Solar + Wind in Spain/ World. Closing the growing gap?

VII ANNUAL INTERNACIONAL ASPO CONFERENCE.

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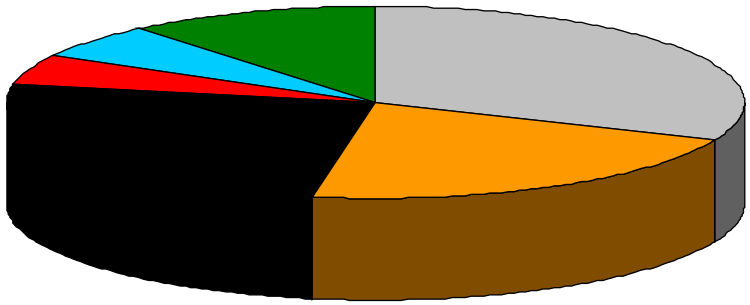
The World Energy Consumption at present

Annual World Consumption of Primary Energy by Sources	Oil	Natural Gas	Coal	Nuclear	Hydro electric	Biomass	Total
In MToes	3,906	2,654	3,136	622	709	1,389	12.284
In %	31.5	21.4	25.3	5.0	5.7	11.2	100%
From them fossils	31.5	21.4	25.3				78.2 %



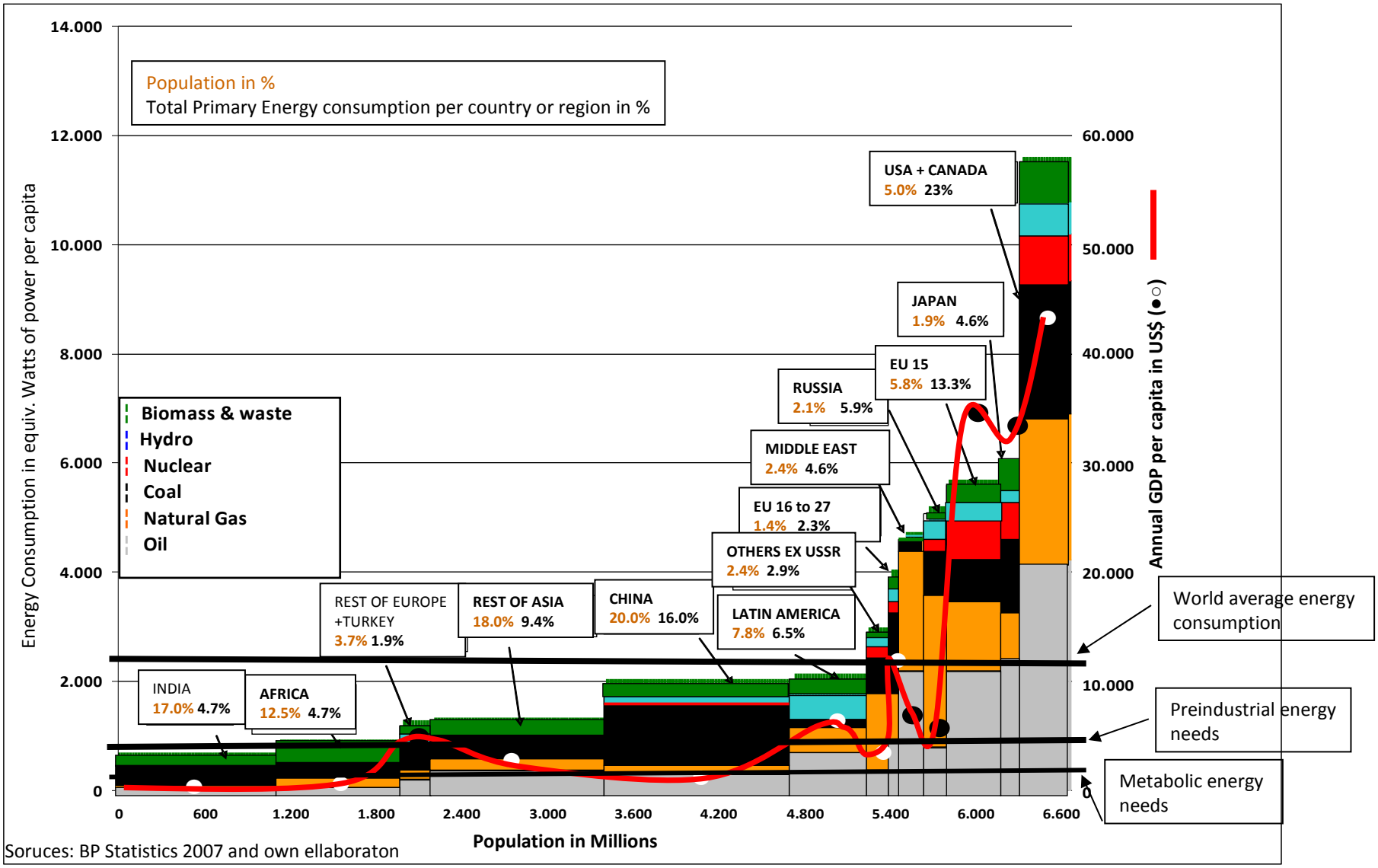
Burning Fossil fuels

Global CO2 emissions in millions Tm

	1980	2004
North America	5,439.17	6,886.88
Central & S.America	623.36	1,041.45
Europe	4,657.92	4,653.43
Eurasia	3,027.53	2,550.75
Middle East	494.75	1,319.70
Africa	534.47	986.55
Asia & Australia	3,556.07	9,604.81
Total	**18,333.26**	**27,043.57**

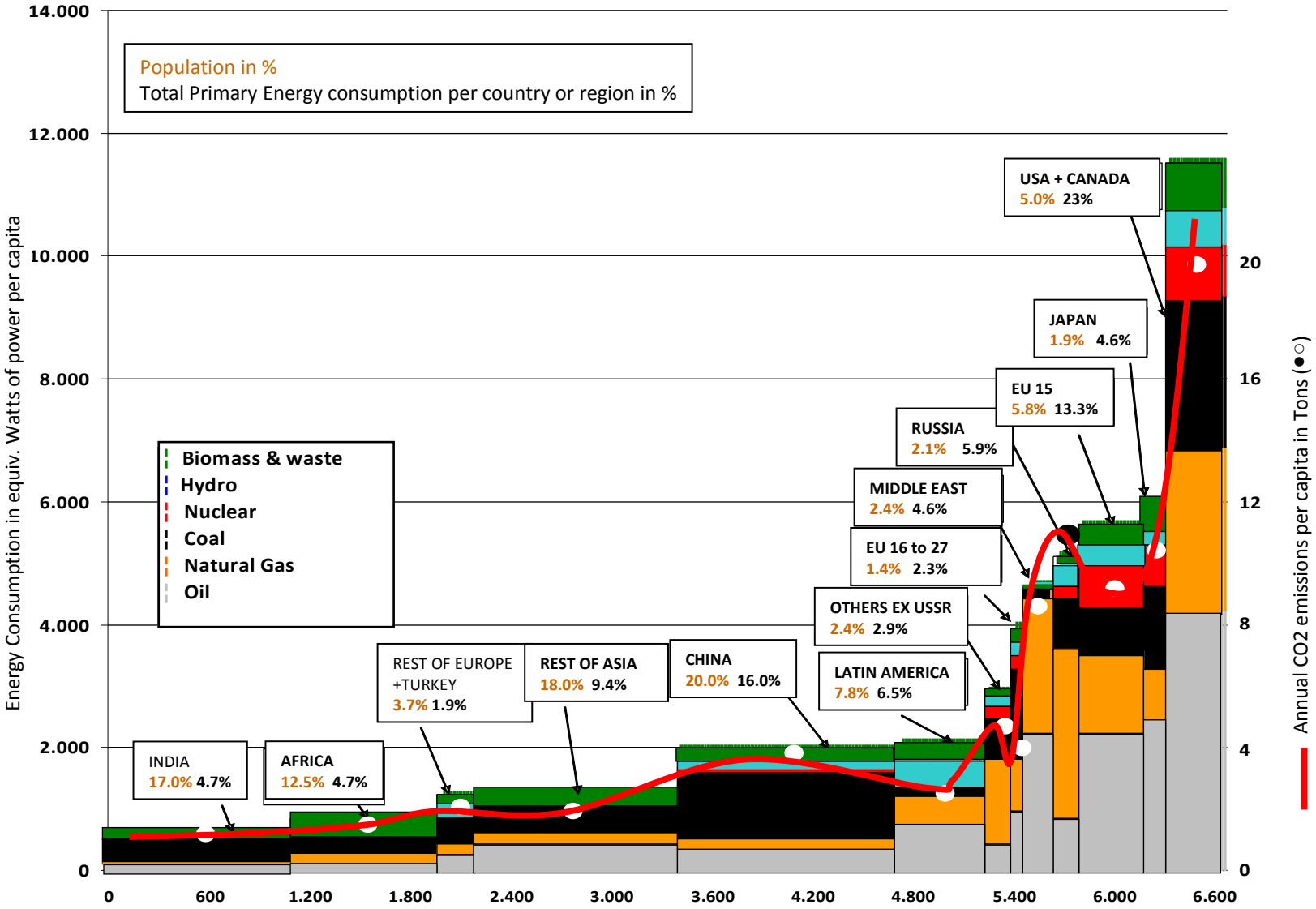
Sources: BP Statistical Review 2007, DOE
http://www.usatoday.com/tech/science/environment/2007-05-21-carbon-dioxide-emissions_N.ht
Others and own ellaboration

Economy and Energy Consumption: An Identity Despite Singularities



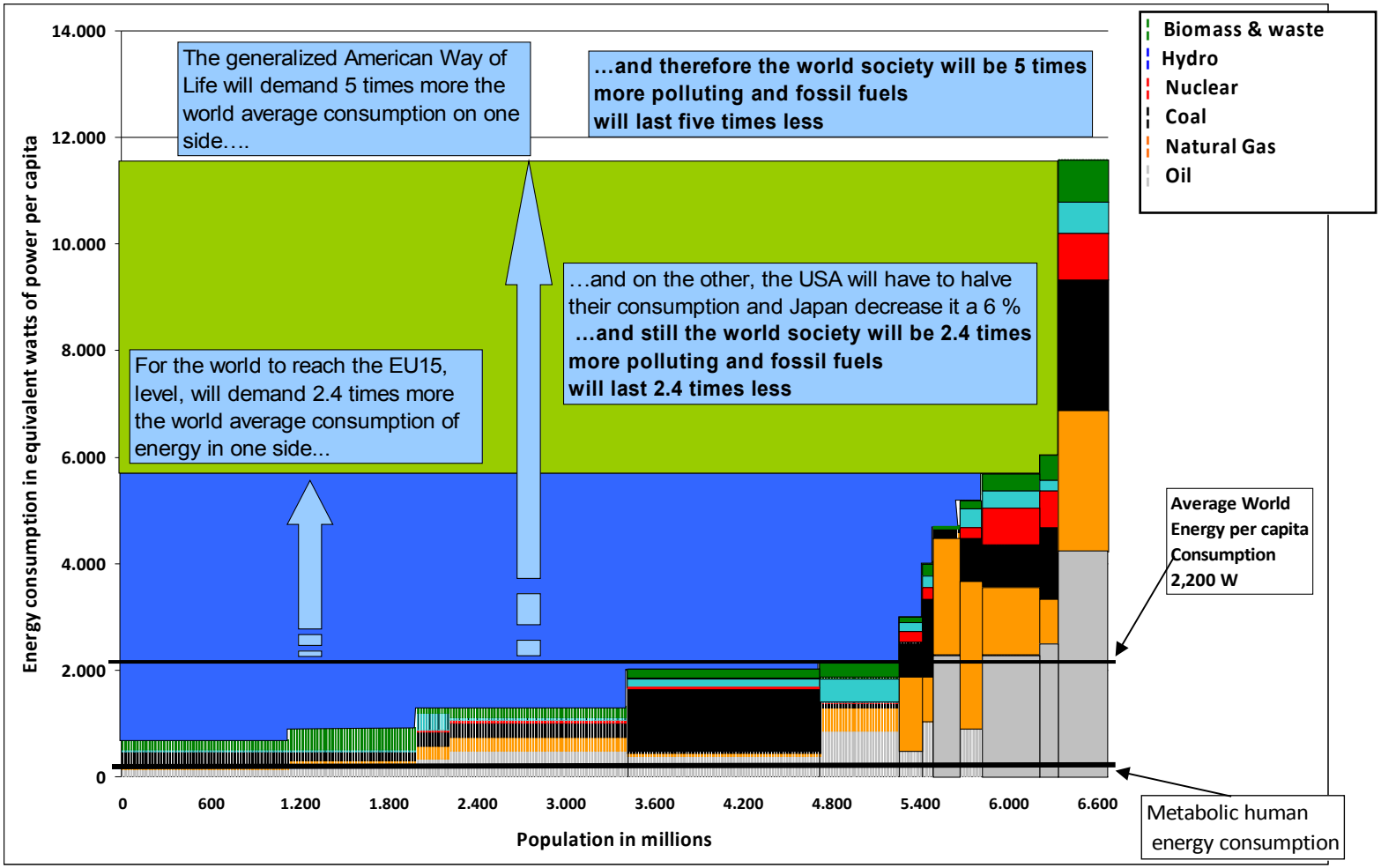
Soruces: BP Statistics 2007 and own ellaboraton

Economy and emissions: Another identity (or GDP Pollutes)

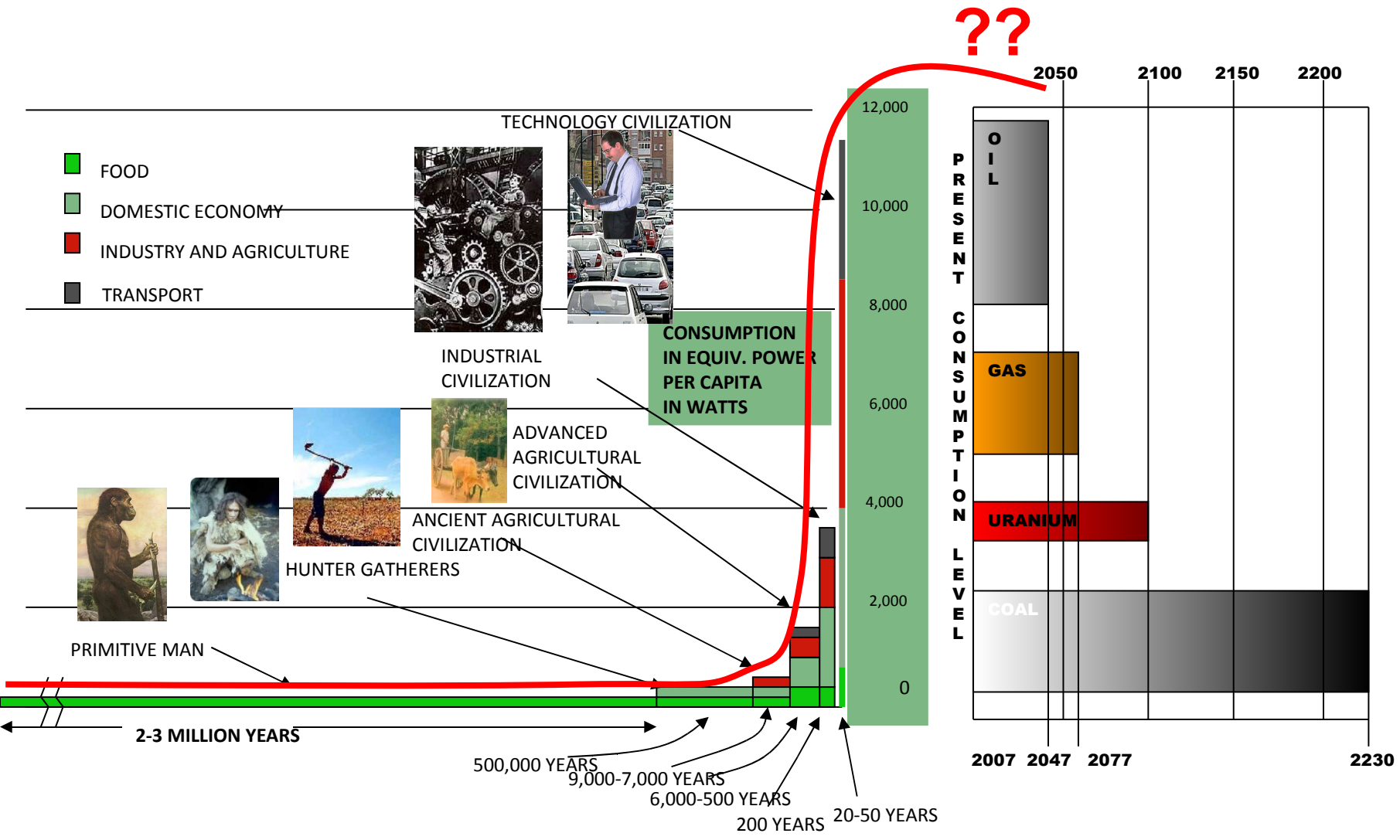


Sources: BP Statistics 2007
UN Stats air CO2 emissions and http://www.renewables2004/de

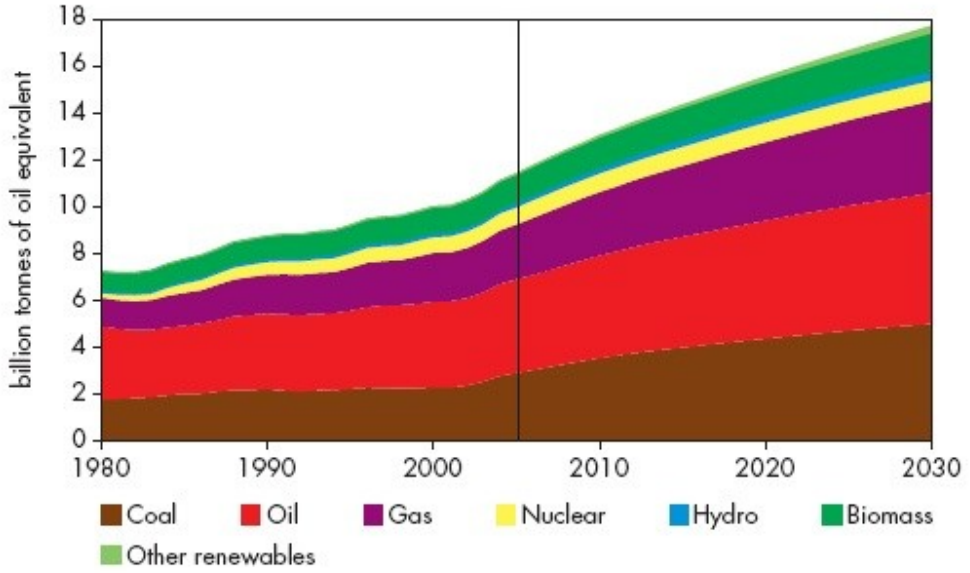
Economy Energy and emissions: ¿Quo Vadis?

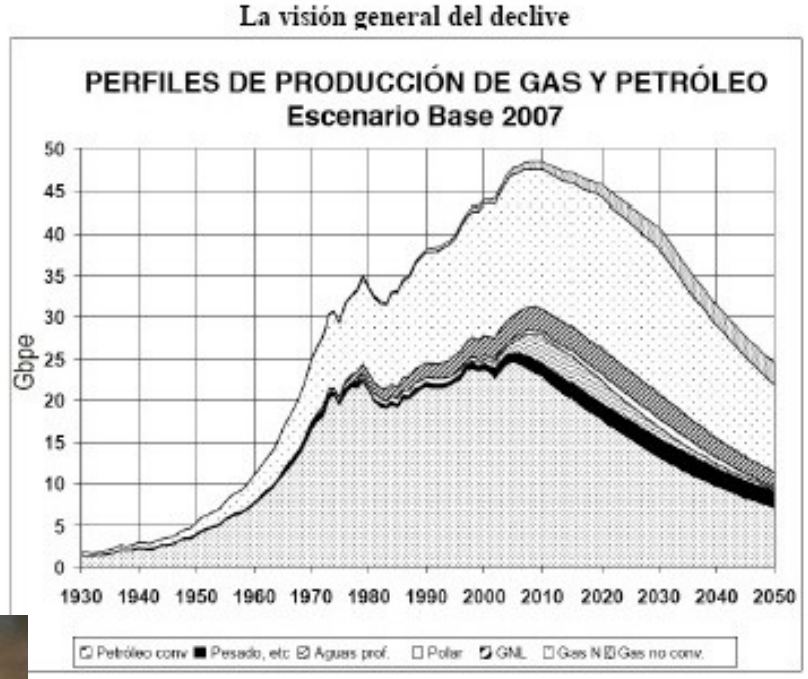


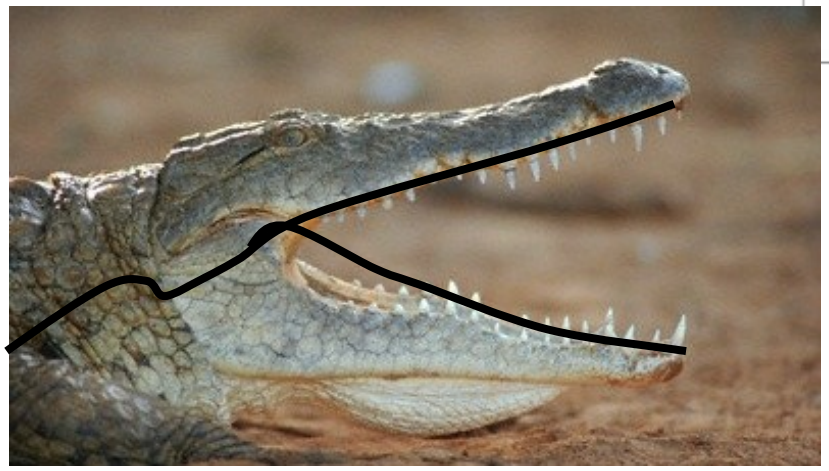
The energy consumption roadmap



The ASPO and IEA forecasts for gas and oil. Quo Vadis?







Sources: IEA WEO 2007 and ASPO Newsletter June 2008.

An overview to the growing gap

The Oil-i-Gator (Skrebowski)

The Growing Gap

Bumpy plateaus

Set teeth on edge

Let us explore the renewables!

Renewables

Two Basic Principles:

The so calles “renewable energies” are, in fact,
NOT RENOVABLE SYSTEMS
able to capture part of the renewable energies

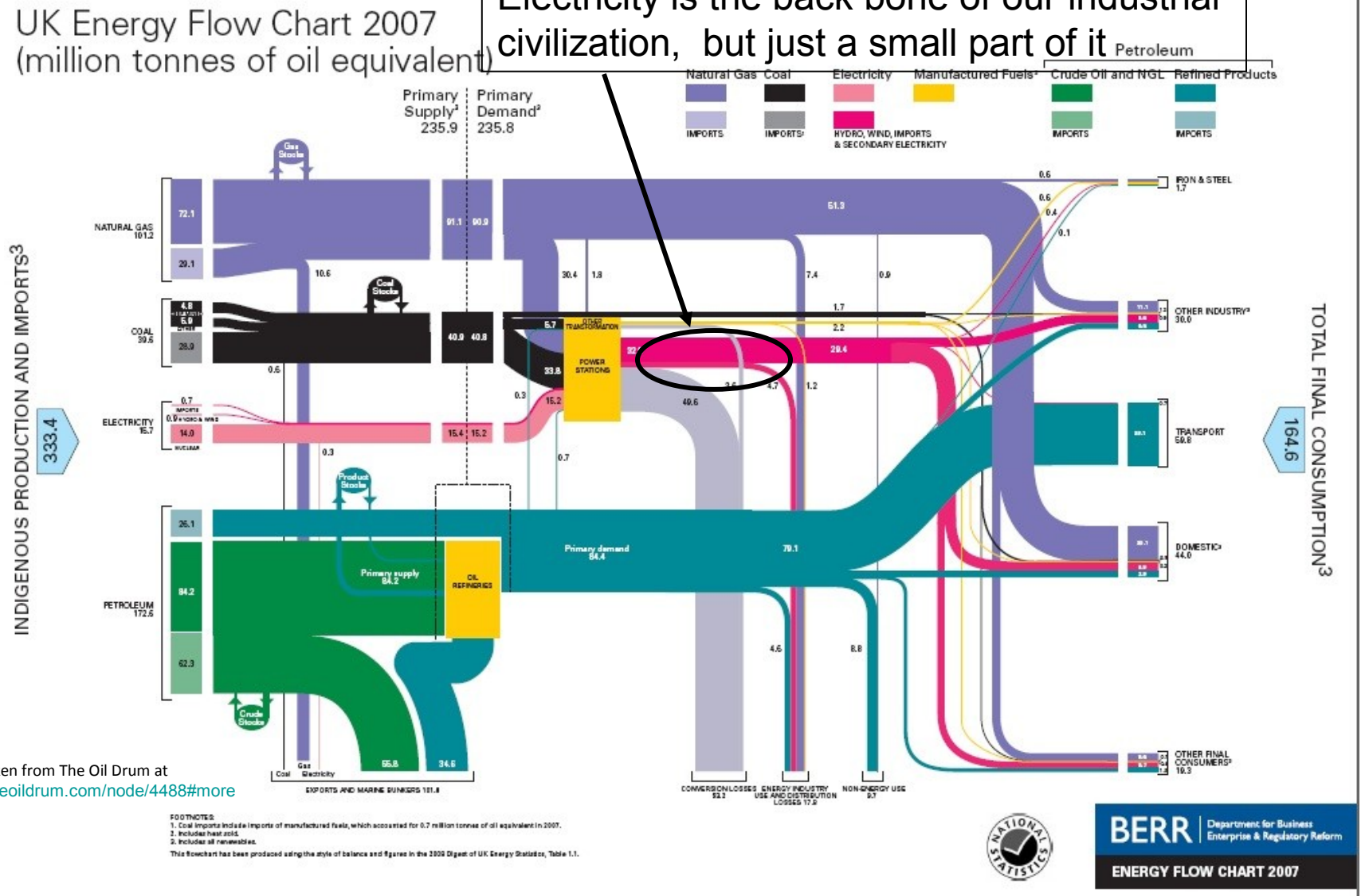
Even renewable energies may end being renewables if
the exploitation rates go beyond the natural renewability rates

The Possible Renewable Systems

- **Biomass**
- **Hydro electric**
- **Wind**
- Geothermal
- **Solar**
  - Photovoltaic
  - Thermal
  - Thermo-elctric
  - Stirling Engines
  - Solar Chimneys
- **Wave energy**
- **Tidal Energy**
- Ocean currents
- Oceanic Temperature differential

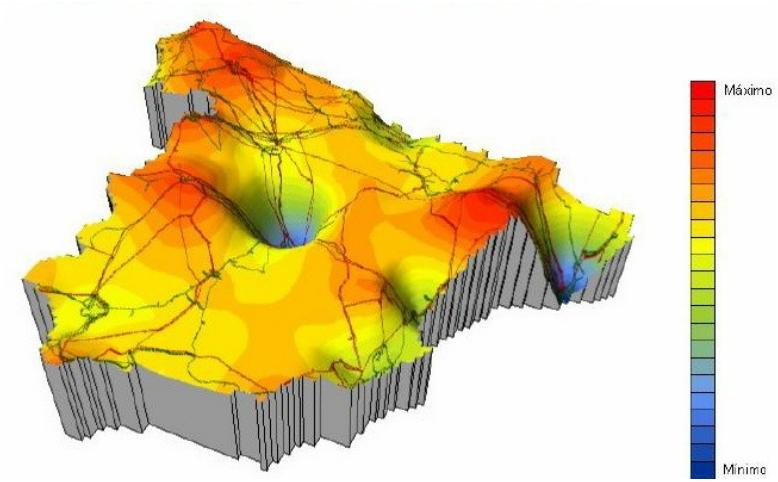
The electricity: a quality energy, but…

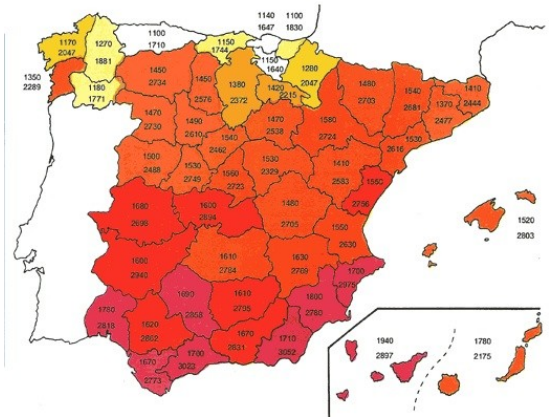
Electricity is the back bone of our industrial civilization, but just a small part of it



Source: BERR taken from The Oil Drum at http://europe.theoildrum.com/node/4488#more

Some previous considerations for electric generation





Sun and wind does not shine and blow equally for all.
Existing electric grids are not coincident
with best generation and consumption areas

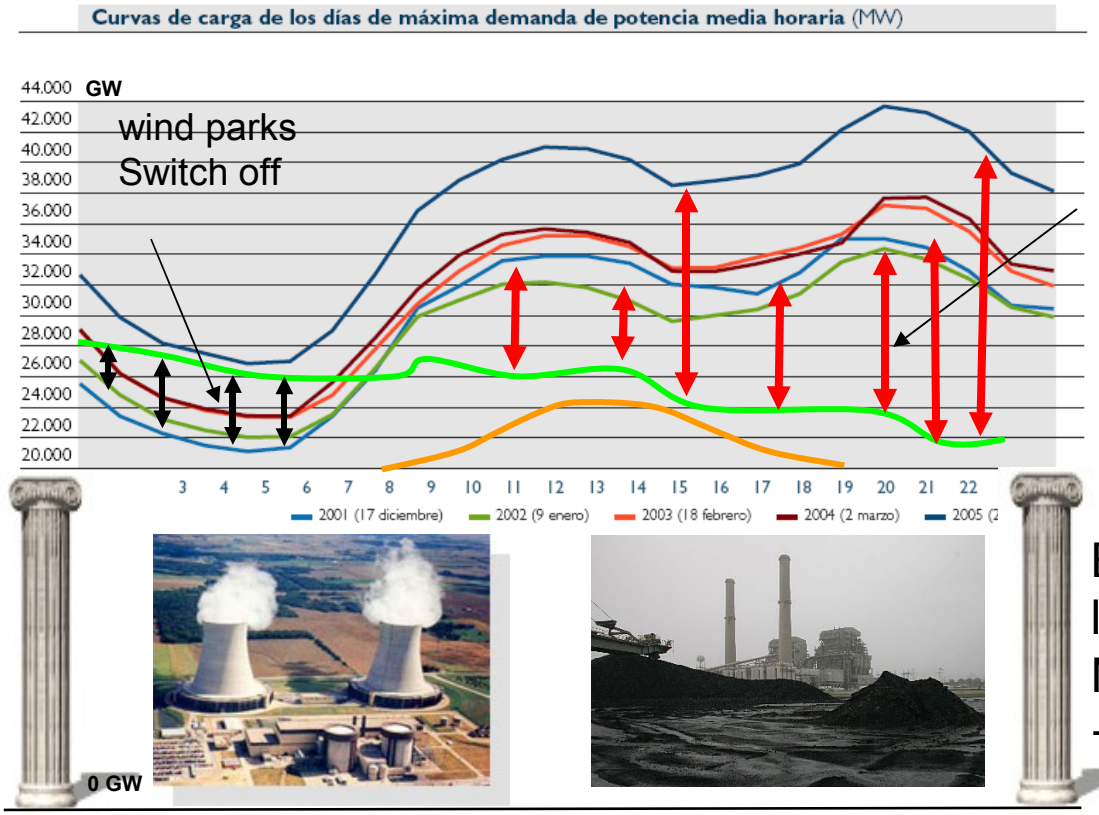
Sources: Red Eléctrica Española and Censolar map of solar radiation averages by provinces

The Spanish consumption patterns

Wind is unpredictable

Solar energy too, but it matchs better, when available, with the first consumption daily peak,

4 Solar GW of installed power will match quite well in the Spanish network

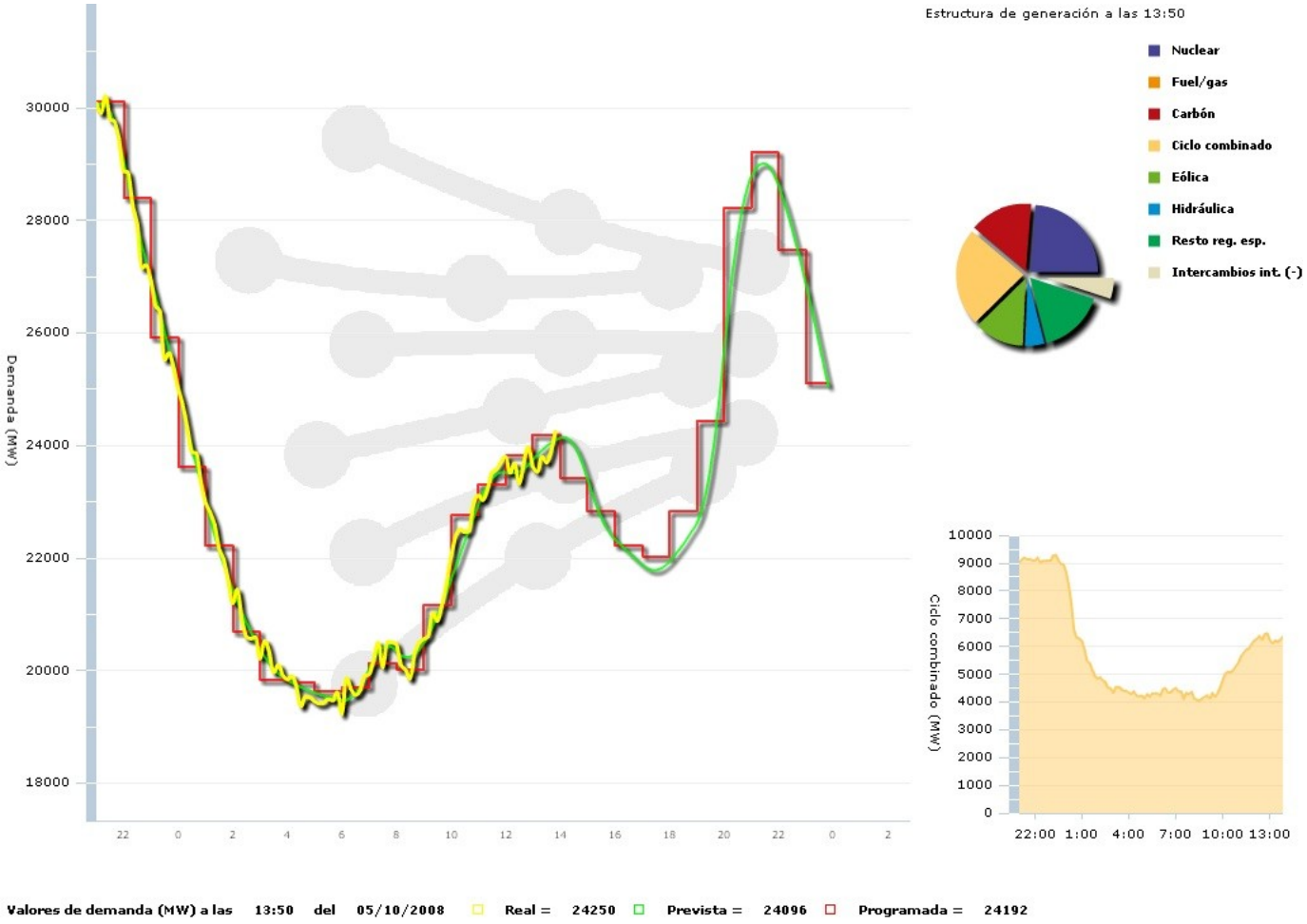


Deficit of wind parks

Base load Nuclear + coal

Source: Red Eléctrica Española (www.ree.es) and own ellaboration

The structure of Spanish electricity generation and demand

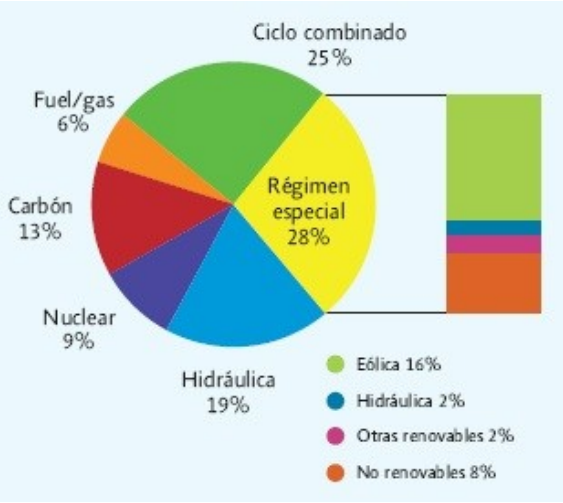


Source: Red Eléctrica Española https://demanda.ree.es/demanda.html

The Electric Cakes in Spain and the problem of storing electricity

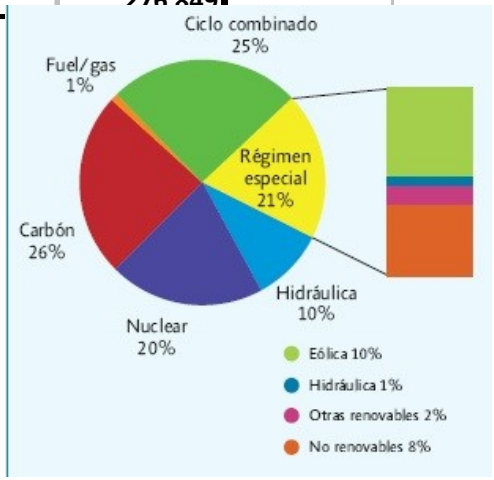
INSTALLED POWER IN MW	2007	2007 (in %)
Hydraulic	**16,658**	**19%**
Nuclear	**7,716**	**9%**
Coal	**11,867**	**13%**
Fuel/gas	**7,629**	**6%**
Combined Cycle	**22,107**	**25%**
Total Ordinary Regime	**65,997**	
Hydro (mini+micro)	1,914	2%
Wind Power	14,058	16%
Other Renewables	1,598	2%
Non renewables	6,912	8%
Total Special Regime	**24,481**	**28%**
Grand Total	**90,459**	

DEMAND COVERAGE IN GWh	2007	
Hydraulic	26,352	**10%**
Nuclear	55,102	**20%**
Coal	75,028	**26%**
Fuel/gas	10,827	**1%**
Combined Cycle	72,219	**25%**
Total Ordinary Regime	**239,529**	**82%**
Consumption in generation	9,600	**-3%**
Special Regime	**57,020**	**21%**
Hydro	3,966	1%
Wind Power	27,247	10%
Other Renewables	5,226	2%
Non renewables	20,580	8%
Net Generation	**286,948**	**100%**
Pump up consumption	**-4,349**	**1.6%**
Int'l exchanges	-5,750	2%
Demand	**276,849**	



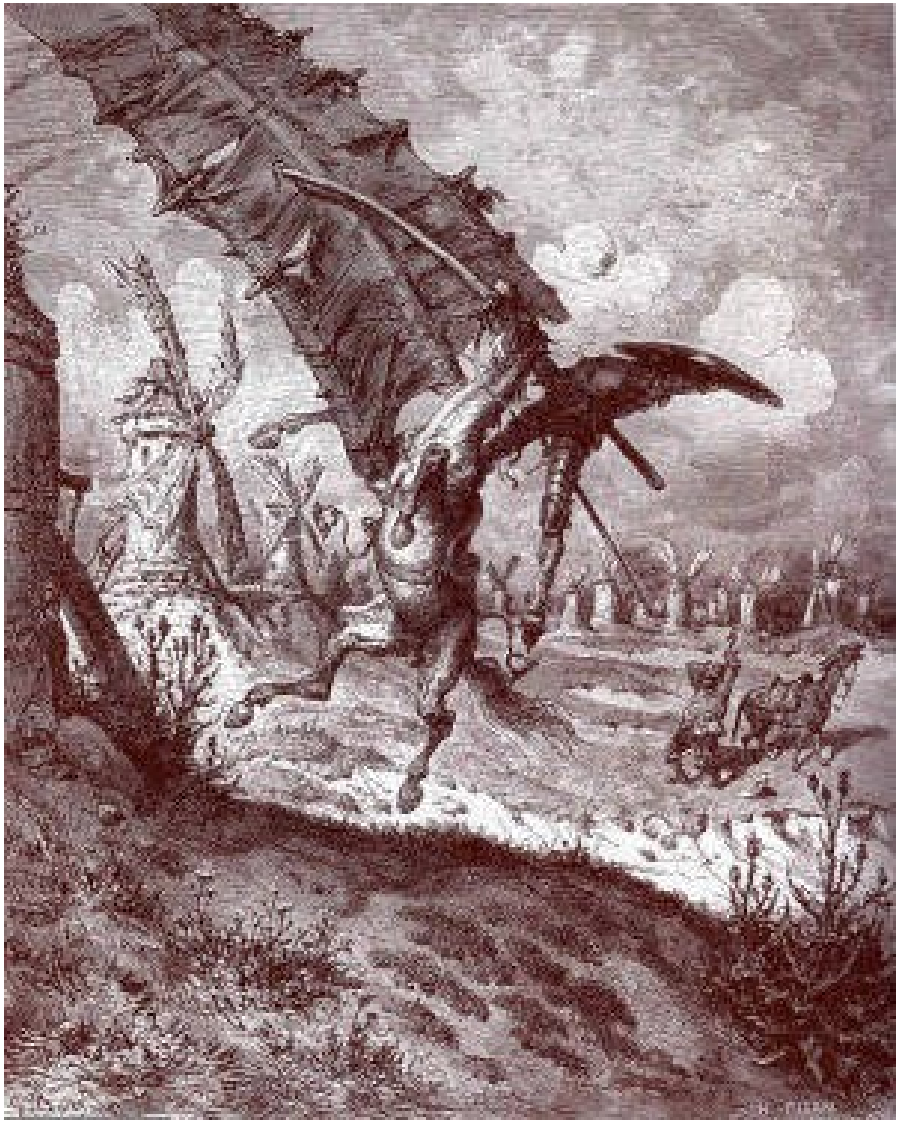
Pumping up is just 1.6% of the electric activity requiring a 3% of the electric installed base in the second most mountainous country in Europe

And over 90% of the big river basins already used up



Source: Red Eléctrica Española http://www.ree.es/sistema_electrico/pdf/infosis/Inf_Sis_Elec_REE_2007_v2.pdf

Wind energy



Source: Don Quixote fighting the wind mills. Gustavo Doré engravings

How does it worrk

Bentz Constant(59%)

Limit per size (5 MW approaching to limit)

Power is a cubic function of wind speed

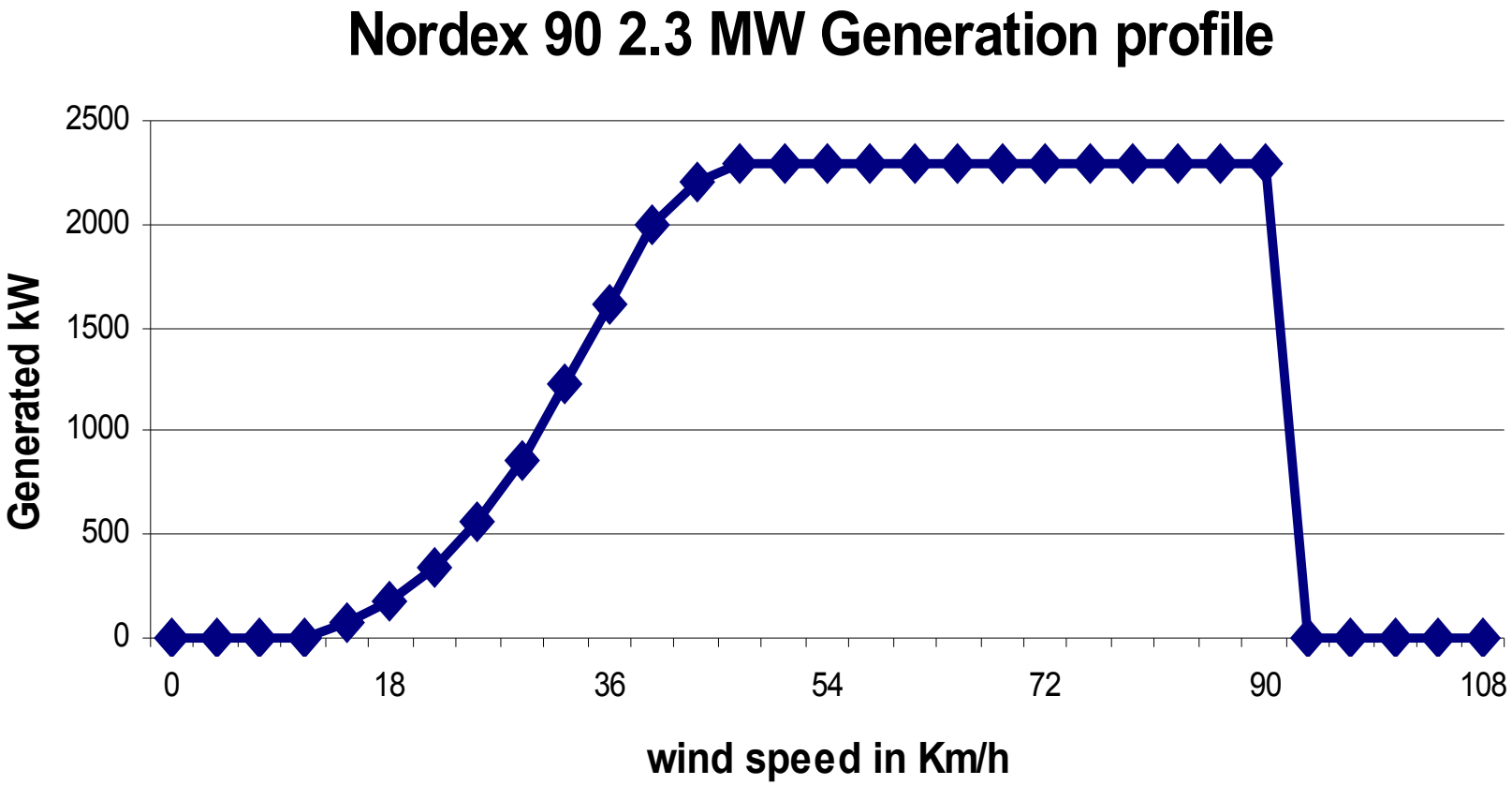
$$P_0 = \frac{1}{2} \cdot \rho \cdot \frac{\pi \cdot D^2}{4} \cdot v_1^3$$

Maintenance becomes more complex with size

WINDS	**AVERAGE V** **in Km/h**	**MW** **GENERATED**	**NOMINAL OUTPUT POWER**	ADDITIONAL PARK TO INSTALL
Class 6	**29.6**	2.22	**100**	
Class 5	26.6	1.63	73	36%
Class 4	25.2	1.39	62	61%
Class 3	**23.4**	1.11	**50**	100%
Class 2	21.6	0.83	37	270%
Class 1	18.4	0.54	24	416%

A Class 3 field needs double the same type of generators to produce the same energy than in installed in a class 6 field

How does it work



Advantages & Strenghts

One of the most proven and competitive renewable systems

EROEI seems superior to the solar PV

Not very polluiting, once installed and depending on the scale.

Limits & Weaknesses

- Intermitent supply
- Need conventional back up plants (thus less efficient) to keep up a national grid
- It just produces electricity.
- When going beyond electricity production to other uses, carriers are needed (p.e. hydrogen)

Limits & Weaknesses

- Load Factor is low in good fields (2,500-3,000 equiv. hours/year) some 28-35%)

- In a top/down analysis wind in the world is limited (1,200 TW or about 70 times the present world primary energy consumption)

Trying to capture 1% of all planet winds (at all heights and places):

- Is technically implausible and unfeasible
- Could have serious ecologic problems at this scale
- Winds could drift by the minimum effort law
- Will represent an insurmountable cost in materials and energy.
- A very heavy industry
- Will only provide 70% of the present primary energy demand at maximum

Limits & Weaknesses

- Corrosion of elements have to be carefully analyzed in the long term, specially in offshore platforms.
- Maintenance is very reliant on fossil fuel energy and conventional machinery, also very much fossil fuel underpinned
- A carbon fiber blade weights 70% of an equal fiber glass blade, but its manufacturing energy cost is several times bigger

5 MW Generator
Blade 61.5 m
Tower 120 m.
Maximum height 183 m.

Photos: National Geographic. August 2005. “Las energías del futuro” and own ellaboration

Wind energy worldwide

Country	Installed Capacity MW	National Electricity Coverage %
1. Germany	23,000	10
2. U.S.A.	20,152	1.5
3. Spain	15,900	10
4. India	8,800	2
5. China	7,562	0.2
6. Denmark	3,124	20
7. Italy	3,076	1.5
8. France	3,067	1
9. U.K. / DTI	2,920	1.5
10. Portugal	2,375	9
11. Canada	1,856	0.6
12. Netherlands	2,053	4.1
13. Japan	1,675	0.2
14. Austria	982	3
Others	6,098	
TOTAL	102,640	1.2

- It is about 1% of the world electricity consumption
- They represent some 15 Mtoe's or about 0.12% of the world primary energy consumption.
- Developed countries have 82% of the installed base
- Emergent countries (China + India) have 16% of the world's installed base.
- Developing countries have a 2% of the world's installed base

Fuente: Wind Energy Statistics worldwide as of Sept. 19th 2008 . http://home.wxs.nl/~windsh/stats.html

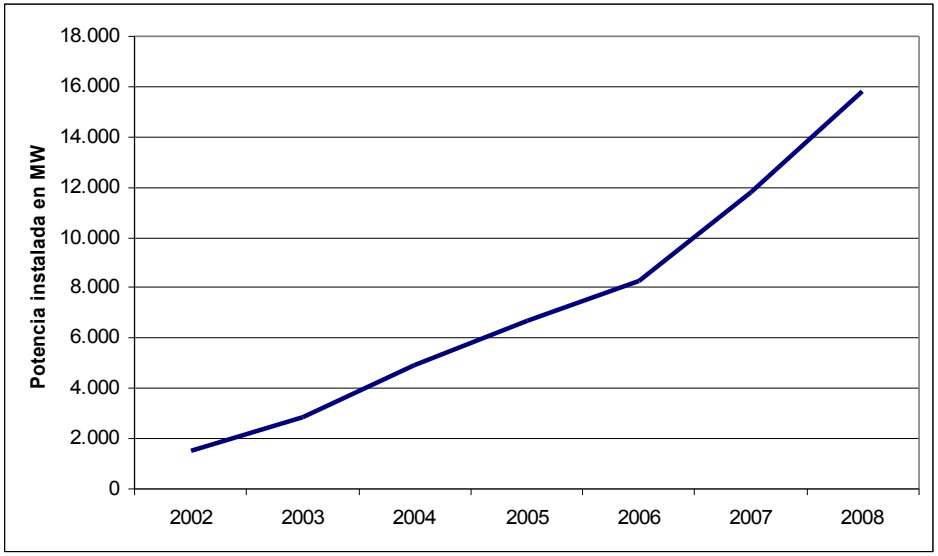
Wind Power. Some data

SPAIN

Third world installed base (15,900 MW)

27,247 GWh/year generated in 2007
This being 10% of the national electricity
And 1.7% of the primary energy (2.6 MToe)

It is foreseen to reach 20,000 MW in 2010
and 29 GW by 2016…



The wind power growth % 07/06 was 18.3% (4,152 GWh)
The national electricity consumption growth % 07/06 was 3.1% (7,828 GWh)

That means that the spectacular wind energy
growth covered just half of the electricity consumption
increase in 2007

Companies are looking for even 1,800 hours/year fields
and offshore projects. (Equiv. to go from class 6 to class 5 and 4 windfields)

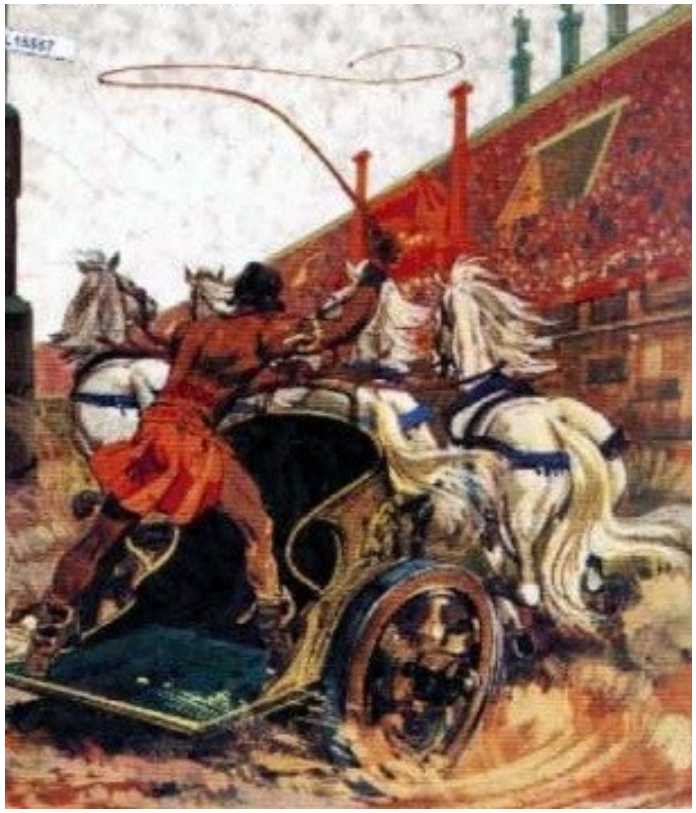
Wind Power. Some data

WORLD

All the world wind installed park up to 2007 (102,000 MW) produces almost 5 times less electricity than the world electricity consumption increase between 2006 and 2007 (907 TWh)

All the world wind installed park in 2007 (20 GW), will produce 23 times less than just the increase of the electricty consumption during the same period.

The Energy Consumption Chariot goes
23 times faster than the Wind Power horses!!



Wind energy deployment scenario
Some data on material use

Building up 3TW of wind power up to 2020 will cover 30% of the world electricity consumption in 2007 and will demand a 27% annual cumulative growth throughout The period.

The 1.5 million times 2 MW wind generators required Will imply:

- 2 times the present world steel production of 2006
- Almost half of the world extraction of coal
- 30 times the world production of glass fiber
- The world concrete production
- Almost half of the copper world production

Is this demand and use of materials renewable?

Can we afford these start up energy expenses?

Solar Energy

Solar Thermal. Status

1 million m^2 <> 73,000 Toe (2006) in Spain

115 Thermal GW <>14 Mtoe/ 2007
worldwide

Approx. 0.1% of world primary energy

China leads the world market
With over 60% of total installed base

Sources: APPA and IEA

Solar Thermo-Electric Plants (CSP)

Two Basic Types:

Two axis tracking mirrors focusing on a boiler or a point in a tower.

One axis parabolic trough mirrors, heating a fluid going through the pipe running along the focus

When combined with gas turbines (combined cycle) they may offer reasonable efficiencies

Sources: Plataforma Solar de Almeria and Fergón Montajes

Solar Thermo-electric plants (CSP). Advantages/Strenghts

Its renewable

It complements well with conventional fuel/gas combined cycle plants.

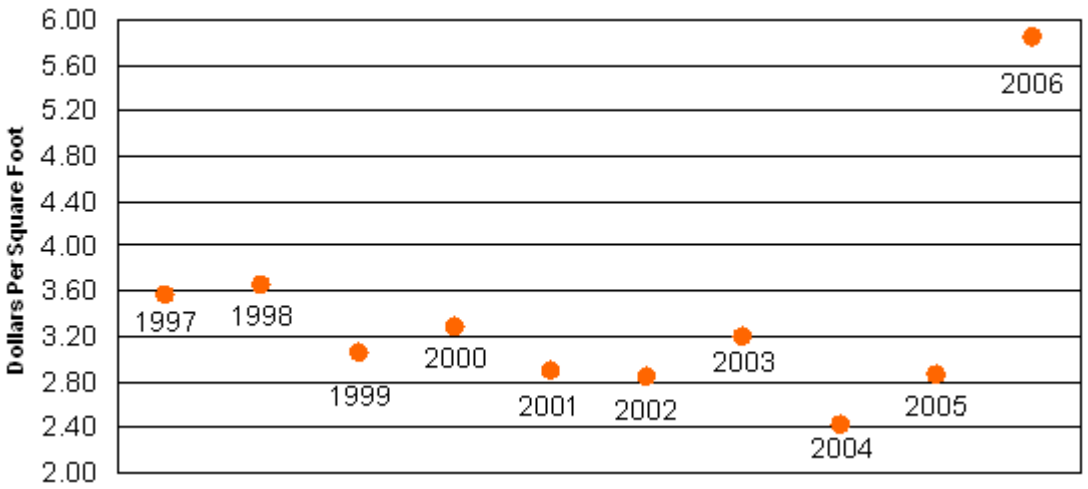
It is cheaper per watt generated than solar PV (today)

Solar Thermo-electric Plants (CSP). Limits and weaknesses

- Require a big conditioned surface (1 Km^2/50MW)
- Only generates electricity, although could also melt materials and other high temperature uses
- May vaporize birds intercepting the beam in their flight
- Complex maintenance, in junctions and moving parts
- They need a close fossil fuel back up reliable system
- Close to the plant and a water supply (300,000 m^3/y)
- Only within the reach of big corporations
- The salt deposits to accumulate and exchange energ are huge and its maintenance is complex
- Still in experimental phase (Few MW fed in)

A small breakdown of the Solar Mediterranean Plan of Sarkozy

Countries of the Solar Mediterranean Plan (SMP)	Electric Generation in TWh	Consumption /person In kWh/year	Population in Millions
France	566,5	9.442	60
Italy	314,4	5.515	57
Spain	322,3	7.162	45
Total Mediterranean Europe	**1.203,2**	7.427	**162**
Morocco	21,3	710	30
Mauritania	0,3	83	3
Algeria	36,7	1.146	32
Tunisia	12,9	1.290	10
Lybia	21,1	3.517	6
Egypt	119,0	1.700	70
Palestine	0,0	3	4
Lebanon	9,1	2.275	4
Syria	34,9	1.939	18
Jordan	9,0	1.800	5
Turkey	191,0	2.652	72
Israel	43,2	6.171	7
Total Africa and Middle East	**455,2**	1.744	**261**
Gran Total Países PSM	**1.658,4**	3.921	**423**



Average Price of Solar collectors un US$/Sq feet (1US$/sqf = 7€/m2)

OFFICIAL PROPOSAL:

- 38,000 M€ (60,000 MUS$) investments
- 20 Gw solar thermo electric by year 2020
- 44 TWh of expected annual generation
- 2.6% of the electricity already consumed

Typical CSP Cost breakdown

Solar Field 45%
Power Block 13%
HTF Systems 7%
Site Work & Infrastructure 3%
Services 7%
BoP 7%
Others 18%

Sources: Termosolares en el Magreb. Pedro A. Prieto at Energy Information Administration of the United States. http://www.eia.doe.gov/cneaf/solar.renewables/page/solarreport/highlights4.html
Solar Paces presentation

A small breakdown of the Solar Mediterranean Plan of Sarkozy

Some of the Material Requirements:

50 to 100 M m^3/year of clean, deionized water (50 to 100 Hm^3)

- 3 to 6% electricity auto consumption to desalinate water and to maintain the plants
- 5 to 10% of electricity in transport losses in the loop
- 400 km^2 of adequate land
- 1.8 to 3.6 million tons of steel and other metals

- 3 to 6 million Tons of coal for the smelting processes
- 2 t o4 million Tons of glass
- 400 to 800,000 Tons of concrete
- Hundreds of millions of cubic meters of earth movements
- 5 to 10 million Tons of melting salts for 8 hours autonomy of the plants

Status of CSP's in Spain

500 MW planned to 2010
with premium tariff (27c€/kWh)

Close to 1,000 MW under
construction in Spain with
at least 5 different technologies,
all of them in experimental phase

About 20,000 MW requested
to the government (!!!) with the
preceptive bank guarantees
deposited (1M€/50 MW)

Power grid under redefinition. Costs of upgrading/adapting, not covered in the plan
Fed-in round tables (autonomous regions, promoters, manufacturers)
set up in several regions to deal with this problem (several billon Euros)

Solar Energy. Stirling Engines

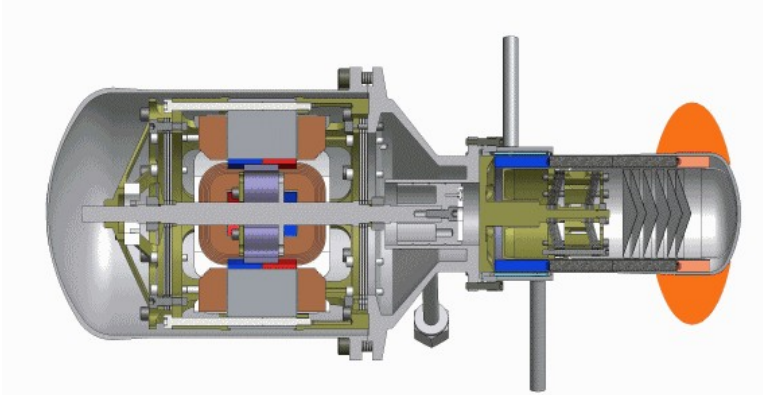
In Spain they are considered within the CSP's Group, with the same premium tariff (27c€/kWh)

STRENGHTS

Thermal efficiencies claim close to 90%
Electrics efficiencies claim > 20%
Generate in VAC, thus avoiding the bottleneck of inverters
Good scalability. No need of water or other energy back up flows

WEAKNESSES

Just generate electricity.
Mobile parts for tracking and generation. Complexity
Not proven at high scale



Solar Chimneys

STRENGHTS

The only mobile part is the power block or turbine

WEAKNESSES

Same than other solar plants: intermitent generation.
Just generate electricity.
Require big spaces.
Demand a lot of material and a gigantic chimney, usually self sustained.
Not proven technology
Relatively exposed to harsh environment

Decommissioned plant in Guadalix de la Sierra (Madrid)

Solar Photovoltaic

Main module types:

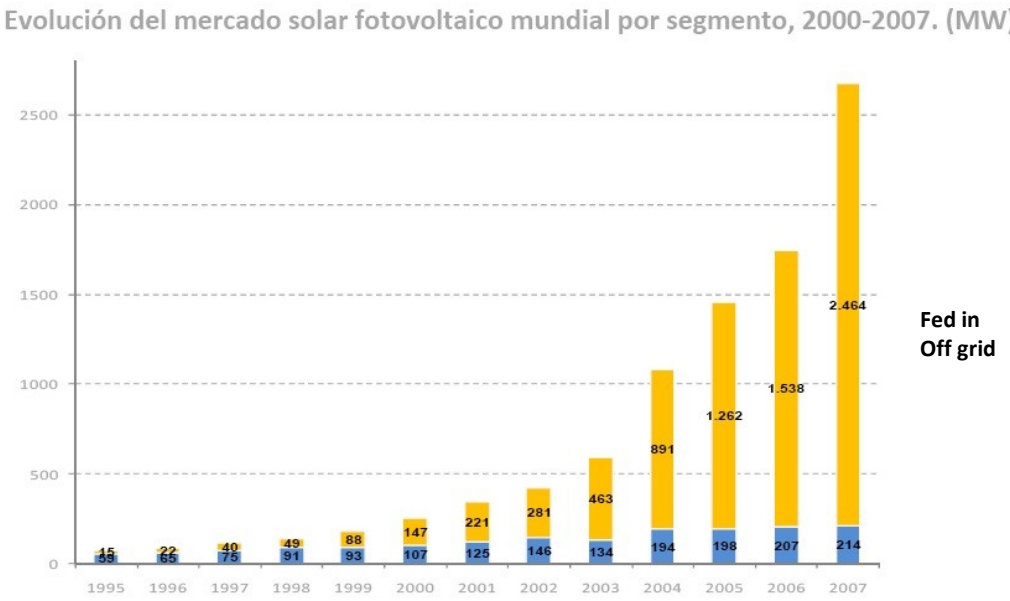
- Amorphous
- Multi crystalline
- Mono crystaline
- Thin film
- High efficiency cells (27-40%)
- Organic Materials
- Titanium Oxide
- Nanotechnologies

Main systems:

Fix modules
- One axe tracking
- Two axis tracking
    - With Conventional modules
    - Low Concentration systems
    - High Concentration systems

Solar Photovoltaic

Global Solar PV Market by segment (2000-2007) in MW

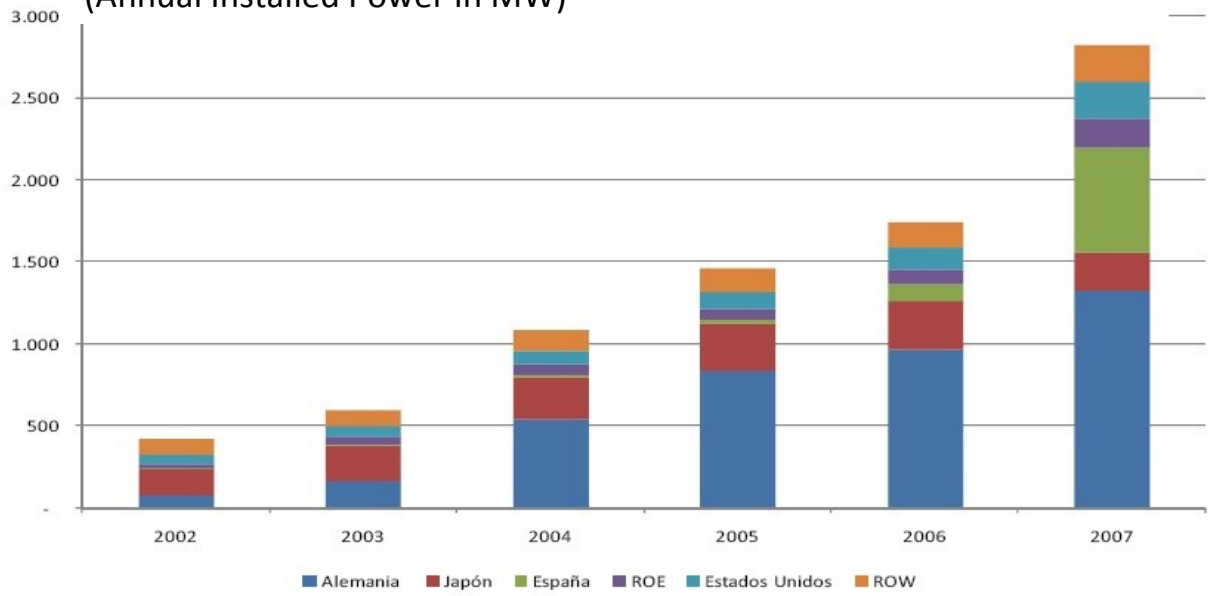


Source: Solarbuzz, CNE and Isofotón

Solar Photovoltaic

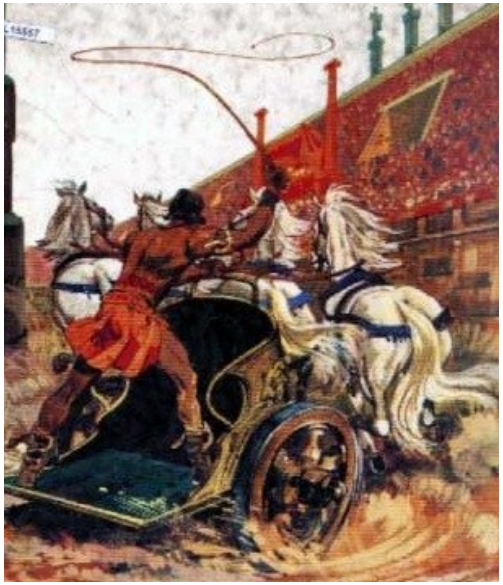
Market Annual Evolution by main countries 2002-2007

(Annual Installed Power in MW)



The total word installed park in 2007 (8 to 10 GW) generated 12.6 TWh; that is 72 times less than the annual electricity increase between 2006 and 2007

And a 0.006% of the world electricity consumption in 2007



The Energy Consumption Chariot goes over 200 times faster than the Solar Power horses!!

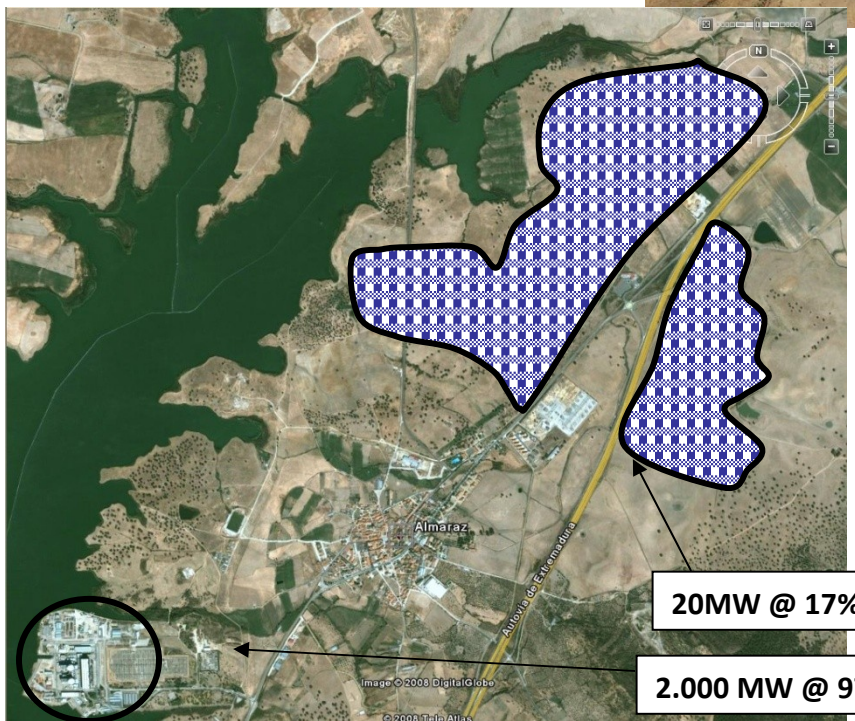
Sources: Marketbuzz 2008. Solarbuzz, BP Statistical Yearbook 2008 and own ellaboration

Solar Photovoltaics. Some facts

8% of the installed base is in emerging countries
92% in developed countries

The installations occur where there are premium tariffs, subsidies, tax exemptions or tax holidays or fiscal benefits.

But it is more than doubtful that a low entropy society could adequately maintain these structures throughout the life cycle



500 times this size (120 Ha or 266 acres) to equal in power the near nuclear power plant (600 Km²)

20MW @ 17% load factor

2.000 MW @ 97% load factor

Source: OPDE. 20' MW plant in Almaraz (Cáceres, Spain

Solar Photovoltaic in Spain

400 MW granted for the period 2004-2010 at 45 c€/kWh (~60 $/kWh) for 25 years, increased by the Cost of Living -0.25% (Fed-in Systems)

- They were taken as a pure financial product (12-14% of ROI), rather than as encouragement to develop the technologies and lower the costs
- Lack of serious quality controls in many installations
- Poor contracting conditions for supply, installation, and over all, maintenance
- Big Corporations, foreign investment groups and even pension funds took over single owners, evading the 100 kW maximum inst. power for the premium
- In 2007, already 600 Mw were installed and connected and many more imported to reach on time.
- 2.8 B€ were of imported modules in 2007 (about 700 MWp) (Minister of Industry)
- It is expected to end 2008 with some 1.2 -1.4 GW
- Prices of modules, inverters, transformers, labor, land, etc. were moving upwards wildly, while envisaging to enter into the premium rate quotas and going down sharply (some) , when quotas were surpassed.
- The cost of 1% of the Spanish electricity from PV (~2 GWp), costs 4% of the electric bill to citizens
- A 16% increase in the electricity bill has collapsed many industries heavily dependent.

Solar Photovoltaic in Spain

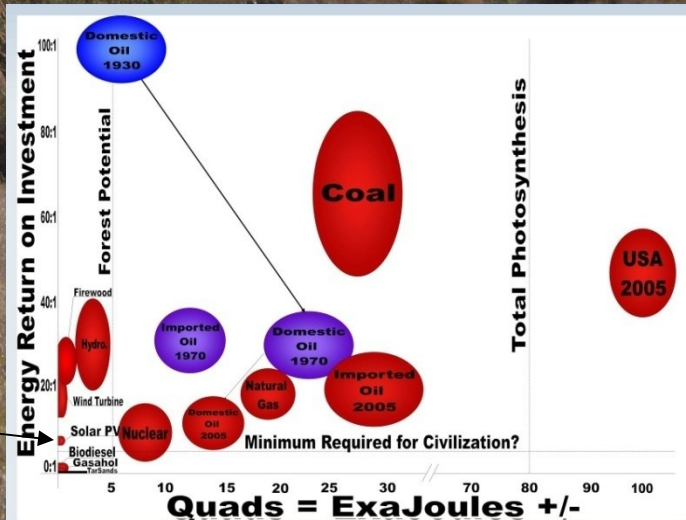
New extension granted by the Government of 500 MW/year more until 2010,
but at 32 c€/kWh (~48c$/kWh) and 10% decrease of premium rate every passing year

- Undergoing installations are already covering the 2008 and 2009 quotas
- ROI target at 6-7%. Many solar PV companies/investors dropping at this level.
- End of story.

Solar Photovoltaic

They are systems totally underpinned and supported by a fossil fuel, high entropy, high mobility society, today parasiting it, from the energy point of view

It is not only a question of EROEI, (ER/EI) but also of the weakest link of a complex and long Supply and Maintenance chain



Solar Systems.
A small study case for Spain

The replacement of all fossil and nuclear Spanish electricity by Solar PV (32 GW peak; 20 GW valley; 320 TWh/year) will demand about 188 GW of PV modules in 6,000 Km^2.

Close to a Spanish national budget (1.2 Billion €) at current prices in PV modules, inverters, transformers and networks.

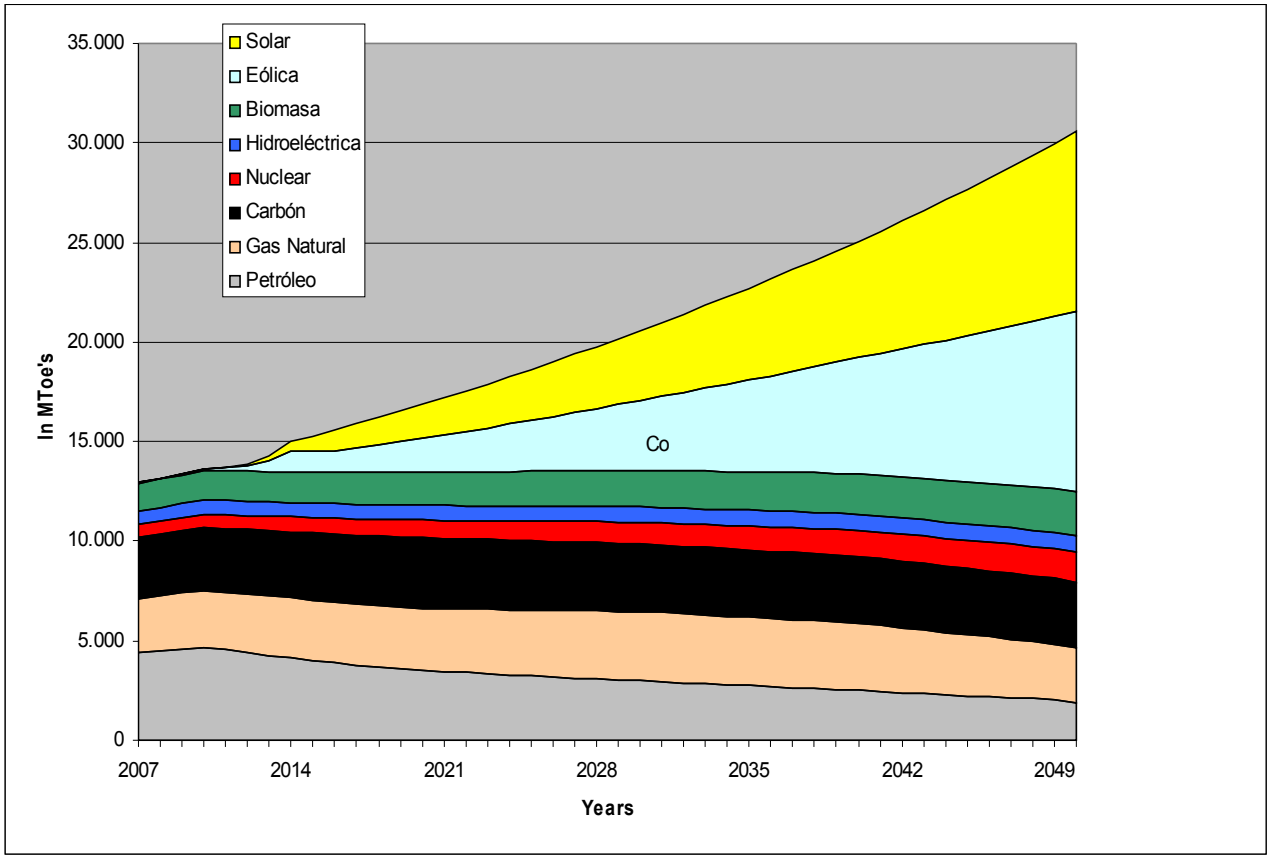
And storage systems for minimum 200 GWh, equivalent to 300 billion car batteries (~ 80 Ah @ 12V)

The replacement of all fossil and nuclear Spanish primary energy (138 MTpe~620 TWh) by Solar will demand about 370 GW PV Modules in 12,000 Km^2.

And storage systems for a minimum of 500 GWh

A Renewable Scenario: Growth as usual + Savings

- Assumed 3% annual growth throughout the period
- Technical improvements + energy savings at 1% per annum throughout the period
- Oil and gas as per ASPO. Include non conventional oil and gas
- Coal as per Energy Watch Group
- Nuclear assumed more than double
- Biomass and waste increase in a 63% throughout the period
- Wind starts with 100 GW growing 80% per year up to 2015 and then 50% with solar
- Solar starts with 8 GW and grows 260% per year until 2015 and then 50% with wind



- **Ignored the necessary replacements of the renewables during the period**
- **Ignored the energy spent in producing these renewable systems**
- **Ignored any improvement in quality of living to 80% of the planet inhabitants**
- **The electric/liquid fuels conversion rates assumed 1/3 always in favor of renewables**
- **With these assumptions, fossil fuels levels around 10 BToe and 25-27 BTons CO2 per year until 2030**

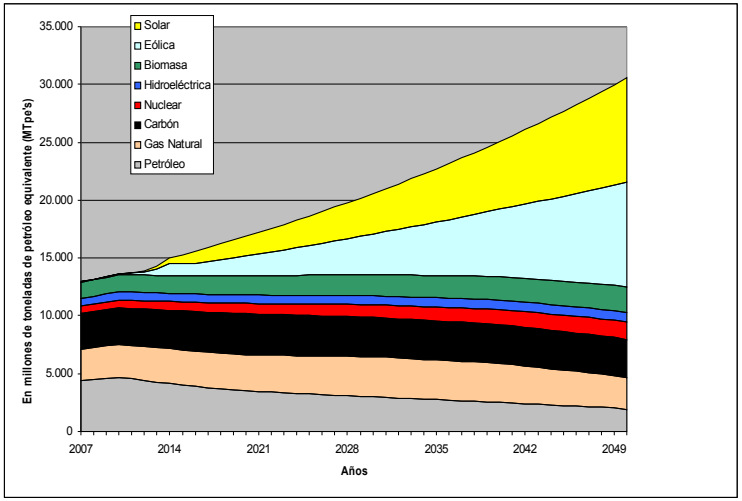
Sources: ASPO, Energy Watch Group, British Petroleum (2007), others and own ellaboration

A Renewable Scenario: Growth as usual + Savings

- 60 TW wind park required at the end of period (600 times the present world installed base)

This will represent:

- 9 times the world steel production of 2006
- 6,000 the glass fiber world production
- 60 times the world concrete production



- Plus 120 TW solar plants installed base (thermal, CSP and PV) at the end of the period (12,500 times the present world installed park)

- This represents, in land occupation, between 500 and 700,000 Km^2
- And in economic costs at present prices, some 600 trillion Euros.

Sources: ASPO, Energy Watch Group, British Petroleum (2007), others and own ellaboration

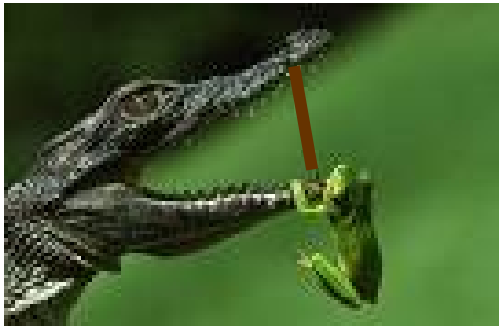
CONCLUSIONS

‘This is not Plan A: business-as-usual.
This is Plan B: an all-out response at wartime speed proportionate to the magnitude of the threats facing civilization’.

Lester Brown.
Plan B 3.0: Mobilizing to Save Civilization

‘We are not living ordinary times!
And what is impossible in ordinary times may turn feasible in extraordinary times’

Jorge Riechmann.
Poet and philosopher



Thank you for your attention

Pedro A. Prieto
Vice president

http://www.crisisenergetica.org

http://www.aspo-spain.org/aspo7