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**What limitations
for renewable energies
in the long term
world energy supply ?**

Pierre-René BAUQUIS

**Former Director of Strategy & Planning for TOTAL Group
Associated Professor at the IFP school (French Institute of Petroleum)**

world energy mix outlook to 2100 (authors view) rev 2010

commercial energy sources only

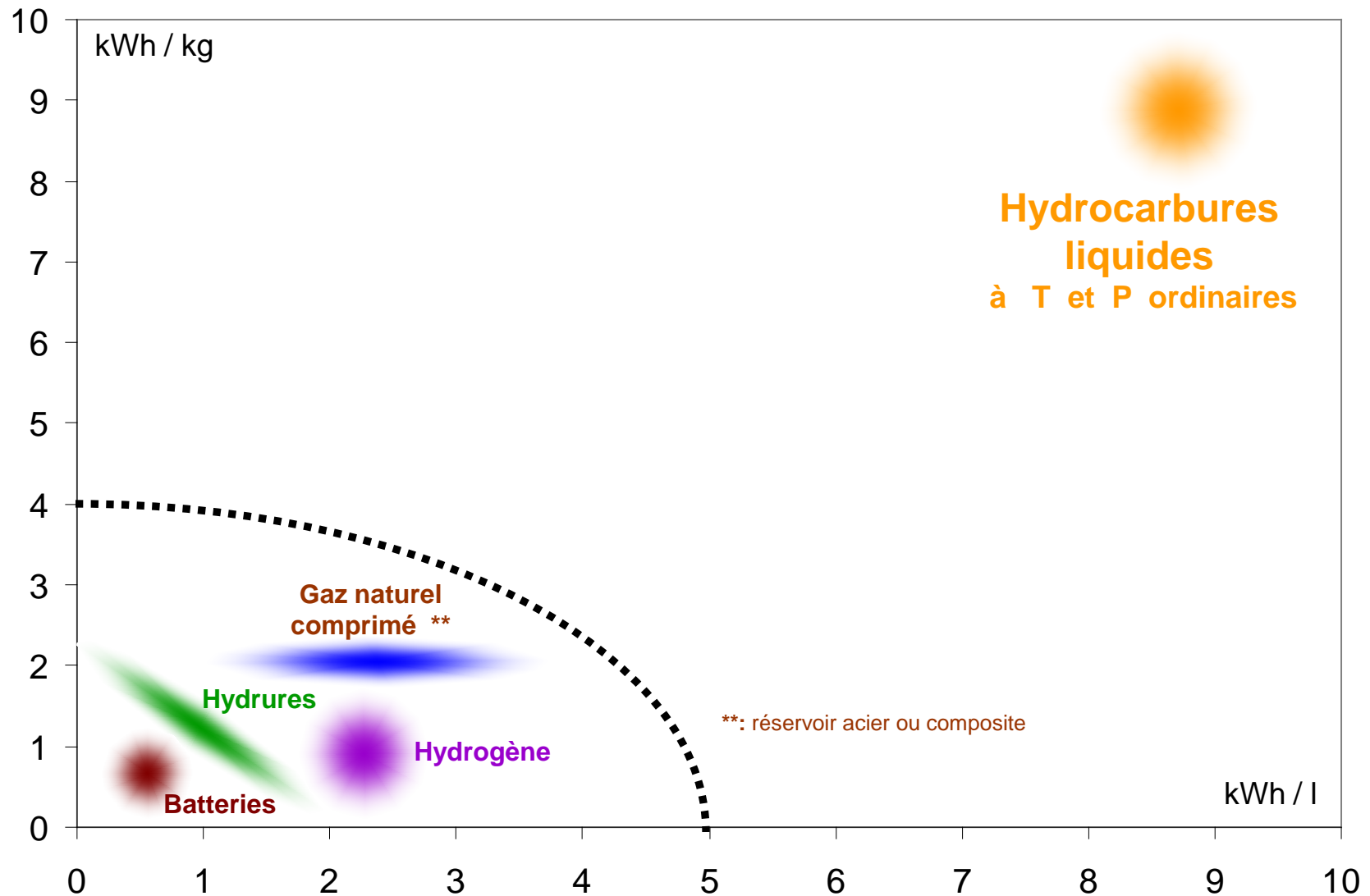
Source : P. BAUQUIS
Revue de l'Énergie, Sept. 1999
rev RG 2010

	2000 (6 Ghab)		2050 (9 Ghab)		2100 (? Ghab)	
	Gtoe	%	Gtoe	%	Gtoe	%
oil	3.6	39	3.5	19	1.5	8
gas	2.1	23	3.5	19	1.5	8
coal	2.3	25	5.0	28	5.0	28
Total fossil fuels	8.0	87	12.0	66	8.0	44
hydro electricity	0.6	6	1.0	6	1.0	6
other RES (wind, solar,etc...)	0.1	1	2.0	11	3.0	17
nuclear electricity	0.6	6	3.0	17	6.0	33
Total all sources	9.3	100.0	18.0	100.0	18.0	100.0

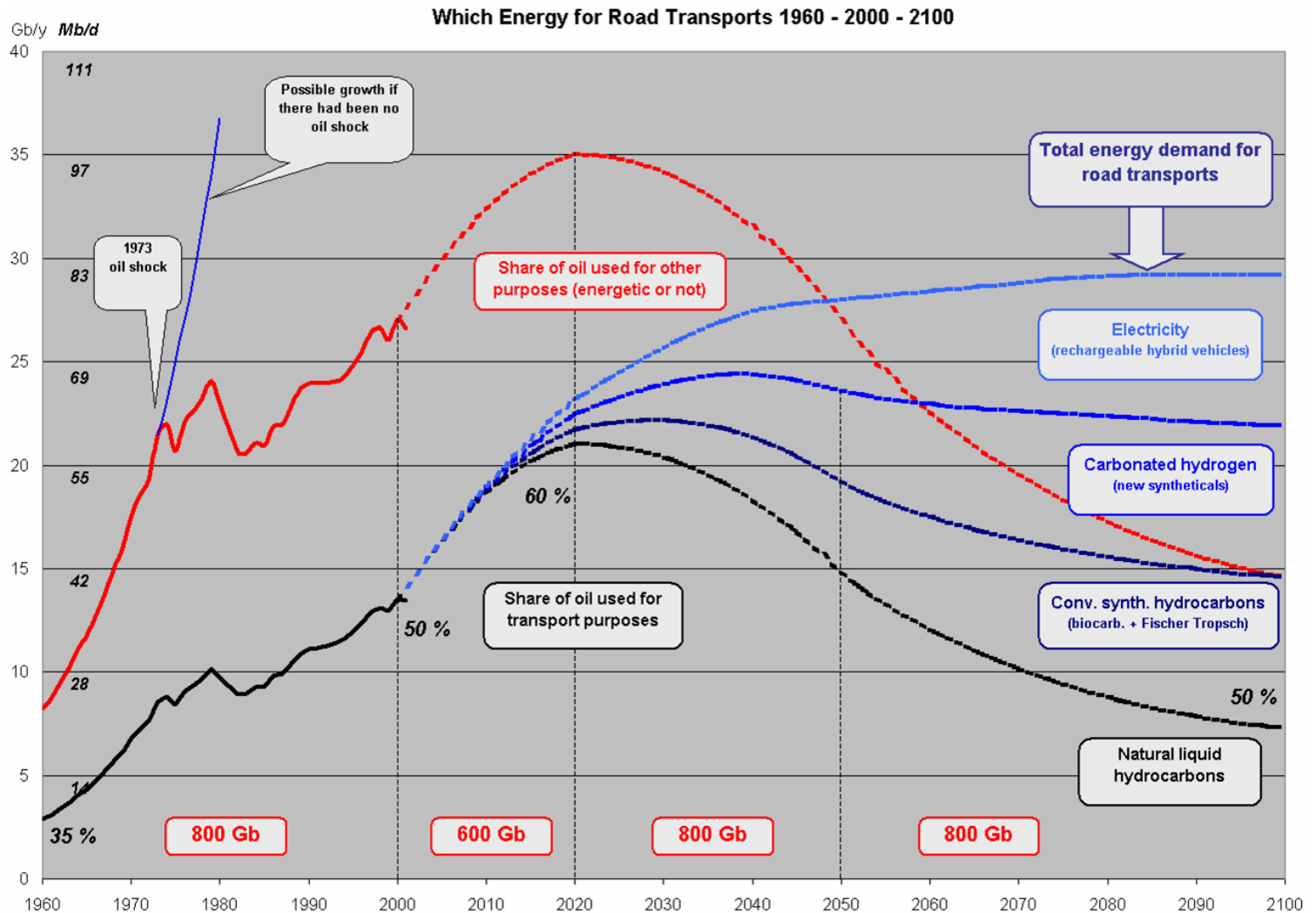
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les hydrocarbures liquides : une compacité énergétique inégalée



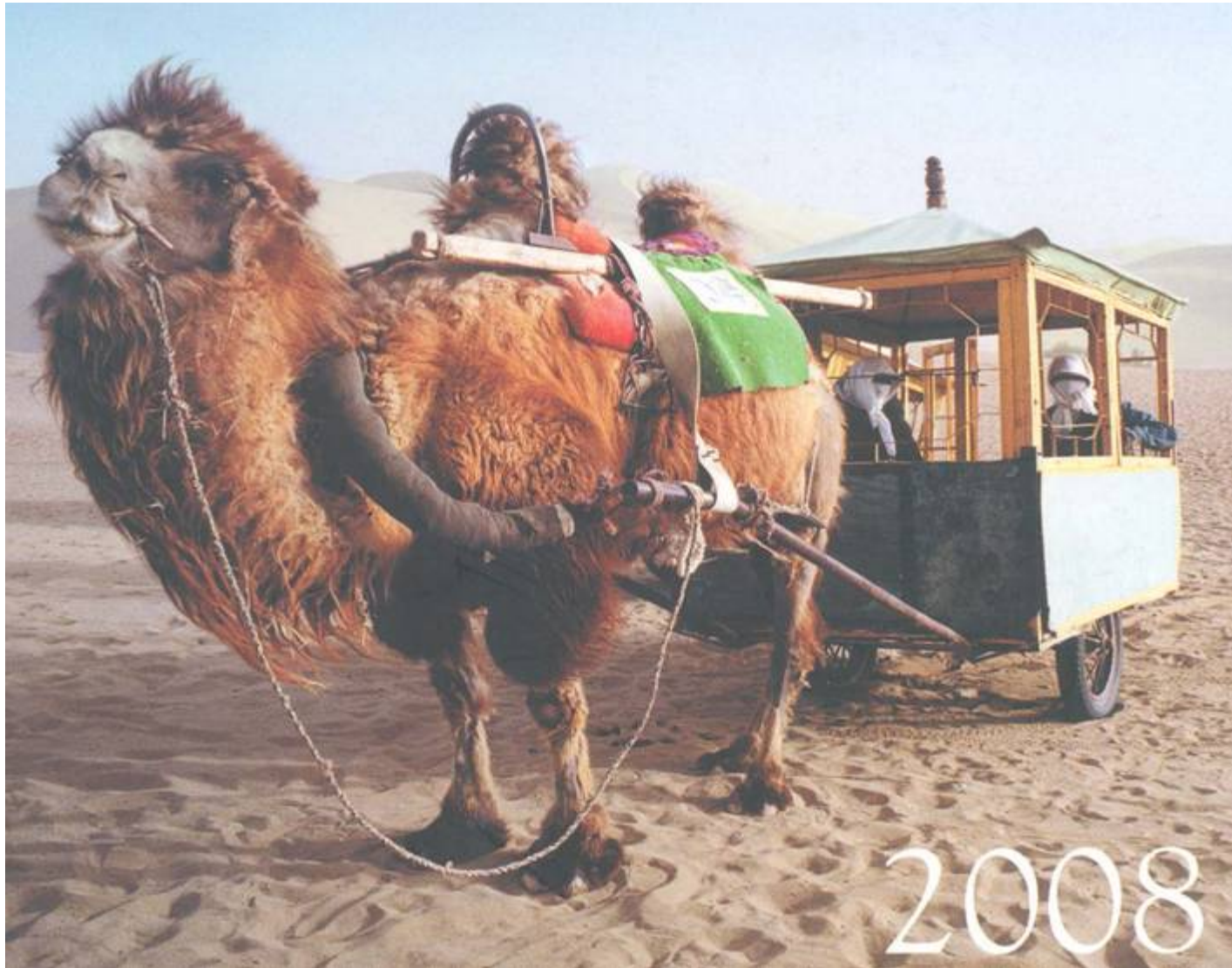
Which Energy for Road Transports after "peak oil" ?



Source : P.R. Bauquis

PRB / VL 2003

which individual vehicles for the future ?



wind power vs nuclear power

WIND

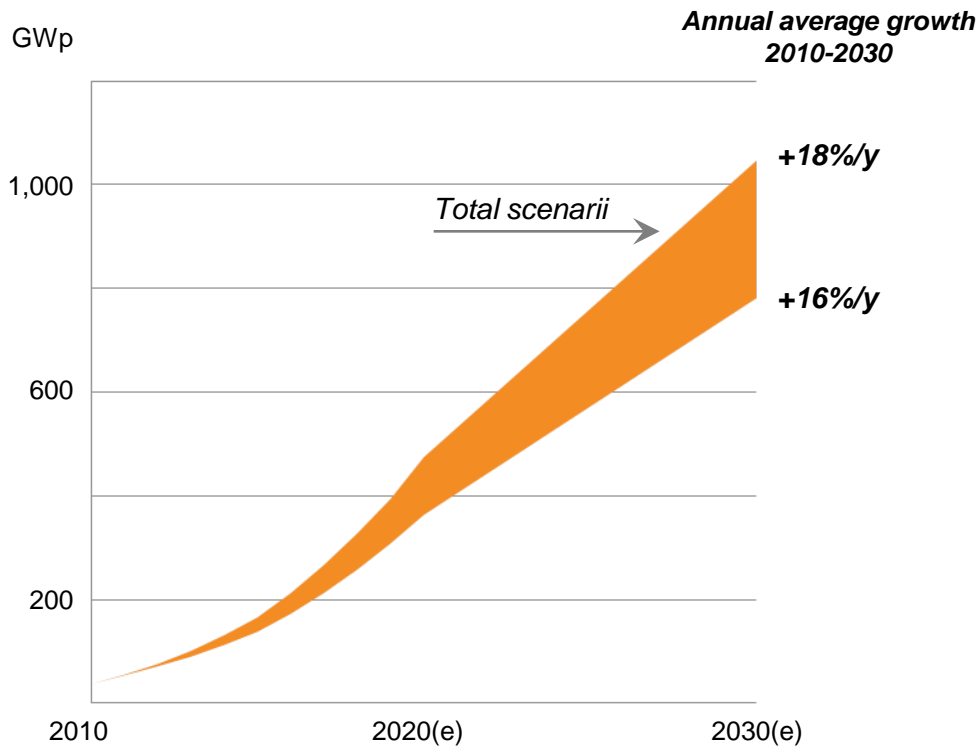
- no CO2 emission
- max 10 MW installed per km²
- 0.01 TWh / km²
- not available on call
- unit investment small
- equipment life 20 years
- free fuel
- 10 to 20% max in electrical mix

NUCLEAR

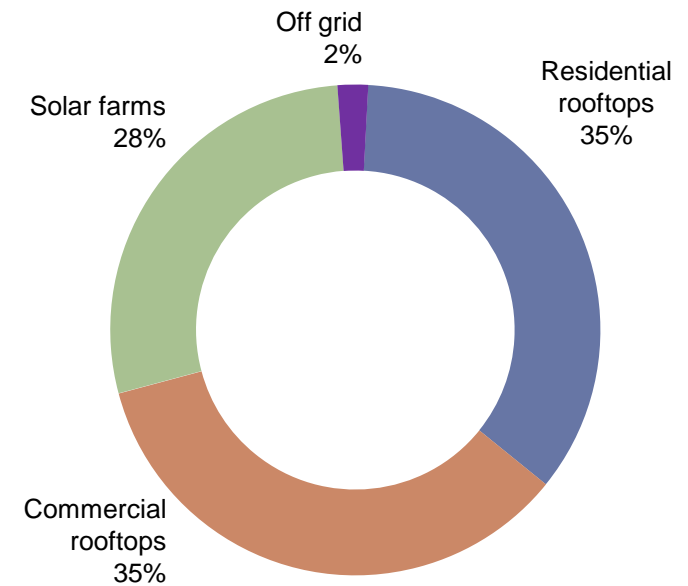
- no CO2 emission
- 1000 to 1500 MW per km²
- 10 TWh / km²
- base load
- unit investment large
- equipment life 40 years +
- fuel cost (but marginal)
- security and waste problems

Capturing solar market growth

Estimated worldwide solar photovoltaic cumulative capacity

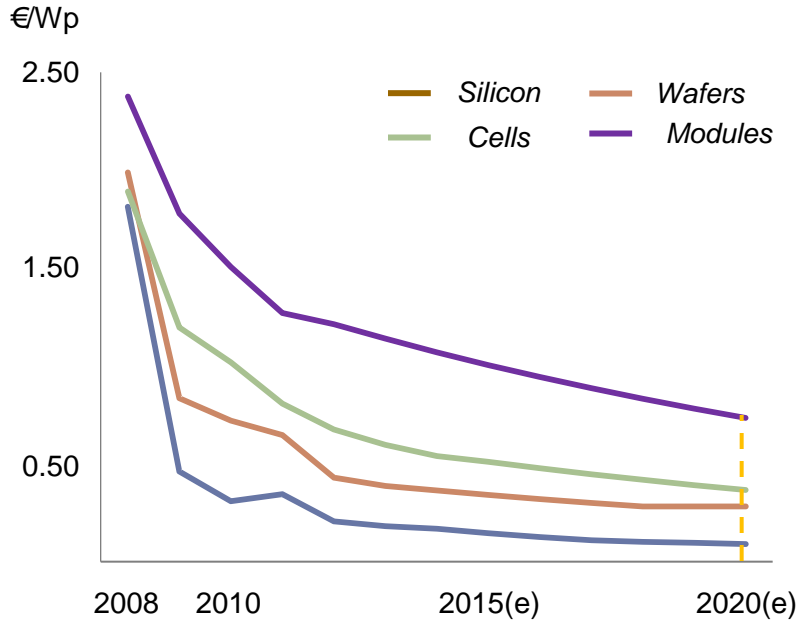


Estimated solar installed capacity (2011)

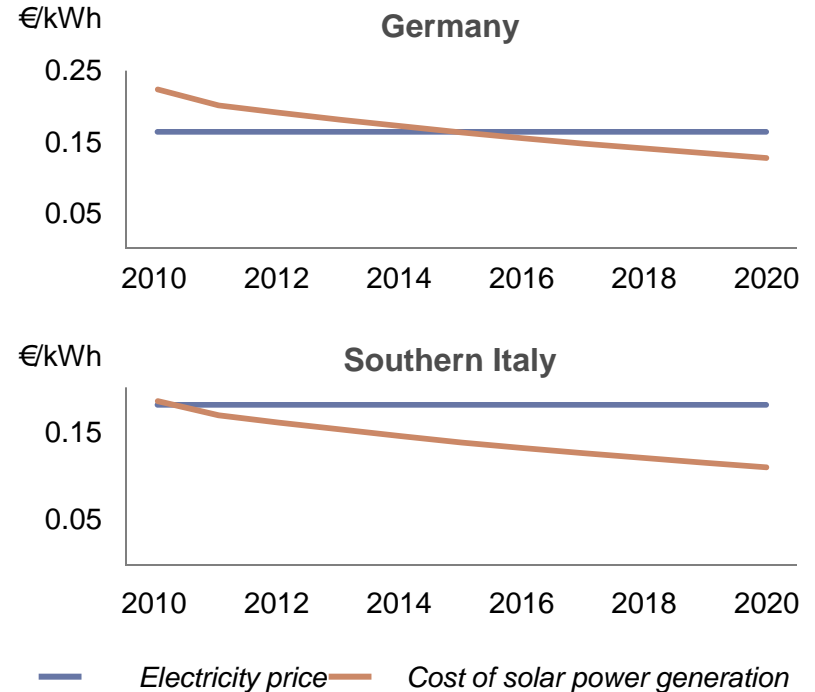


Closing the gap to grid parity

Main components estimated spot price evolution



Estimated grid parity - Residential

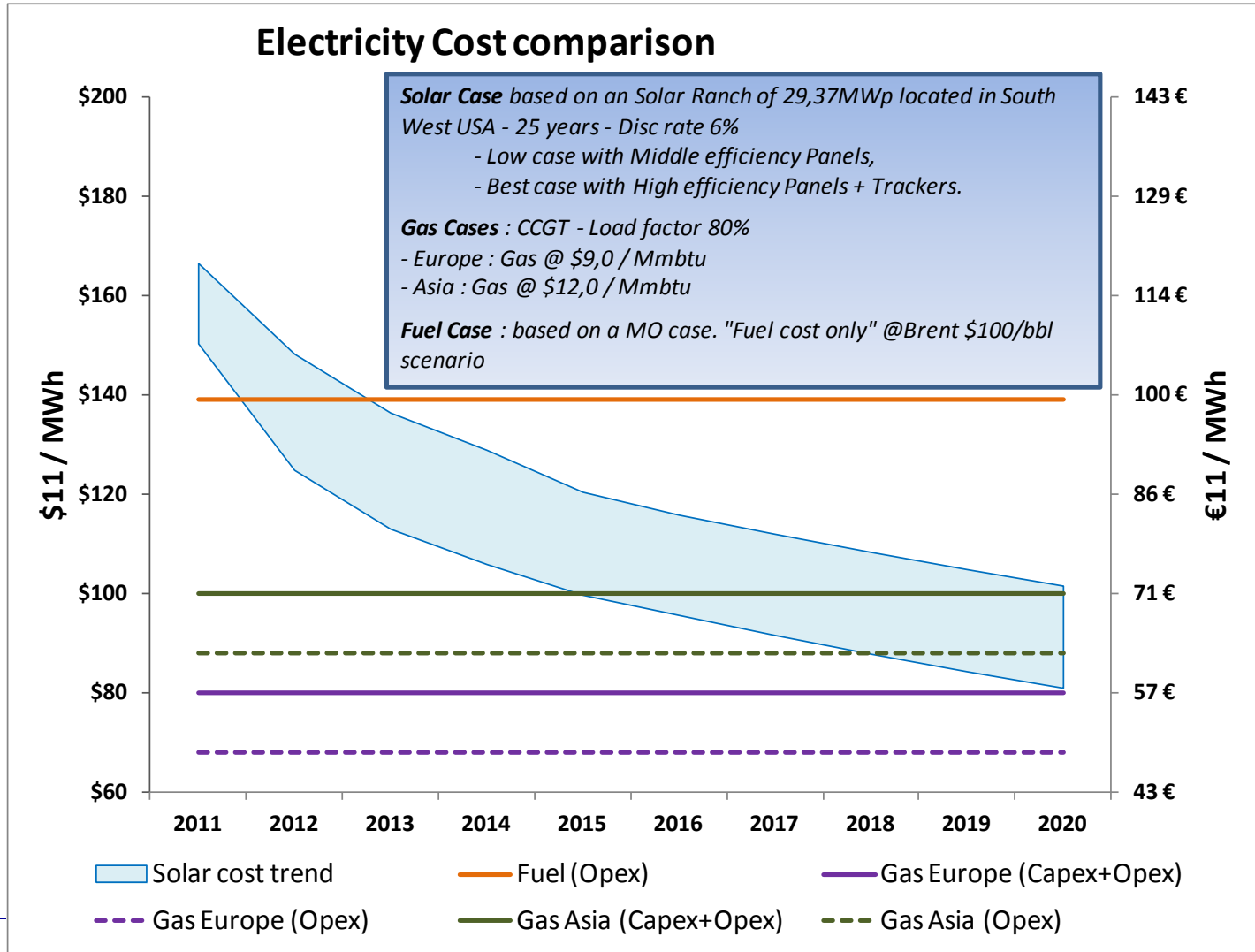


◆ **Cost reduction: -6% per year expected on modules over the next 5 years**

➤ **High efficiency panels offer maximum savings on rooftops**

Solar rooftop systems expected to become competitive without subsidies for most OECD residents by 2020

Photovoltaic narrowing the cost gap with other fuels for electricity generation



conclusions 1 for energy planners & governments

- ✓ **by mid 21st century the share of fossil fuels in world commercial energy mix is expected to decrease from 84% today to 66% in 2050 and still 44% in 2100**
- ✓ **this decrease will have two causes :
peakoil (plateau) at 100 Mbpd (+/- 5) around 2020 and
peakgas (plateau) at 5 000 Gm3/yr (+/- 500) around 2030/2040
combined with worldwide CO2 emissions restrictions**

conclusions 2 for energy planners & governments

- ✓ **non-carbon emitting sources will have to fill the gap ; most renewable energies can cover only a very limited share of this gap (hydropower, biomass, wind, ocean energies, geothermal,...) as each of them faces strong economic limitations**
- ✓ **the bulk of the remaining gap will have to be filled by a combination of solar energies and nuclear energies ; it will not be possible before 2020 to estimate their respective contributions to the long term world energy mix**

conclusions for students & academics

- ✓ paradoxically, the 21st century could still be the oil and gas industry's golden age, despite peak oil and global warming (*high prices, more and more hi-tech*)
- ✓ it will also be the golden age for all renewable energies and for nuclear energy
- ✓ for all students, it is clear that they can engage into very promising careers in all energy related fields and industries : *oil and gas industries, nuclear industry, renewable energies, energy efficiency, energy saving, CCS technologies, etc...*

