Input-output tables, models and environmental-economic analysis

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SEEA Training Seminar for the ECA
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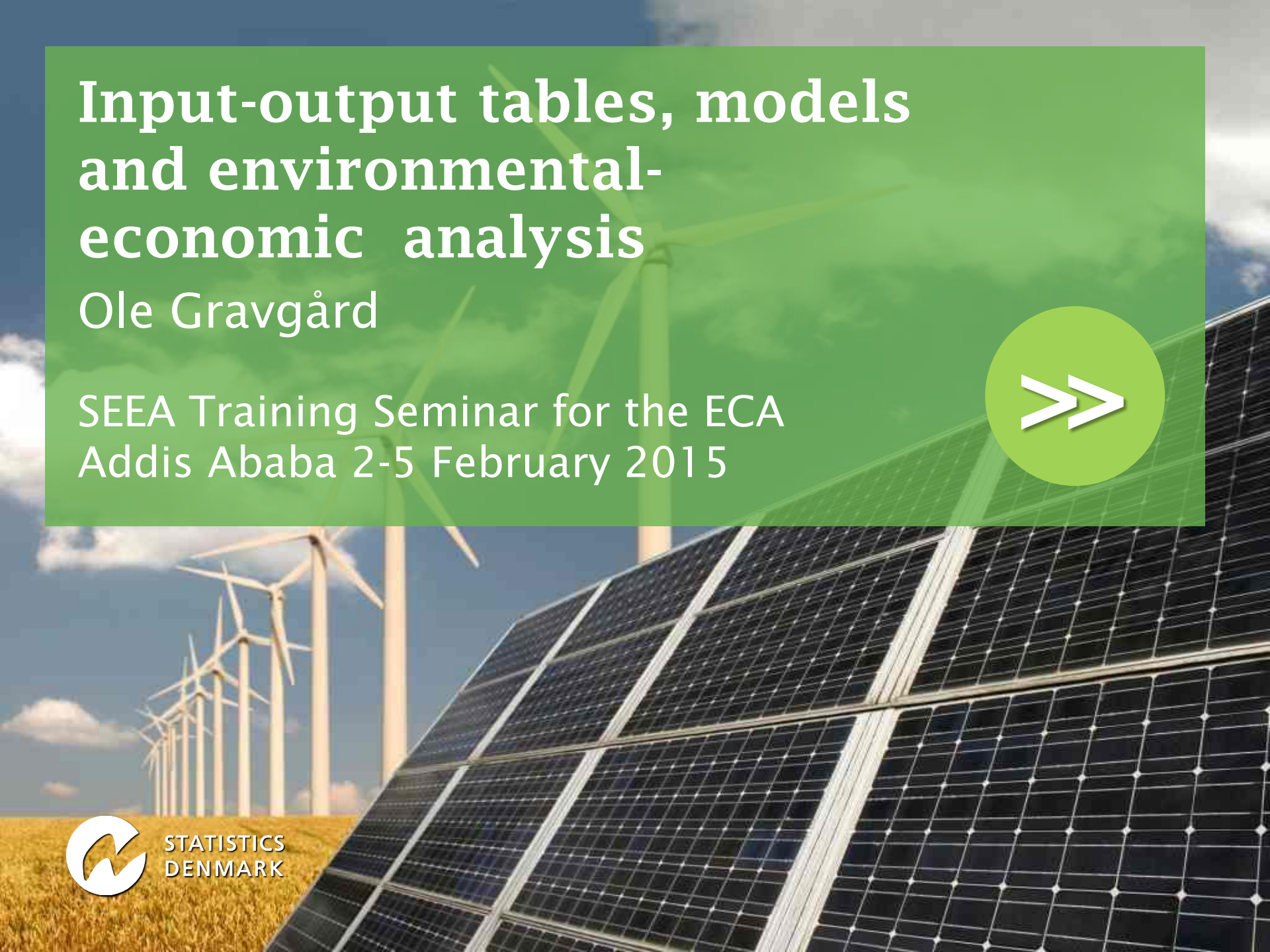
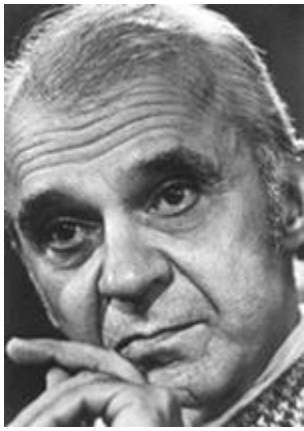


STATISTICS DENMARK

Input-output tables and analysis



- A way to represent central parts of the national accounts' production accounts by using matrices measured in monetary units
- It gives a detailed picture of the links between industries and between industries and final uses, etc.
- IO used for economic planning and analysis all over the world
- Introduced by the russsian mathematician Wassily Leontief i the 1930'ies - Nobel prize in 1973
- Since the 1970'ties also used for economic-environmental analysis
- International input-output association: http://www.iioa.org

Input-output tables and analysis?

- Input-output tables are used as the core of many macro-economic models

- Input-output tables is the basis of the **input-output model** that can give valuable information about the **direct as well as indirect effects** on production, employment, imports, air emissions etc. of changes in final demand.

What kind of questions can be answered by using input-output analysis?

- What is the direct and indirect share of agricultural production in total exports?
- What are the total direct and indirect effects on employment of increasing investment in construction by 10 pct?
- What are the total direct and indirect effects on energy production of increasing private consumption of meat by 1 million dollars?
- etc., etc.

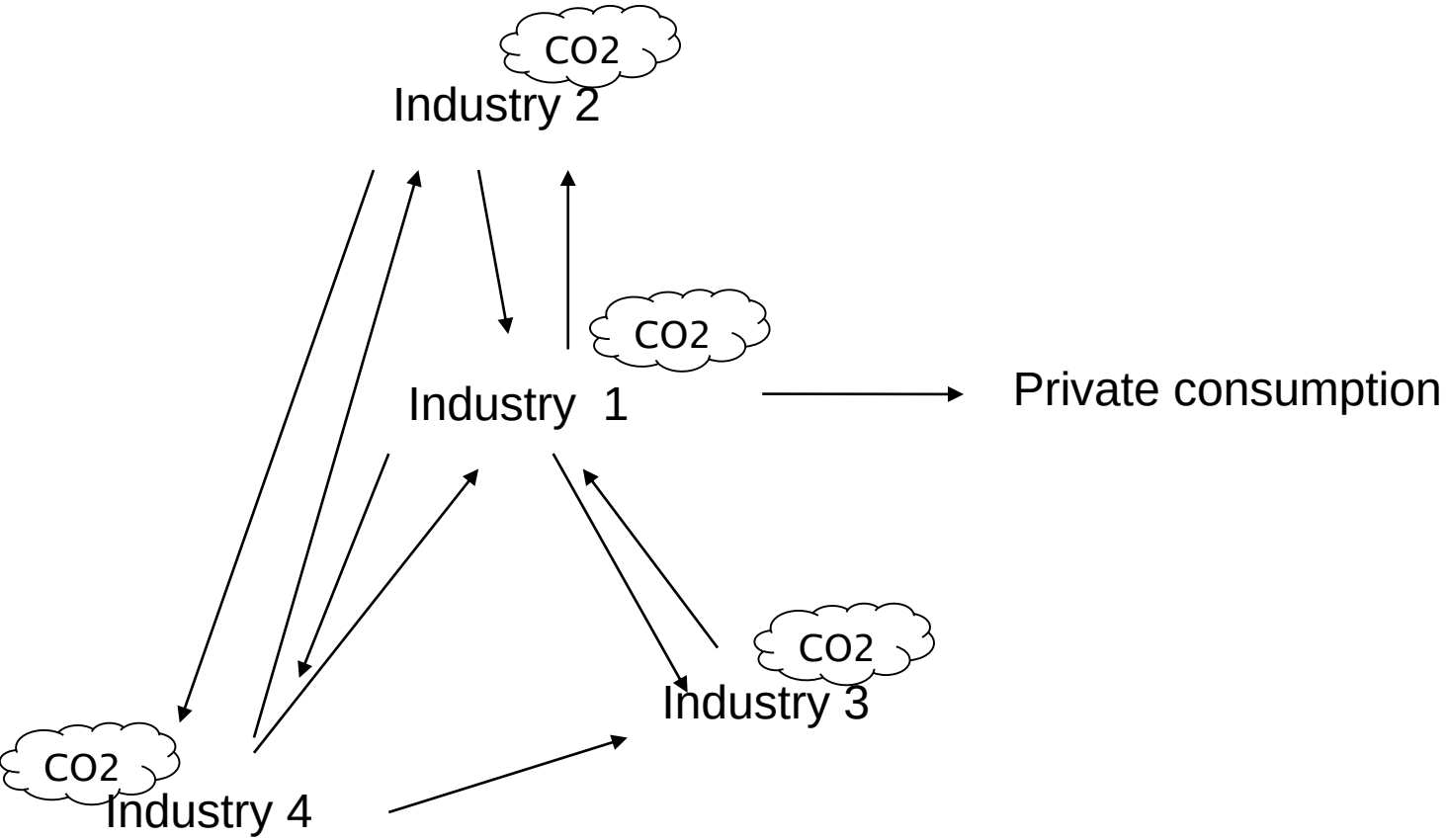
Combining SEEA physical flow accounts with input-output tables

- 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)

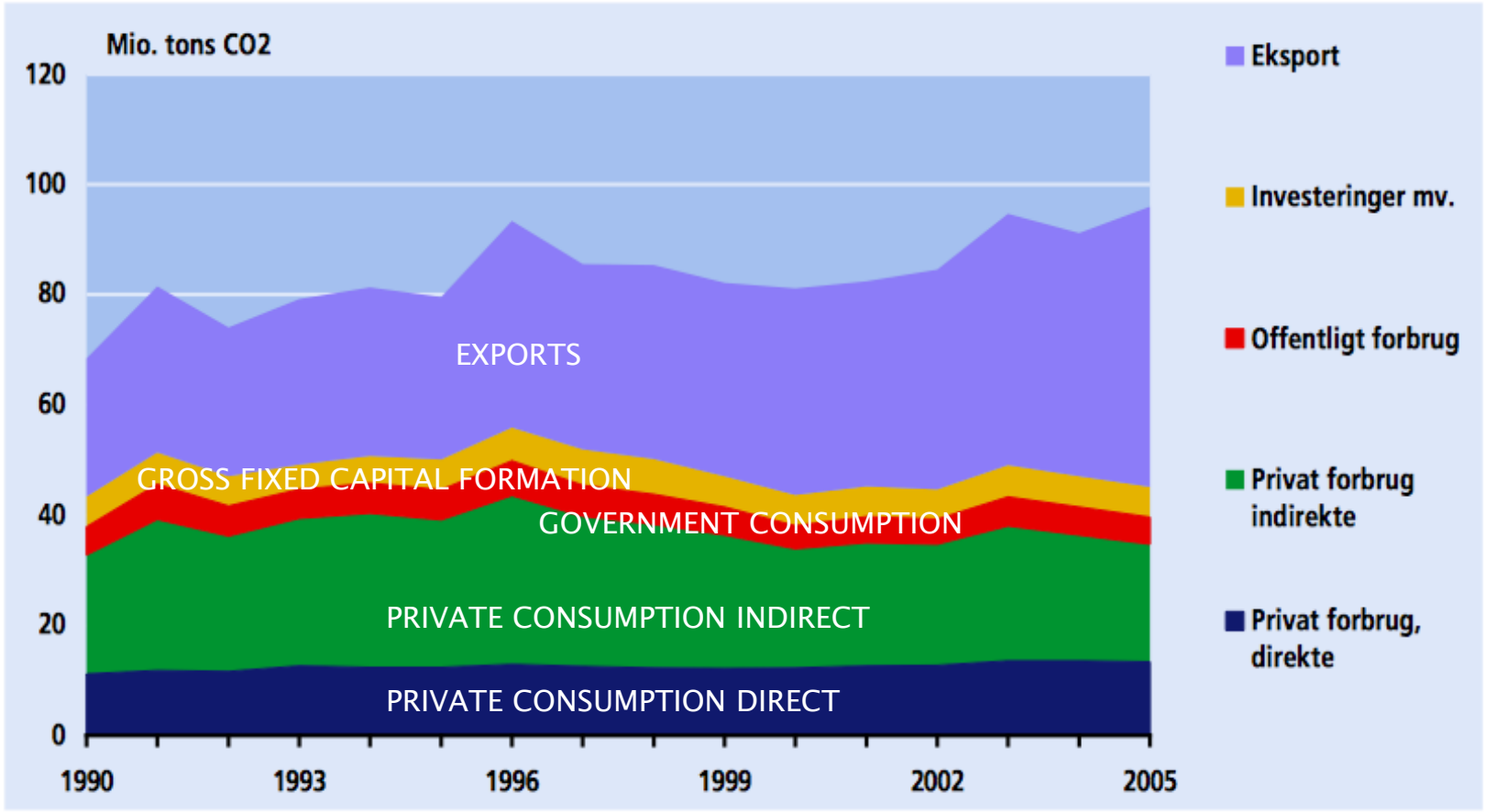
- This facilitates insight into the drivers of the environmental pressures and the indirect effects (footprints) of various economic activities

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



Using input-output modelling gives the answer:

DANISH CO2 EMISSION BY CAUSING ECONOMIC ACTIVITIES



An input-output table

	Intermediate consumption								Final demand					Total
DKK billions, current prices	1.Agriculture, fishing and quarrying	2.Manufacturing	3. Electricity, heat, gas and water supply	4. Construction	5. Trade, hotels and restaurants	6.Transport, post og telecommunication	7. Financial intermediation, business act.	8. Public and personal services	Private consumption	Public consumption	Gross fixed capital formation	Changes in stocks	Export	
1. Agriculture, fishing and quarrying	8	50	9	2	0	0	0	2	3	1	0	1	45	**121**
2. Manufacturing	13	96	1	37	17	7	14	10	49	1	29	7	292	**573**
3. Electricity, heat, gas and water supply	1	7	3	0	4	1	2	4	21	0	0	0	9	**51**
4. Construction	1	3	3	2	2	6	26	7	4	7	125	0	1	**187**
5. Trade, hotels and restaurants	5	30	0	21	15	8	6	10	148	3	22	1	75	**343**
6. Transport, post og telecommunications	1	14	0	2	33	35	17	18	36	1	2	0	163	**323**
7. Financial intermediation, business act.	8	35	3	27	50	18	96	42	193	5	29	0	30	**535**
8. Public and personal services	1	5	1	1	5	3	12	29	81	379	4	0	2	**524**
Import incl. costum duties	11	144	4	23	37	127	29	26	77	4	53	8	141	**684**
Taxes on products, net	3	3	0	2	5	6	17	24	132	2	40	0	-2	**233**
Use at market prices	**52**	**388**	**25**	**116**	**168**	**211**	**220**	**171**	**745**	**403**	**304**	**18**	**757**	**3576**
Other taxes on production, net	-5	-1	0	0	0	0	7	-4						
Compensation of employees	10	131	5	54	130	56	138	301						
Gross operating surplus and mixed income	65	56	22	17	46	57	170	56						
Gross output at basic prices	**121**	**573**	**51**	**187**	**343**	**323**	**535**	**524**						

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From IO-table to IO-model: two industries and private consumption

	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:

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

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

From IO-table to IO-model

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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

Input-output model

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

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

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

Generalised input-output model, n industries

$AX + Y = X$

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

$X - AX = Y$

$(I - A)X = Y$

X and Y are n x 1 column vectors
A and $(I-A)^{-1}$ are n x n matrices

$\underline{X = (I - A)^{-1} \cdot Y}$ 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

Environmental extended input-output model

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:

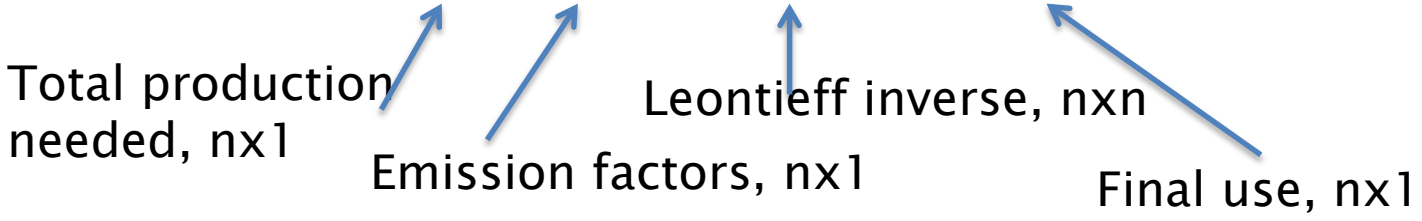
- $e_i = E_i / X_i$ matrix notation $EM = \begin{vmatrix} e1 \\ e2 \\ e3 \\ \dots \\ en \end{vmatrix}$

Environmental extended IO-model

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

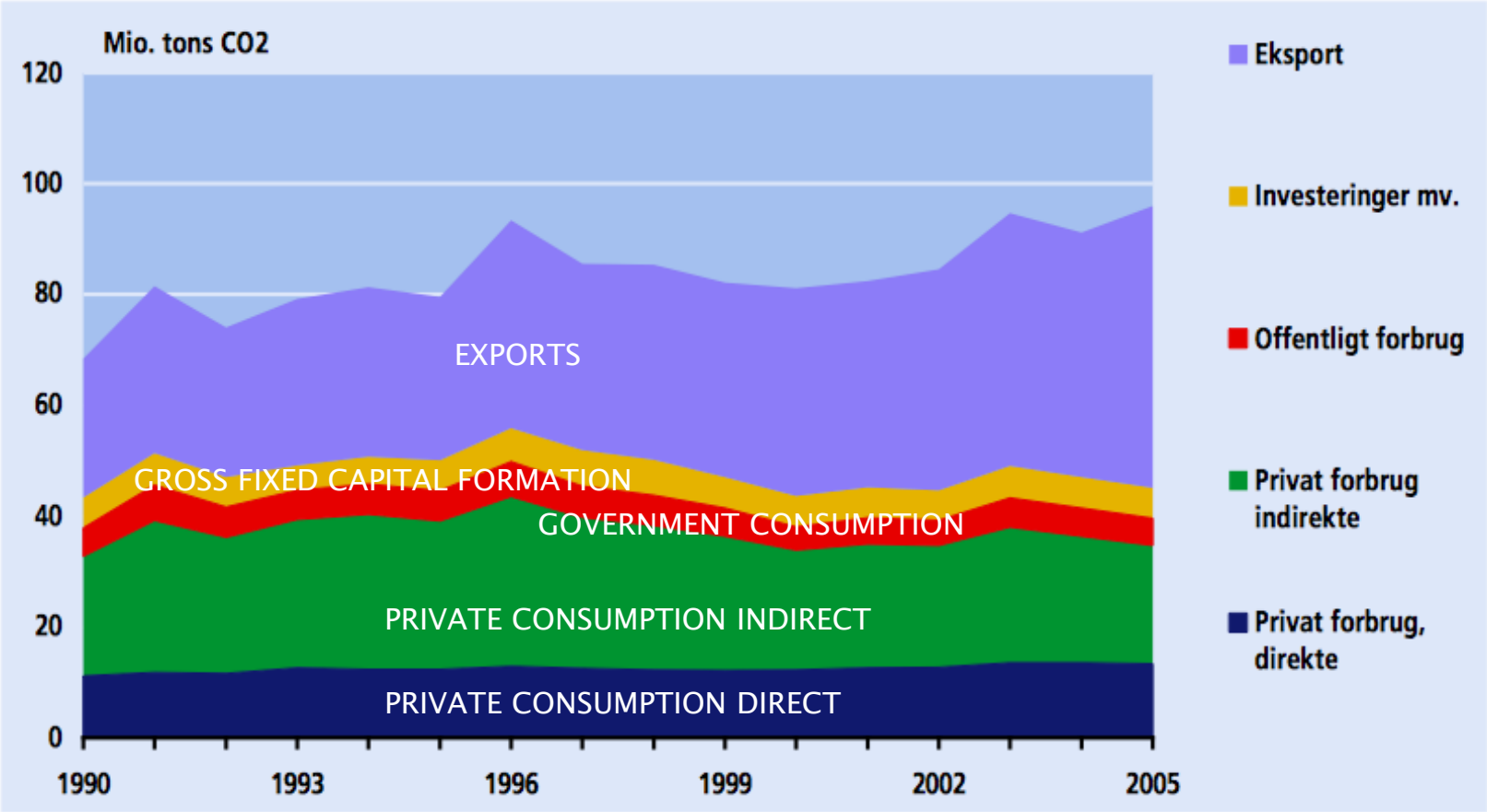
Total air emissions from production in industries needed to satisfy the final demand Y:

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



Examples of EE-IOmodelling

DANISH CO2 EMISSION BY CAUSING ECONOMIC ACTIVITIES



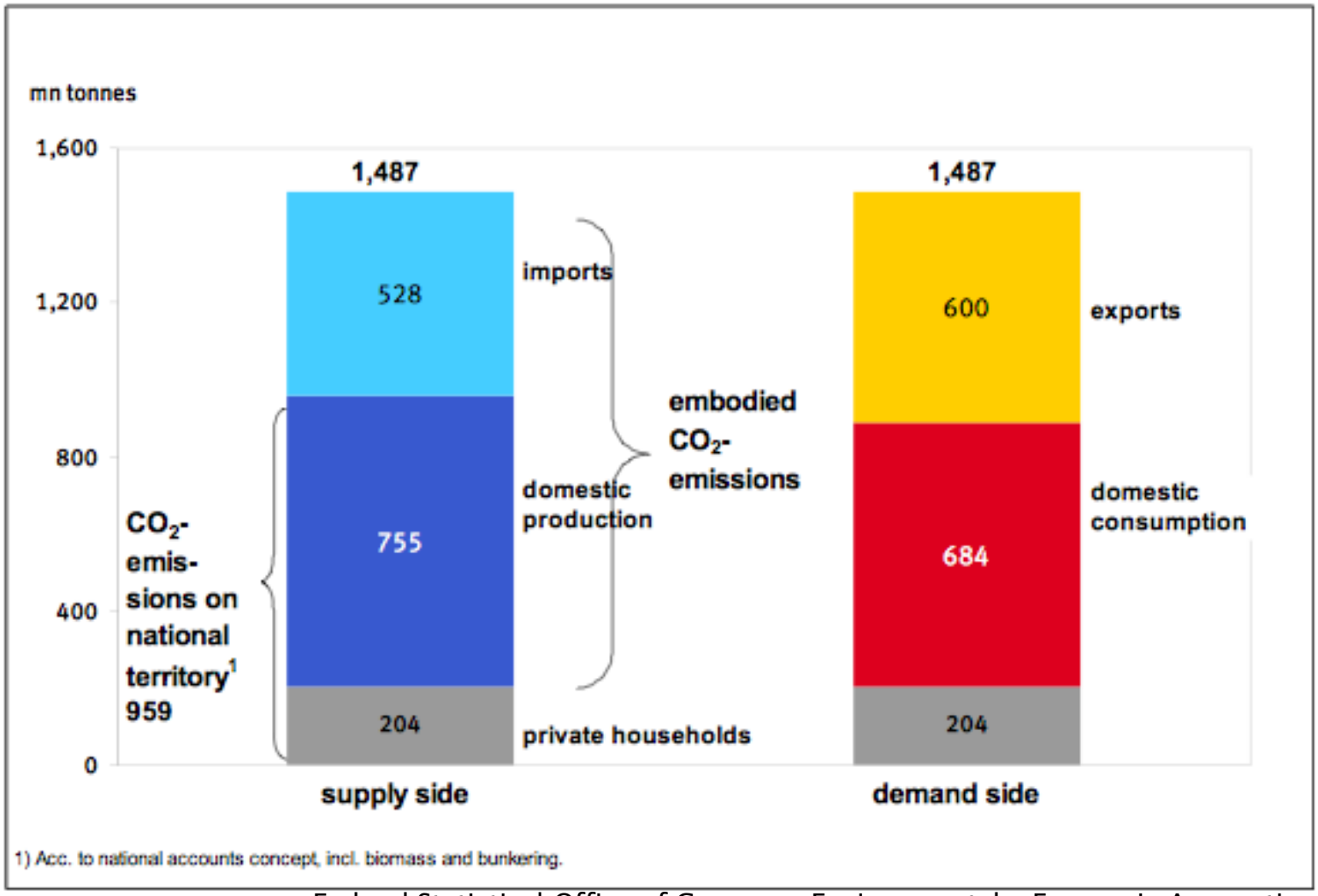
Consumption of water by industries by final demand that caused them – Denmark 2005

Water consumption by industries 2005.						
	Total	Private consumptio	Government consumptio	Investment, buildings	Investment others	Export
Agriculture	160.368	33.345	1.863	231	-137	122.165
Horticulture, orchards etc.	7.926	3.217	240	46	11	4.272
Agricultural services; lands	912	150	284	115	3	345
Forestry	74	19	8	3	1	26
Fishing	38.776	2.132	312	43	47	36.227
Extr. of crude petroleum, r	2	0	0	0	0	2
Extr. of gravel, clay, stone a	3.254	590	313	842	33	1.373
Production etc. of meat an	36.292	10.012	609	78	124	25.153
Processing etc. of fish and f	8.071	1.582	55	7	13	6.328
Processing etc. of fruit and	4.355	356	55	8	9	3.939
Mfr. of vegetable and anim	1.169	516	36	4	5	601

CO2 embodied in Danish exports and imports

	CO2 balance for Danish foreign trade
	1000 tonnes CO_2
Emissions embodied in exports	20,368
Emissions embodied in imports	26,795
Surplus on CO_2 balance	-6,427

Diagram 3: CO_2 emissions and embodied CO_2 in Germany 2007



Federal Statistical Office of Germany: Environmental – Economic Accounting. Extended Input-Output Model For Energy and Greenhouse Gases

Diagram 8: CO_2 emissions of exports by type of goods 2007 (percentage)

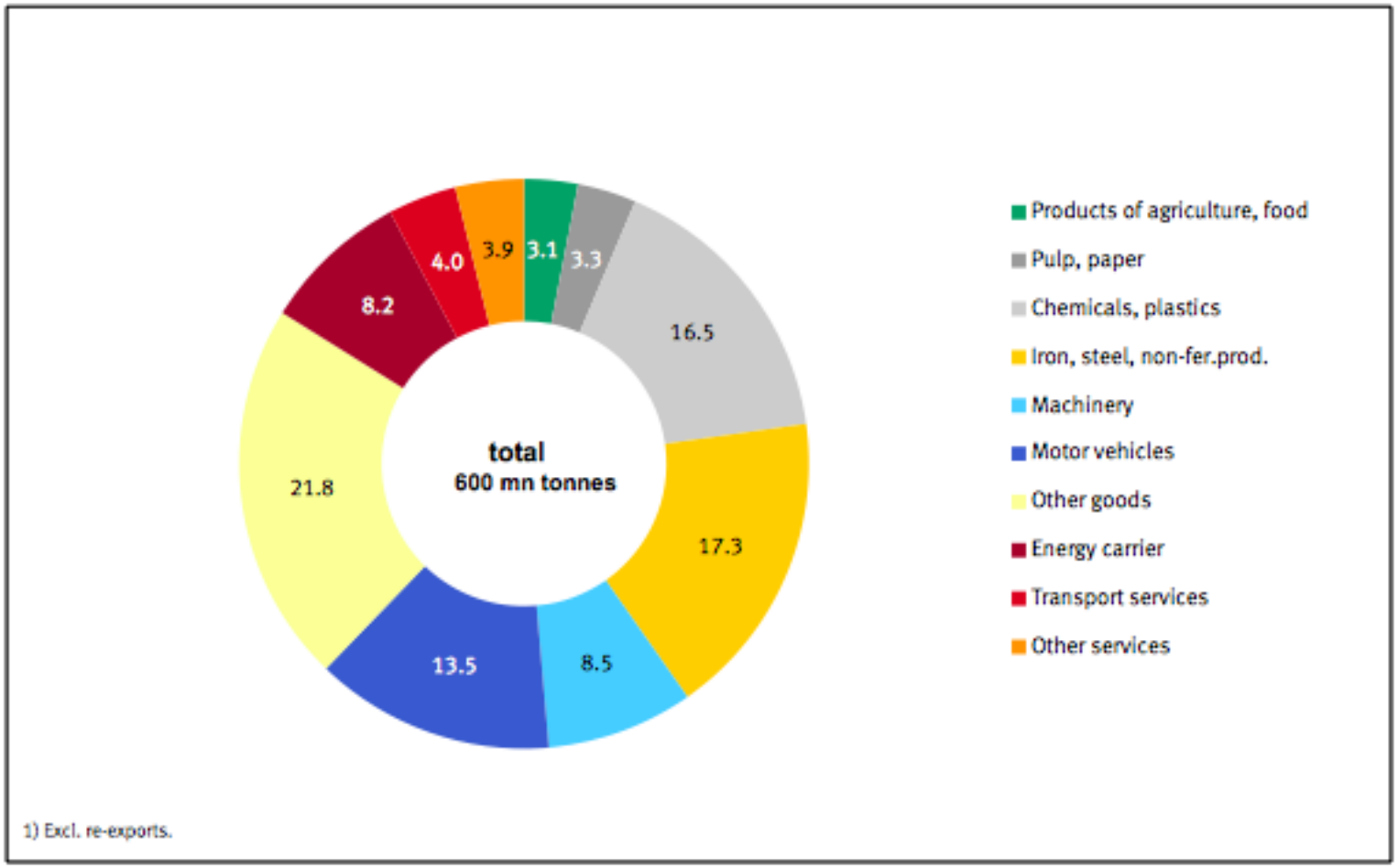


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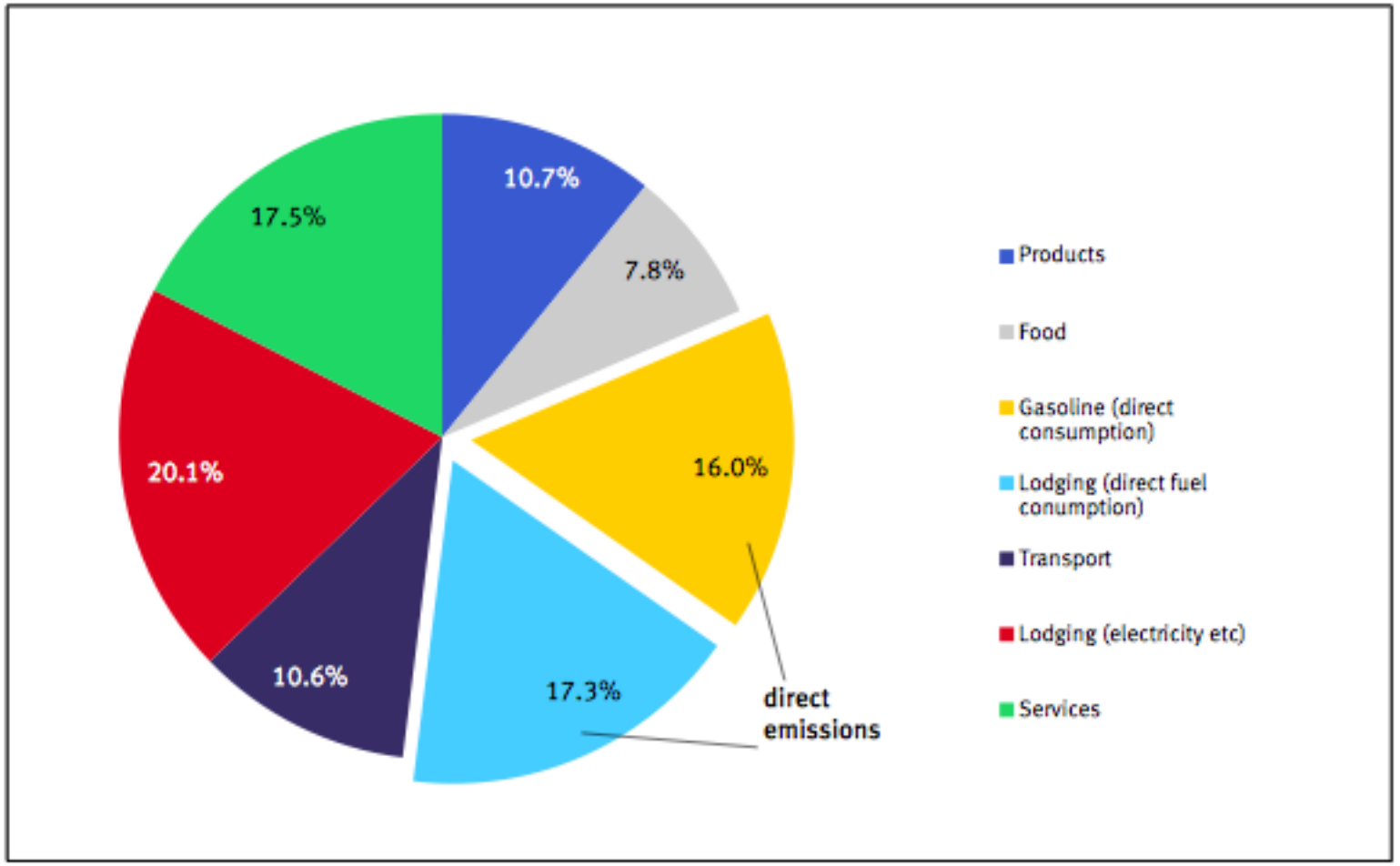
Diagram 10: CO_2 emissions of private households and embodied CO_2 of consumer goods 2007 (percentage)



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