An study of the driving forces of CO_2 emissions in the member states of the European Union (EU-28)

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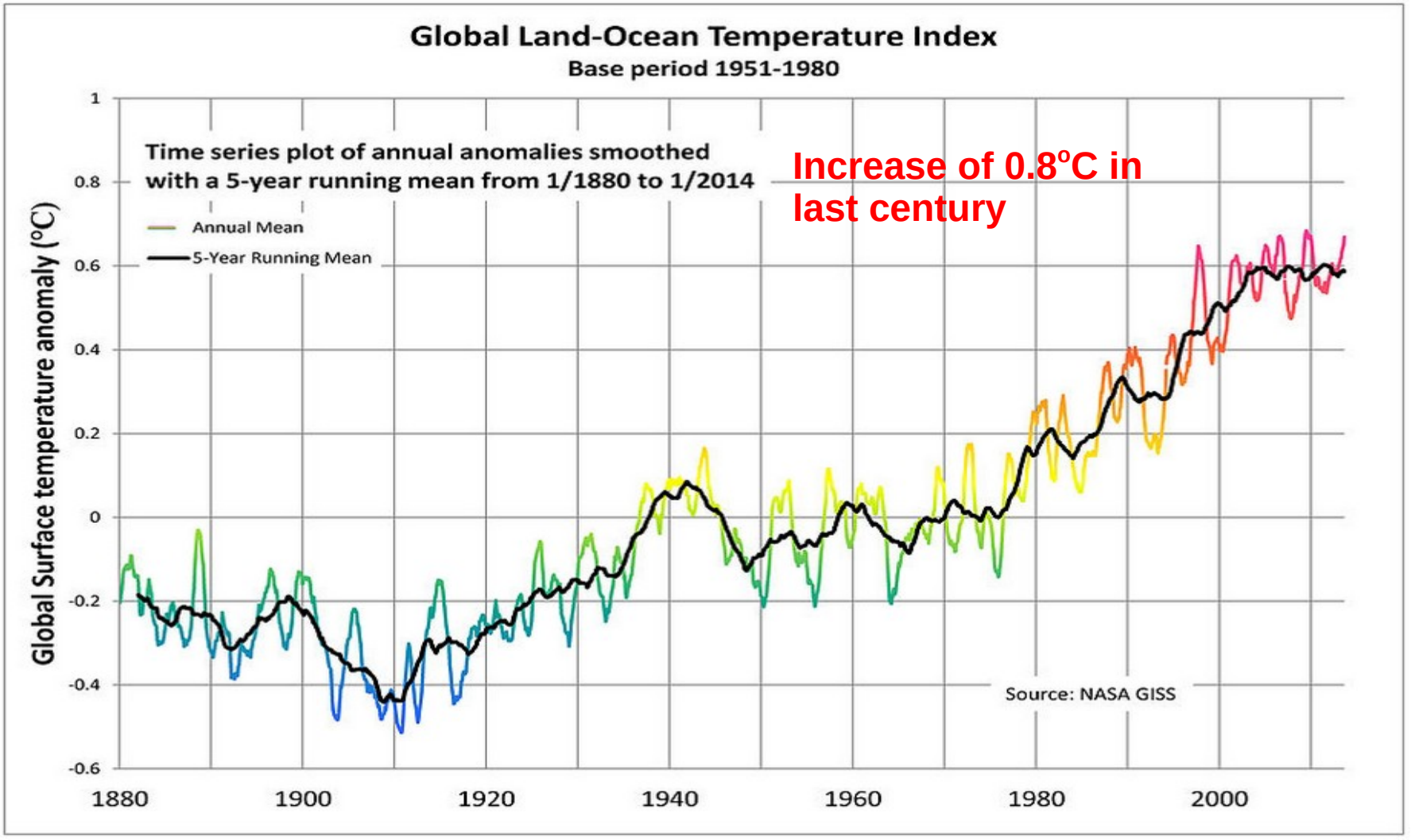
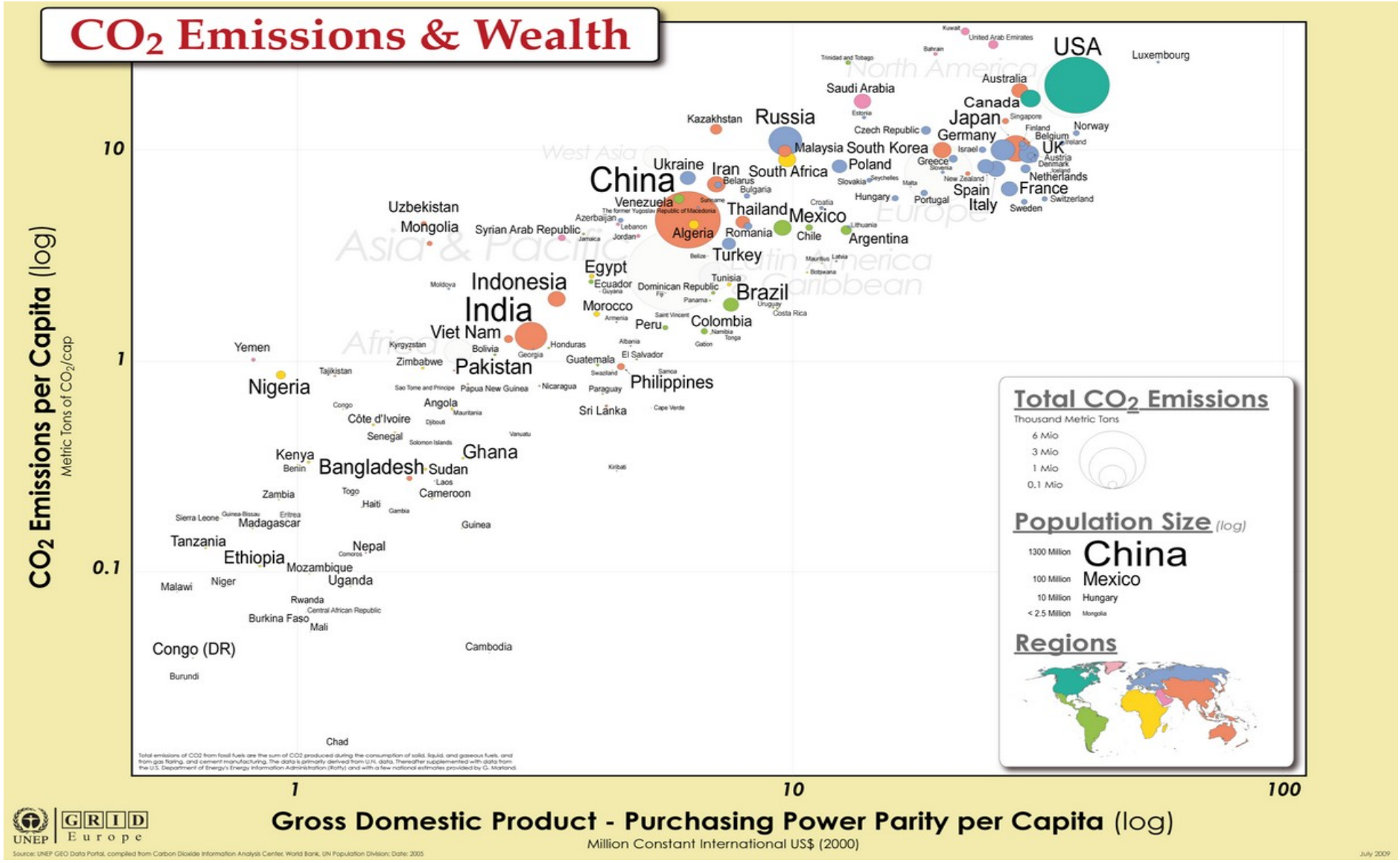
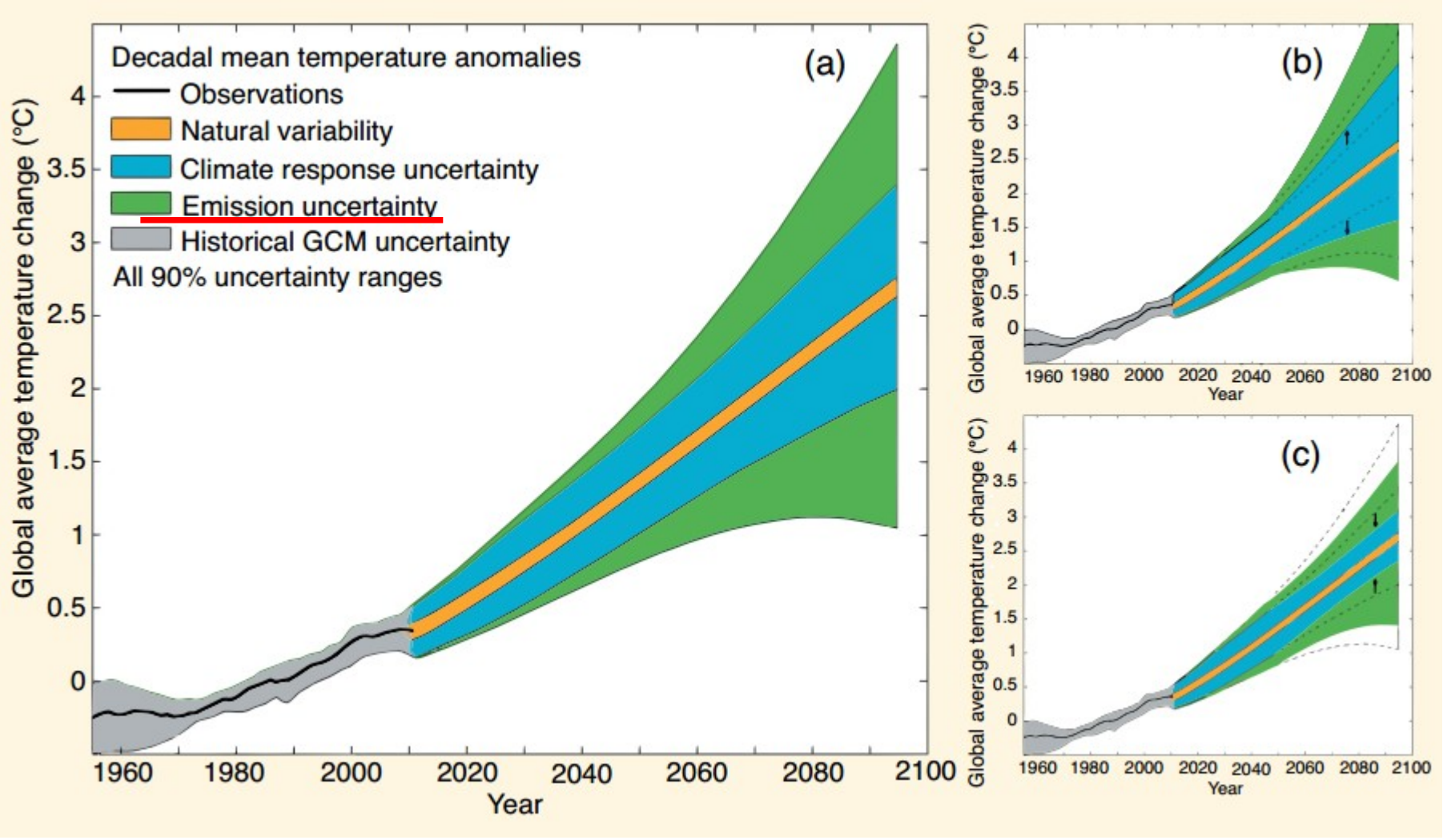
Global warming: a reality



CO_2 and GDP


CO2 Emissions & Wealth
CO2 Emissions per Capita (log)
Metric Tons of CO2/cap
10
1
0.1
1
10
100
Gross Domestic Product - Purchasing Power Parity per Capita (log)
Million Constant International US$ (2000)
USA
Luxembourg
Australia
Saudi Arabia
Canada
Japan
Russia
Kazakhstan
Germany
Norway
Malaysia
South Korea
UK
Ukraine
Iran
South Africa
Poland
China
Netherlands
Spain
France
Italy
Uzbekistan
Mongolia
Thailand
Mexico
Syrian Arab Republic
Algeria
Romania
Chile
Argentina
Turkey
Egypt
Indonesia
Brazil
India
Morocco
Colombia
Peru
Viet Nam
Pakistan
Philippines
Yemen
Nigeria
Zimbabwe
Guatemala
Sri Lanka
Angola
Côte d'Ivoire
Senegal
Kenya
Ghana
Bangladesh
Sudan
Cameroon
Zambia
Haiti
Madagascar
Guinea
Tanzania
Ethiopia
Nepal
Mozambique
Malawi
Niger
Uganda
Rwanda
Burkina Faso
Mali
Congo (DR)
Cambodia
Burundi
Chad
Total CO2 Emissions
Thousand Metric Tons
6 Mio
3 Mio
1 Mio
0.1 Mio
Population Size (log)
1300 Million
China
100 Million
Mexico
10 Million
Hungary
< 2.5 Million
Mongolia
Regions
UNEP
GRID Europe
Source: UNEP GEO Data Portal, compiled from Carbon Dioxide Information Analysis Center, World Bank, UN Population Division; Date: 2005
July 2009

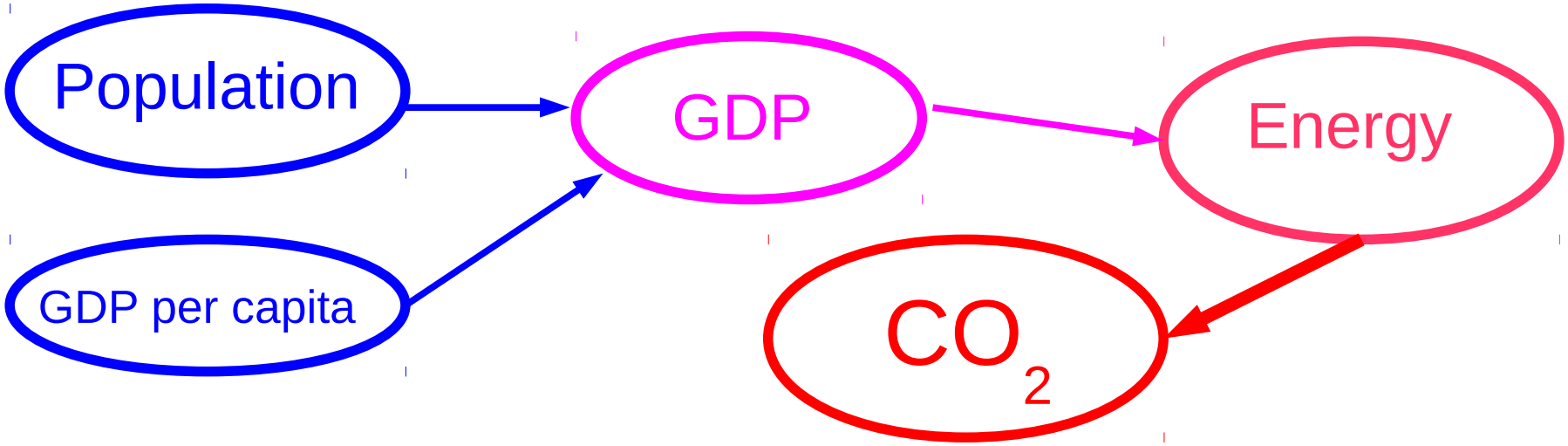
Uncertainties



From IPCC 5th Assessment Report: Climate Change 2013

CO_2 vs economic growth

- The gross domestic product (GDP) of a given country is directly connected with its population.
- The energy consumption of a given country is directly connected with its GDP.
- Greenhouse gas emissions of a given country, as CO2 and other contaminants, are directly related with its energy consumption.



Kaya identity

Definition

An equation that mathematically relates the factors that determine the level of human impact on climate. It was developed by Japanese energy economist Yoichi Kaya in his book Environment, Energy, and Economy: strategies for sustainability.

From The Dictionary of the Climate Debate (DCD)
http://www.odlt.org/dcd/ballast/kaya_identity.html

Kaya identity

CO_2= Population x
GDP_pc x
Energy_intensity x
CO_2_intensity

Kaya identity

CO2= Population x
GDP_pc x
Energy_intensity x
CO2_intensity

CO2= Population x
GDP/Population x
Energy/GDP x
CO2/Energy

Kaya identity:

A real equation or just an educated guess?

- It can be seen as a trivial identity or a tautology: it's just saying C=C
- It is not a real equation because all the unknowns are really not known.
- It is a useful tool to design energy and environmental policies.
- The IPCC uses it to estimate emissions from fossil fuels.
- Once an scenario is defined it is very convenient for calculating CO_2 emissions.

The modified Kaya identity

$$C = \sum_i C_i = \sum_{ij} C_{ij} = \sum_{ij} P_i \frac{Q_i}{P_i} \frac{E_i}{Q_i} \frac{E_{ij}}{E_i} \frac{C_{ij}}{E_{ij}} = \sum_{ij} P_i \cdot G_i \cdot EI_i \cdot M_{ij} \cdot U_{ij}$$

i stands for country or region and *j* for kind of fuel

- Ci is the CO2 emission in country *i*
- Pi is the population in country *i*
- Qi is the total GDP of country *i*
- Gi is the GDP per capita in the country *i*
- Ei is the energy consumption in the country *i*
- Eij is the consumption of fuel j in the country *i*
- EIi in the energy intensity in the country *i*
- Mij is the energy matrix of country *i*
- Uij is the emission factor

The LMDI method

(*logarithmic mean divisia index*)

The LMDI allows to decompose the CO_2 emissions in terms of their driving forces, namely, population GDP per capita, energy intensity and energy mix (Ang B.W. and Choi K.-H., Energy Journal 18, 59-73, 1997).

Additive decomposition

$$\begin{aligned}\Delta C(t) &= C(t) - C(0) = \Delta C_{pop}(t) + \Delta C_{gdp}(t) \\ &+ \Delta C_{energ-int}(t) + \Delta C_{mix}(t) + \Delta C_{emission}(t)\end{aligned}$$

$$\Delta C_{pop}(t) = \sum_{ij} \frac{C_{ij}(t) - C_{ij}(0)}{\ln C_{ij}(t) - \ln C_{ij}(0)} \ln \frac{P(t)}{P(0)}$$

Multiplicative decomposition

$$D(t) = C(t)/C(0) = D_{pop}(t) \cdot D_{gdp}(t) \cdot D_{energ-int}(t) \cdot D_{mix}(t) \cdot D_{emission}(t)$$

$$D_{pop}(t) = \exp\left(\sum_{ij} \frac{\frac{C_{ij}(t)-C_{ij}(0)}{\ln C_{ij}(t)-\ln C_{ij}(0)}}{\frac{C(t)-C(0)}{\ln C(t)-\ln C(0)}} \ln \frac{P(t)}{P(0)} \right)$$

(I)NDC for the European Union

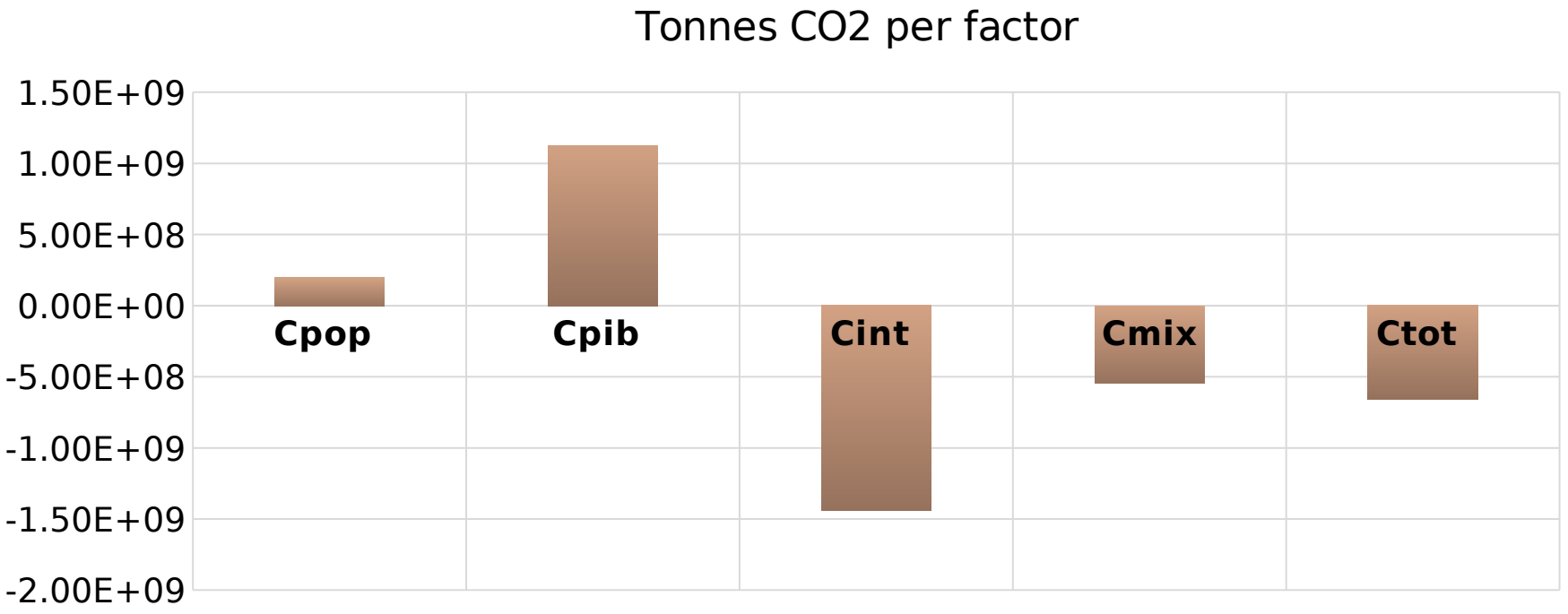
The EU and its 28 Member States are fully committed to the UNFCCC negotiating process with a view to adopting a global legally binding agreement applicable to all Parties at the Paris Conference in December 2015 in line with the below 2°C objective.

The EU and its Member States wish to communicate the following INDC. The EU and its Member States are committed to a **binding target of an at least 40% domestic reduction in greenhouse gas emissions by 2030 compared to 1990**, to be fulfilled jointly, as set out in the conclusions by the European Council of October 2014. In line with the Lima Call for

Results

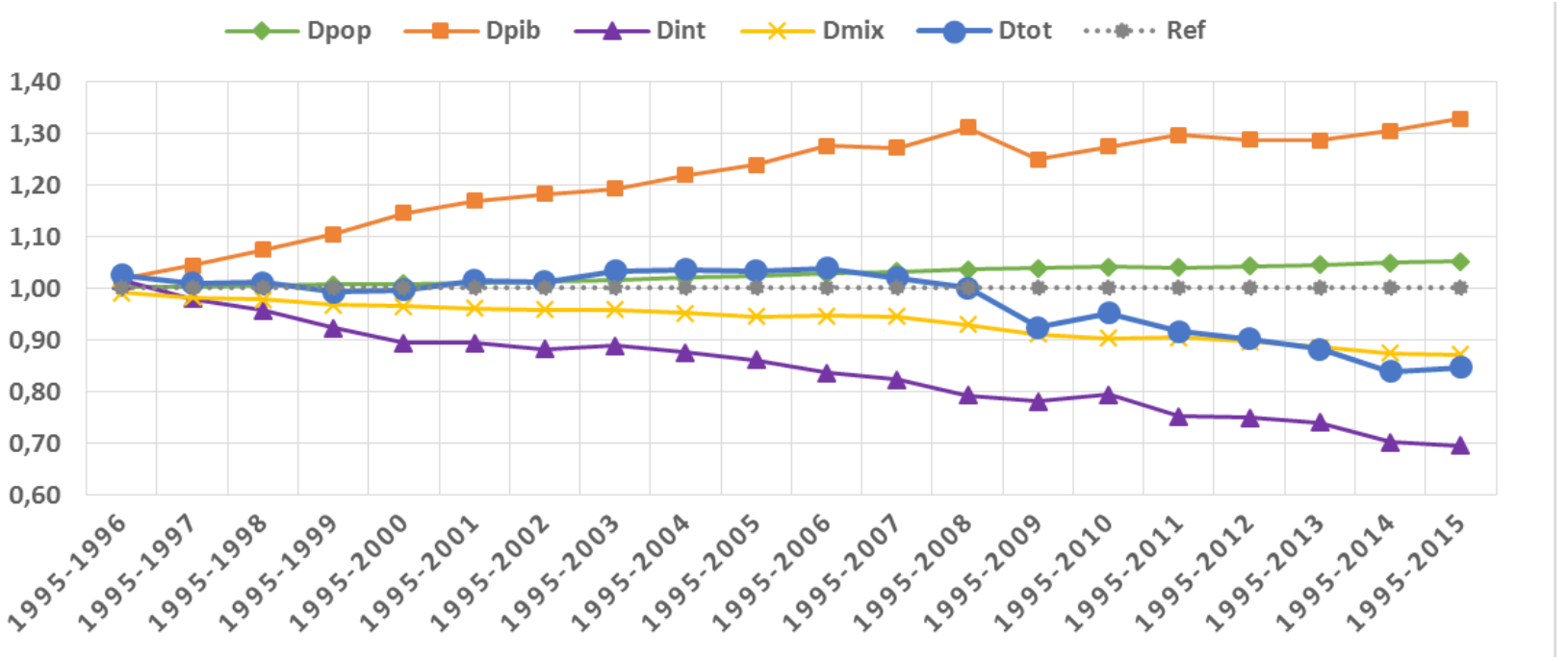
Global result 1995-2015 for the whole EU (additive decomposition)

Cpop	Cpib	Cint	Cmix	Ctot
2,02E+08	1,12E+09	-1,44E+09	-5,43E+08	-6,56E+08



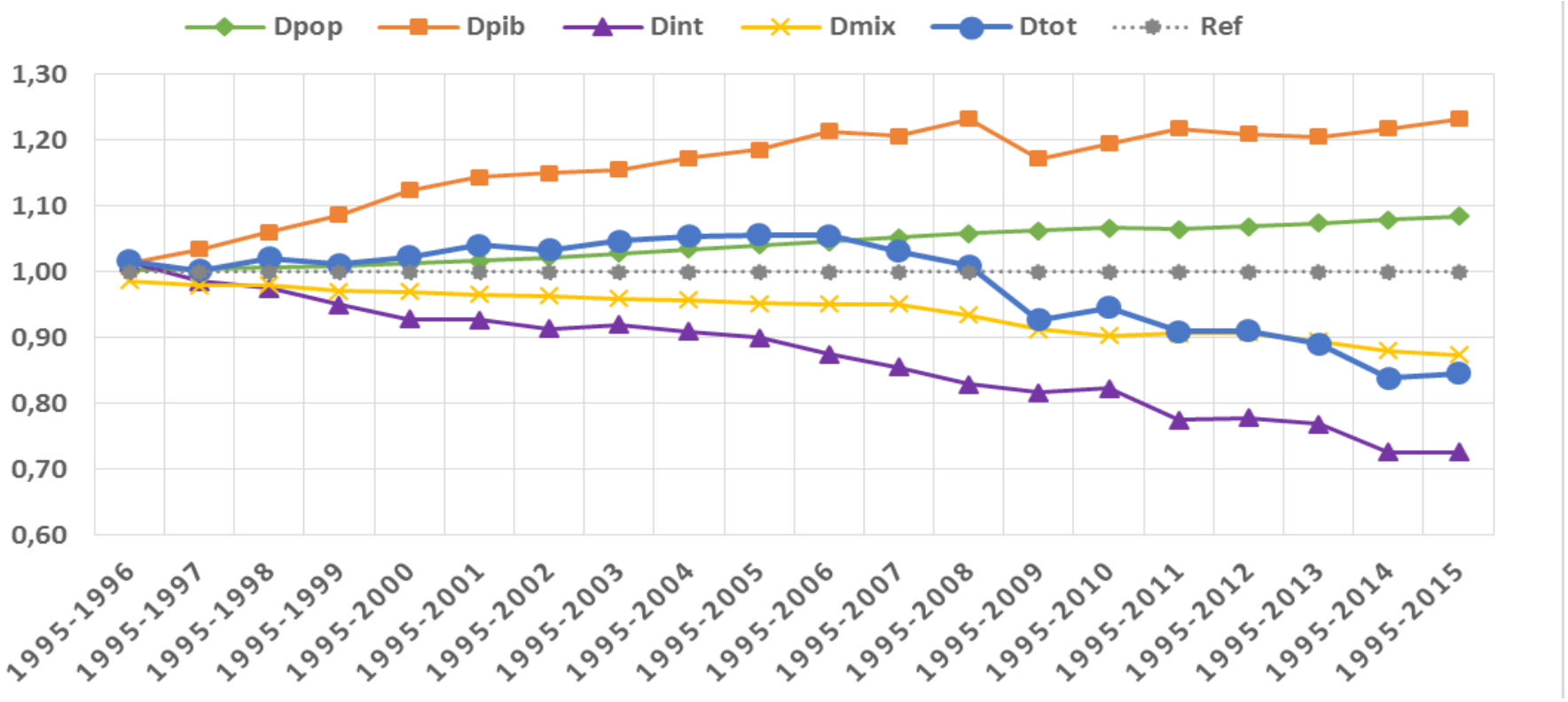
Results

Time series 1995 – 2015 for the **whole EU**
(multiplicative decomposition)



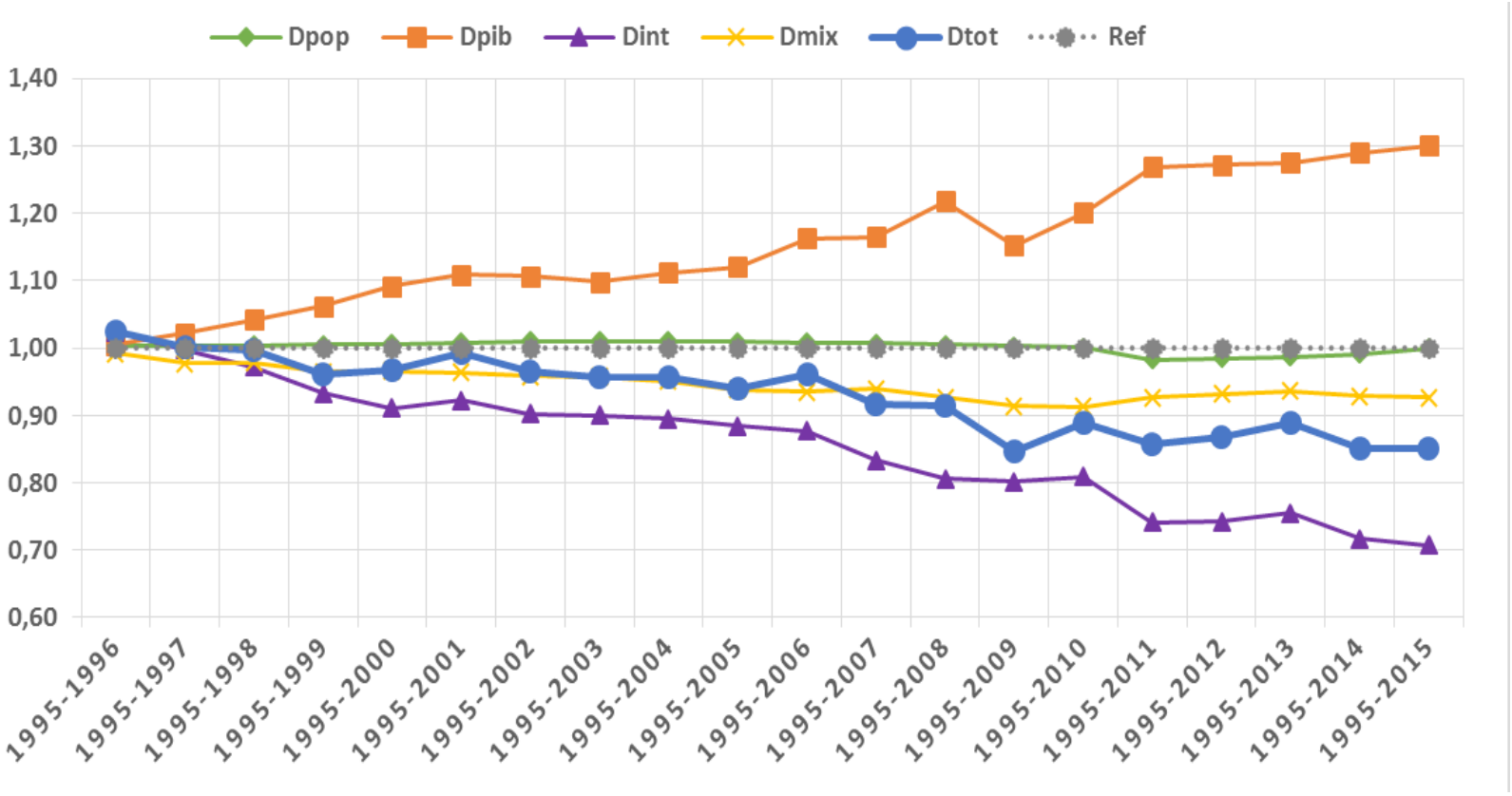
Results

Time series 1995 – 2015 for the **France, Germany, Italy, Spain and UK** (multiplicative decomposition)



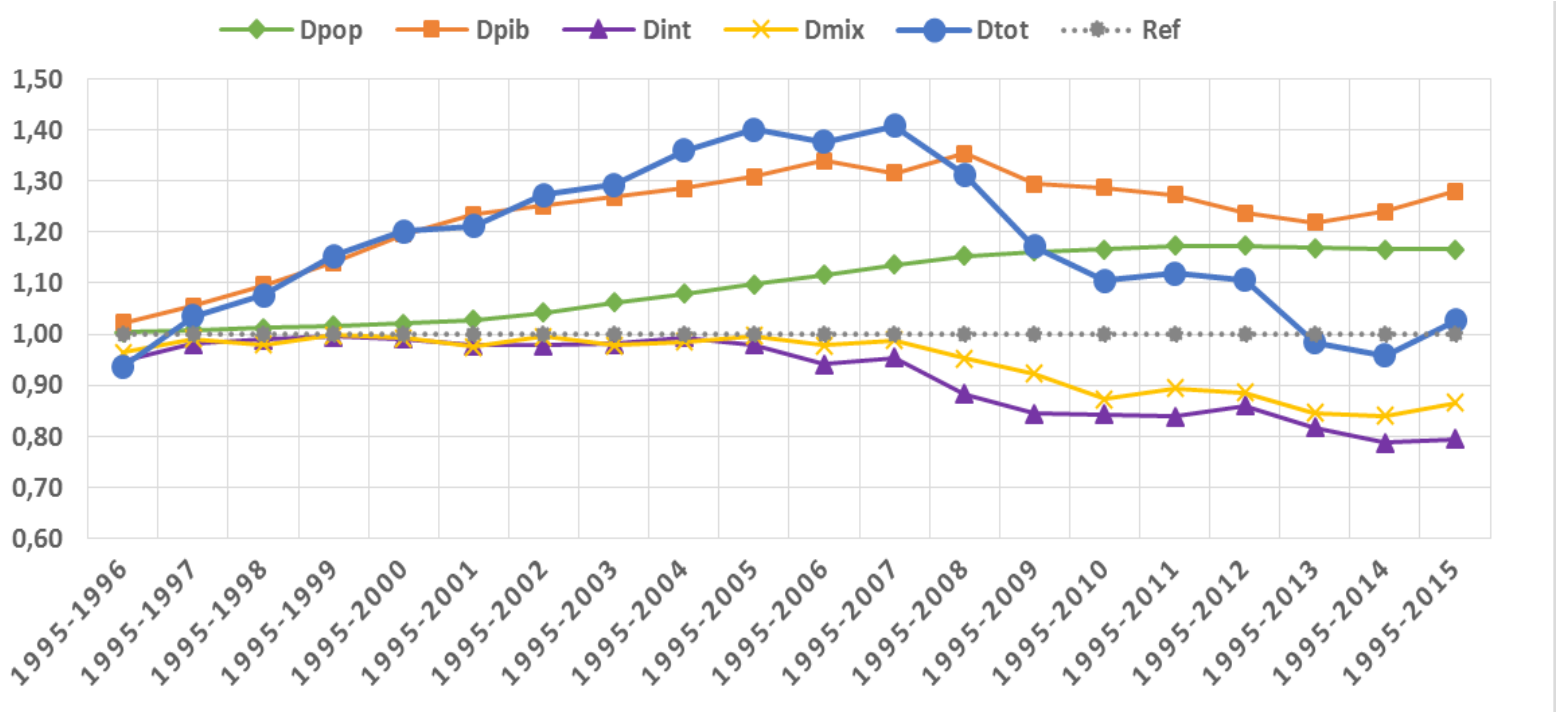
Results

Time series 1995 – 2015 for **Germany**
(multiplicative decomposition)



Results

Time series 1995 – 2015 for **Spain**
(multiplicative decomposition)



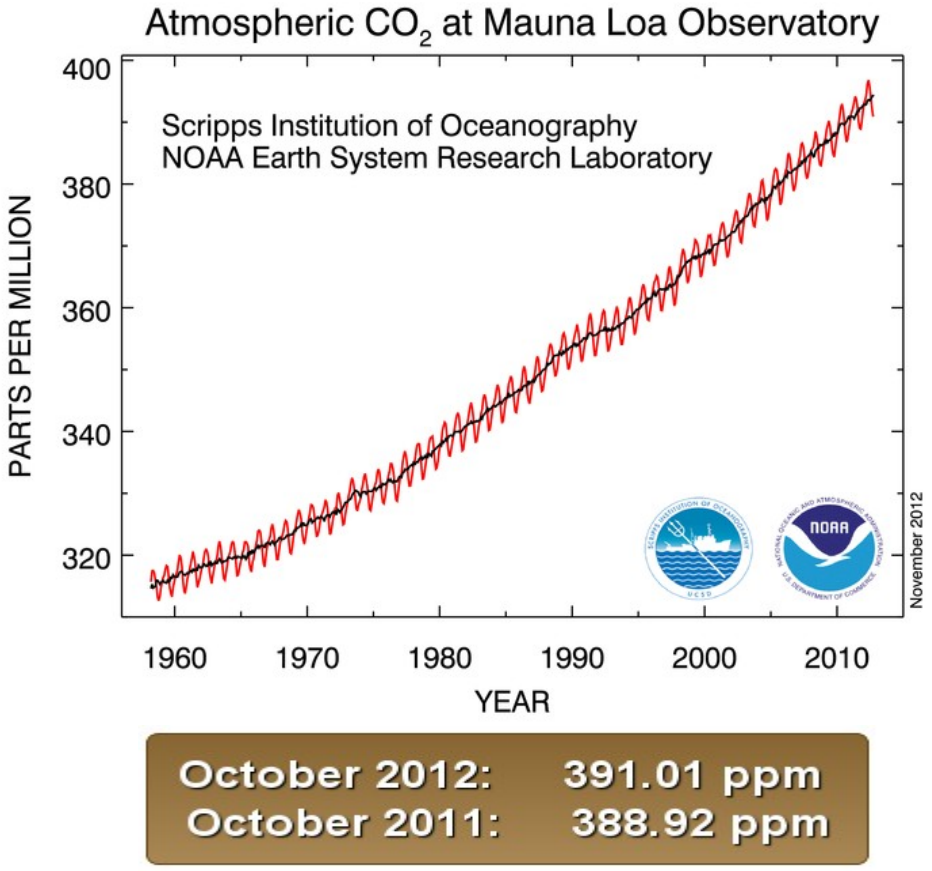
Summary and conclusions

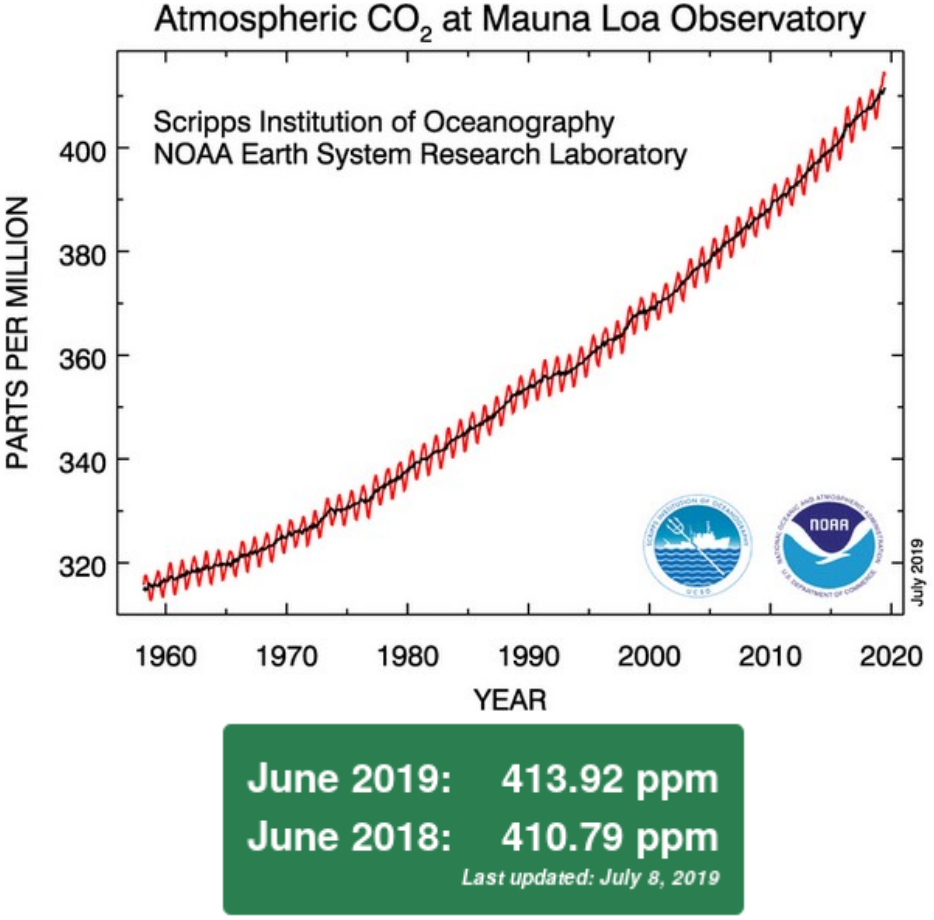
- There exists a direct relationship between Global Warming and economic activity, mediated through the use of energy.
- The time series for the period 1995-2015 for the 28 members of the EU have been studied (not shown here) as well as the evolution of several ensembles of countries.
- It as been qualitative shown how energy intensity and the use of renewable energies (energy matrix) are both key factors to mitigate CO_2 emissions.
- To fulfill the European NDC it is compulsory to carried out a stronger effort.
- This kind of analysis is expected to be useful for policymakers.

Gracias

Global warming: a reality

In 1958 Roger Revelle from Scripps Institution of Oceanography understood the importance of taking a global and continuum record of CO_2 concentrations





Source of data

WORLD BANK GROUP

http://data.worldbank.org/

International Energy Agency

Working together to ensure reliable, affordable and clean energy

http://www.iea.org/

ipcc

INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

http://www.ipcc.ch/

http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/8108.php

Eurostat

+ Local agencies and Central Banks