Introduction to air emission accounts

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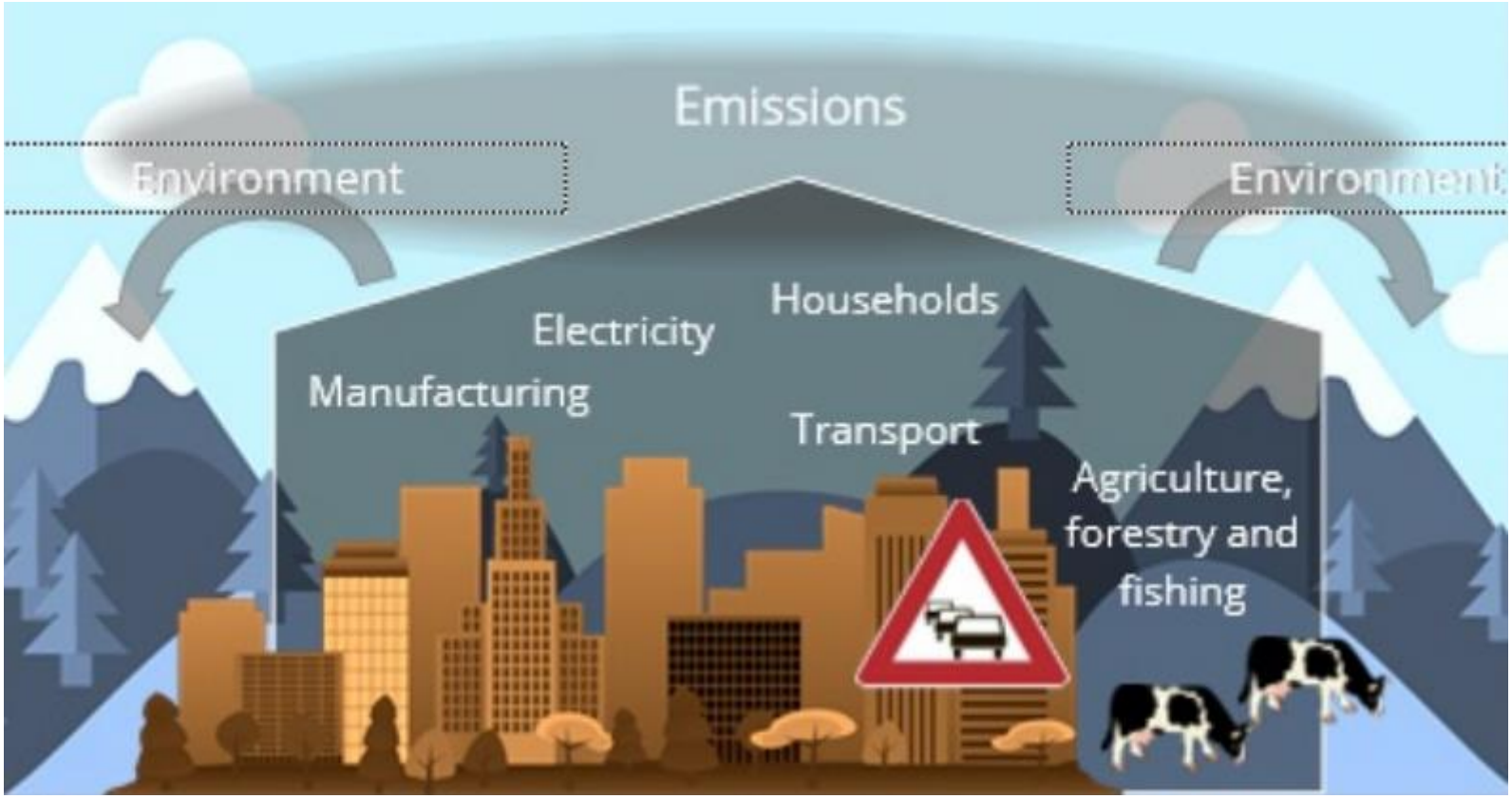
Air emission account: overview



Air emission account: what are we measuring and how

Emissions of greenhouse gases:

- Carbon dioxide (CO_2)
- Nitrous oxide (N_2O)
- Methane (CH_4)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Nitrogen trifluoride (NF_3)
- Sulphur hexafluoride (SF_6)

Air pollutants:

- Sulphur oxides (SO_x)
- Carbon monoxide (CO)
- Nitrogen oxides (NO_x)
- Ammonia (NH_3)
- Non-methane volatile organic compounds (NMVOCs)
- Coarse particulate matter (PM_{10} $PM_{2.5}$)

Emission = Activity Data * Emission Factor

What is in and what is out?

Include

Flows of air emissions from the economy into the environment, such as:

- **All emissions from combustion of fuels** including biomass when it is use as fuel (e.g. wood > heating)
- **Flaring and venting** of e.g. natural gases
- **Emissions from livestock**
- **Emissions from manure** collected and spread on agricultural land (dissipative use)
- **Emissions from landfills** and waste incineration
- **Leakages from accumulations** (durable goods like refrigerators, landfills, etc.) should be recorded as they occur and attributed to the owner of the goods at the time of the leakage
- All emissions **from conversion processes**

Exclude

Flows of air emissions within the environment, or within the economy such as:

- **Transboundary flows** of air emissions
- **Capture of gases** by the environment, for example, carbon captured in forests and soil
- Emissions such as **unintended forest** and **grassland fires**
- **Secondary emissions** results from processes in the environment
- Gaseous and particulate substances generated through economy activity **that are captured for use in other production processes** (e.g. methane captured in a landfill to generate electricity)

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Air emission account: a sample

Air emissions account *(tonnes)*

Supply table for air emissions

	Generation of emissions								Accumulation	
	Industries—by ISIC					Households				
	Agriculture ISIC A	Mining ISIC B	Manufacturing ISIC C	Transport ISIC H	Other	Transport	Heating	Other	Emissions from landfill	Total supply of emissions
Type of substance										
Carbon dioxide	10 610.3	2 602.2	41 434.4	27 957.0	82 402.4	18 920.5	17 542.2	1 949.1	701.6	204 119.6
Methane	492.0	34.1	15.8	0.8	21.9	2.4	15.5	1.7	222.0	806.3
Dinitrogen oxide	23.7		3.5	0.8	2.6	1.0	0.2	0.1	0.1	32.0
Nitrous oxides	69.4	6.0	37.9	259.5	89.0	38.0	12.1	1.3	0.3	513.6
Hydrofluorocarbons			0.3		0.4					0.7
Perfluorocarbons										
Sulphur hexafluoride										
Carbon monoxide	41.0	2.5	123.8	46.2	66.2	329.1	51.2	5.7	1.1	666.9
Non-methane volatile organic compounds	5.2	6.5	40.0	16.4	27.2	34.5	29.4	3.2	0.9	163.3
Sulphur dioxide	2.7	0.4	28.0	62.4	8.1	0.4	0.4	0.1	0.0	102.5
Ammonia	107.9		1.7	0.2	0.9	2.3	11.4	1.2	0.2	125.9
Heavy metals										
Persistent organic pollutants										
Particulates (including PM10 and dust)	7.0	0.1	8.5	9.3	4.4	6.0	2.8	0.5	0.0	38.5

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Air emission account: relationship with inventory

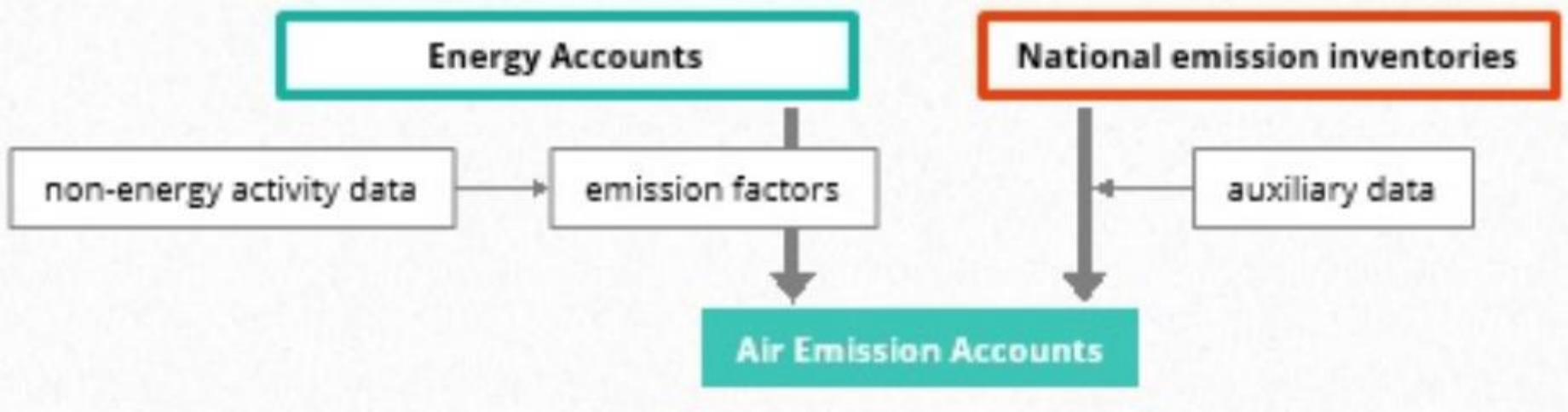
Inventories	Accounts
Territorial principle	Residence principle
Emissions are assigned to **the country where the emission takes place**.	Emissions are assigned to **the country where the company causing the emission is based**.
Emissions are assigned to **technical processes** (e.g. combustion in power plants, solvent use).	Emissions are classified by **economic activity** (using the classification, as used in the system of national accounts).
Emissions from international **shipping and aviation** are assigned to the countries **where the associated fuel is purchased** regardless of where the purchasing company is based.	Emissions from international **shipping and aviation** are assigned to the countries **where the airline/shipping company is based**, regardless of where the emission takes place.

From air emissions to inventories

Table 5.1 **Bridge table for CO_2 emissions - UNFCCC method and the green national accounts**

		1990	1995	2000	2005	2013	2014
		million tonnes					
1	Total emissions: UNFCCC method	54.2	62.1	55.0	52.2	42.2	38.0
2	CO_2 from biomass used as fuel	4.6	5.6	6.8	10.7	15.0	14.9
3	Total emissions abroad (international transport)	9.4	11.4	19.6	34.4	34.0	33.0
	Of which: ships:	9.2	10.9	19.1	32.3	30.9	30.0
	aircrafts:	0.3	0.4	0.5	1.6	1.8	2.0
	vehicles:	0.0	0.0	0.0	0.5	1.3	1.0
4	Other differences in emissions from transport and cross-border trade	2.5	1.8	2.0	0.8	0.9	0.7
5 (=1+2+3+4)	Total emissions from Danish economic activities, incl. biomass	70.7	81.0	83.4	98.1	92.0	86.6
6	Total emissions from Danish economic activities, excl. biomass	66.2	75.3	76.5	87.4	77.0	71.7

Air emission account: how do we compile



Some indicators that rely on the Air Emissions Account

- **Total GHG emissions from the national economy**
- **Direct GHG emissions from households**
- **Total GHG emissions from production activities**

- **GHG emission intensity of production activities**
- **CO_2 emissions from fuel combustion attributable to the national economy**
- **Total CO_2 intensity of energy used in production activities of the national economy**

- **Carbon footprint**

Total GHG Emission from production activities

* Linking economic activities and GHGs
* Often tax/subsidies are sectoral: can be disaggregated by ISIC

	Carbon dioxide (CO_2)	GWP for CO_2=1
+	Methane (CH_4)	* GWP for CH_4
+	Nitrous oxide (N_2O)	* GWP for N_2O
+	Perfluorocarbons (PFCs)	* GWP for PFCs
+	Hydrofluorocarbons (HFCs)	* GWP for HFCs
+	Sulphur hexafluoride (SF_6)	* GWP for SF_6
+	Nitrogen trifluoride (NF_3)	* GWP for NF_3
Sum = Total GHG emissions		

GHG intensity of production activities

- Need air emission accounts and national accounts
- Useful to disaggregate by different ISIC sectors

$$\text{GHG emission intensity (in kt/currency)} = \frac{\text{GHG emissions of all industries (in kt } CO_2\text{)}}{\text{GDP (in currency)}}$$

Let's practice!

* We will have two-part exercise
* First is to compile an air emission account (focusing on GHGs)
* We have as the starting point the energy account
  * An advantage here is that we don't have to reassign the energy use for transportation
* We also have some additional information on other flows (more information in the word document and excel).

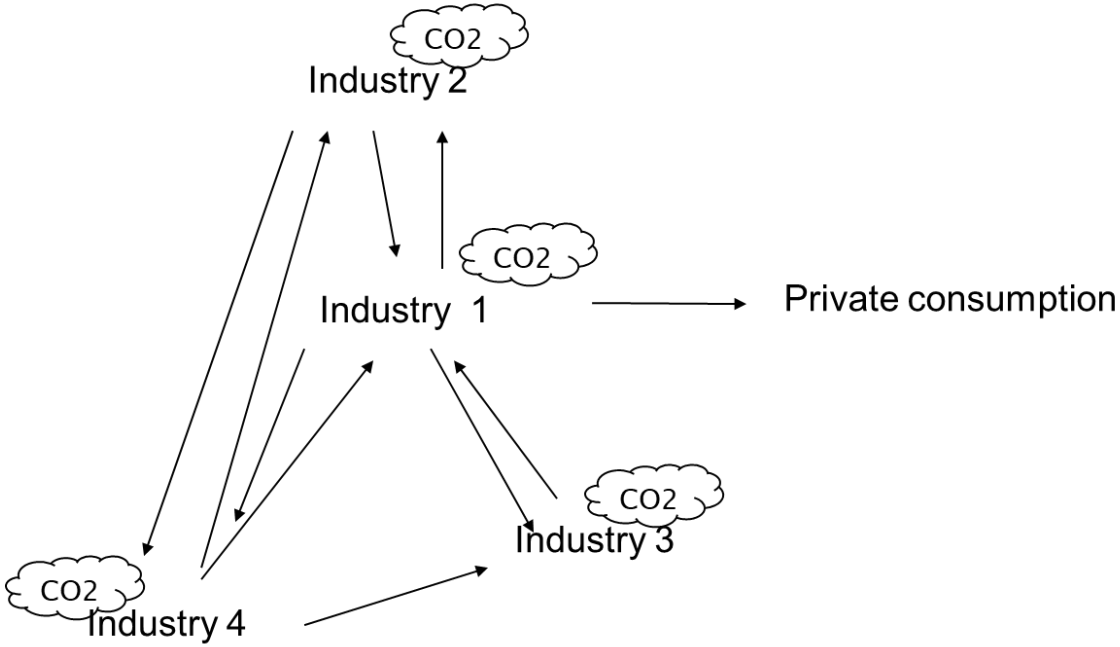
* After completing the air emission account, in the second part we will come back to the indicators (some of them).
* And if time permit/there is interest—some details about EE-IOTs (with thanks to Ole Pederson of Statistics Denmark)

Some details about EE-IOT

- For analytical purpuses it is useful to link the information from the SEEA physical flow accounts with the input-output tables measured in monetary units (hybrid tables)
- Environmentally extended input-output tables (EE-IOT)
- This facilitates insight into the drivers of the environmental pressures and the indirect effects (footprints) of various economic activities

Some details about EE-IOT

Example: What are the air emissions throughout the economy resulting from private consumption, exports, etc.?



Some details about EE-IO

	Agriculture	Manu-facturing	Private consump-tion	Total Output
Agriculture	1	9	10	20
Manufacturing	8	2	13	23
Value added	11	12		
Total input	20	23		

Two equations:

$1 + 9 + 10 = 20$

$8 + 2 + 13 = 23$

Using symbols:

	Agriculture	Manu-facturing	Private consump-tion	Total Output
Agriculture	B11	B12	Y1	X1
Manufacturing	B21	B22	Y2	X2
Value added	V1	V2		
Total input	X1	X2		

Two equations:

$B_{11} + B_{12} + Y_1 = X_1$

$B_{21} + B_{22} + Y_2 = X_2$

Some details about EE-IO

	Agriculture	Manu-facturing	Private consump-tion	Total Output
Agriculture	B11	B12	Y1	X1
Manufacturing	B21	B22	Y2	X2
Value added	V1	V2		
Total input	X1	X2		

Two equations:

$B_{11} + B_{12} + Y_1 = X_1$

$B_{21} + B_{22} + Y_2 = X_2$

equal to:

$(B_{11}/X_1)*X_1 + (B_{12}/X_2)*X_2 + Y_1 = X_1$

$(B_{21}/X_1)*X_1 + (B_{22}/X_2)*X_2 + Y_2 = X_2$

equal to:

$A_{11}*X_1 + A_{12}*X_2 + Y_1 = X_1$

$A_{21}*X_1 + A_{22}*X_2 + Y_2 = X_2$

Where A_{ij} are the input-output coefficents B_{ij}/X_j

Some details about EE-IO

$$A_{11}*X_1 + A_{12}*X_2 + Y_1 = X_1$$
$$A_{21}*X_1 + A_{22}*X_2 + Y_2 = X_2$$

using matrix notation: $\underline{AX + Y = X}$

$$\begin{vmatrix} A11 & A12 \\ A21 & A22 \end{vmatrix} * \begin{vmatrix} X1 \\ X2 \end{vmatrix} + \begin{vmatrix} Y1 \\ Y2 \end{vmatrix} = \begin{vmatrix} X1 \\ X2 \end{vmatrix}$$

Some details about EE-IO

$AX + Y = X$

(Input-output coefficients * output) plus final use = output

$X - AX = Y$

$(I - A)X = Y$

$X = (I - A)^{-1} \cdot Y$ which is the IO-model

It calculates the total output, X, needed for a certain final use, Y (e.g. private consumption) by multiplying the Leontieff inverse $(I-A)^{-1}$ by the final use.

It takes all deliveries between industries into account

Some details about EE-IO

Once the output X needed for a certain final use has been estimated it is possible to estimate employment, energy use, water use, air emissions etc.

For instance, from the emissions accounts we first estimate emissions intensities, i.e. how much air emissions is on average generated in industries:

Emission intensity, e_i, for industry *i* is total emission E_i divided by output X_i:

- $e_i = E_i / X_i$ matrix notation

$$EM = \begin{vmatrix} e1 \\ e2 \\ e3 \\ \dots \\ en \end{vmatrix}$$

Some details about EE-IO

- From the IO-model and the emissions coefficients we estimate the air emissions corresponding to a certain final use.

Total air emissions from production in industries needed to satisfy the final demand Y:

$$\text{Air emissions} = X \# EM = (I - A)^{-1} \cdot Y \# EM$$

Total production needed, nx1

Emission factors, nx1

Leontieff inverse, nxn

Final use, nx1