The importance of energy balances to estimate greenhouse gas emissions
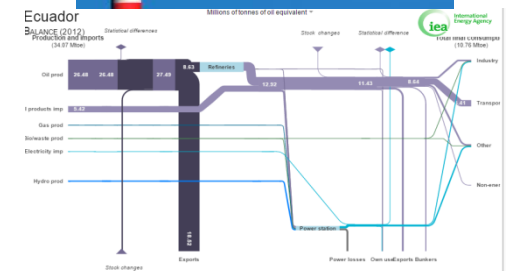
Roberta Quadrelli

*Head - Energy Balances, Prices, Emissions, Efficiency*

IEA Energy Data Centre

Capacity Development for Mainstreaming Energy Sustainable Development Goals (SDGs), Targets and Indicators into Statistical Programmes in Selected Latin American Countries
Panama, February 2015

GHG emissions: why do we focus on energy balances?

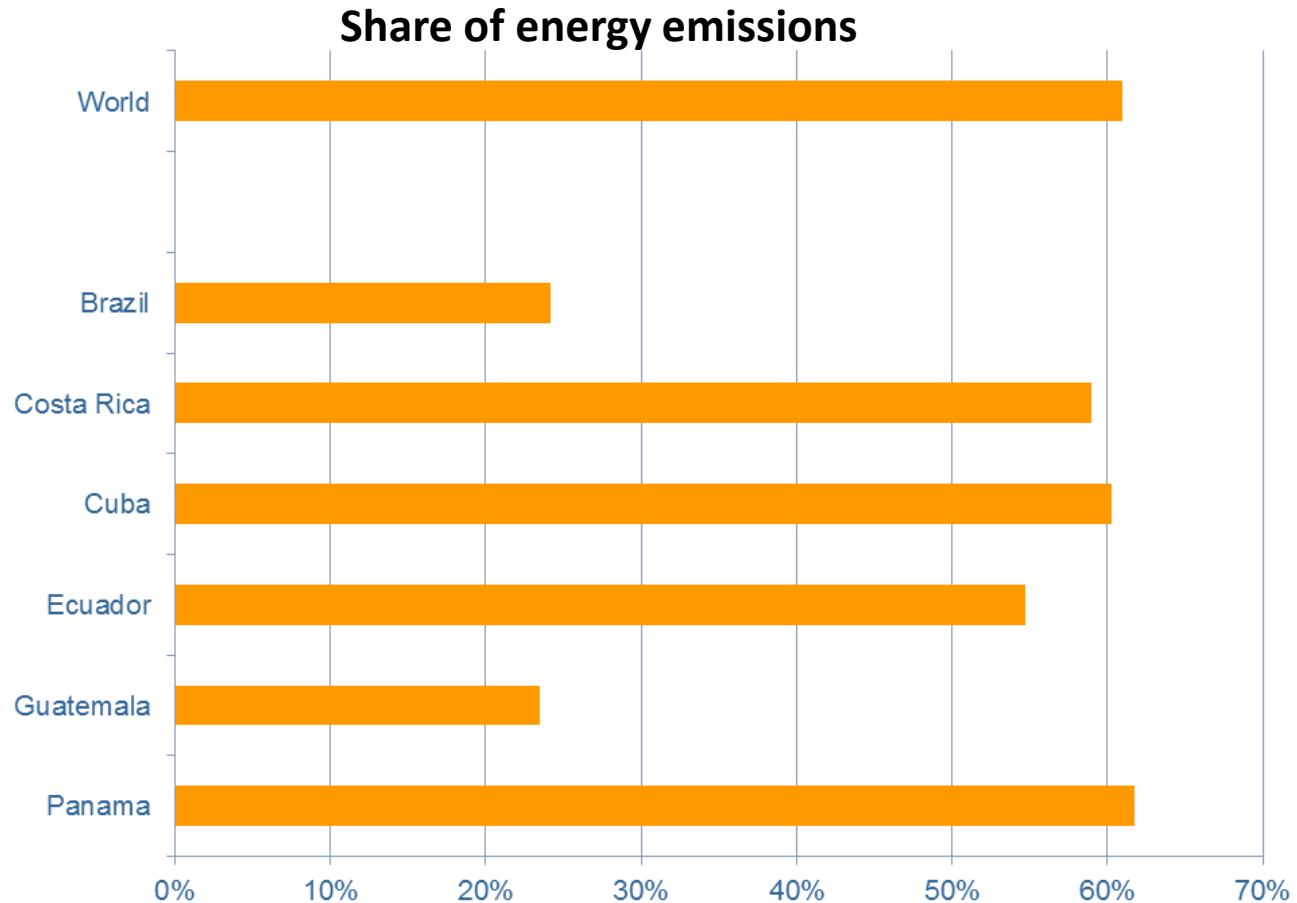# What sectors drive GHG emissions?

Waste 3%

Agriculture 8%

Industrial processes 7%

Energy 82%

CO_2 93%

CH_4 6%

N_2O 1%
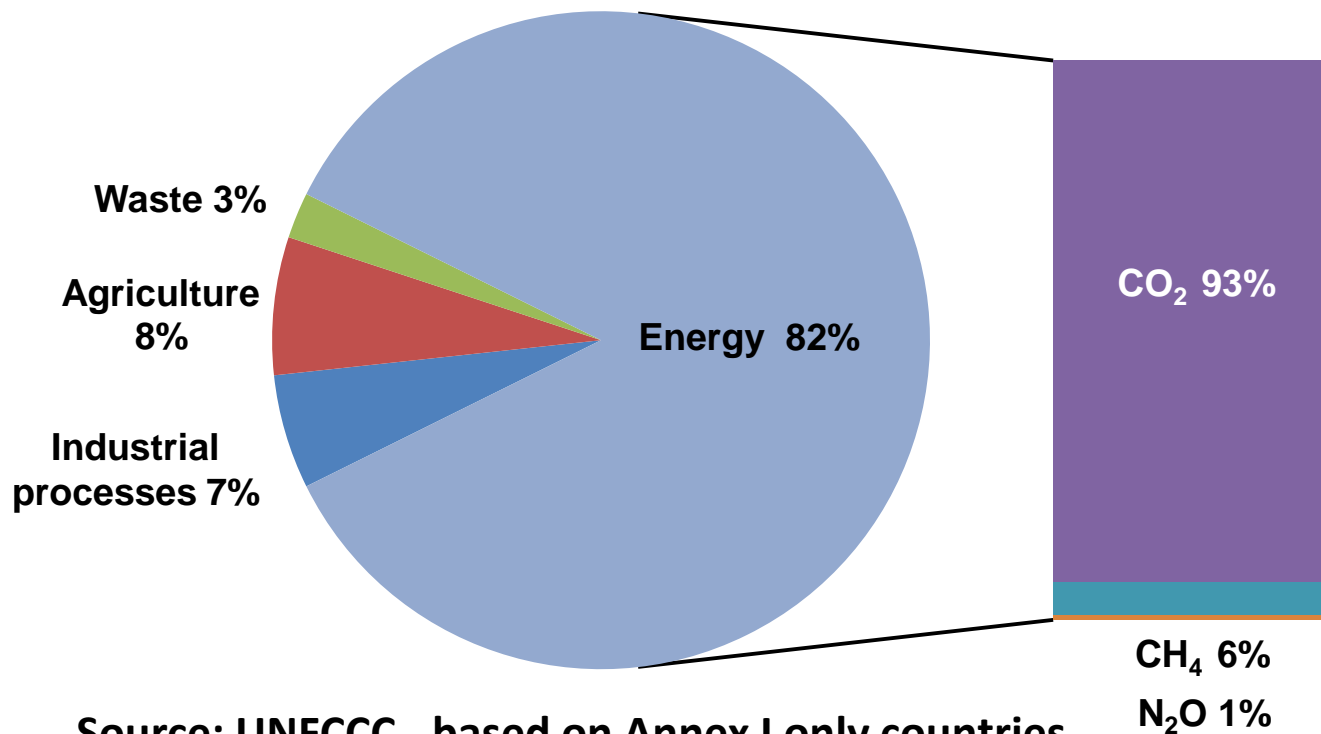
Source: UNFCCC - based on Annex I only countries data for 2012

Generally, energy-related CO_2 dominate GHG emissions

Note: Energy role varies across countries

Share of energy emissions

Source: IEA / EDGAR estimates, 2014

Always need to consider country circumstances

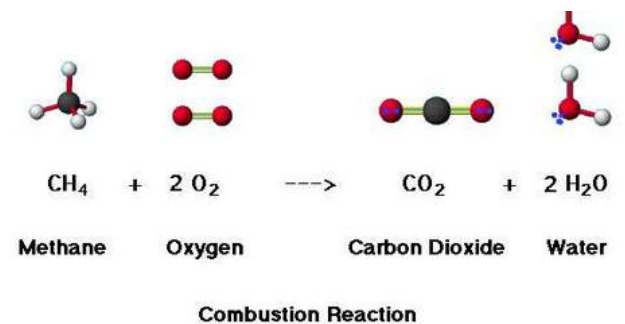# In all cases: an accurate accounting of all energy flows is essential

Supply

Transformation

Final consumption

201▼	Indicators	Balances	Coal and Peat		Electricity and Heat		Natural Gas		Oil	Renewables and Waste	
	Coal and peat	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total*
Production	33658	173317	0	132349	24390	32309	901	12106	0	0	409029
Imports	5954	34510	12790	25960	0	0	0	759	1287	0	81260
Exports	-20076	-118761	-19053	-76831	0	0	0	-570	-4430	0	-239722
International marine bunkers**	0	0	-524	0	0	0	0	0	0	0	-524
International aviation bunkers**	0	0	-1214	0	0	0	0	0	0	0	-1214
Stock changes	66	1064	-206	2092	0	0	0	0	0	0	3016
TPES	19603	90130	-8207	83569	24390	32309	901	12295	-3144	0	251845
Transfers	0	-3781	7993	0	0	0	0	0	0	0	4213
Statistical differences	2329	4585	4579	2410	0	0	0	-1	0	-32	13872
Electricity plants	-17629	0	-1820	-10824	-24390	-32309	-901	-2426	53814	0	-36484
CHP plants	0	0	-41	-2468	0	0	0	-39	958	544	-1047
Heat plants	0	0	0	0	0	0	0	-62	0	34	-28
Gas works	0	0	0	0	0	0	0	0	0	0	0
Oil refineries	0	-91737	95461	-849	0	0	0	0	0	0	2875
Coal transformation	-1182	0	0	0	0	0	0	0	0	0	-1182
Liquefication plants	0	802	0	-1940	0	0	0	0	0	0	-1138
Other transformation	0	0	0	0	0	0	0	0	0	0	0
Energy industry own use	-4	0	-7956	-13986	0	0	0	-1	-4019	0	-25966
Losses	0	0	0	0	0	0	0	0	-2984	0	-2984
Total final consumption	3117	0	90009	55912	0	0	0	9766	44625	546	203975
Industry	2450	0	6067	23876	0	0	0	5840	17698	545	56476
Transport	0	0	54404	2436	0	0	0	1637	331	0	58808
Other	33	0	8935	26208	0	0	0	2289	26596	0	64062
Residential	33	0	2647	14661	0	0	0	2279	13161	0	32782
Commercial and public services	0	0	3008	10823	0	0	0	10	12623	0	26464

The importance of the energy balance to estimate CO_2 emissions

How to estimate CO$_2$ emissions?

CH$_4$ +   2 O$_2$ --->   CO$_2$ +   2 H$_2$O

Methane   **Oxygen**   **Carbon Dioxide**   **Water**

Combustion Reaction

Focus on fuel combustion: the largest source of energy emissions

Brazil: Balances for 2012	Coal*	Crude oil*	Oil products	Natural gas
Production	2479	112660	0	16248
Imports	12248	17815	24284	10980
Exports	0	-27546	-6292	0
International marine bunkers***	0	0	-3767	0
International aviation bunkers***	0	0	-2231	0
Stock changes	520	542	1365	0
TPES	15247	103471	13359	27228
Transfers	0	-2251	2167	0
Statistical differences	0	-372	-714	68

Combustion of fossil fuels (coal, oil, natural gas) generates CO_2

Note: Biofuels are considered as "not emitting" within energy sector (IPCC Guidelines)

For all products: estimating CO_2 emissions based on carbon conservation

MODULE	ENERGY				
CATEGORY	FUEL COMBUSTION ACTIVITIES				
CATEGORY CODE	1A (FOR EACH SOURCE CATEGORY)				
SHEET	CO_2, CH_4 AND N_2O FROM FUEL COMBUSTION BY SOURCE CATEGORY – TIER 1				
	Energy consumption			**CO_2**	
	A — Consumption (Mass, Volume or Energy unit)	B — Conversion Factor (TJ/unit)	C — Consumption (TJ)	CO_2 Emission Factor (Kg CO_2/TJ)	CO_2 emissions (Gg CO_2)
			C=(AxB)		E=(CxD)
Crude Oil					
Other Kerosene					
Gas/Diesel Oil					
Residual Fuel Oil					
…					

Energy consumption X **Calorific values** X **CO_2 emission factors** = **CO_2 Emissions**

Source: 2006 IPCC Guidelines

Accuracy of energy data by product and by sector – including calorific values reflected in emissions data quality

# Strengthening the energy balance to produce accurate emissions indicators

1: Energy supply

Guatemala: Balances for 2012
in thousand tonnes of oil equivalent (ktoe) on a net

	Coal	Crude oil*	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total**
Production	0	587	0	0	0	383	211	7057	0	0	8238
Imports	356	0	3546	0	0	0	0	0	32	0	3934
Exports	0	-495	-131	0	0	0	0	0	-30	0	-655
International marine bunkers***	0	0	-311	0	0	0	0	0	0	0	-311
International aviation bunkers***	0	0	-44	0	0	0	0	0	0	0	-44
Stock changes	-49	-19	-22	0	0	0	0	0	0	0	-90
TPES	307	73	3039	0	0	383	211	7057	2	0	11072

Guatemala - CO2 emissions
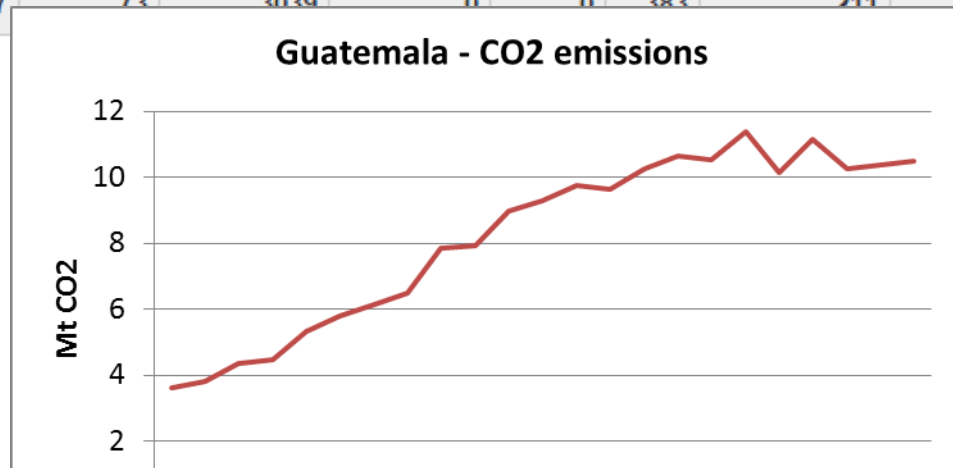
**Basis for "reference approach" emissions ("top-down")
and quick indicator of overall trends**

Note the relevance of international bunkers data

Panama
BALANCE (2012)

Thousands of tonnes of oil equivalent ▾

Sources: IEA, 2014
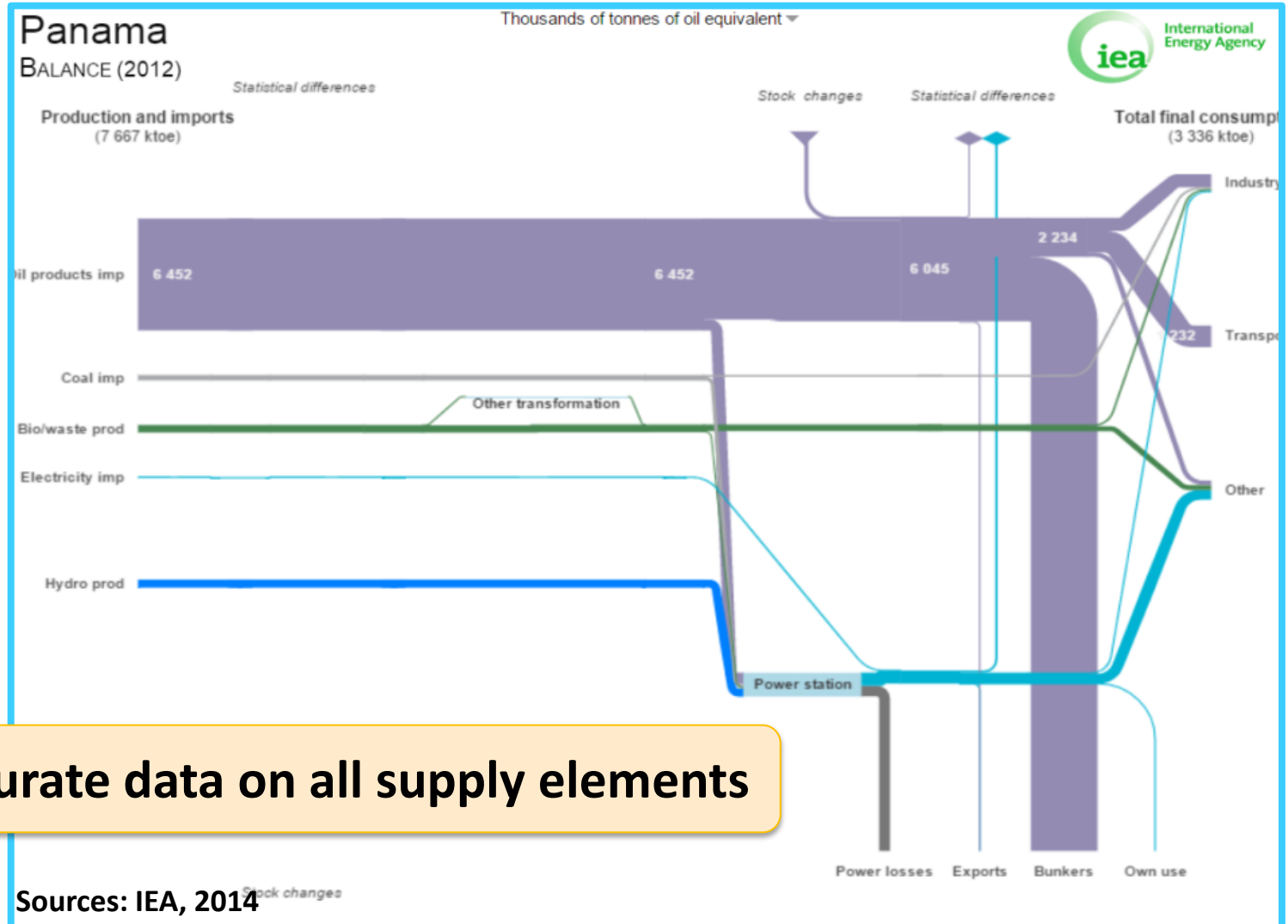
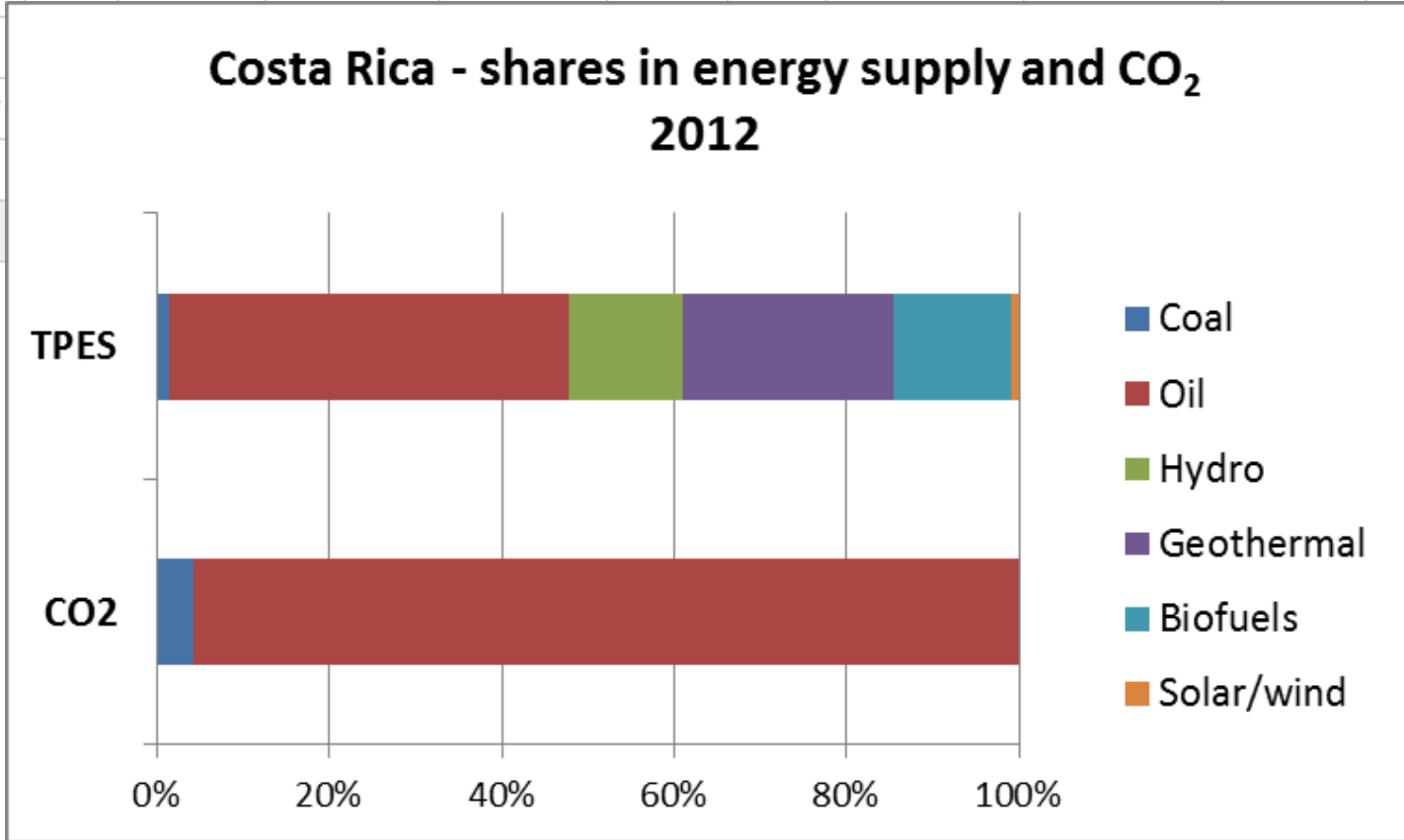**Need accurate data on all supply elements**

IPCC Guidelines: international aviation and marine bunkers
are not included in national emissions totals

Energy and emissions: understanding the relative weights of sources

Costa Rica: Balances for 2012

	Coal*	Crude oil*	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	To
Production	0	0	0	0	0	622	1207	635	0	0	
Imports	65	0	2366	0	0	0	0	0	36	0	
Exports	0	-65	0	0	0	0	0	0	-35	0	
International marine bunkers***											0
International aviation bunkers***											0
Stock changes											0
TPES										0	

Costa Rica - shares in energy supply and CO_2 2012

(TPES and CO2 stacked bar chart — categories: Coal, Oil, Hydro, Geothermal, Biofuels, Solar/wind)

A "supply" indicator: CO_2/TPES "carbon intensity" of the energy mix

Brazil	Coal	Oil	Gas	Nuclear	Hydro	Biofuels	Other	Total
TPES (PJ)	638	4892	1140	175	1495	3269	186	**11795**
CO_2 (Mt)	60	325	63	0	0	0	0	**448**
CO_2/TPES (tCO2/TJ)	94	66	55	0	0	0	0	**38**
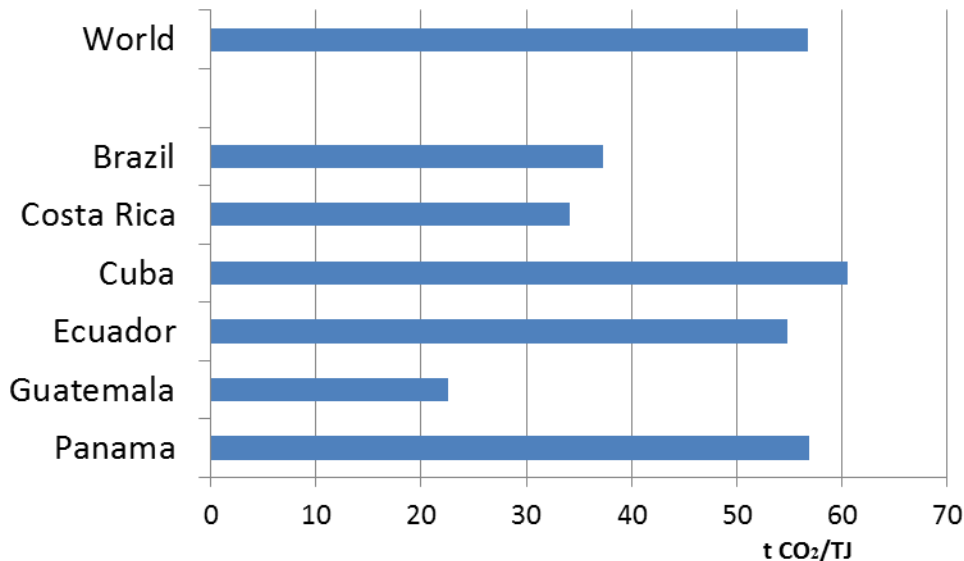
Total CO_2/TPES Weighted average across supply fuels

Source: IEA CO_2 emissions from fuel combustion, 2014

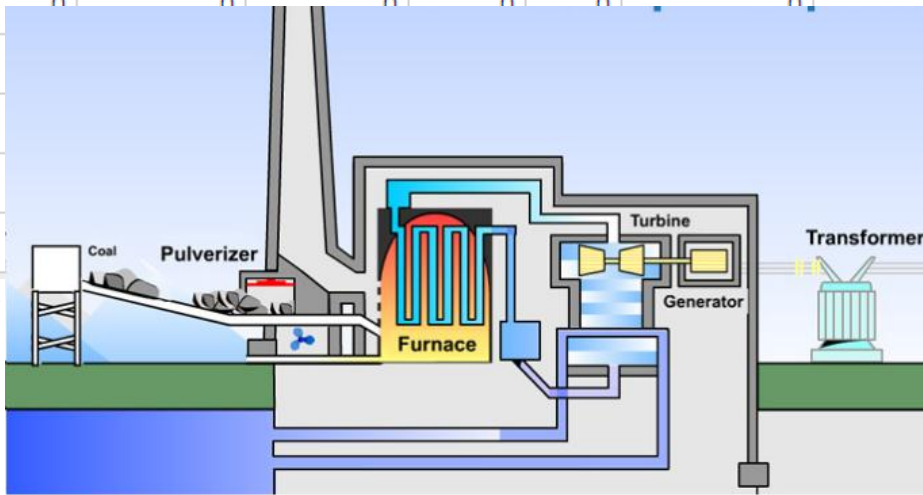**Need accurate supply data for all fuels – including solid biofuels!**

2: Transformation sector

Cuba: Balances for 2012

	Coal and peat	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total*
Electricity plants	0	-2491	-2487	-450	0	-10	-2	-31	1585	0	-4172
CHP plants	0	0	0	0	0		0	0	0	0	0
Heat plants	0							0	0	0	0
Gas works	0							0	0	0	-2
Oil refineries	0	-4706	4536	0	0	0	0	0	0	0	-170
Coal transformation	-1	0	0	0	0	0	0	0	0	0	-1
Liquefication plants	0							0	0	0	
Other transfo	0							-76			
Energy indus	0							0			
Losses	0							0			

Transforming energy sources

Input (oil)

Output (electricity)
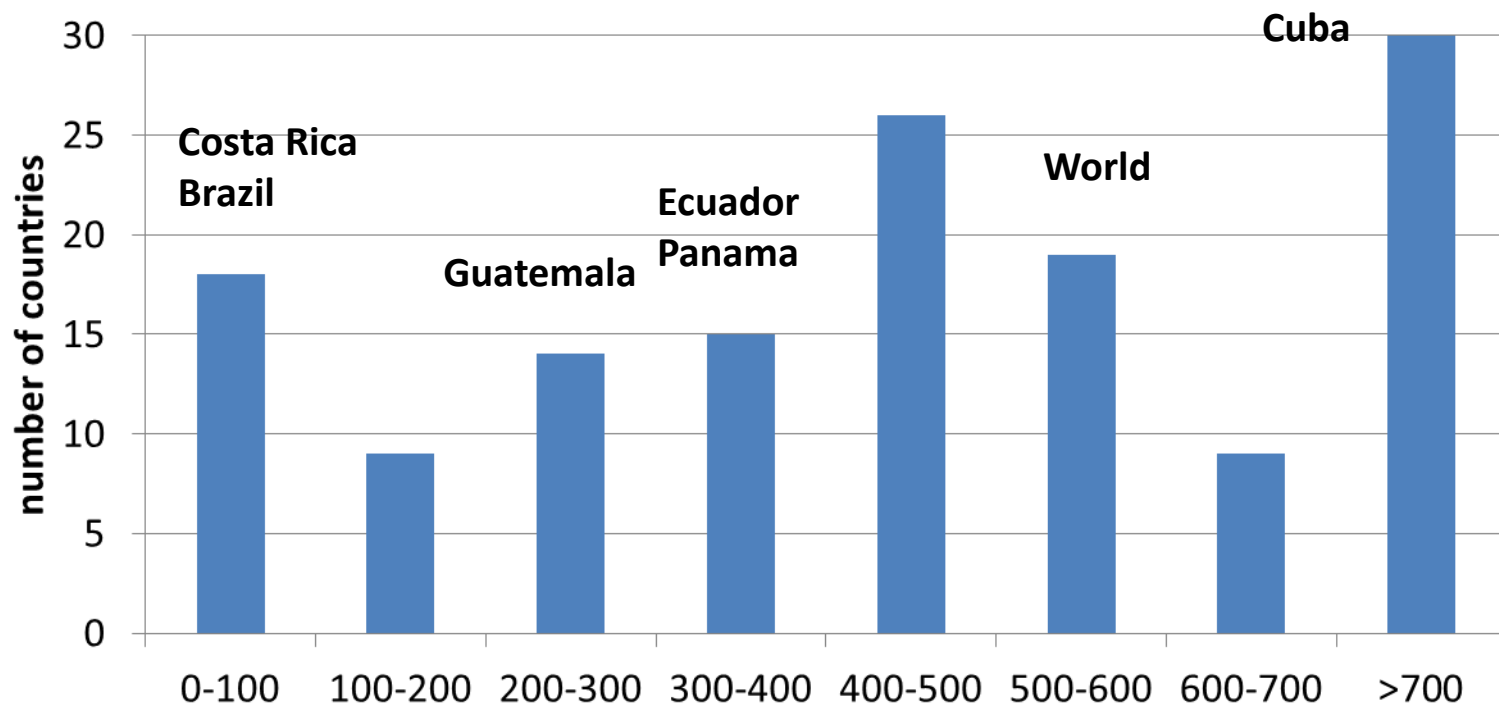
Coal | Pulverizer | Furnace | Turbine | Generator | Transformer

Need accurate input/output data by product type (e.g. electricity generation)

A "transformation" indicator: CO_2/kWh the "carbon intensity of electricity"

Total CO_2/kWh: weighted average across all power plants

For an individual power plant: Increases with carbon intensity of (fossil) fuel used

Decreases with efficiency of electricity generation

Need accurate data on amounts of combusted fuels and of electricity generated, by source

3: Final consumption

	Coal and peat	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total*
Total final consumption	3117	0	90009	55912	0	0	0	9766	44625	546	203975
Industry	2450	0	6067	23876	0	0	0	5840	17698	545	56476
Transport	0	0	54404	2436	0	0	0	1637	331	0	58808
Other	33	0	8935	26208	0	0	0	2289	26596	0	64062
Residential	33	0	2647	14661	0	0	0	2279	13161	0	32782
Commercial and public services	0	0	3008	10823	0	0	0	10	12623	0	26464
Agriculture / forestry	0	0	3280	724	0	0	0	0	812	0	4816
Fishing	0	0	0	0	0	0	0	0	0	0	0
Non-specified	0	0	0	0	0	0	0	0	0	0	0
Non-energy use	634	0	20603	3392	0	0	0	0	0	0	24629

Basis for "Sectoral approach" emissions estimates ("bottom-up")

Reconciling supply and demand sides

Ecuador - CO_2 emissions estimates
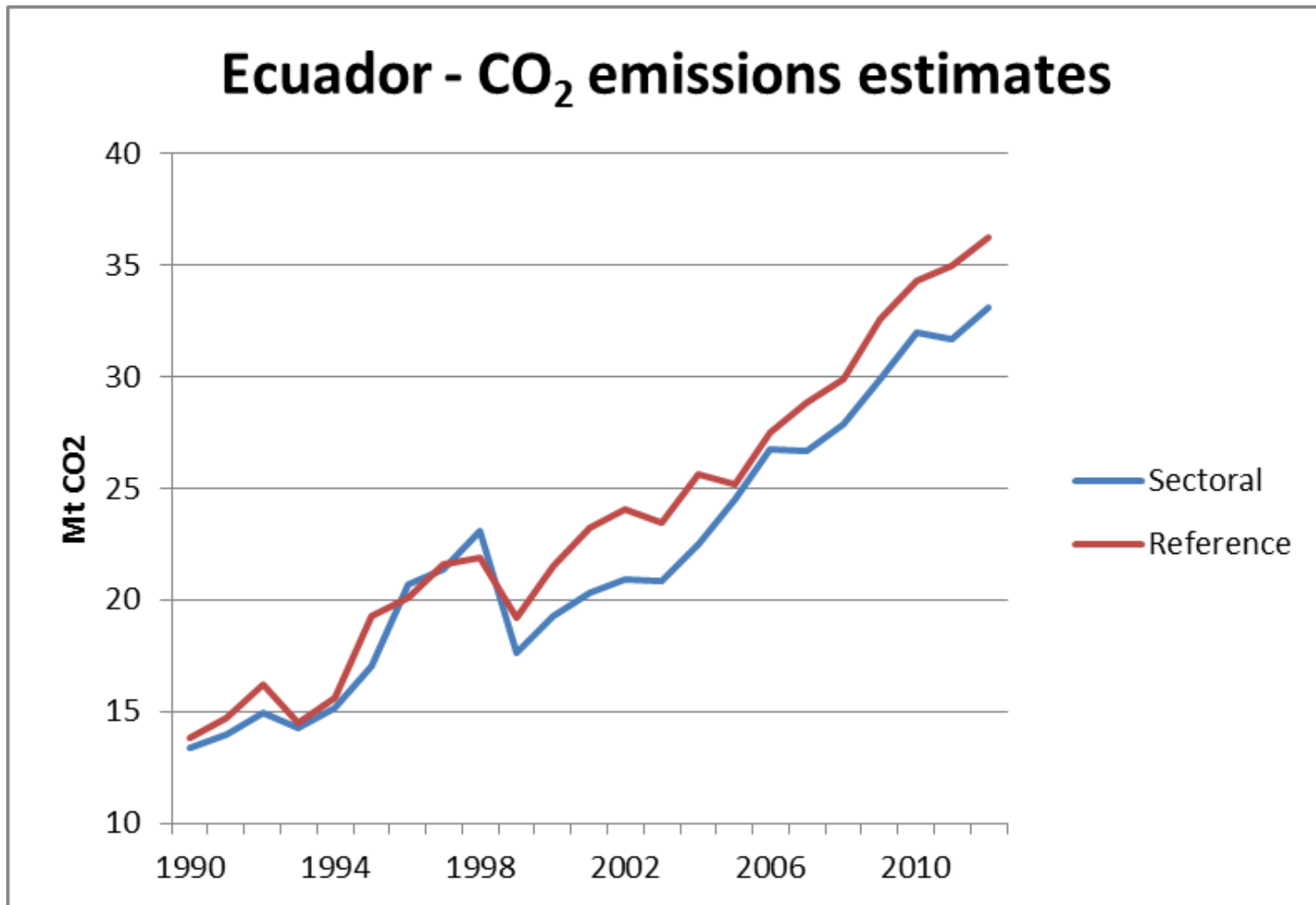
Assessing differences to enhance data quality

"Demand" indicators: shares by sector

Cuba - CO_2 shares, 2012

- 2%
- 6%
- 7%
- 28%
- 57%

Ecuador - CO_2 shares, 2012

- 7%
- 8%
- 22%
- 14%
- 49%

Legend:
- Electricity
- Industry
- Transport
- Residential
- Other
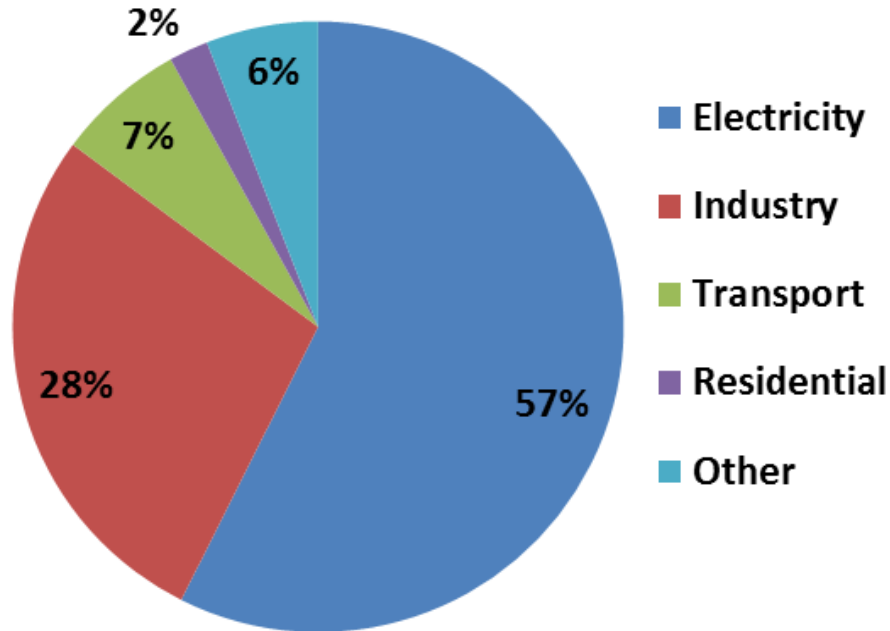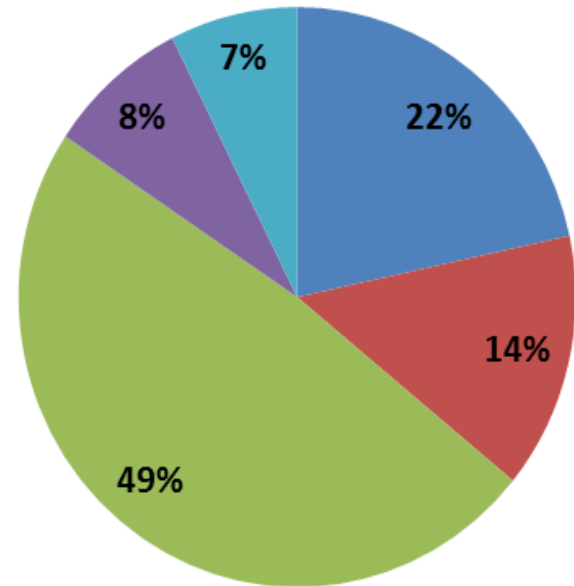
Understanding country-specific drivers of emissions

Analysing indicators together
to understand drivers of emission trends
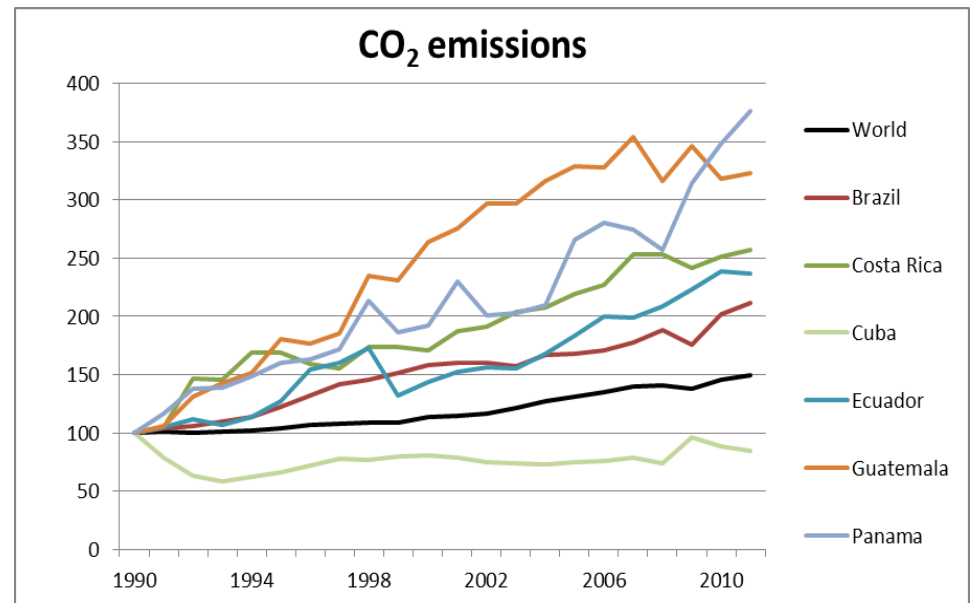
What drives global CO$_2$ trends?

Applying the "Kaya identity":
CO$_2$ = population x GDP/population x TPES/GDP x CO$_2$/TPES

Population	Per capita GDP	Energy intensity of the economy	Carbon intensity of energy mix

1990 = 100

Legend:
- CO2 emissions
- GDP/population
- Population
- CO2/TPES
- TPES/GDP

Source: CO$_2$ emissions from fuel combustion, 2013
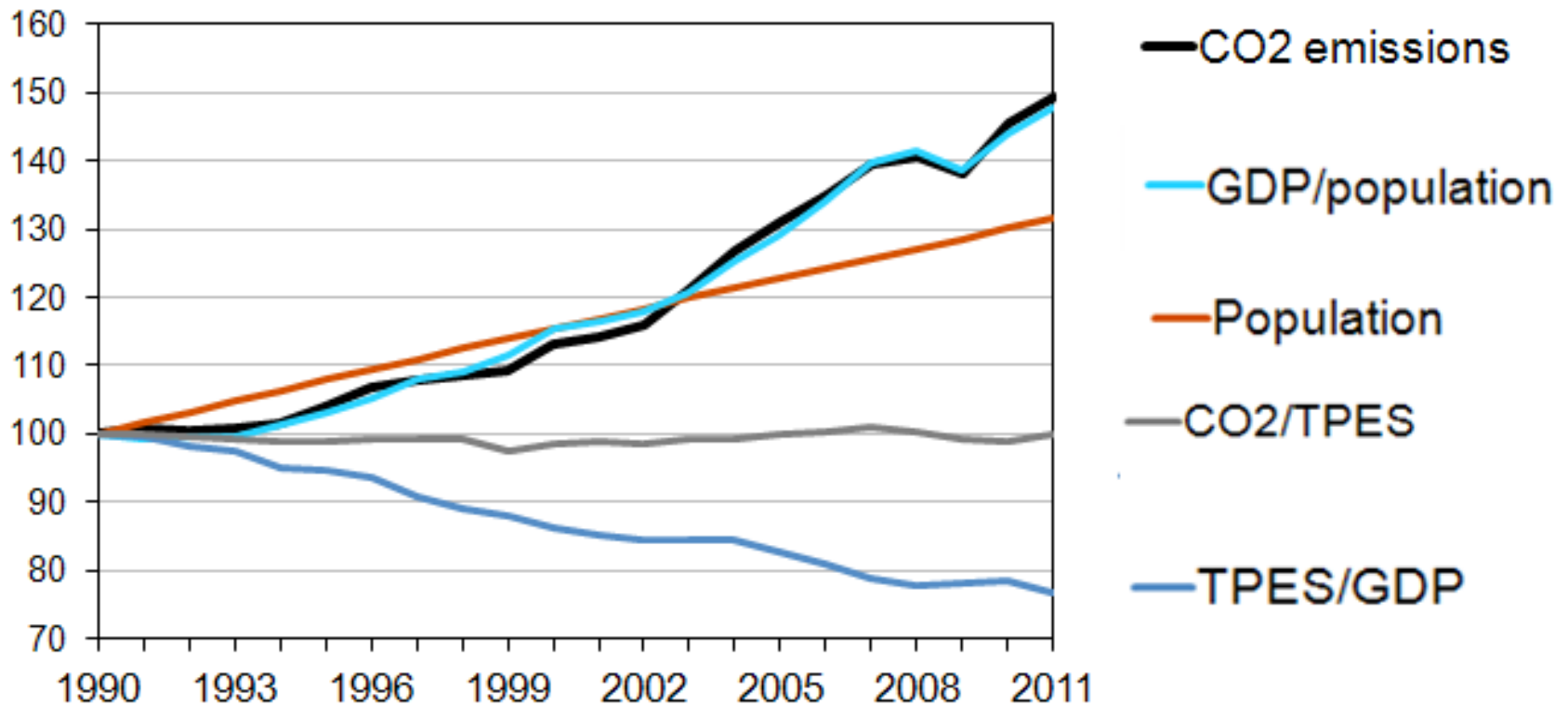
Understanding different dynamics at country level

Legend (left chart):
- CO2 emissions
- GDP/population
- Population
- CO2/TPES (
- TPES/GDP

$$CO_2 = \text{population} \times \text{GDP/population} \times \text{TPES/GDP} \times CO_2/\text{TPES}$$
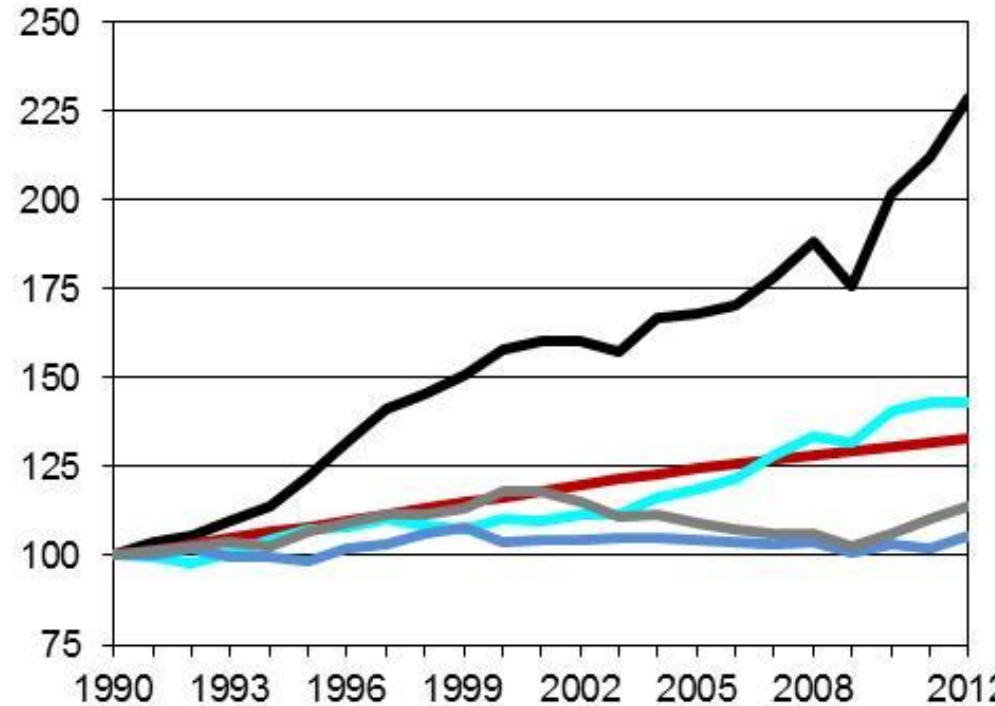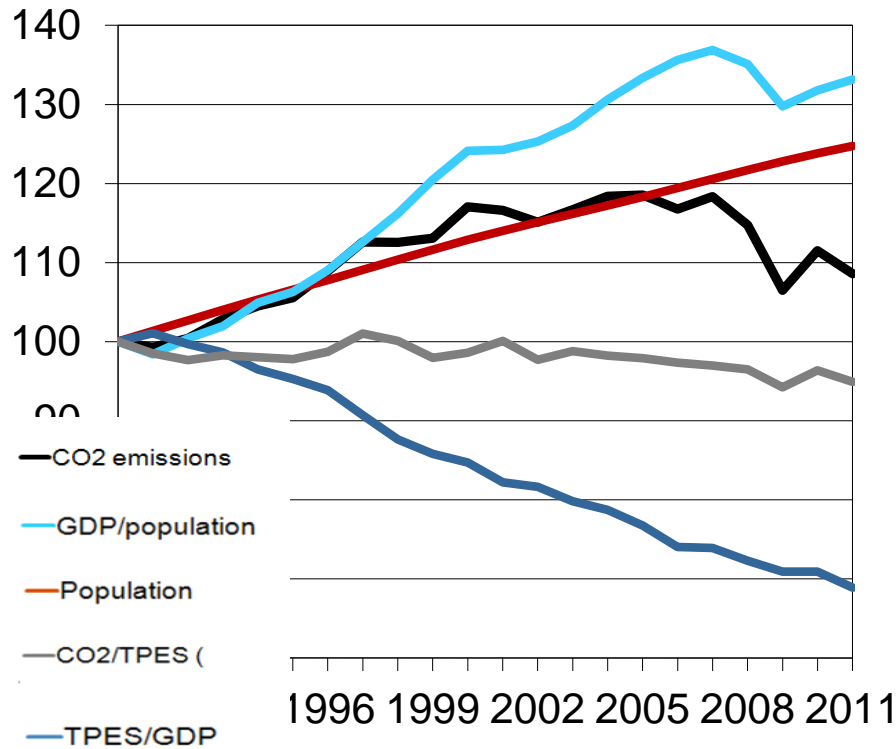
Population

Per capita GDP

Energy intensity of the economy

Carbon intensity of energy mix

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The importance of energy balances: bringing all pieces of information together

Emissions indicators: another good reason to develop a complete and accurate national energy balance