Introduction to Energy Balance Table (EBT)

AIM Training Workshop

Tsukuba, Japan Oct 27-31, 2008

Contents

- Basics of energy data
- General descriptions of EBT
- Interpretation
- Rules/Conventions
- Analysis

Contents

Basics of Energy Data

Contents

General Energy Flow

Production

Total Primary Energy Supply

Import/Export

Energy stock

Transformation Technologies

Total Final Energy Consumption

Losses

Technology producing the demanded services

Services

Terms (Definitions)

- Primary Energy

  Energy embodied in natural resources (e.g. coal, crude oil, sunlight, uranium) that has not undergone any anthropogenic conversions or transformations (IPCC).

- Secondary Energy

  Form of energy generated by conversion of primary energies, e.g. electricity from gas, nuclear energy, coal, and gasoline from mineral oil, coke and coke oven gas from coal (European nuclear society).

- Total primary energy supply (TPES)

  Total primary energy supply (TPES) is made up of production + imports - exports - international marine bunkers stock changes (IEA)

- Total final energy consumption (TFC)

  Total final consumption (TFC) is the sum of consumption by the different end-use sectors (IEA).

Terms (Definitions)

- Energy intensity

  Ratio between the consumption of energy to a given quantity of output.

- Carbon intensity

  The relative amount of carbon emitted per unit of energy or fuels consumed.

- Energy Service

  Useful energy output of any final technical energy consumption system. Examples of energy services would include
  - mechanical work, transportation, force
  - pumping, venting and vacuum applications
  - thermal uses (specific heating and cooling)
  - lighting / illumination / magnification

General Descriptions of EBT

What is Energy Balance Table?

- Simple Table Format
- Illustrate general energy flow (production to end-use) of a region in question
- Flow (in row), Product (in column)
- Input (-), Output (+)
- Available at;
  - *IEA, Energy Balances and Statistics (170 countries)*
  - *APEC, APEC Energy Handbook etc.*
  - *National statistics (each country)*

Why is EBT so important?

- Easy comparison (by country, by year)
- Easy interpretation
- "Double count" avoided
- Same format data available (Internationally)

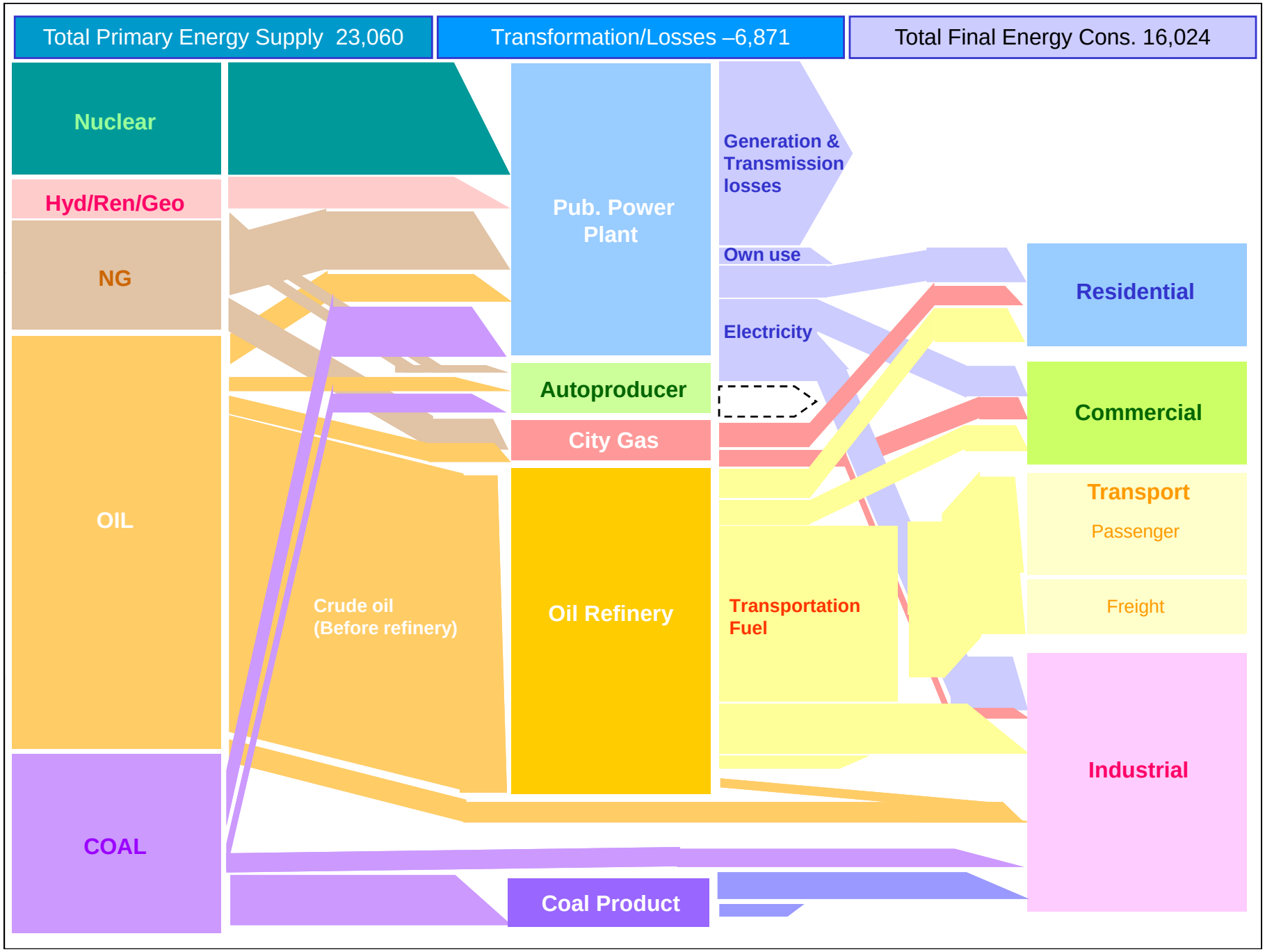
- But…a little differences in "definitions" (Be careful!!)

How is it look like?

	Crude oil	Petro. Products	Hydro/ Nuclear	Elec.	Coal/ Gas etc.	**Total**
Production	0.7	0.0	81.6	0.0	10.5	**92.8**
Imports	220.3	54.6	0.0	0.0	175.8	**450.7**
Exports & Stock Change	0.2	-15.2	0.0	0.0	-1.7	**-16.7**
TPES	**221.2**	**39.4**	**81.6**	**0.0**	**184.6**	**526.8**
Electricity Plants	-6.2	-24.1	-81.6	93.2	-111.8	**-130.5**
Petro. Refineries	-214.4	212.7	0.0	0.0	0.0	**-1.7**
Other Transformation	-1.2	-2.1	0.0	-0.1	0.1	**-3.3**
Own Use / Trans. losses	0.0	-12.3	0.0	-9.3	-4.0	**-25.6**
Statistical Differences	0.6	6.3	0.0	0.0	0.6	**7.5**
TFC	**0.0**	**219.9**	**0.0**	**83.8**	**69.5**	**373.2**
Industry	0.0	93.3	0.0	35.9	50.9	**180.1**
Domestic. & Commercial	0.0	37.6	0.0	46.1	18.7	**102.4**
Transportation	0.0	89.2	0.0	1.9	0.0	**91.1**

TPES: Total Primary Energy Supply

TFC: Total Final Consumption


Total Primary Energy Supply 23,060
Transformation/Losses –6,871
Total Final Energy Cons. 16,024
Nuclear
Hyd/Ren/Geo
NG
OIL
COAL
Pub. Power Plant
Autoproducer
City Gas
Oil Refinery
Coal Product
Crude oil (Before refinery)
Generation & Transmission losses
Own use
Electricity
Transportation Fuel
Residential
Commercial
Transport
Passenger
Freight
Industrial

Interpretations

How to interpret EBT ?

	Crude oil	Petro. Products	Hydro/ Nuclear	Elec.	Coal/ Gas etc.	**Total**
Production	0.7	0.0	81.6	0.0	10.5	**92.8**
Imports	220.3	54.6	0.0	0.0	175.8	**450.7**
Exports & Stock Change	0.2	-15.2	0.0	0.0	-1.7	**-16.7**
TPES	**221.2**	**39.4**	**81.6**	**0.0**	**184.6**	**526.8**
Electricity Plants	-6.2	-24.1	-81.6	93.2	-111.8	**-130.5**
Petro. Refineries	-214.4	212.7	0.0	0.0	0.0	**-1.7**
Other Transformation	-1.2	-2.1	0.0	-0.1	0.1	**-3.3**
Own Use / Trans. losses	0.0	-12.3	0.0	-9.3	-4.0	**-25.6**
Statistical Differences	0.6	6.3	0.0	0.0	0.6	**7.5**
TFC	**0.0**	**219.9**	**0.0**	**83.8**	**69.5**	**373.2**
Industry	0.0	93.3	0.0	35.9	50.9	**180.1**
Domestic & Commercial	0.0	37.6	0.0	46.1	18.7	**102.4**
Transportation	0.0	89.2	0.0	1.9	0.0	**91.1**

Production etc.

Transformation

End-use

TPES: Total Primary Energy Supply

TFC: Total Final Consumption

Interpretation (Production etc.)

- Production: Coal, Gas and Oil mine
- Stock change: Stock building (-), Stock using (+)

	Crude oil	Petro. Products	Hydro/ Nuclear	Elec.	Coal/ Gas etc.	**Total**
Production	0.7	0.0	81.6	0.0	10.5	**92.8**
Imports	220.3	54.6	0.0	0.0	175.8	**450.7**
Exports & Stock Change	0.2	-15.2	0.0	0.0	-1.7	**-16.7**
TPES	**221.2**	**39.4**	**81.6**	**0.0**	**184.6**	**526.8**

Oil dependence (%)

*=(221.2+39.4)/526.9*100=49.5%*

Import dependence (%)

*=450.7/(450.7+92.8)*100=82.9%*

Interpretation (Transformations)

- Primary Energy⇨ Secondary Energy
- Input(-), Output(+)

	Crude oil	Petro. Products	Hydro/ Nuclear	Elec.	Coal/ Gas etc.	**Total**
TPES	**221.2**	**39.4**	**81.6**	**0.0**	**184.6**	**526.8**
Electricity Plants	-6.2	-24.1	-81.6	93.2	-111.8	**-130.5**
Petro. Refineries	-214.4	212.7	0.0	0.0	0.0	**-1.7**
Other Transformation	-1.2	-2.1	0.0	-0.1	0.1	**-3.3**
Own Use / Trans. losses	0.0	-12.3	0.0	-9.3	-4.0	**-25.6**
Statistical Differences	0.6	6.3	0.0	0.0	0.6	**7.5**
TFC	**0.0**	**219.9**	**0.0**	**83.8**	**69.5**	**373.2**

Interpretation (Energy end-use)

- Energy consumption by sector (by energy)
- Detailed Analysis possible
  - *Compare among countries*
  - *Historical change of energy consumption in certain sectors*

	Crude oil	Petro. Products	Hydro/ Nuclear	Elec.	Coal/ Gas etc.	**Total**
TFC	**0.0**	**219.9**	**0.0**	**83.8**	**69.5**	**373.2**
Industry	0.0	93.3	0.0	35.9	50.9	**180.1**
Domestic. & Commercial	0.0	37.6	0.0	46.1	18.7	**102.4**
Transportation	0.0	89.2	0.0	1.9	0.0	**91.1**

Rules/Conventions

Primary Energy Equivalent

- Conventions for primary energy (Renewables, Nuclear, Hydro, and Geothermal)
  - *The partial substitution method:*
    - The amount of energy that would be necessary to generate an identical amount of electricity in conventional thermal power plants
  - *The physical energy content method (IEA)*
    - Renewables, Hydro: 100%
    - Geothermal (electricity): 10%
    - Geothermal (Heat): 50%
    - Nuclear: 33%

Unit of energy used in EBT

- Different unit used for each energy sources
  ("tonnes" for coal, "kl" for oil "m^3" for gas etc)
- Same unit should be used for easy analysis
  - "toe" (tonnes of oil equivalent)
  - "cal" (calories)
  - "J" (joules)

  *Energy unit in IEA:ktoe = 10^{10} kcal
- Unit prefix is commonly used

Unit Prefix	
K	Kilo (10^3)
M	Mega (10^6)
G	Giga (10^9)
T	Tera (10^{12})
P	Peta (10^{15})
E	Exa (10^{18})

Conversion factors (Energy)

- Conversion factors for Energy

To	TJ	Gcal	Mtoe	MBtu	GWh
From:	multiply by:				
TJ	1	238.8	$2.388*10^{-5}$	947.8	0.2778
Gcal	$4.2868*10^{-3}$	1	10-7	3.968	$1.163*10^{-3}$
Mtoe	$4.1868*10^{4}$	107	1	$3.968*10^{7}$	11630
MBtu	$1.0551*10^{-3}$	0.252	$2.52*10^{-8}$	1	$2.931*10^{-4}$
GWh	3.6	860	$8.6*10^{-5}$	3412	1

TPES in Japan (2004) :562,777 10^{4}(Gcal)

$=562,777*10^{4}$ (Gcal) $*4.29*10^{-3}$(TJ/Gcal)$=2.41*10^{7}$(TJ)

$=562,777*10^{4}$ (Gcal) $*10^{-7}$(Mtoe/Gcal)$=563$(Mtoe)

$=562,777*10^{4}$ (Gcal) $*3.97$(MBtu/Gcal)$=2.23*10^{10}$ (MBtu)

$=562,777*10^{4}$ (Gcal) $*1.16*10^{-3}$(GWh/Gcal)$=6.53*10^{6}$ (GWh)

Conversion factors (Mass/Vol.)

•Conversion factors for Mass

To	kg	t	lt	st	lb
From:	multiply by:				
Kilogramme (kg)	1	0.001	$9.84*10^{-4}$	$1.102*10^{-3}$	2.2046
tonne (t)t	1000	1	0.984	1.1023	2204.6
Long ton (lt)	1016	1.016	1	1.120	2240.0
Short ton (st)	907.2	0.9072	0.893	1	2000.0
pound (lb)	0.454	$4.54*10^{-4}$	$4.46*10^{-4}$	$5.0*10^{-4}$	1

•Conversion factors for Volume

To	gal U.S.	gal U.K.	bbl	ft3	l	m3
From:	multiply by:					
U.S. gallon (gal)	1	0.8327	0.02381	0.1337	3.785	0.0038
U.K. gallon (gal)	1.201	1	0.02859	0.1605	4.546	0.0045
Barrel (bbl)	42.0	34.97	1	5.615	159.0	0.159
Cubic foot (ft3)	7.48	6.229	0.1781	1	28.3	0.0283
Litre (l)	0.2642	0.220	0.0063	0.0353	1	0.001
Cubic metre (m3)	264.2	220.0	6.289	35.3147	1000.0	1

CO2 Emissions (Energy related)

CO2 Emissions derived from energy use (tCO2)

*=Energy Cons. (tJ)*CO2 emission factors (tCO2/tJ)*

*=Energy Cons. (tJ)*C emission factors (tC/tJ)*44 /12*

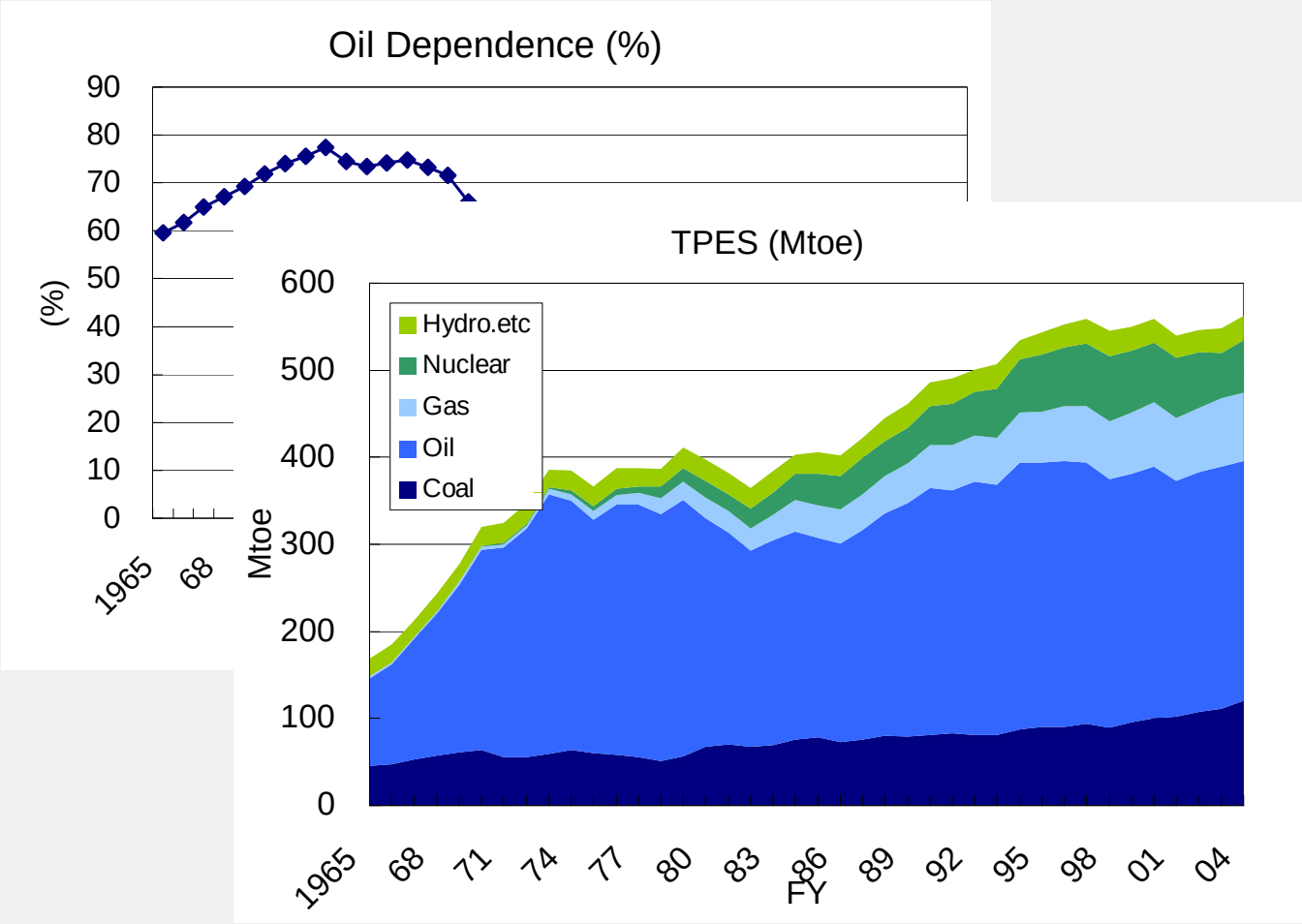
– *"tC" or "tCO2"?*

TABLE 1-2 CARBON EMISSION FACTORS (CEF)	
Fuel	Carbon Emission Factor (t C/TJ)
LIQUID FOSSIL	
Primary fuels	
Crude oil	20.0
Orimulsion	22.0
Natural Gas Liquids	17.2
Secondary fuels/products	
Gasoline	18.9

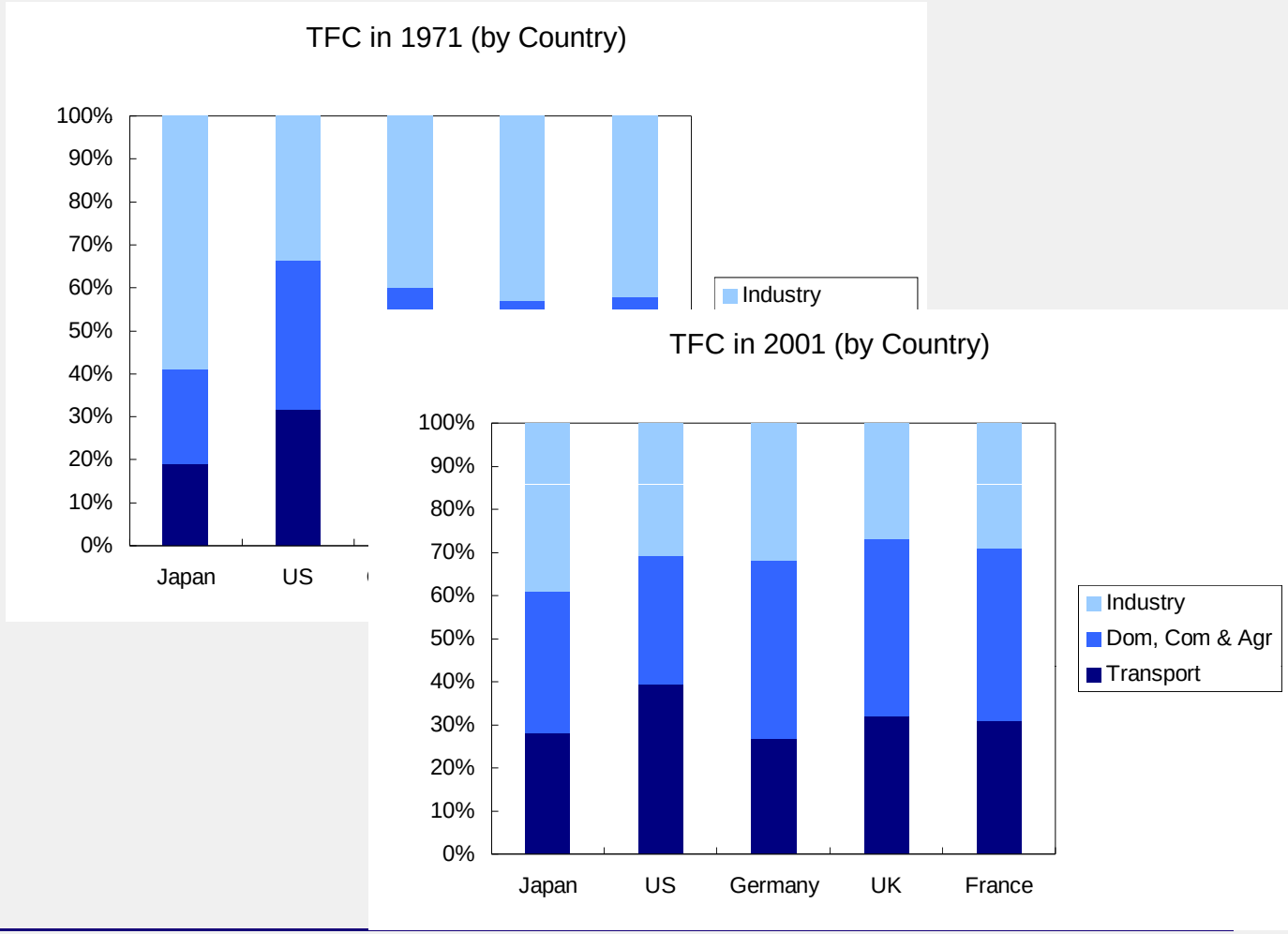
Ref. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories

Analysis (Examples)

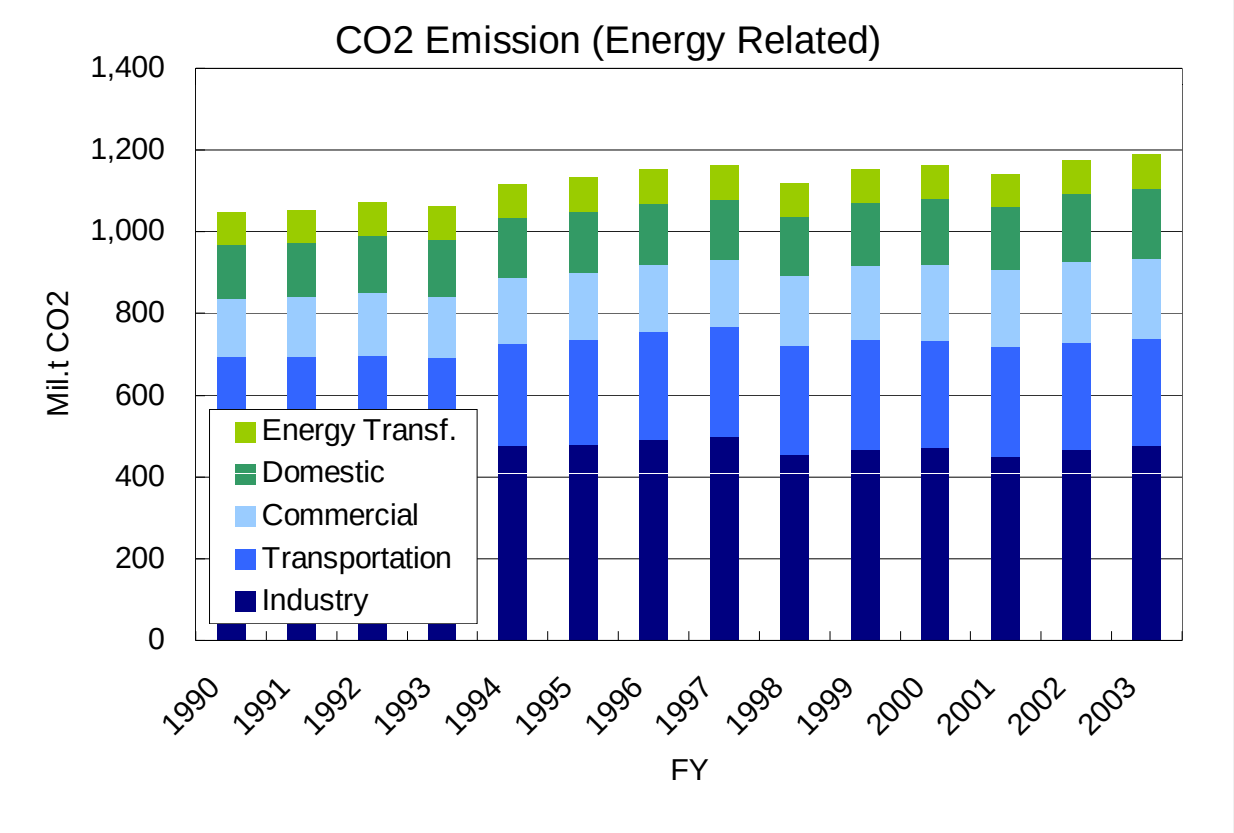
Historical Trends



Comparisons among Countries



CO2 Emission analysis



Any Questions?

Thank you for your attention!!