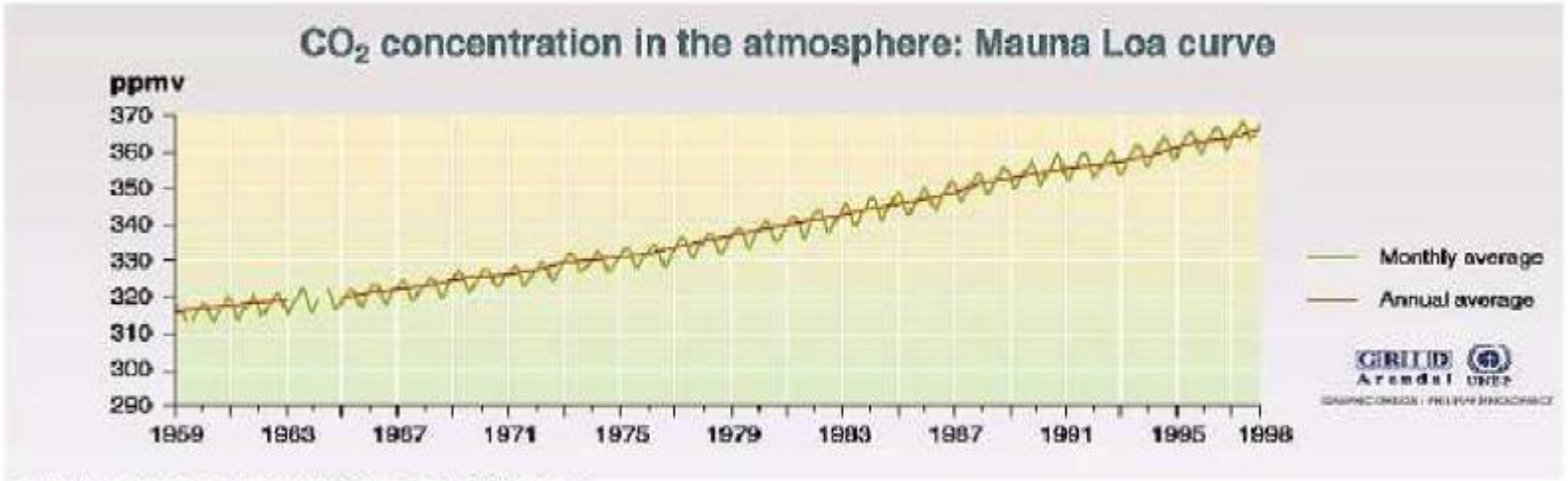
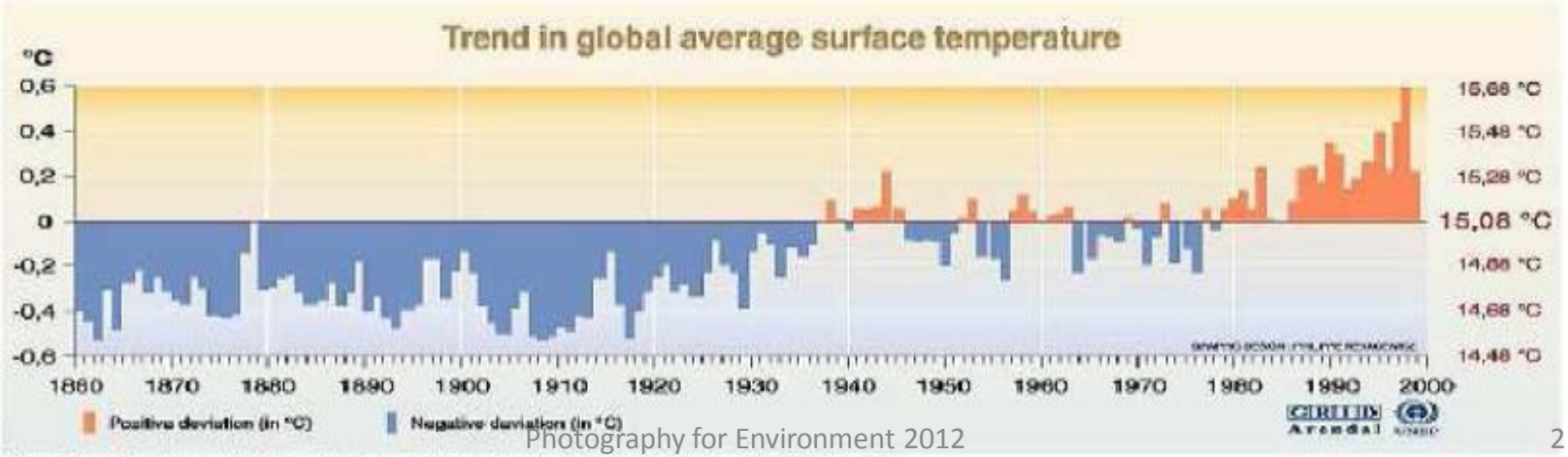
Outlook and initial statement on Renewable Energy Sources

The first problem: CO_2 concentration and temperature

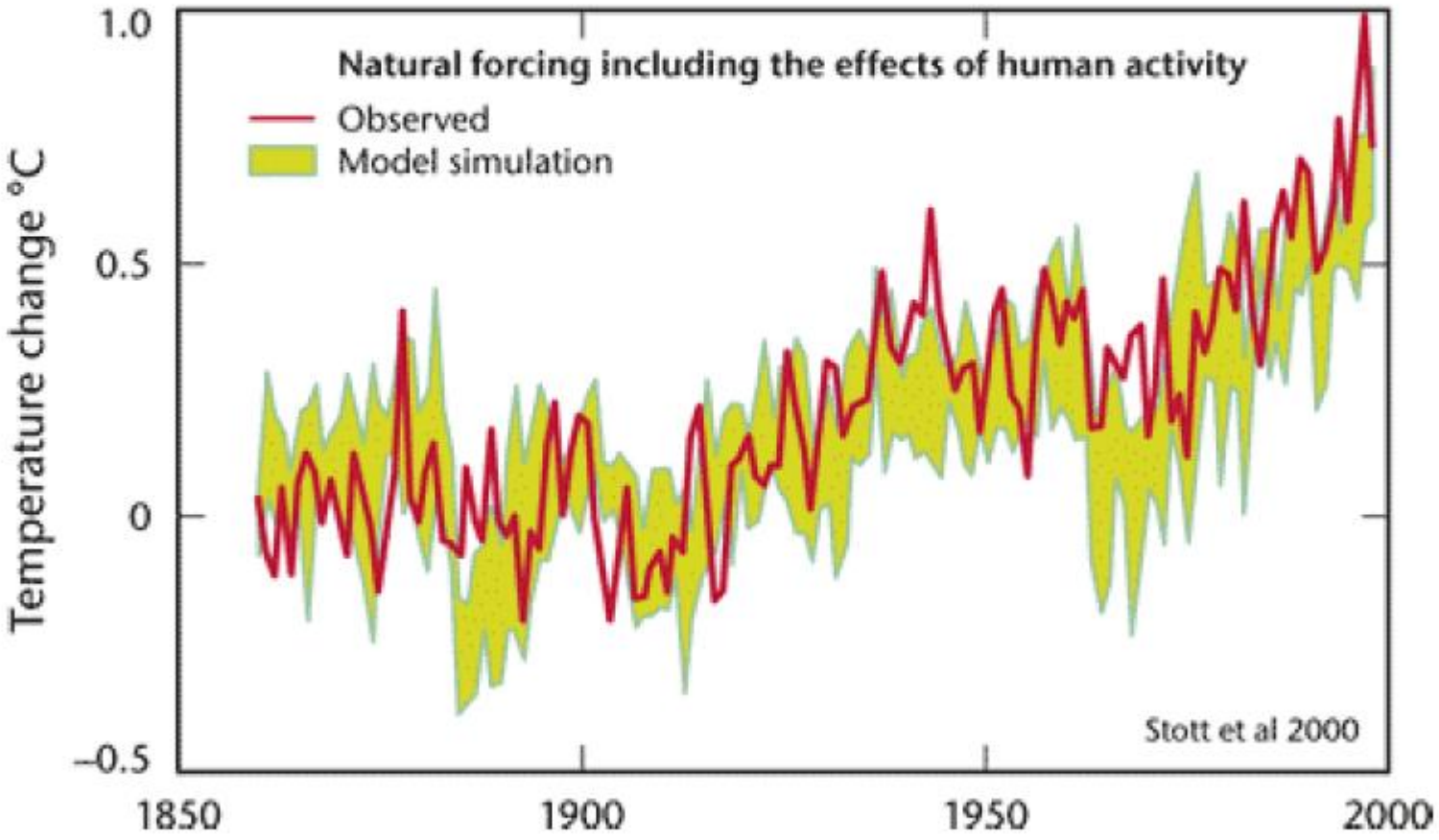


Source : Scripps Institution of oceanography (SIO), University of California, 1998



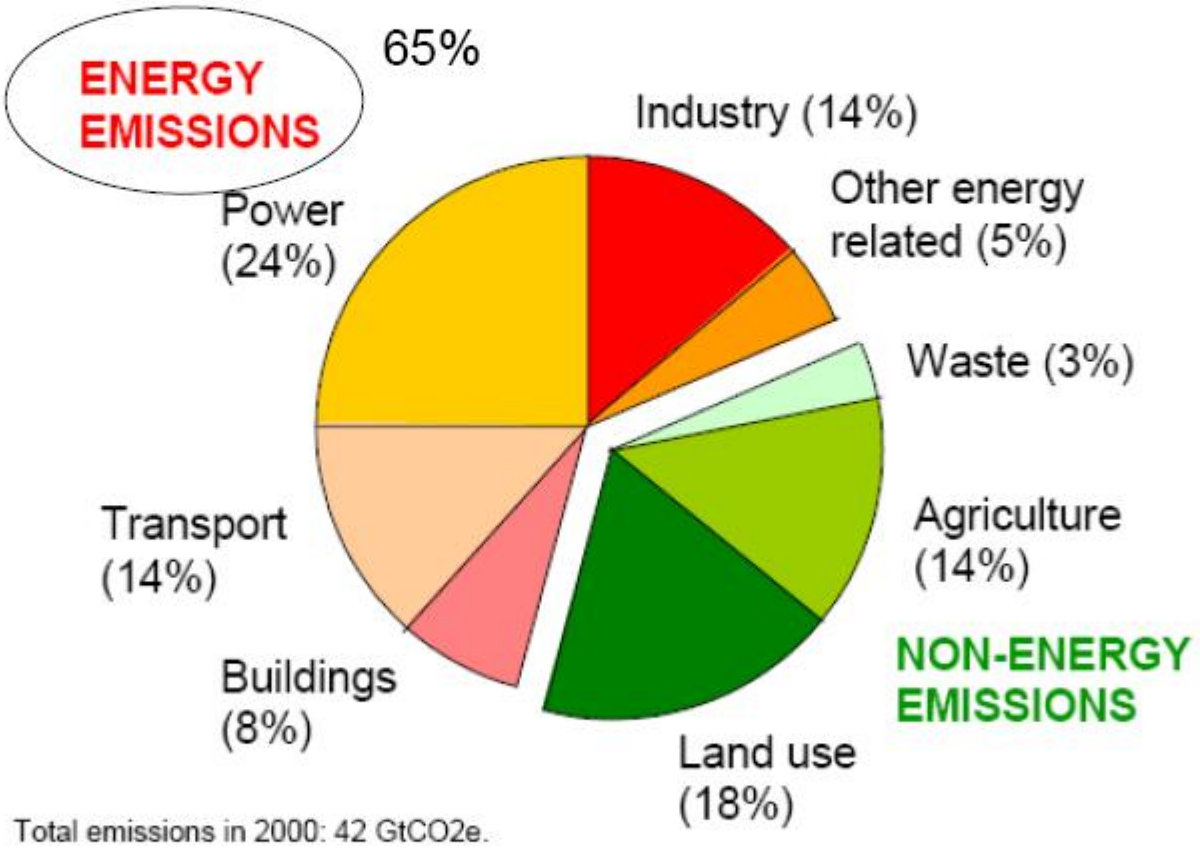
Source: School of environmental sciences, climatic research unit, university of East Anglia, Norwich, United Kingdom, 1999.

Climate simulation models



Source: IPCC 2007 - AR4 Technical Summary

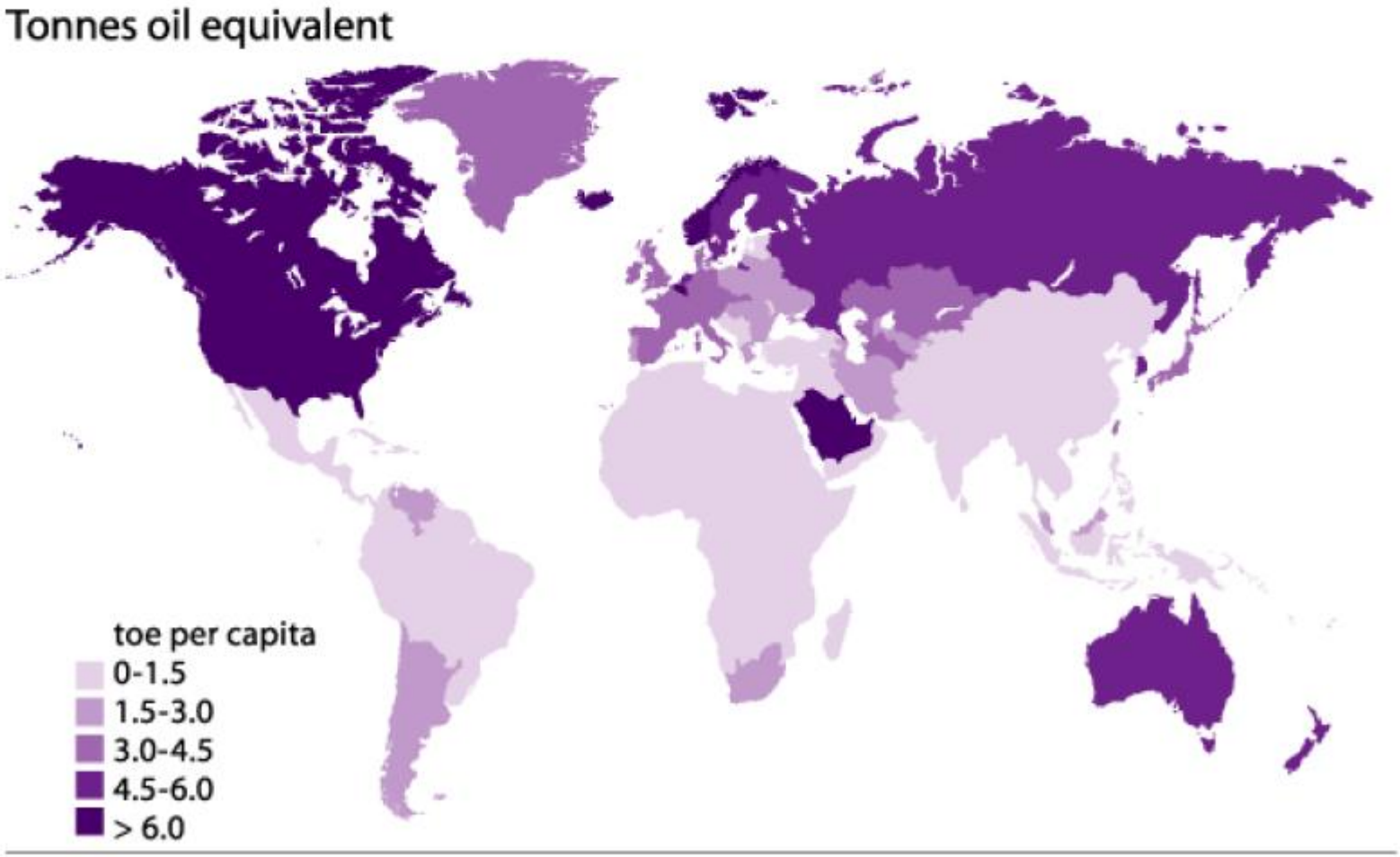
Greenhouse Gas (GHG) sources



Total emissions in 2000: 42 GtCO2e.

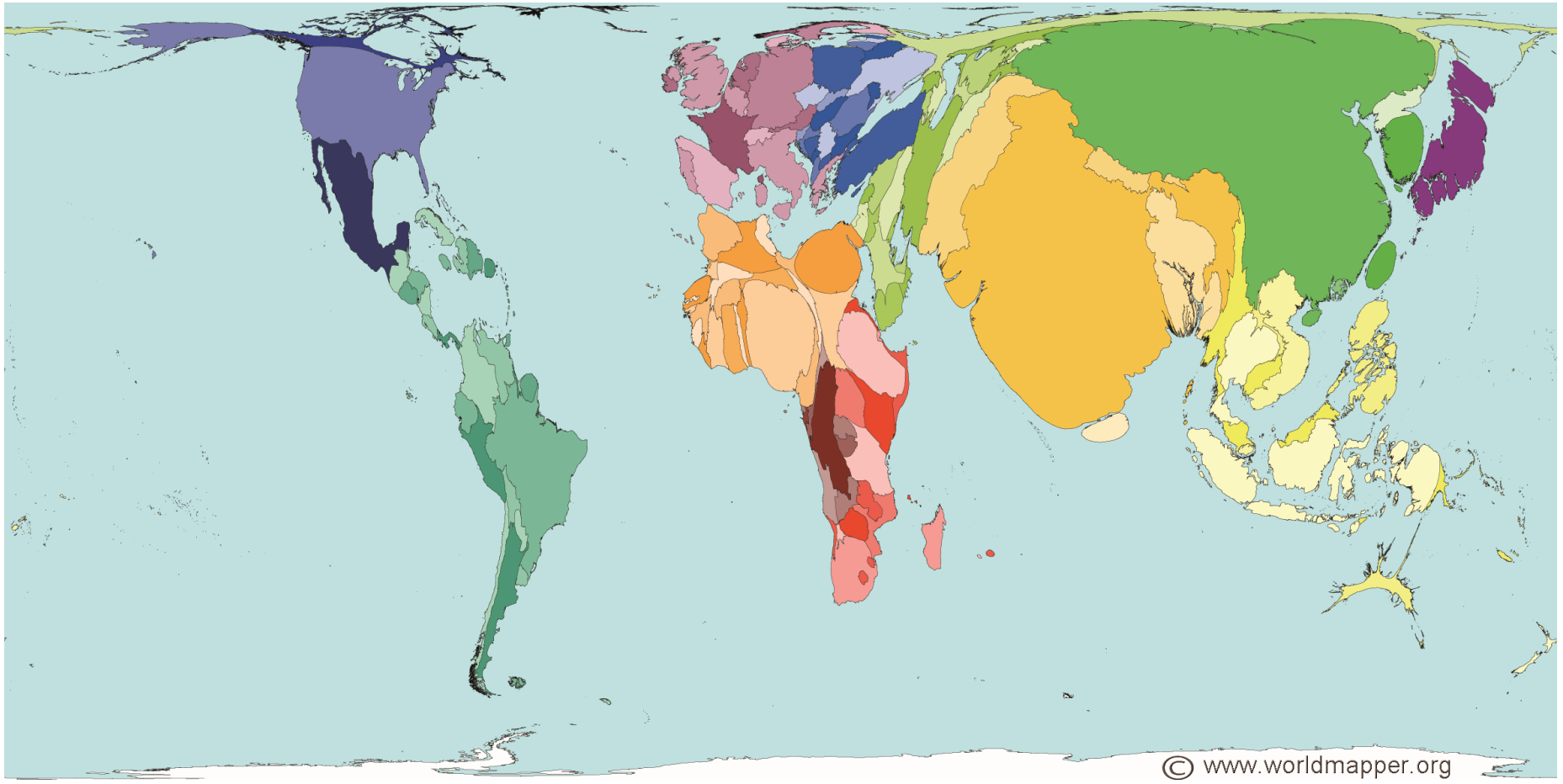
Energy emissions are mostly CO_2 (some non-CO_2 in industry and other energy related).
Non-energy emissions are CO_2 (land use) and non-CO_2 (agriculture and waste).

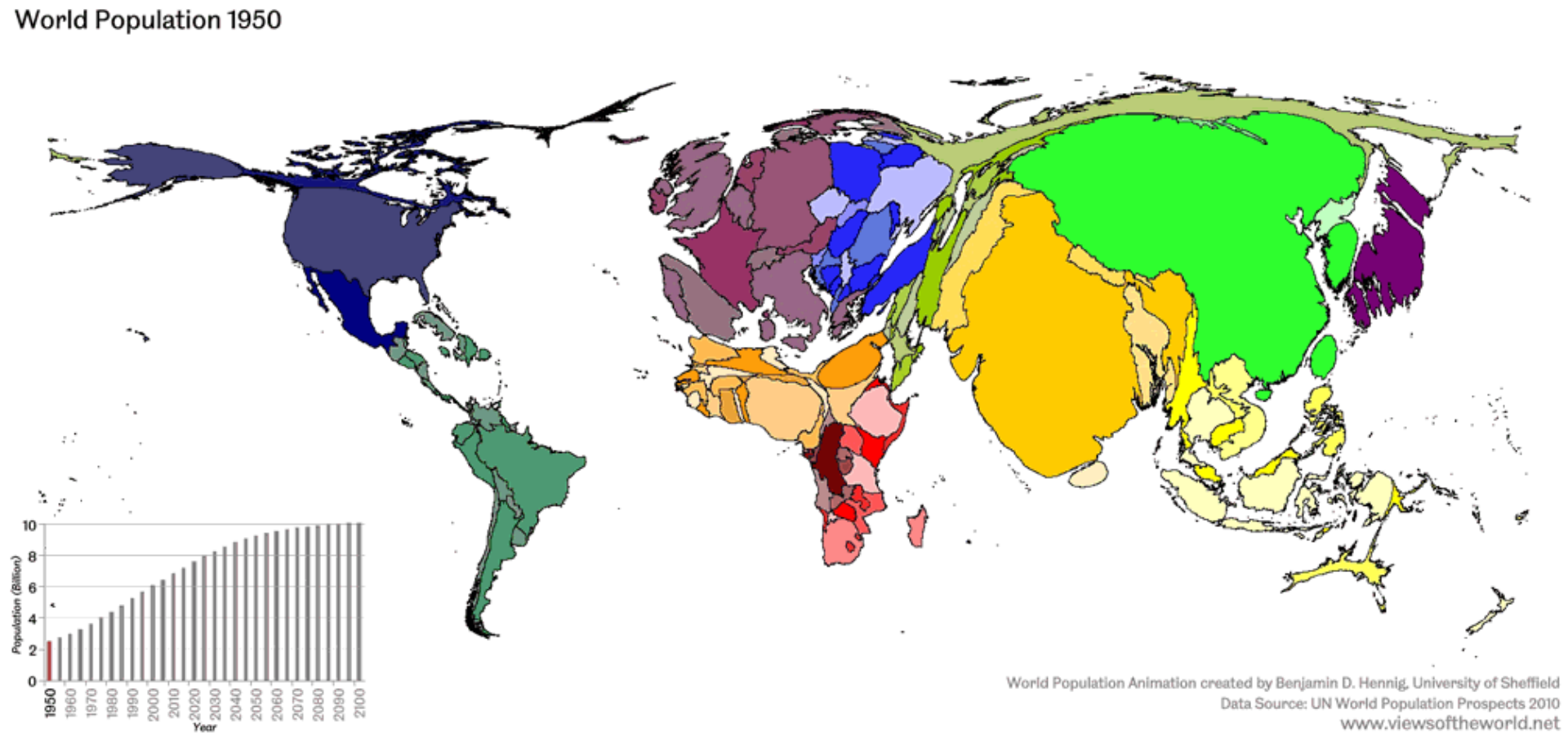
World – Per capita energy consumption



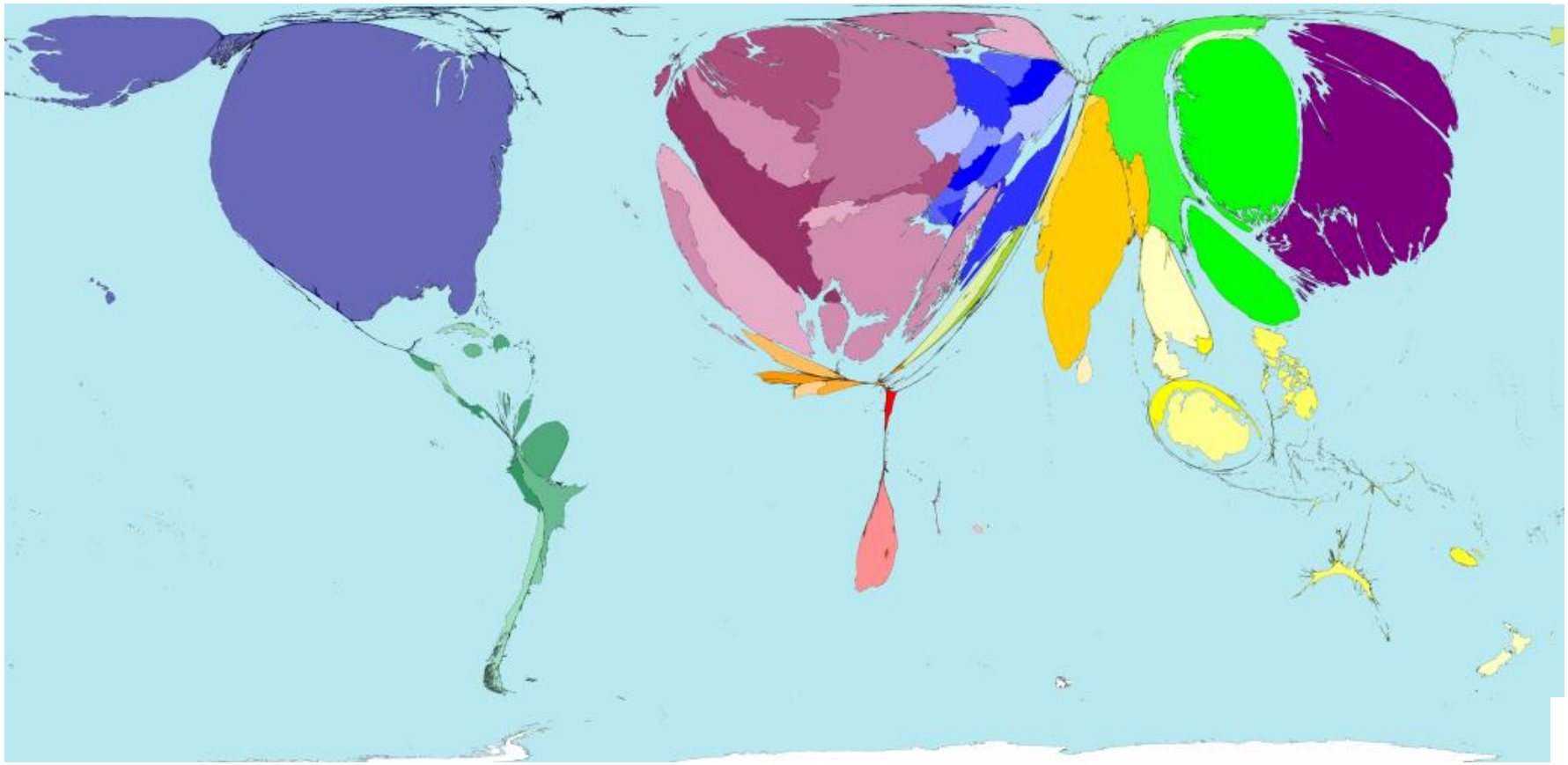
http://www.worldmapper.org/

Land area - Population 2010

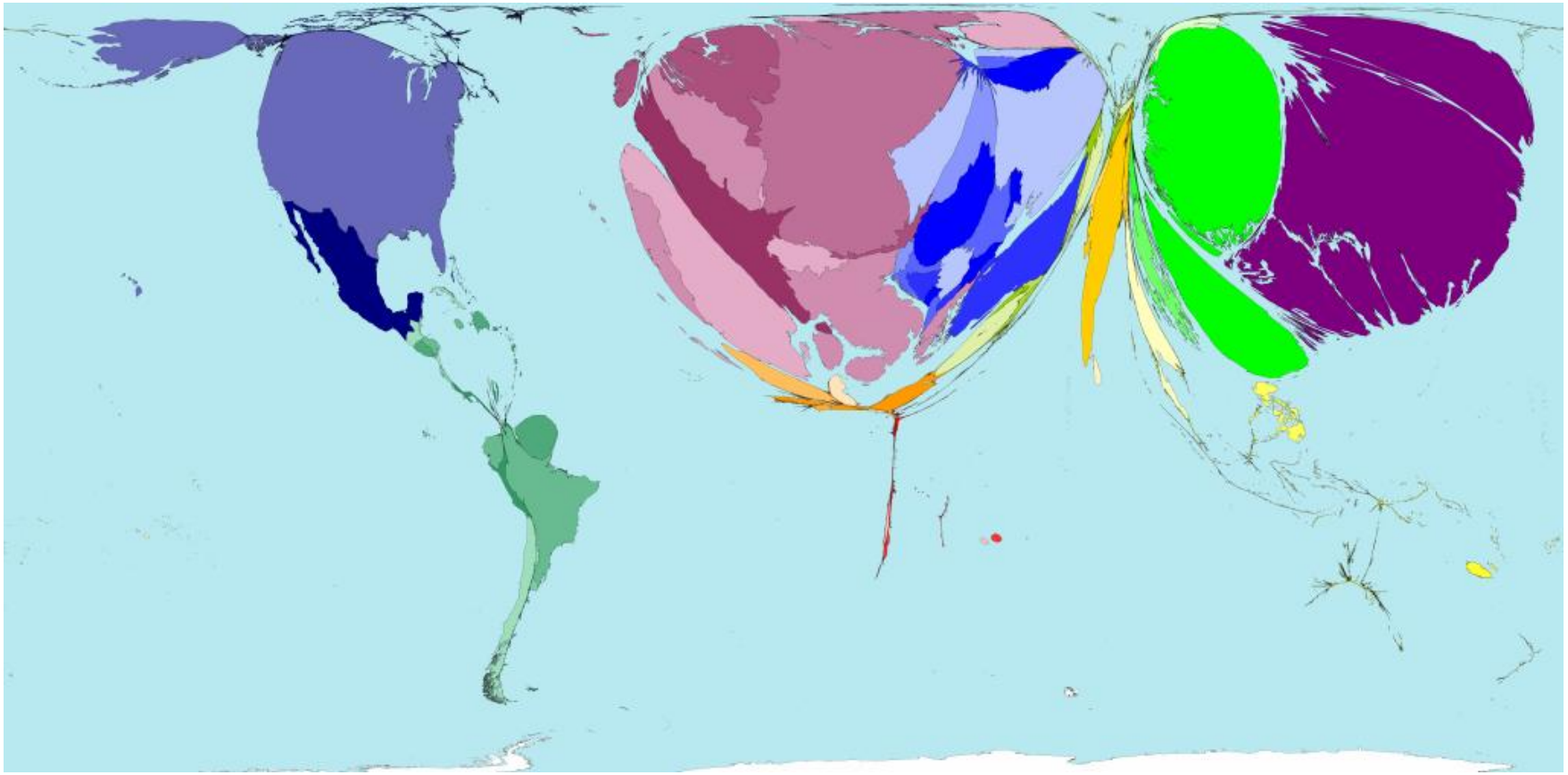



World Population 1950
Population (Billion)
0
2
4
6
8
10
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Year
World Population Animation created by Benjamin D. Hennig, University of Sheffield
Data Source: UN World Population Prospects 2010
www.viewsoftheworld.net

Crude Petroleum Exports - Imports



Gas And Coal Exports - Imports



MINISTRY OF OIL
وزارة النفط

….the perfect storm*

1. Global environmental aspects
2. Local pollution problems in urban areas
3. Progressive increase of energy demand by emerging economies (BRICS)**
4. Progressive depletion and cost increase of fossil energy sources

In a single word: old energy policies are *unsustainable*

* Bob Armstrong, vice President, MIT-Energy Initiative

** see Hans Rosling's speech in India
http://www.ted.com/talks/hans_rosling_asia_s_rise_how_and_when.html

A new energy policy is needed

1. Demand side management
2. Improving the efficiency of traditional energy conversion systems
3. Actions on users and incentives
4. Renewable Energy Sources

Main features of RES

- Perennial
- Non-polluting during conversion process
- Distributed
- Free energy

but..

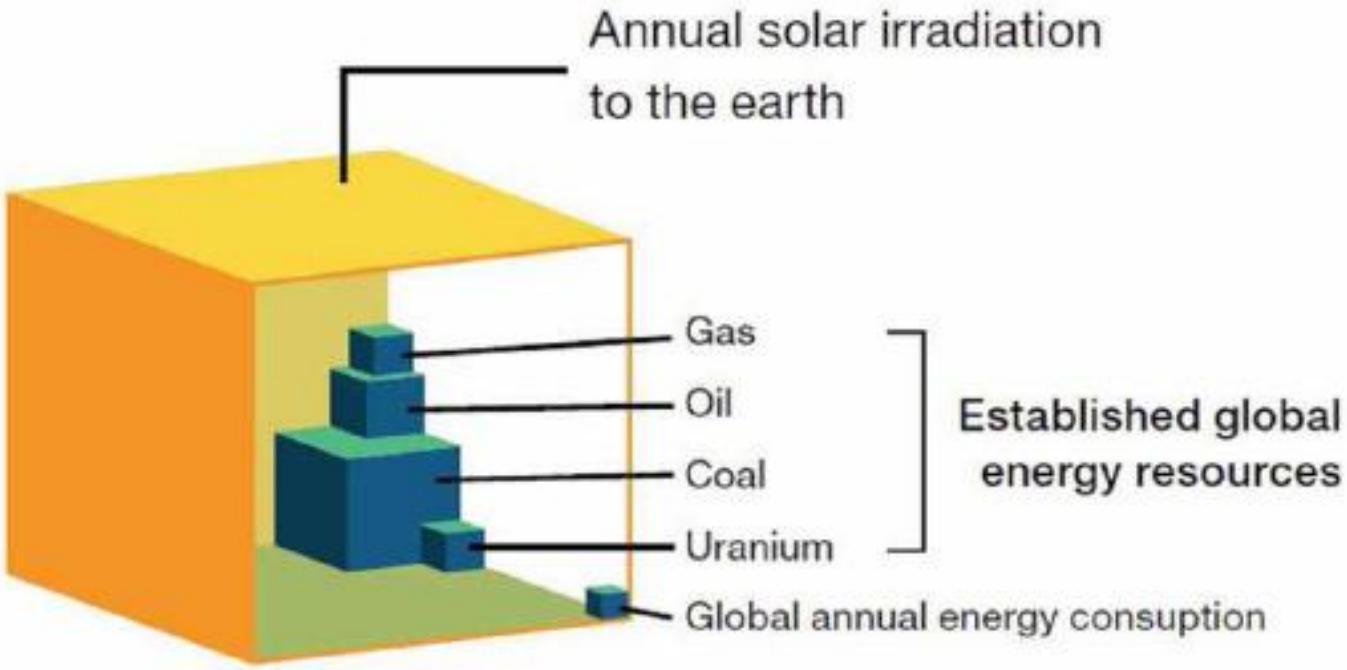
- Diluted
- Discontinuous
- Often unpredictable
- Costly installations

RES types

- **Solar Thermal**
- **Biomass**
- **Geothermal**
- **Solar PV**
- **Wind**
- *Tidal*
- *Waves*
- *Hydraulics*

Thermal

Electric


Annual solar irradiation
to the earth
Gas
Oil
Coal
Uranium
Established global
energy resources
Global annual energy consuption

INNOVATION

RES – Heat Production efficiencies - Overview

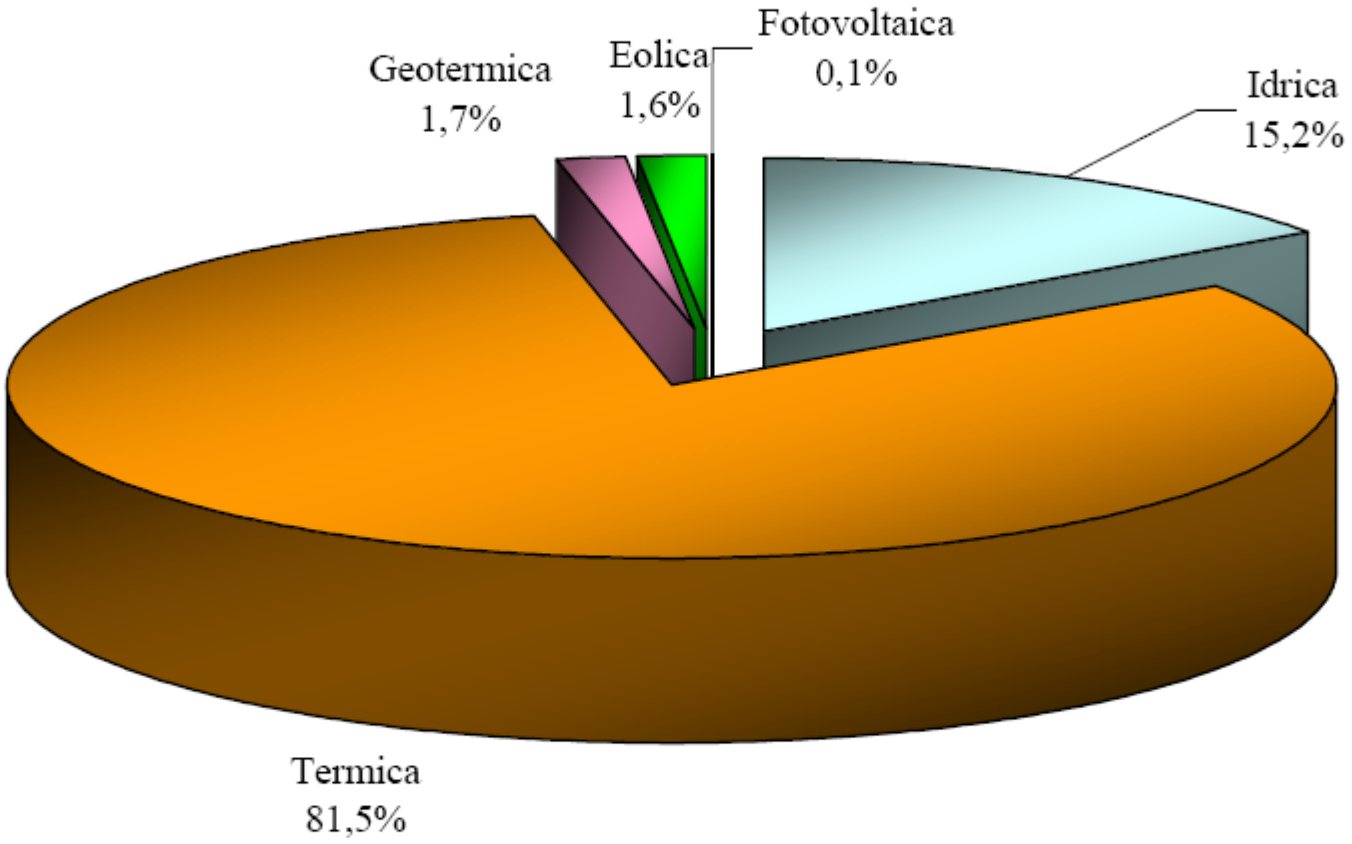
Source	**Thermal Use**	**η %**
Sun	Solar Collectors	40-60
Geothermal	Direct Indirect (through HP)	80-90 COP=4
Biomass, biogas	Boilers	85
Solid Urban Waste	Boilers	80

RES - Electricity Production efficiencies - Overview

Source	**Electrical converter**	**η %**
Sun	Photovoltaic (PV) Cells	8-18
Wind	Wind Turbines	30-50
Geothermal	Geothermal power stations	30-35
Hydraulic	Hydraulic Turbines	80-90
Biomass, biogas	Thermal Power Stations	30-40
Urban waste	Thermal Power Stations	30-40

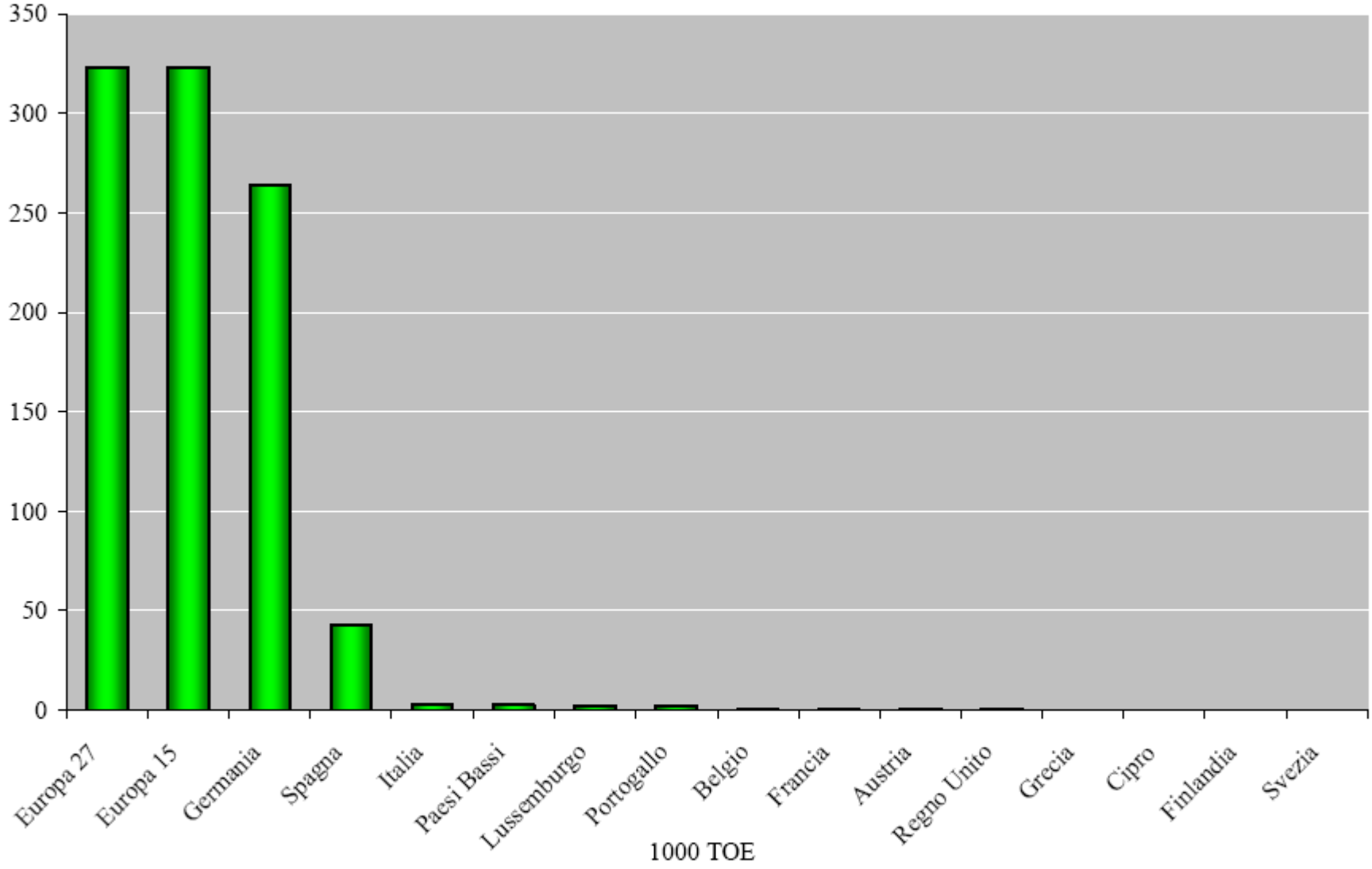
1. **Renewable sources originating from the Sun:**
   - Solar radiation (direct and diffused)
   - Hydraulic Energy
   - Wind
   - Biomass
   - Sea currents, waves
2. **Other renewable sources**
   - Geothermal energy (Earth endogenous heat)
   - Tides (Earth-Moon gravitational energy)
3. **"Practically unlimited" sources**
   - self-breeding nuclear fission
   - nuclear fusion
4. **Non-Renewable sources**
   - fossil fuels: coal, oil, natural gas
   - thermal nuclear fission

Produzione netta di energia elettrica in italia (2008)



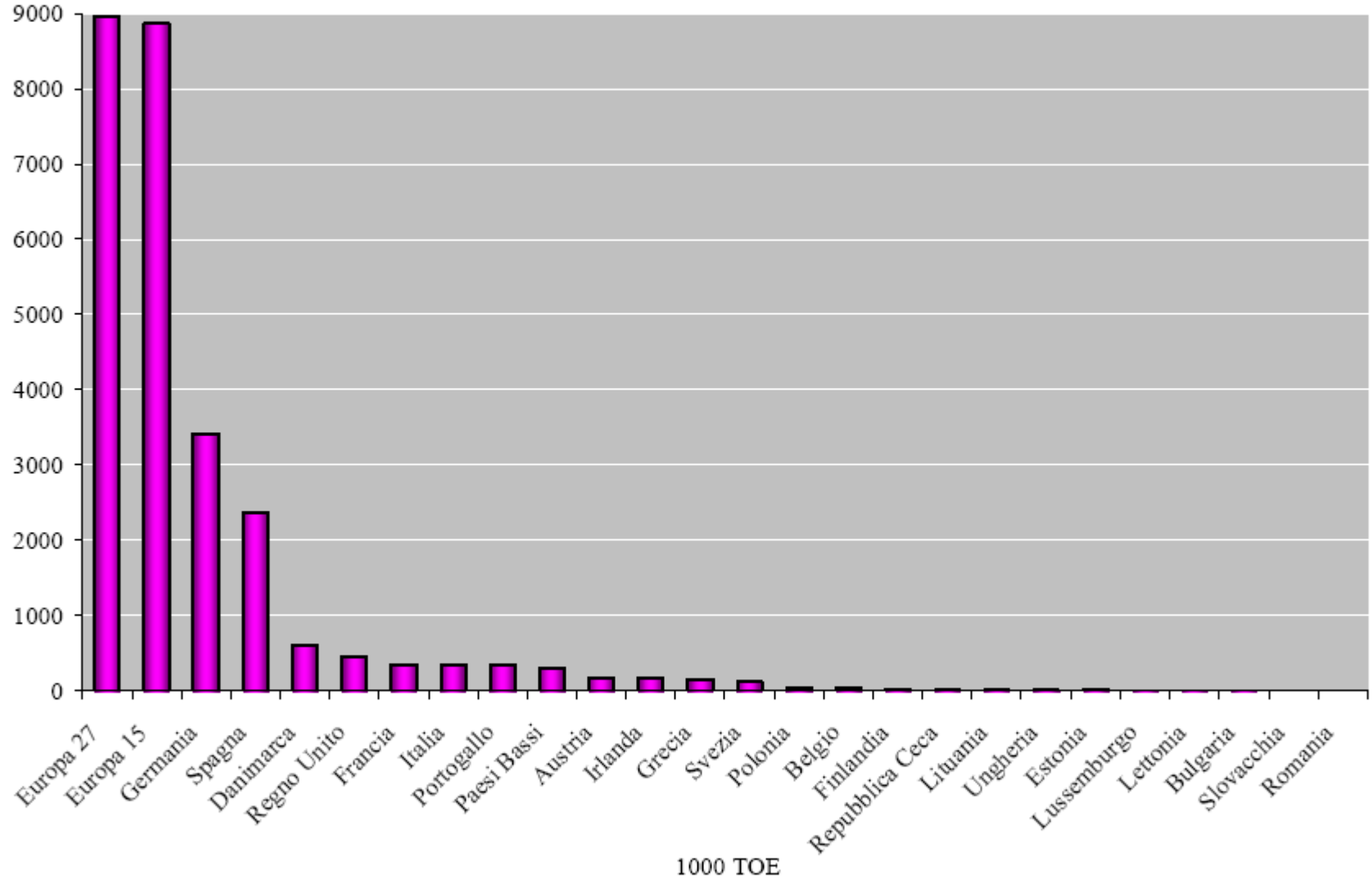
Fonte: Elaborazioni Rie su dati Terna

Consumi primari di energia fotovoltaica nei paesi UE (2007)



Fonte: Elaborazioni Rie su dati Eurostat

Consumi primari di energia eolica nei paesi UE (2007)



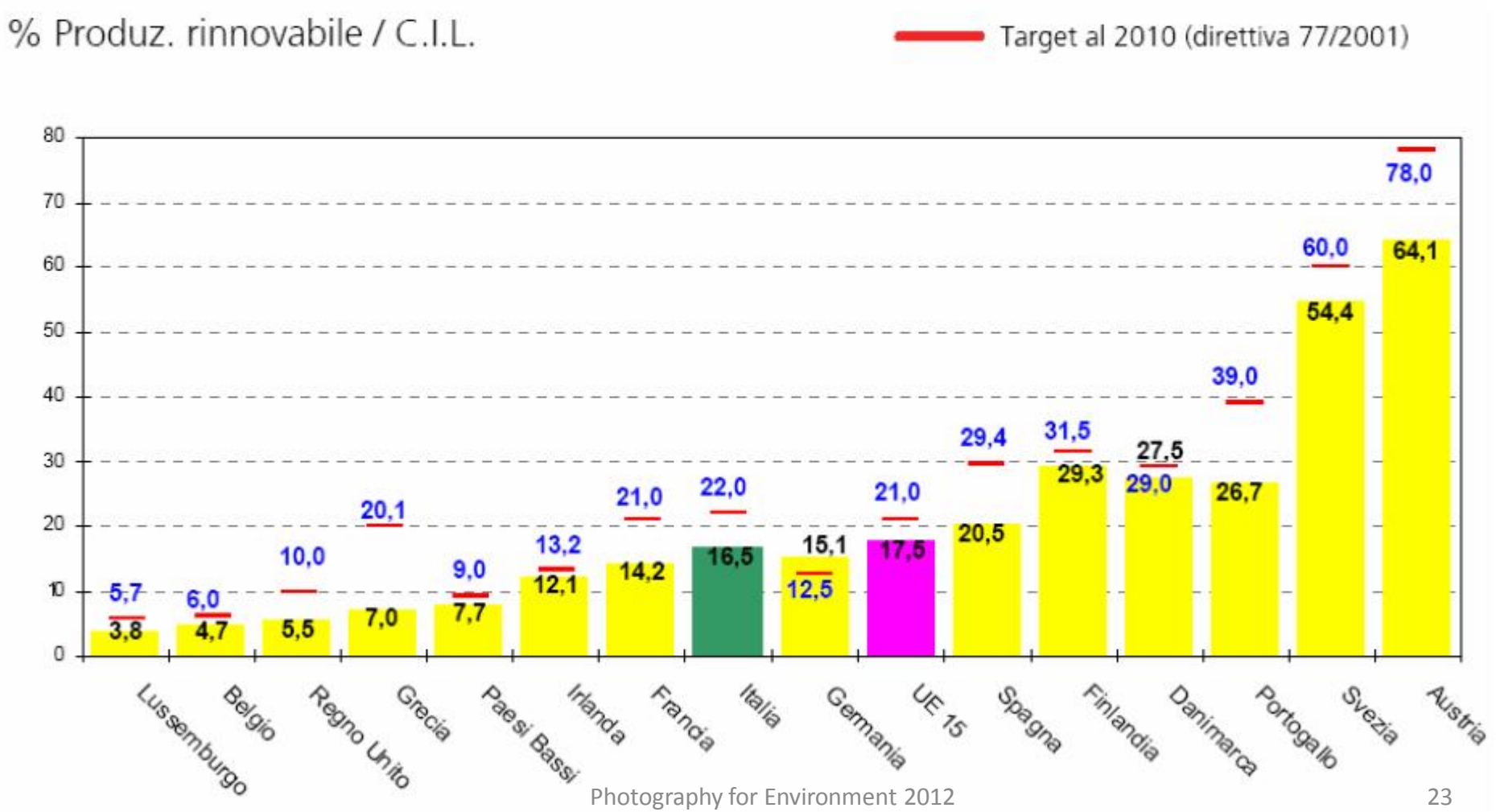
Fonte: Elaborazioni Rie su dati Eurostat

RES regional situation

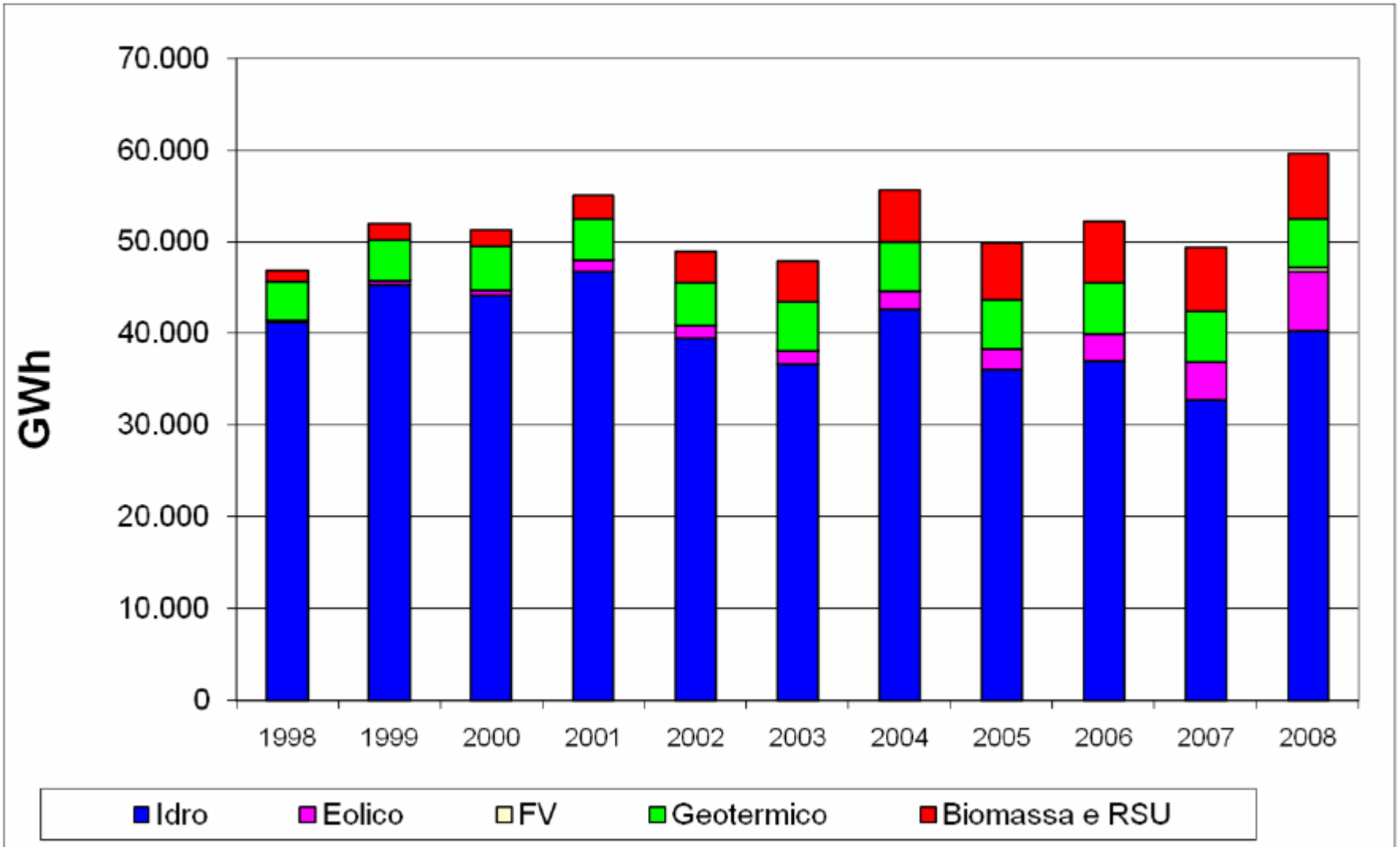
Installed capacity

produced Energy

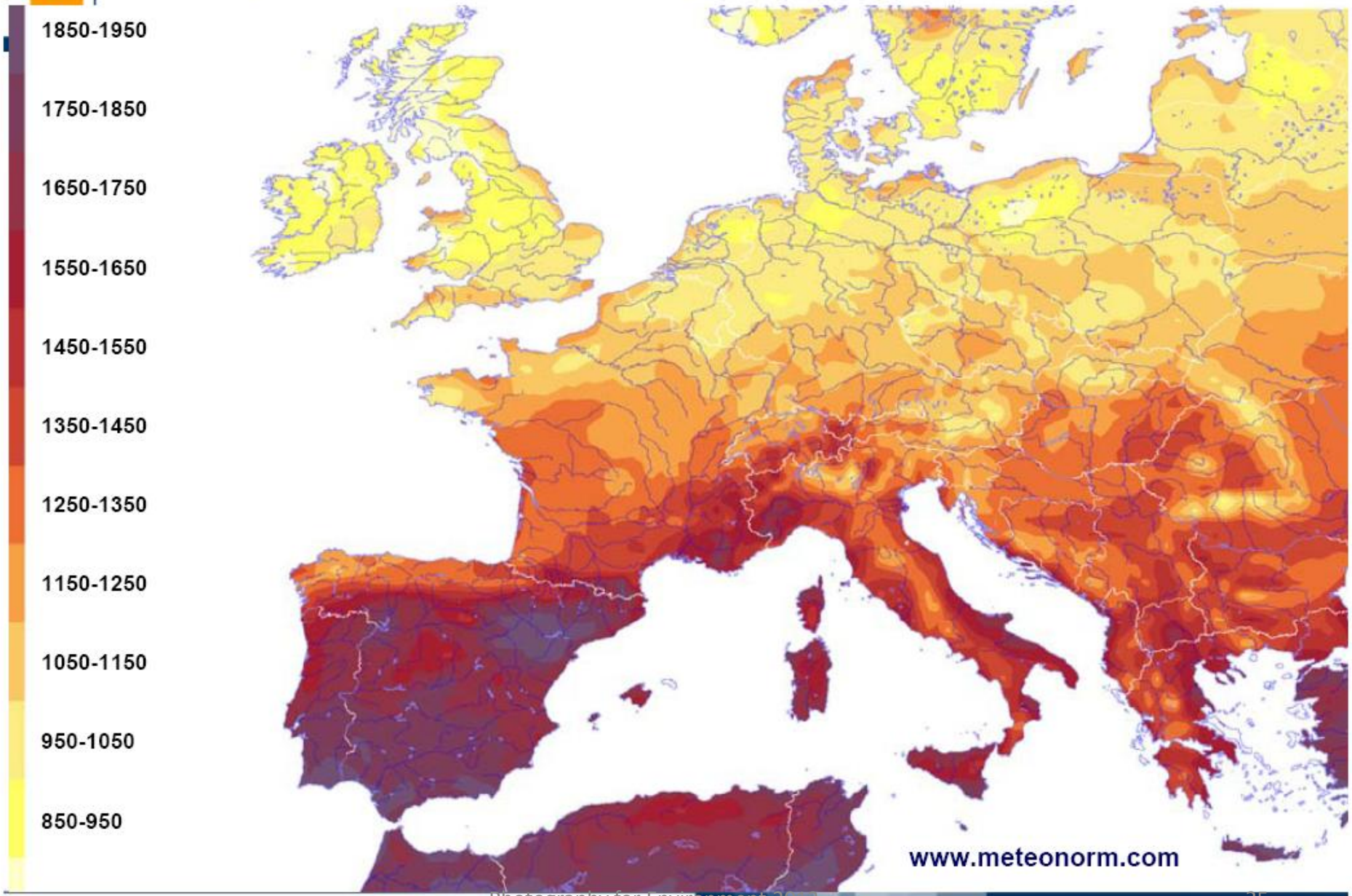
Obiettivo rinnovabili e status 2008



La produzione elettrica da fonti rinnovabili in Italia



Average insolation in Europe (kWh/m²)



Il FV in Italia (valori max)

Desertec

DESERTEC–EUMENA
Concentrating Solar Power
Hydro
Photovoltaics
Biomass
Wind
Geothermal
DESERTEC
CSP collector areas for electricity
World 2005
EU-25 2005
MENA 2005
TRANS-CSP Mix EUMENA 2050

Photo-Voltaic

FV INTEGRATO

BIPV (Building Integrated Photovoltaics)

Corso Duca degli Abruzzi, 24

novabili

Concentration PV

Solar Thermal

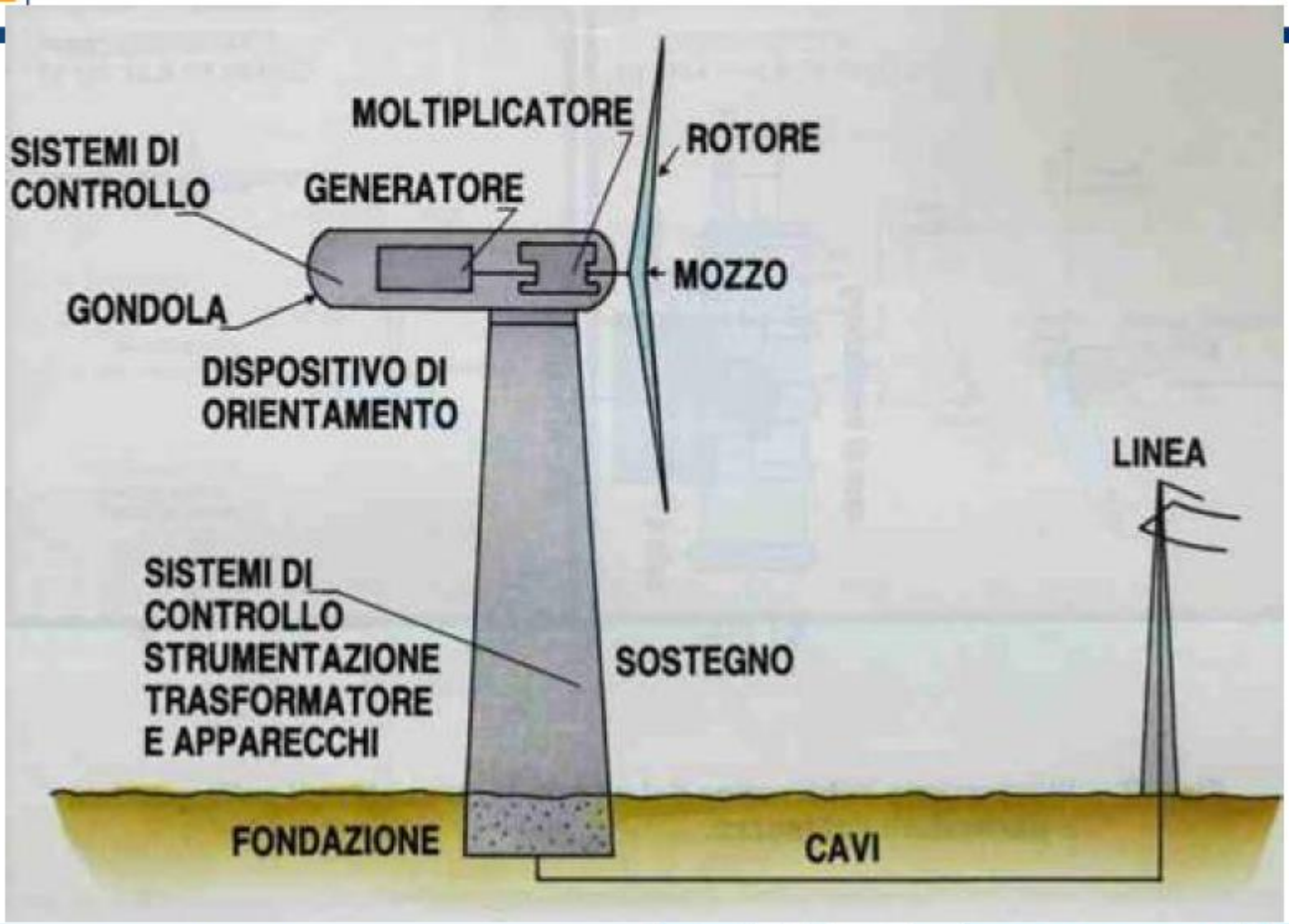
Solar Thermal

Plant at Kramer Junction (CA)

- Peak power 350 MW
- Temperature 380 °C
- Has been operating for 20 years
- Heat carrier is mineral oil

Wind Energy

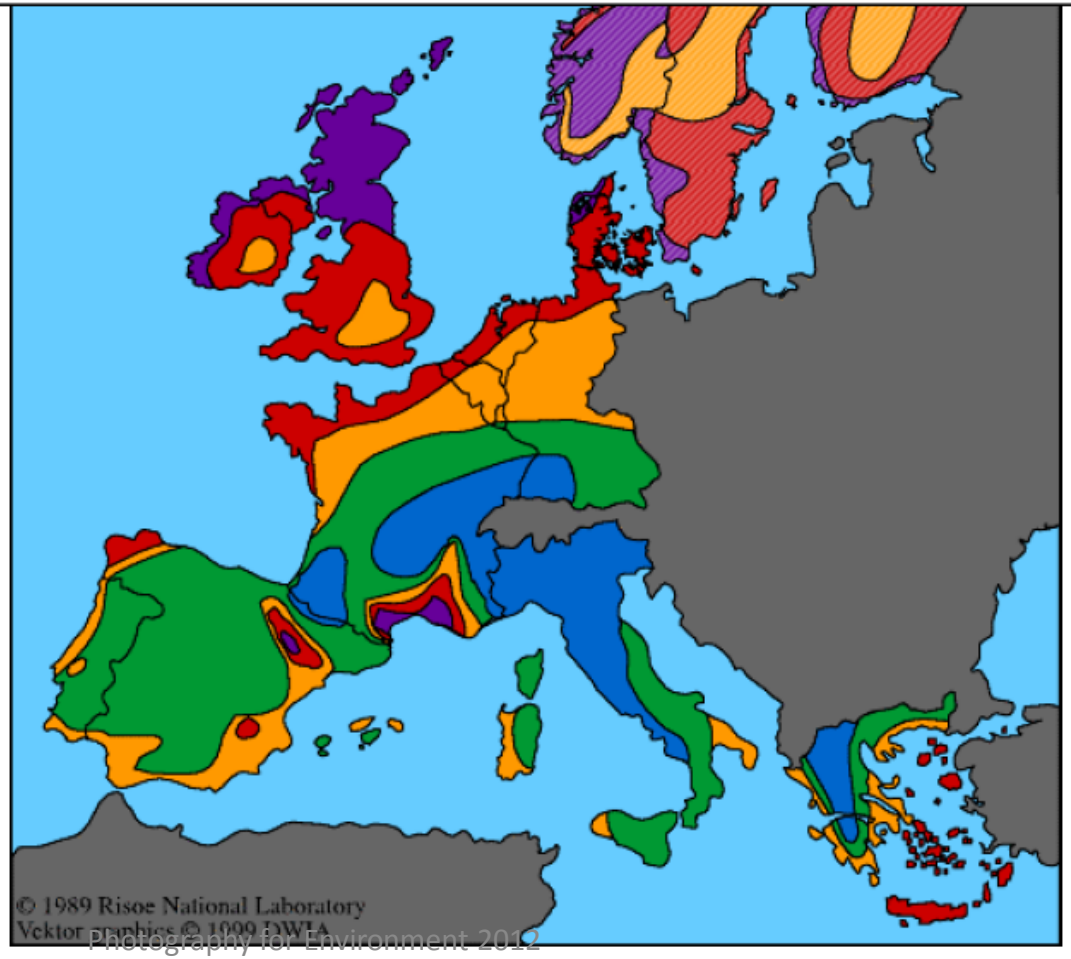
Wind Turbine



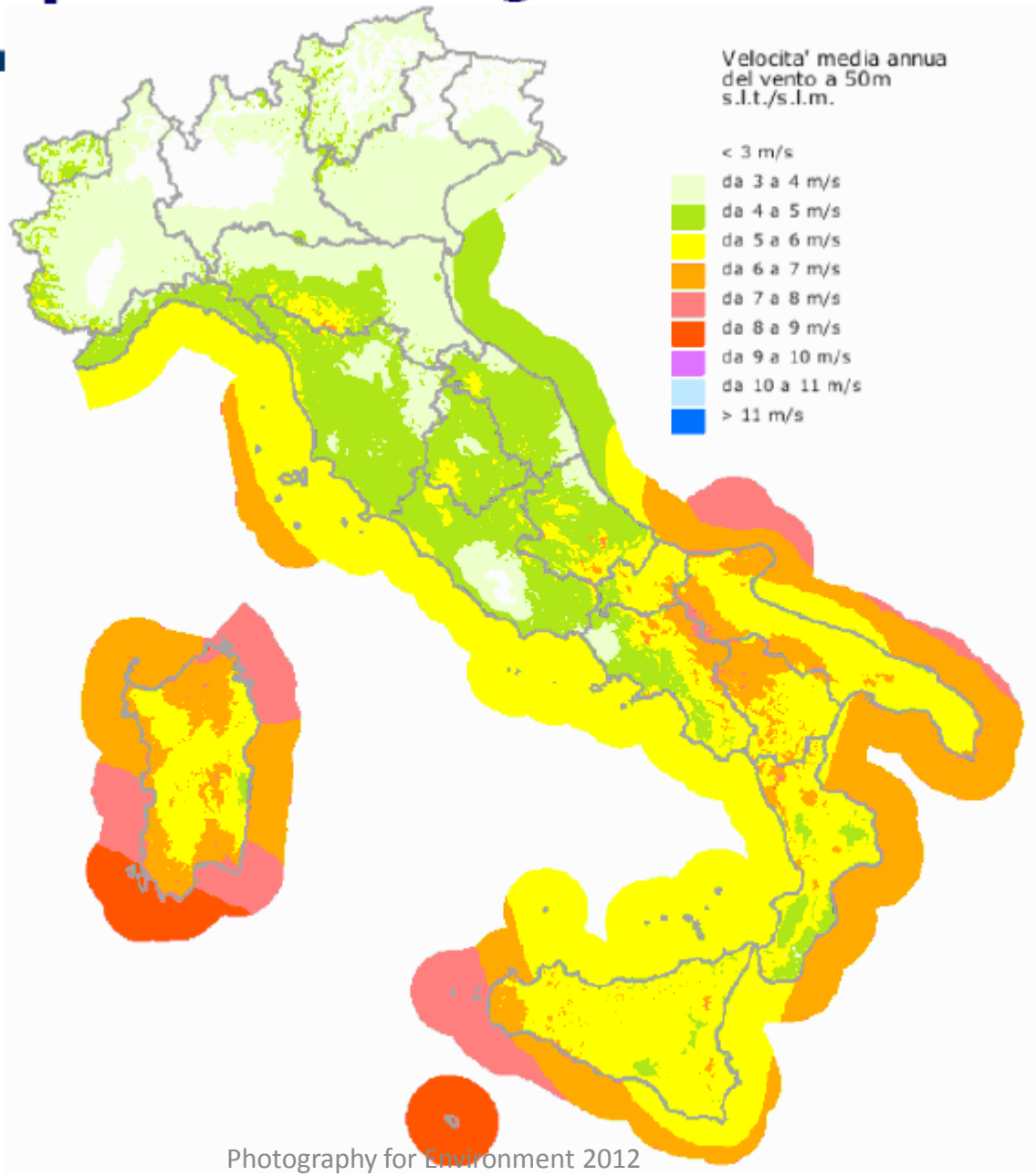
- **Wind Resources at 50 (45) m Above Ground Level**
- Sheltered terrain | Open plain | At a sea coast | Open sea | Hills and ridges

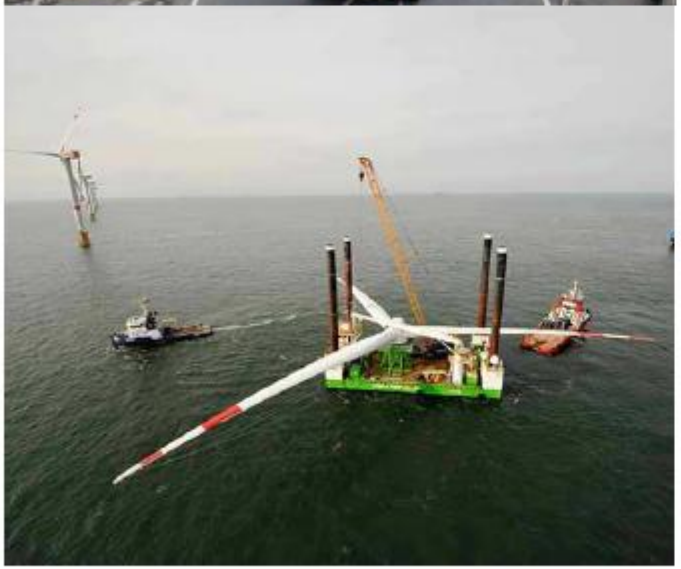
	Sheltered terrain		Open plain		At a sea coast		Open sea		Hills and ridges	
	m/s	W/m²	m/s	W/m²	m/s	W/m²	m/s	W/m²	m/s	W/m²
	>6.0	>250	>7.5	>500	>8.5	>700	>9.0	>800	>11.5	>1800
	5.0-6.0	150-250	6.5-7.5	300-500	7.0-8.5	400-700	8.0-9.0	600-800	10.0-11.5	1200-1800
	4.5-5.0	100-150	5.5-6.5	200-300	6.0-7.0	250-400	7.0-8.0	400-600	8.5-10.0	700-1200
	3.5-4.5	50-100	4.5-5.5	100-200	5.0-6.0	150-250	5.5-7.0	200-400	7.0-8.5	400-700
	<3.5	<50	<4.5	<100	<5.0	<150	<5.5	<200	<7.0	<400
			>7.5							
			5.5-7.5							
			<5.5							

Mappa della potenza disponibile in Europa



Wind Map - 50 m from ground





Finngrunden (Sweden – Baltic sea)

300 offshore 5 MW turbines → 1,5 GW, or 5.6 TWh: power for 1.1 Million people

North Sea Supergrid

- Ten countries (Germany, France, Belgium, Holland, Luxembourg, Denmark, Sweden, Ireland, United Kingdom and Norway)
- The agreement concerns a high voltage submarine direct current network thousands of km long, with a cost of 20-30 billion €
- 68 GW of wind, PV and future wave installations will be connected

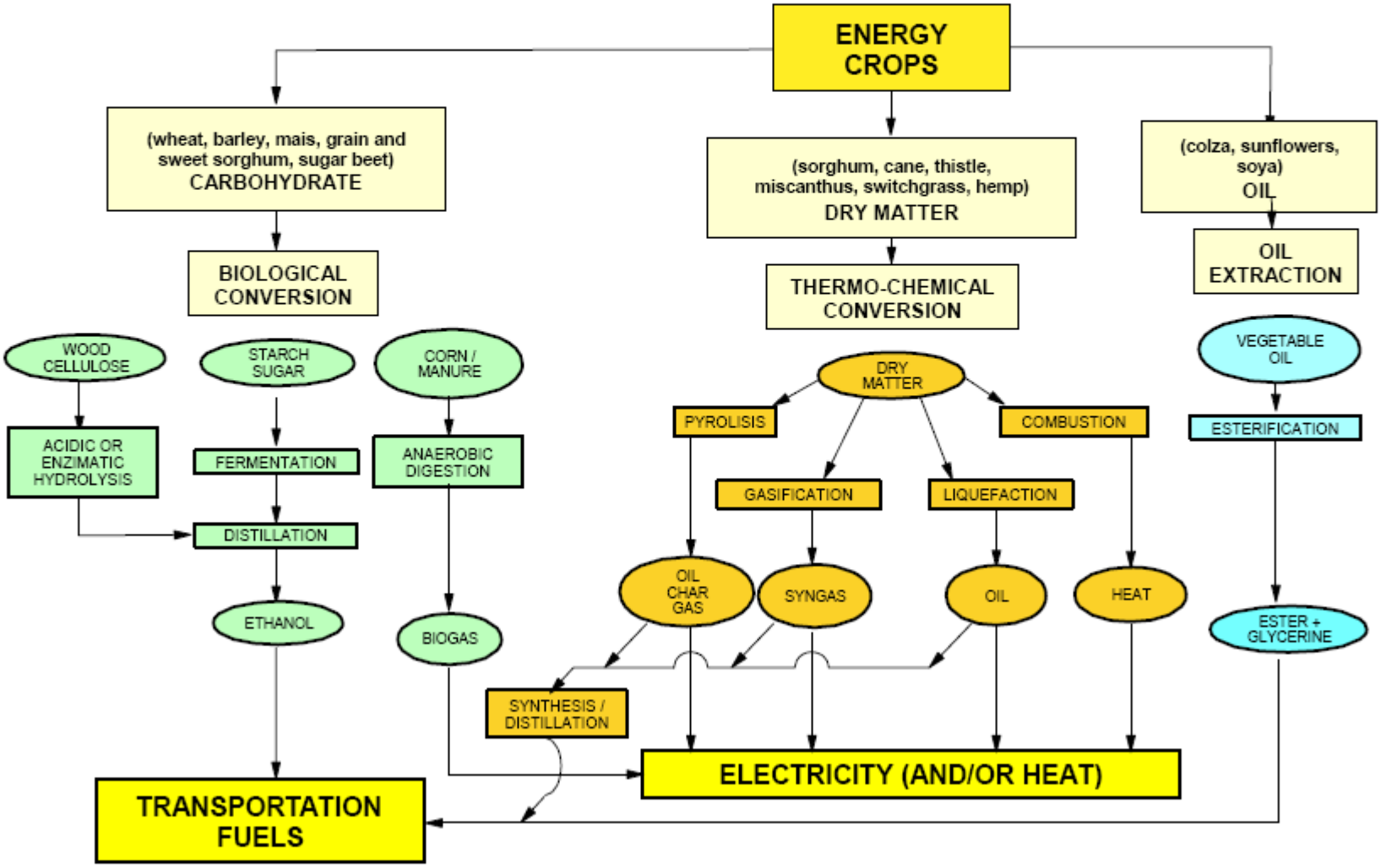
Biomass

Willow

***Switchgrass* (Panicum virgatum)**

Eucaliptus

Electricity and fuels from biomass



Biogas production

Fonte: prof. P. Navarotto, Università di Milano

MASDAR

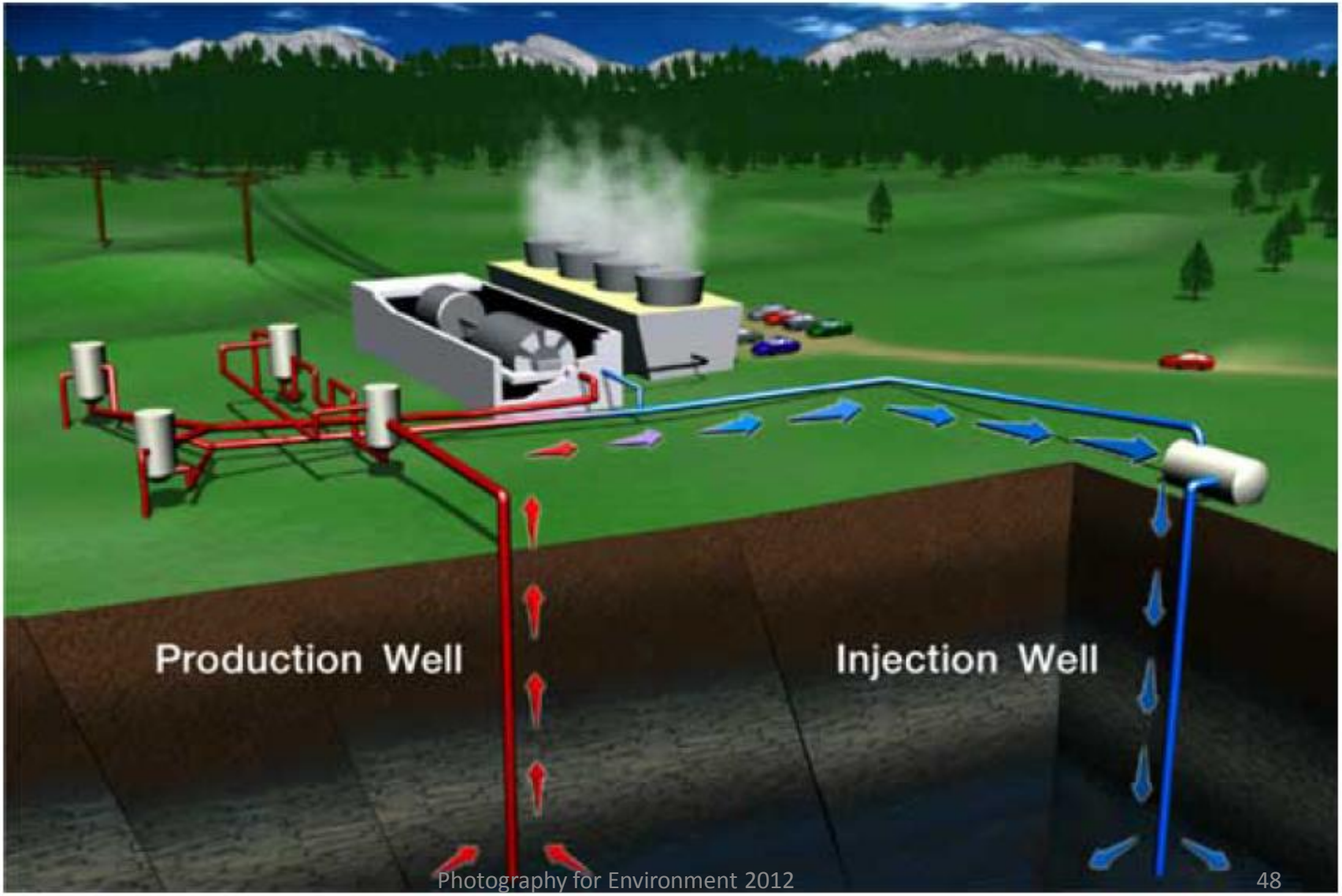
In the beginning it was a desert…

A new city of 50.000 inhabitants, becoming an example of a combination of good practices in energy saving (Reduce, Reuse, Recycle) and RES and a world centre for the study of RES.

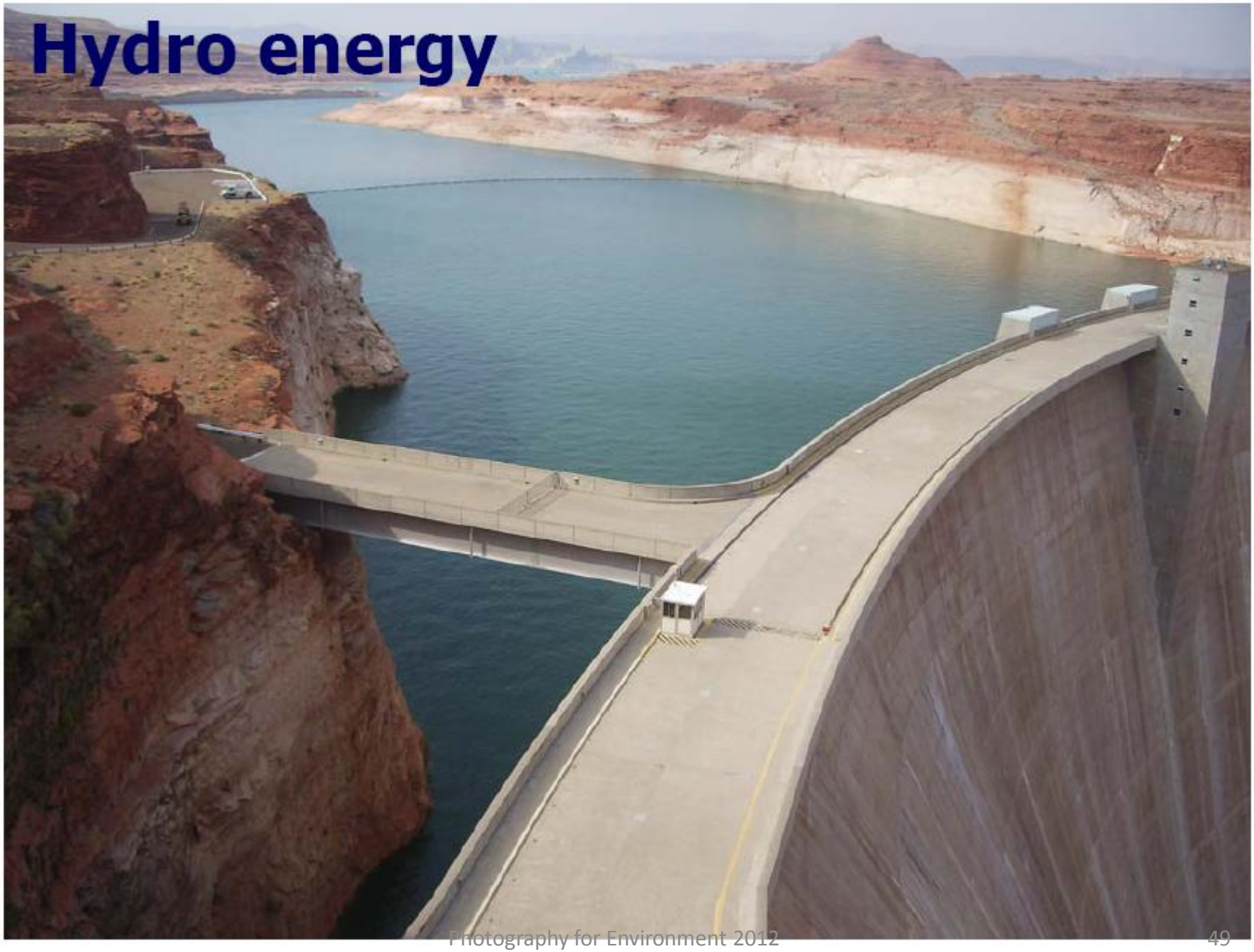
The predicted cost is 22 billion $ (16 billion €)

Energia geotermica

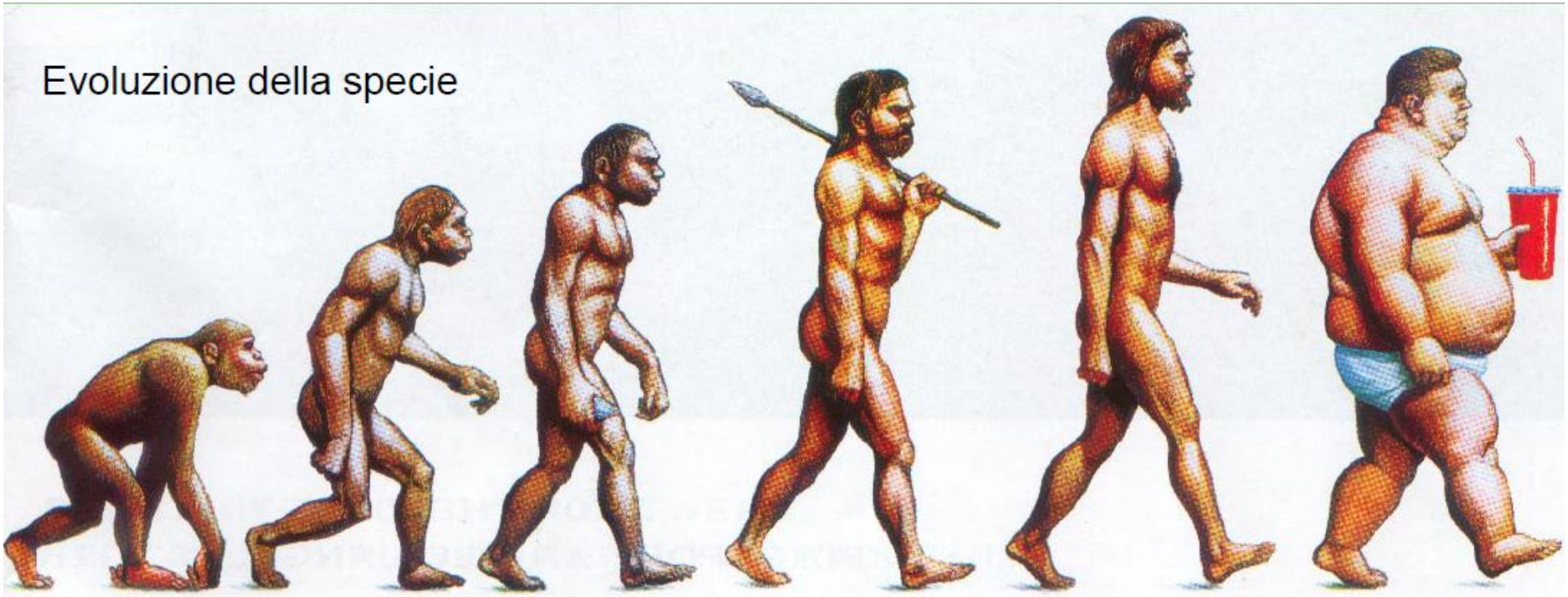
Energia geotermica

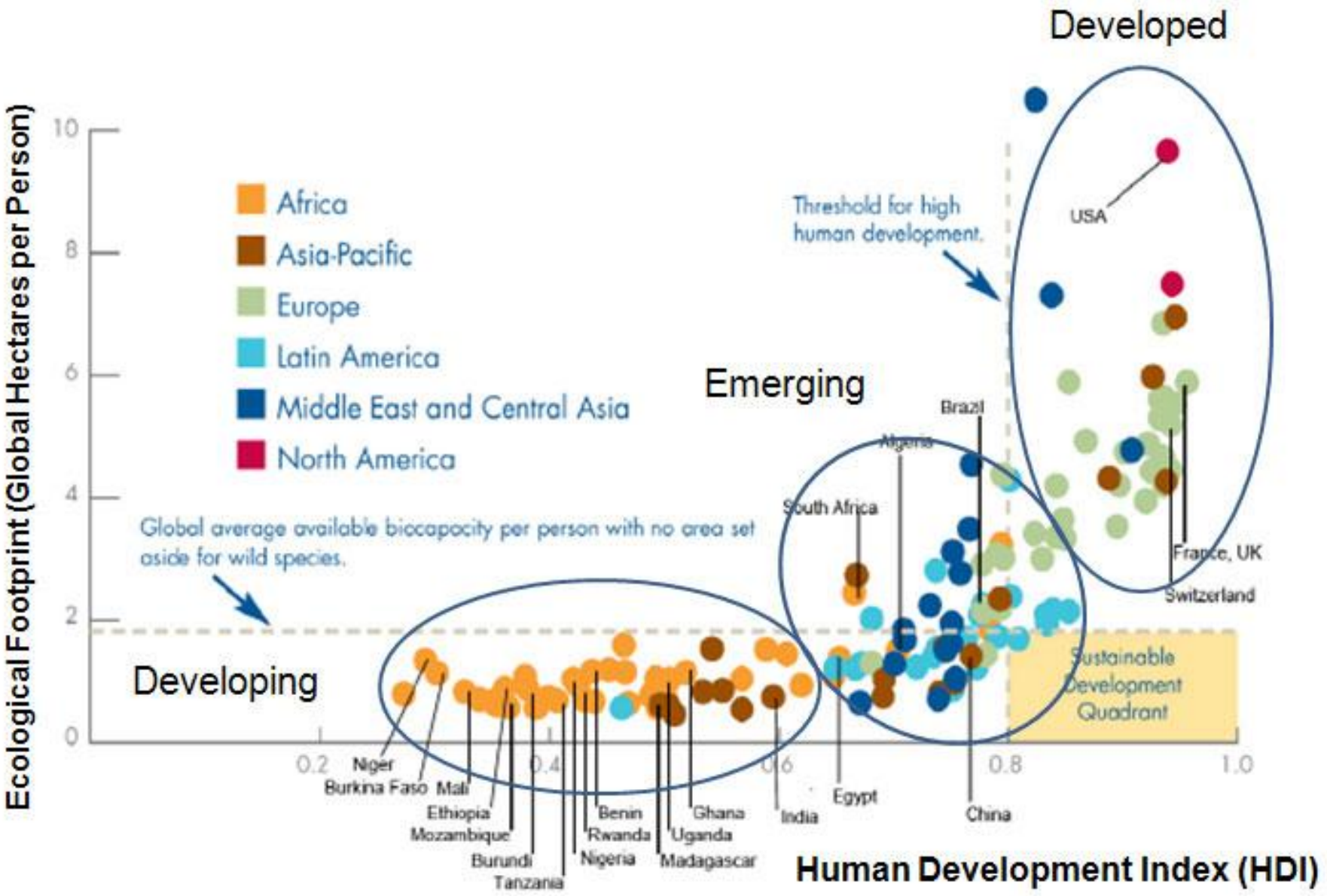


Hydro energy



WEALTH
THIS WAY
WELL-BEING
THIS WAY


Evoluzione della specie


Developed
Emerging
Developing
Africa
Asia-Pacific
Europe
Latin America
Middle East and Central Asia
North America
Threshold for high human development.
Global average available biocapacity per person with no area set aside for wild species.
Sustainable Development Quadrant
USA
Brazil
Nigeria
South Africa
France, UK
Switzerland
Egypt
India
China
Niger
Burkina Faso
Mali
Ethiopia
Mozambique
Burundi
Tanzania
Nigeria
Benin
Rwanda
Ghana
Uganda
Madagascar
Ecological Footprint (Global Hectares per Person)
Human Development Index (HDI)
0
2
4
6
8
10
0.2
0.4
0.6
0.8
1.0

All the slides are taken from lectures of:

Prof. Ing. G. Fracastoro (PoliTO, 2012)

Prof. Ing. S. Consonni (PoliMI, 2009)