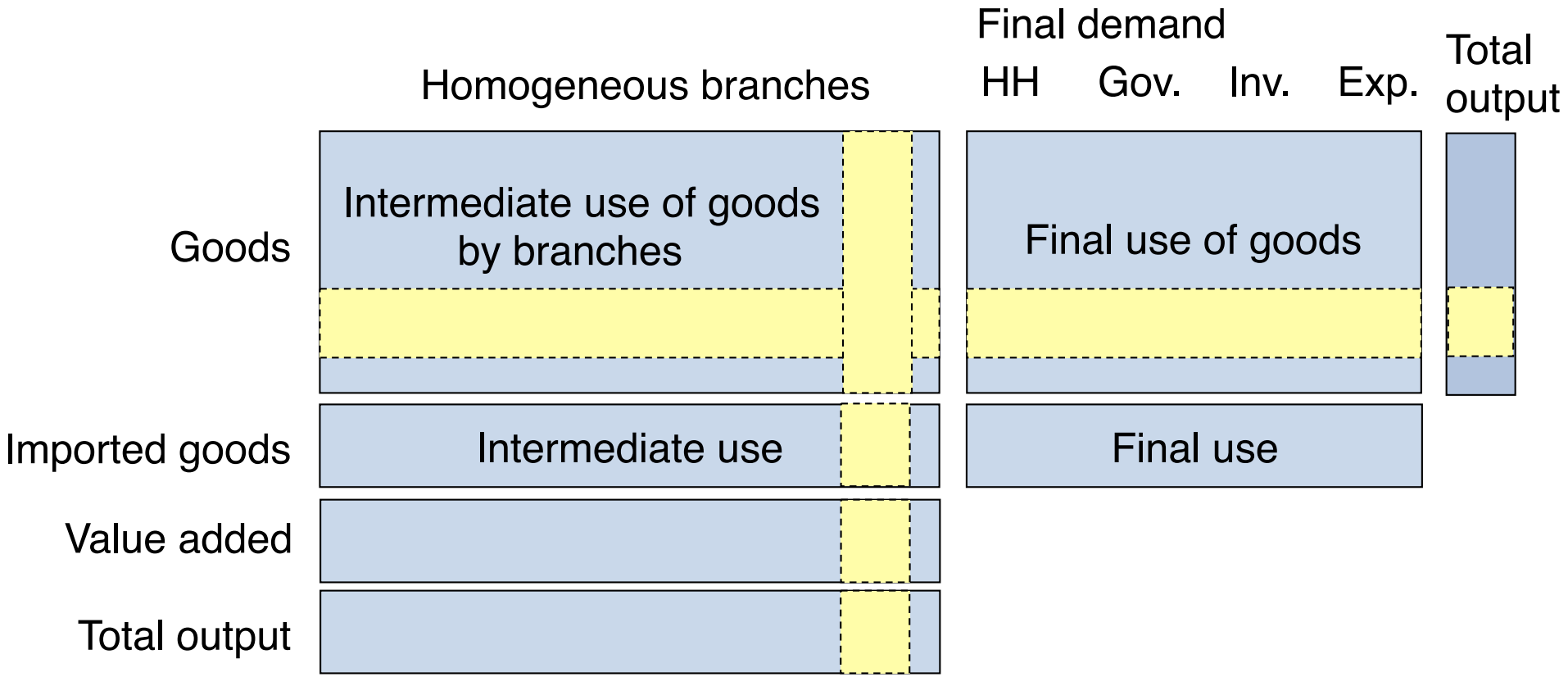
HH: Consumption of private Households expenditures

Gov.: Consumption by government

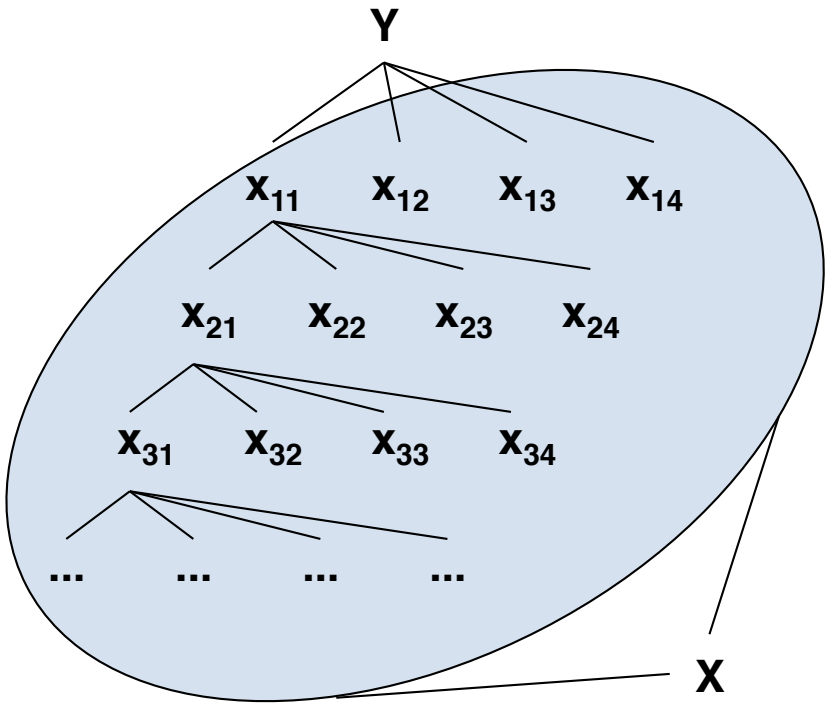
Inv.: Investment

Exp: Export

- Scheme of a **symmetric input-output table (SIOT)**:
  use of goods by homogeneous branches and final demand
- Homogeneous branch: More homogeneous than an industry; aggregation of similar activities

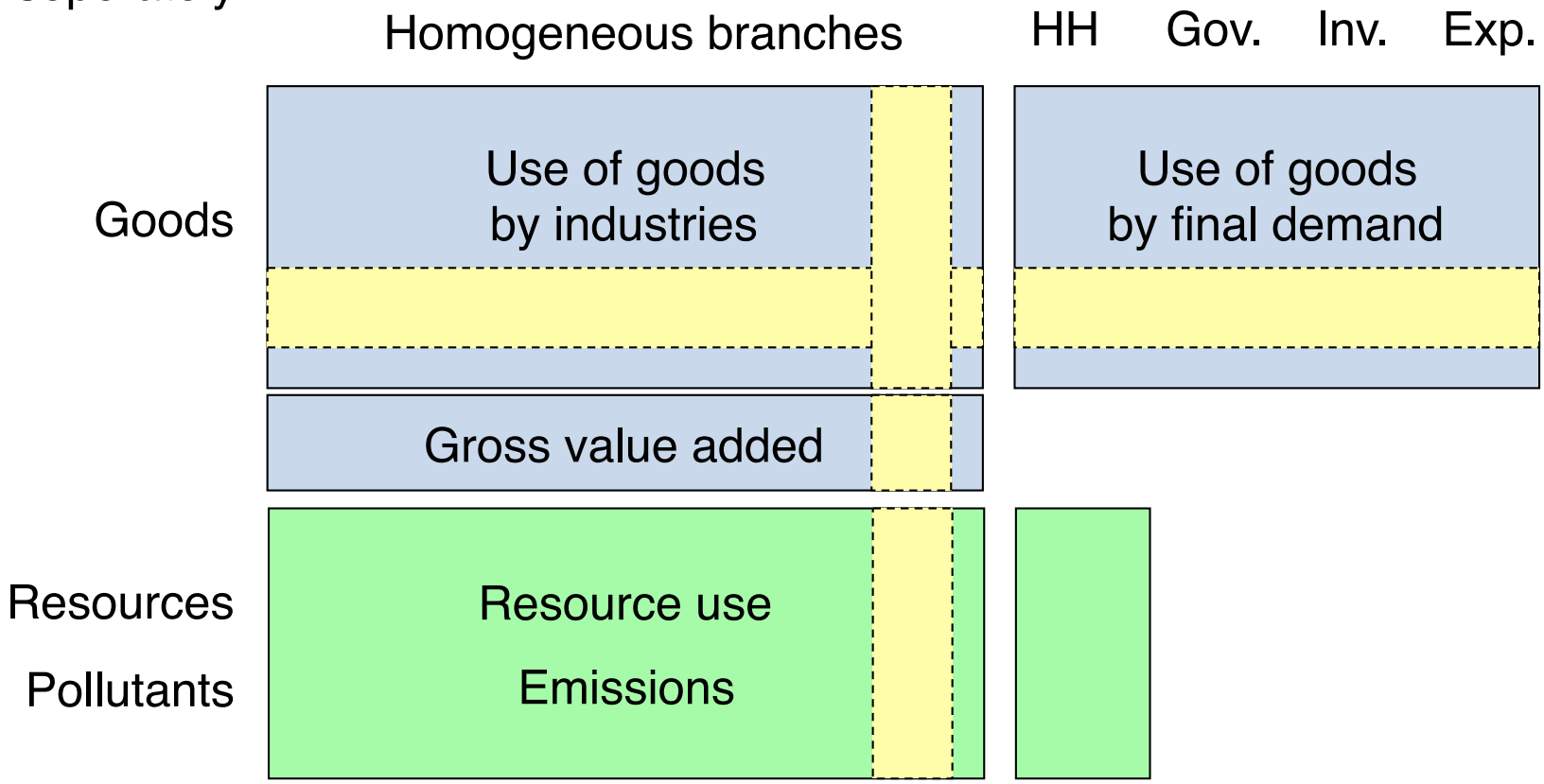


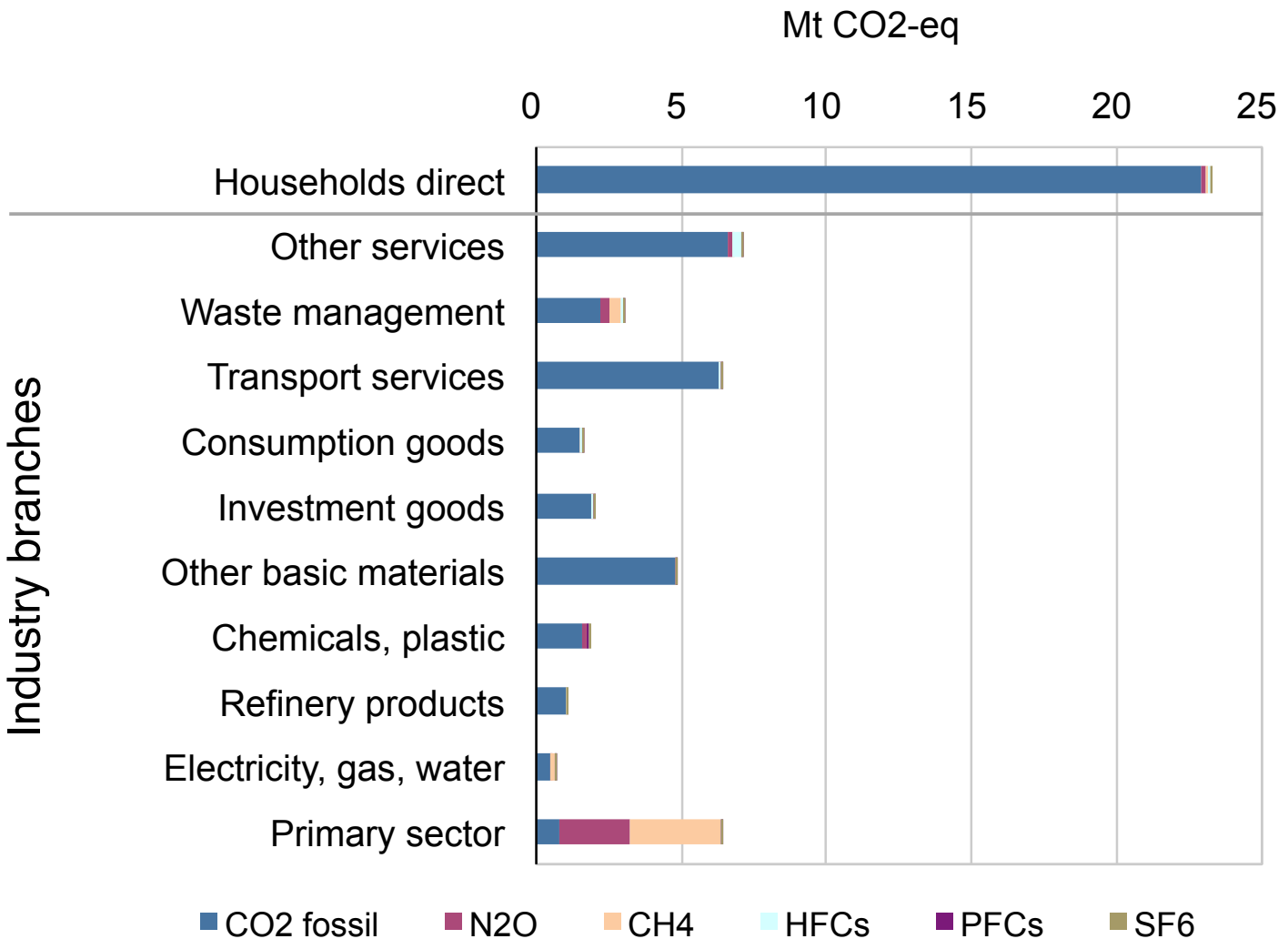
- Example: Input output model based on a SIOT
- Question: How much production is induced in all industries of an economy by an increase in final demand, if you completely consider the supply chains of production
- Calculation steps
  - Given: Final demand Y
  - Calculation of input coefficient matrix A from IOT
  - Calculation of Leontief inverse $L = (I - A)^{-1}$
  - Total output $X = (I - A)^{-1} Y$



Environmentally extended input-output analysis (EE-IOA)

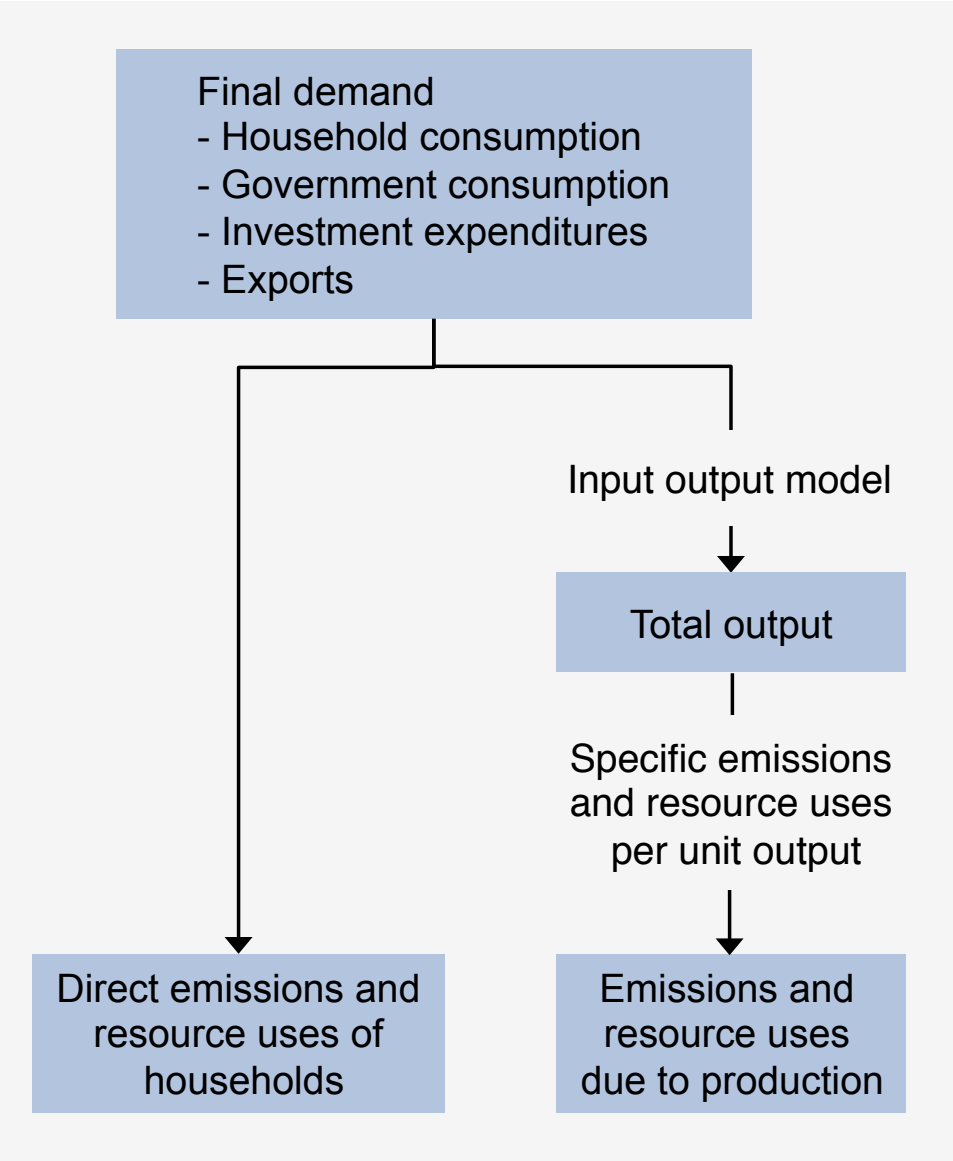
- Equivalent with **NAMEA** (National accounting matrix including environmental accounts)
- For each industry the emissions and resource uses related to its activity are recorded; for households the direct emissions and resource uses are recorded seperately



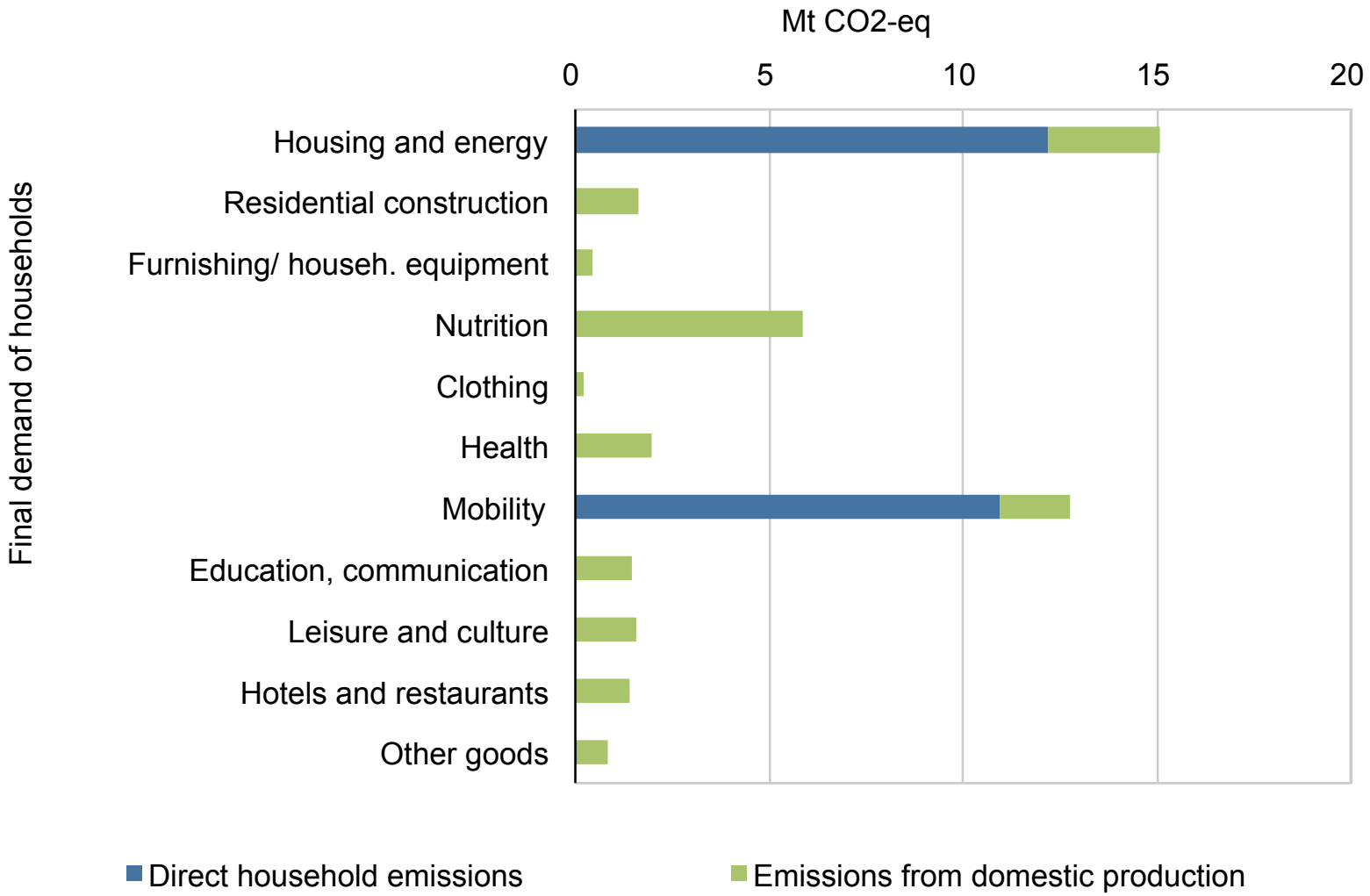

Mt CO2-eq
0
5
10
15
20
25
Industry branches
Households direct
Other services
Waste management
Transport services
Consumption goods
Investment goods
Other basic materials
Chemicals, plastic
Refinery products
Electricity, gas, water
Primary sector
CO2 fossil
N2O
CH4
HFCs
PFCs
SF6

- **Question**: How much emissions and resource use are induced in all industries of an economy by (an increase in) final demand, if you completely consider the supply chains of production

- **Calculation steps**
  - Given: Final demand y and emission coefficient matrix F (= emissions per unit of economic output)
  - Calculation of input coefficient matrix A from IOT
  - Calculation of Leontief inverse $L = (I - A)^{-1}$
  - Total output $x = (I - A)^{-1} y$
  - Total emissions $e = F x = F (I - A)^{-1} y$


Final demand
- Household consumption
- Government consumption
- Investment expenditures
- Exports
Input output model
Total output
Specific emissions and resource uses per unit output
Direct emissions and resource uses of households
Emissions and resource uses due to production

ALLOCATION OF GHG EMISSIONS TO HOUSEHOLD CONSUMPTION



- **Compatible with national accounts** (system boundaries, definitions, etc.)
- **Residence principle**
  - Resident economic units are companies and households resident in a country
  - Compatibility of economic activities by resident units and the related emissions / resource use
  - Deviations from territorial emissions (e.g.):
    - ➔ Energy use / emissions by domestic tourists, transport companies or airlines in foreign countries are considered domestic
- **Waste management** is recorded as a **service** delivered to industries or households.
- **Strengths**:
  - Comprehensive coverage of all transactions within the economy
  - Calculations require rather low resources
- **Limitations**
  - High aggregation level causes aggregation errors

Extensions

- Multiregional EE-IOA
- Structural decomposition analysis
- (Use in hybrid LCA)

- **Database**
  - IO tables of several countries
  - Linked by bilateral trade flow tables
  - Extended with emission and resource use data
    (currently largely restricted to energy use and greenhouse gas emissions)
- **Policy / research questions**
  - What are the total environmental impacts induced by one country‘s final demand in other countries (consumption perspective)
- **Modelling** in principal similar to single country modelling
- Large **data requirements** / internationally harmonised data
- Existing **EE-IOT databases**
  - OECD database (IOT extended with GHG data)
  - GTAP database (IOT extended with GHG data)
  - EXIOPOL (in development)

- Aim: to explain the **causes for change of emissions** during a time period
- Change of total emissions can be explained by the following **components**:
  - Change in the level of final demand
  - Change in the structure of final demand
  - Structural change in industries
  - Change in the environmental intensity of household consumption
  - Change in the environmental intensities of industries
- The more components are distinguished, the larger is the relevance of joint effects

The Swiss IOT and NAMEA used in EE-IOA

Swiss IOT:

- Different from other European countries, the **Swiss IOT** is currently not published by the Swiss statistical office, but **estimated** by research groups
- **Quality of Swiss IOT** is **lower compared to other OECD countries**, since important basic statistics are missing (e.g. commodity statistics, cost structure statistics); intermediate inputs are estimated from foreign IOT
  => **Best you can do**!
- **42 industries** (according to NACE rev 1.1), **12 household consumption categories** (according to COICOP classification)
- The use of domestic and of imported commodities is not distinguished

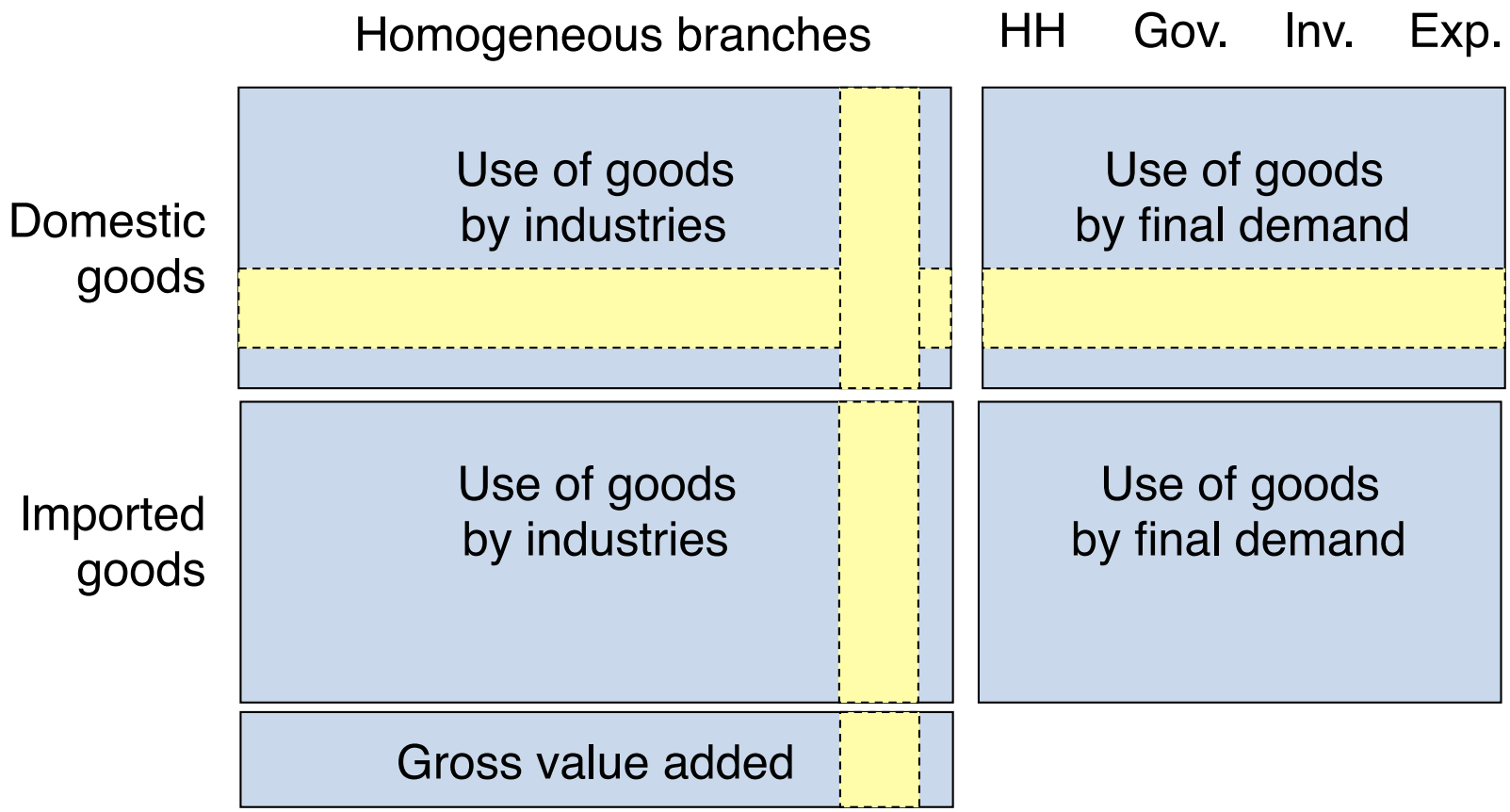
NAMEA:

- **NAMEA Energy**: Use of 16 energy carriers by industries and households
- **NAMEA air**: Emission of 6 greenhouse gases by industries and households

In the project presented in the following we made the following adjustments to the Swiss IOT:

- SIOT for base year 2005
- 43 industries: separation of refineries from chemical industry
- Separation of domestic and imported goods
- Final consumption of non profit institutions and of government is partly allocated to consumption categories of private households (e.g. health, education, culture)
- Residual public final demand includes expenditure for the benefit of the whole society, e.g. expenditure for the security system or the judiciary system
- Capital investment expenditure is reallocated
  - Investment in residential buildings is allocated to housing
  - Investment by industries is allocated to the investing industries (large uncertainty)
  - Government investment expenditure that serves a general purpose (e.g. investments in roads) remains with residual public final demand

- Separation of domestic and imported goods
  Assumption: same use patterns for domestic and imported goods



Before adjustments:

- Household consumption
  - Food and beverages, tobacco
  - Textiles and clothing
  - Housing and energy
  - Household goods and furniture
  - Health
  - Mobility
  - Communication
  - Leisure and culture
  - Education
  - Restaurants and hotels
  - Other goods
- Government consumption
- Investment expenditures
- Exports

After adjustments:

- Household consumption
  - Food and beverages, tobacco
  - Textiles and clothing
  - Housing and energy
  - Household goods and furniture
  - Health
  - Mobility
  - Communication
  - Leisure and culture
  - Education
  - Restaurants and hotels
  - Other goods
- Residual public final demand
- Investment in residential buildings
- Exports

Allocation to industries

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Swiss IOT:

- „Official“ IOT: 42 industries available for 2001, 2005, 2008
- IOT disaggregated in the energy and transport sector: 66 industries
  - currently available for 2005,
  - 2001 available during fall 2011
  - 2008 available in 2012

NAMEA energy and air:

- Currently available for 42 and 66 industries: for 2001 and 2005
- 2008 probably available in 2012