

About the Climate Change Challenge

Alain Bucaille – March 10, 2014

Agenda

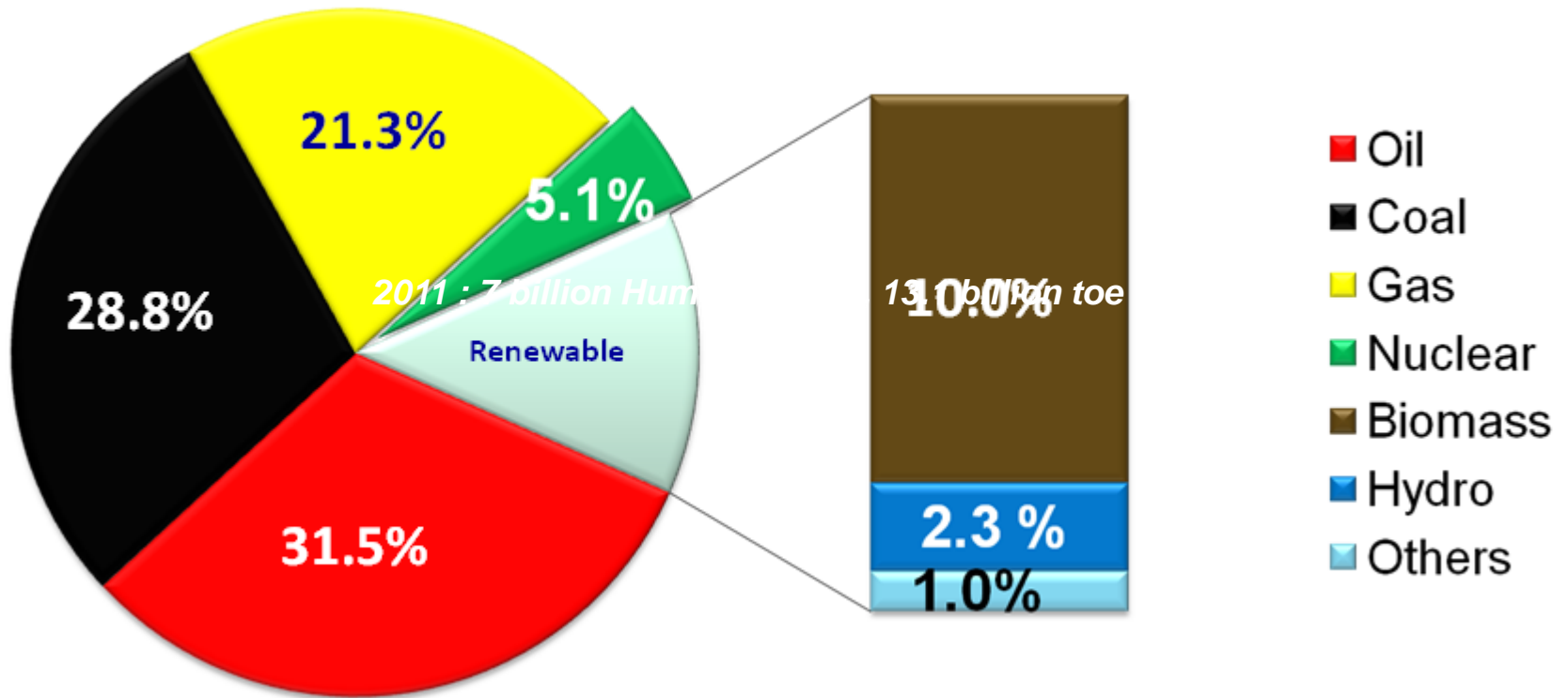
- ▶ **The context**
- ▶ **Technologies exist for meeting the challenge and maintaining economic growth**
- ▶ **10 results in the Economy field for IC investigations**
- ▶ **Conclusions**

The context

2000: 6 billion Human beings, 10 billion toe
 2011: 7 billion human beings, 13.1 billion toe

Total fossil : 81.6%

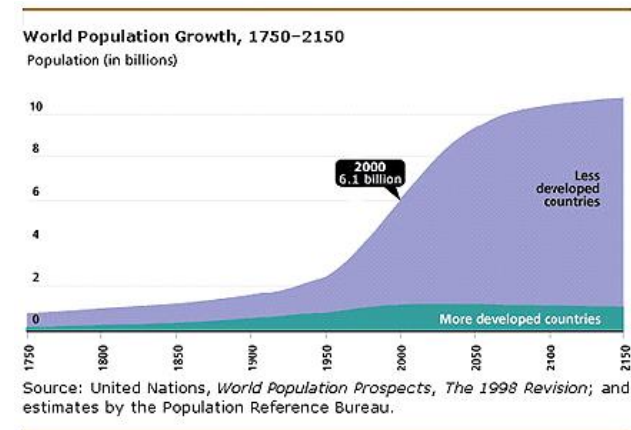
Total renewable : 13.3%



Source : IAE

Roughly speaking...

- ▶ The world population is growing as never before
 - ◆ 3 billion in 1960
 - ◆ 6 billion in 2000
 - ◆ 7 billion in 2011
 - ◆ 8.5 – 9 billion or more in 2050
- ▶ Already 4 billion people are connected to western lifestyle habits through TV
- ▶ All countries aim at more than 2% growth rate
 - ◆ $(1.02)^{40}=2.21$
 - ◆ $(1.02)^{50}=2.69$
 - ◆ $(1.015)^{60}=2.44$
- ▶ Fossil fuels provide 81% of the world's primary energy needs
- ▶ And we need to get back to 3-4 Gt C emissions by year Instead of 9 Gt C today.
- ▶ **How do we do this?**



According to IEA, the world energy scene today (1/3)

■ Some long-held tenets of the energy sector are being rewritten

- *Countries are switching roles: importers are becoming exporters...*
- *... and exporters are among the major sources of growing demand*
- *New supply options reshape ideas about distribution of resources*

■ But long-term solutions to global challenges remain scarce

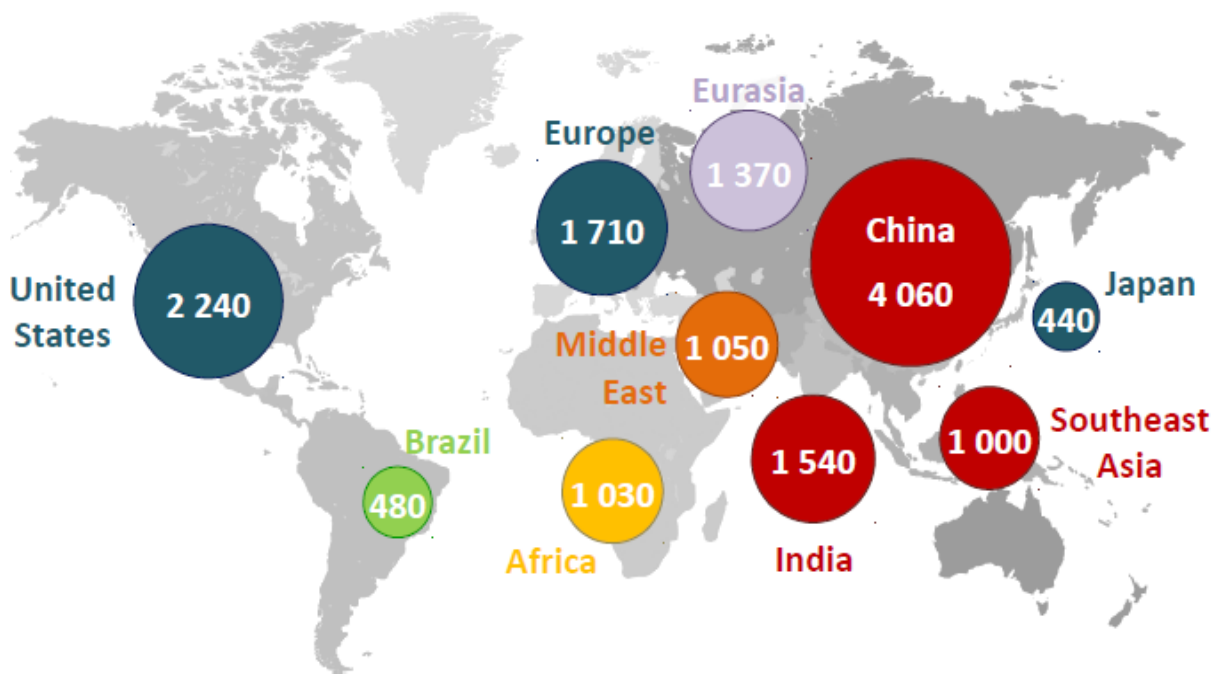
- *Renewed focus on energy efficiency, but CO2 emissions continue to rise*
- *Fossil-fuel subsidies increased to \$544 billion in 2012*
- *1.3 billion people still lack electricity – in Africa and South Asia*

■ Energy prices add to the pressure on policymakers

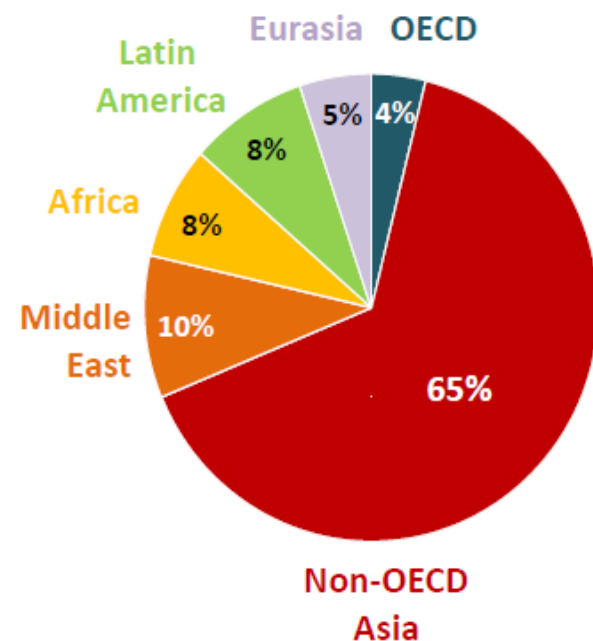
- *Sustained period of high oil prices without parallel in market history*
- *Large, persistent regional price differences for gas & electricity*

The engine of energy demand growth moves to South Asia (2/3)

Primary energy demand, 2035 (Mtoe)



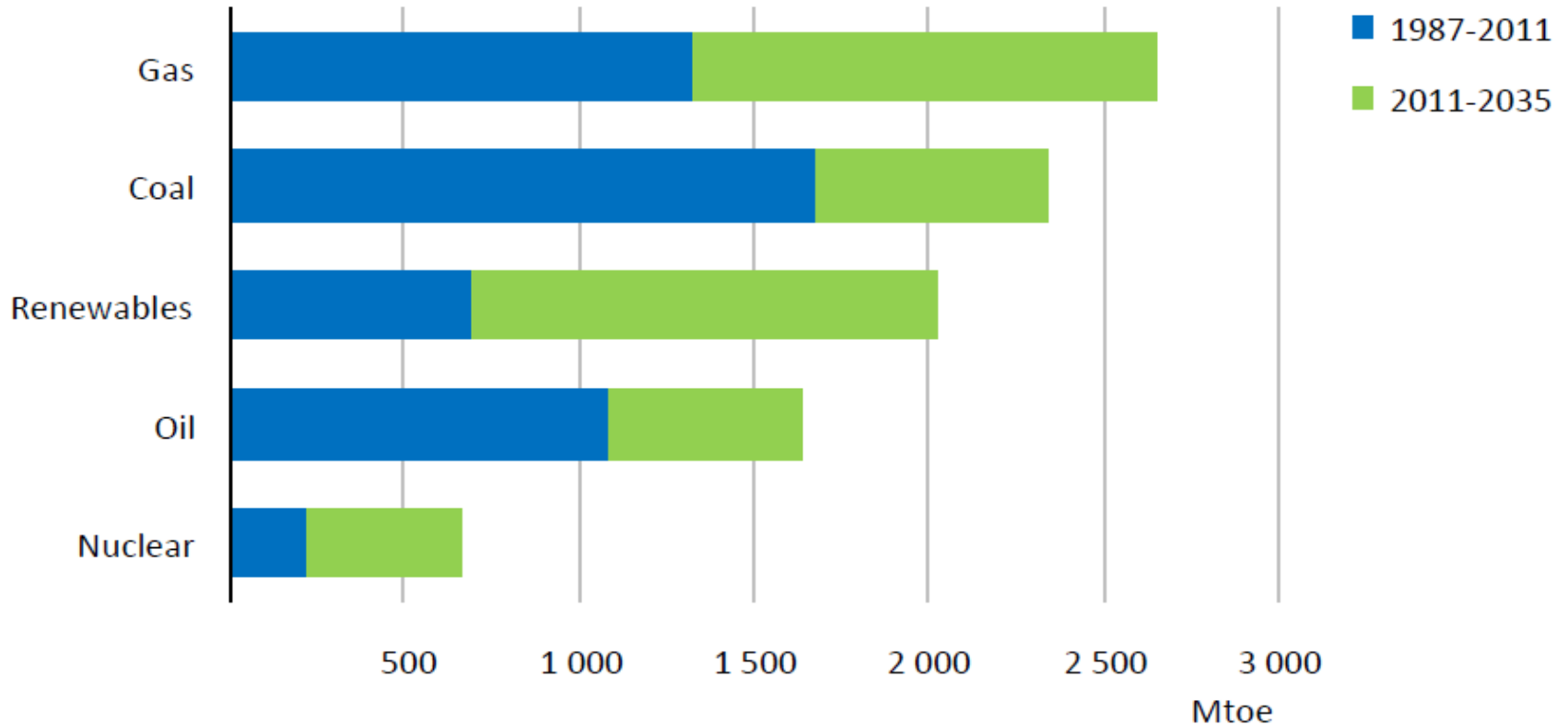
Share of global growth 2012-2035



China is the main driver of increasing energy demand in the current decade, but India takes over in the 2020s as the principal source of growth

A mix that is slow to change (3/3)

Growth in total primary energy demand



25 years ago the share of fossil fuels in the global mix was 82%;
it is the same today & the strong rise of renewables in the future only reduces this to around 75% in 2035.

IPCC established in 1988 (1/3)



WMO



UNEP

**Anthropogenic interference
with the climate system?**



IPCC 1990 : Maybe, Maybe not

IPCC 1995 : Maybe

IPCC 2001 : Likely

IPCC 2007 : Very Likely !

IPCC 2014 : Almost certain...

You do not worry for a few degrees ? Think again ! (2/3)

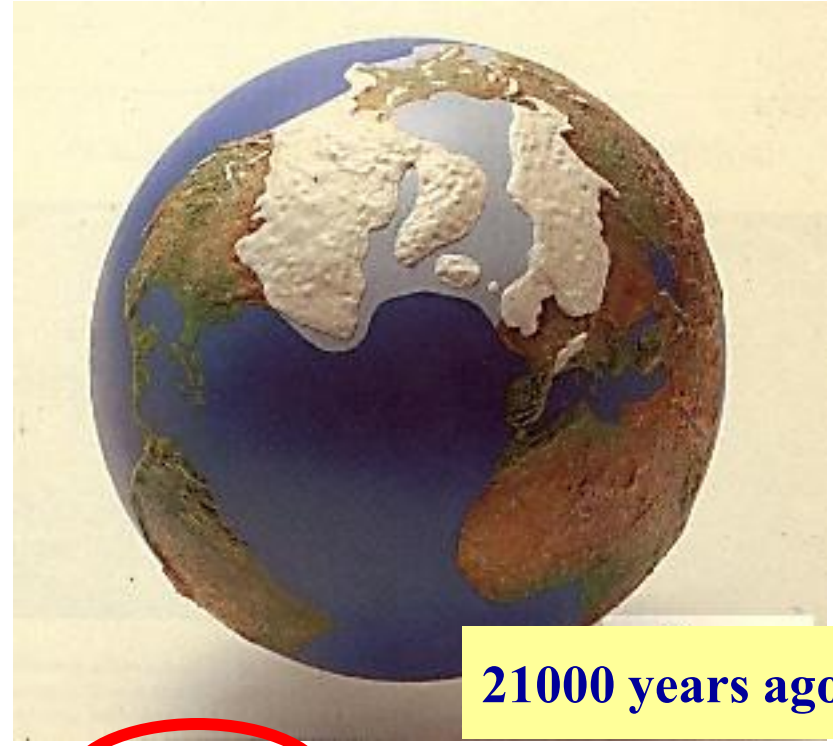


Today

CO₂ Pre-industrial = 280 ppmv

CO₂ 2000 AD = 370 ppmv

(Joussaume, 1993)



21000 years ago

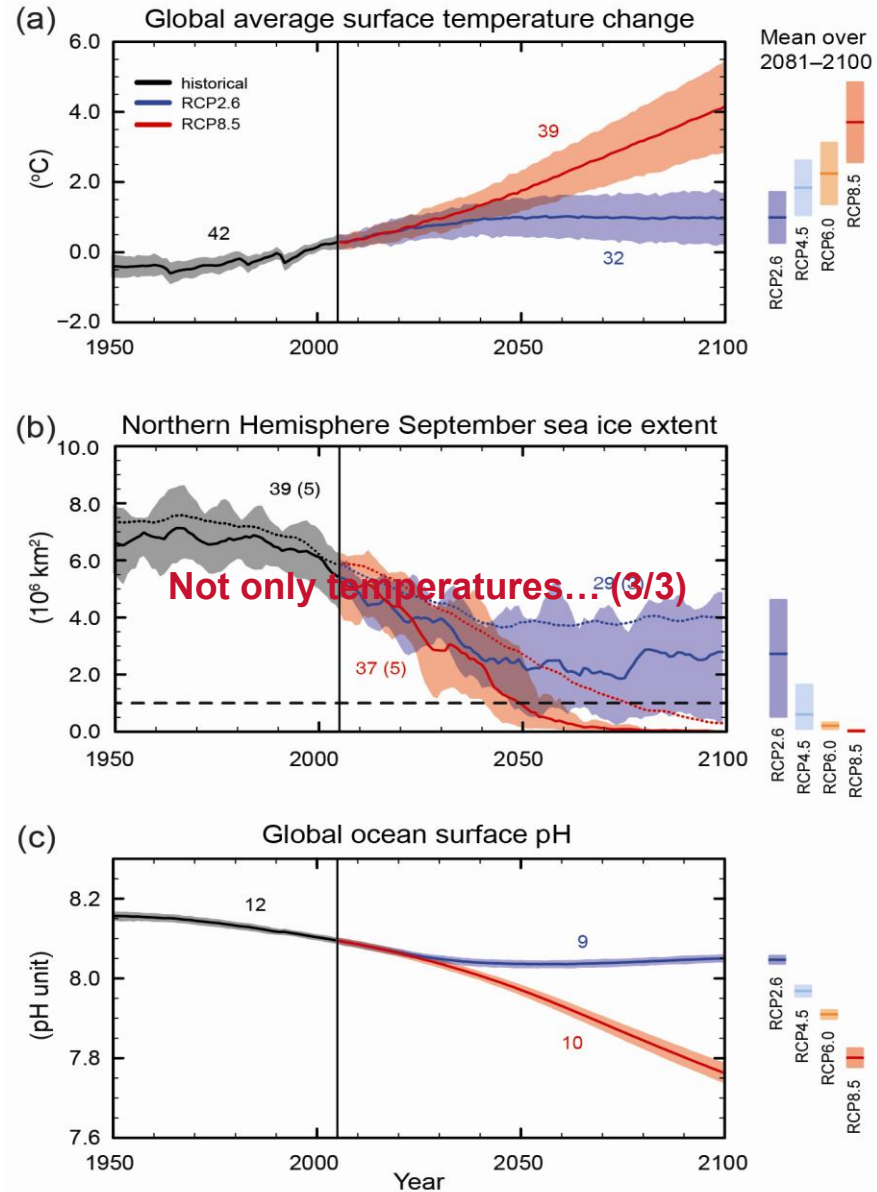
$\Delta T = -5^{\circ}\text{C}$

Δ sea level = -130m

Δ ice volume = +52 10⁶km³

CO₂ = 200 ppmv

Not only temperatures... (3/3)



Projections
2012-2100

The technologies are there

A full list of potentialities (1/3)

► Electricity:

- ◆ A very strong opportunity with nuclear, if reliable safety authorities can be developed.
- ◆ Hydroelectricity, which is possible when water is abundant.
- ◆ Renewables (wind on-shore, solar) but a limit linked to intermittence.
- ◆ Coal and gas plants with high performance standards.
- ◆ CCS where geology is appropriate and emissions are massive.

If all are developed within G20, possible to shift there from 500g CO₂/KWh to 100g CO₂/KWh.

A full list of potentialities (2/3)

► Transport

- ◆ A full list of opportunities for cars.
- ◆ Transport by electric train or electric highway for long distance trucks.
- ◆ For short distance trucks, electricity or hydrogen.
- ◆ Ships even possibly with nuclear.
- ◆ More efficient airplanes-and biofuels.
- ◆ CO₂recycling.

► Industry

- ◆ A need to differentiate the needs:
 - more than 1000 C,
 - between 300 C and 600 C,
 - the reminder.
- ◆ For more than 1000 C, electricity (continuous or plasma torches),
- ◆ Between 300 C and 600 C: high temperature reactors?

A full list of potentialities (3/3)

► Buildings

- ◆ Isolation of old buildings (roofs, windows...).
- ◆ Heat (geothermic, solar heating, wood, heat pump).
- ◆ Positive energy buildings
- ◆ Truly effective smart meters and associated software.

Economics and regulation

Economically speaking: 10 main results... (1/4)

- 1. It is possible to meet the Climate Change challenge with measures costing ~1.5% of the World GNP, but it is urgent to act before 2020.**
- 2. One key factor is increasing the share of electricity in the World energy mix and, of course, decarbonizing power generation.**

We need to multiply by 2 the importance of electricity inside the energy mix.

- 3. Carbon capture and sequestration will be necessary but not possible all around the world.**

It could represent between 10 and 20% of the CO₂ emissions but not more than that.

Economically speaking: 10 main results... (2/4)

4. Power generation:

- ◆ Increase the share of renewables but, because of the intermittency of wind and solar, maintain carbon-free “dispatchable” power sources, nuclear and coal with CCS.
- ◆ Unrealistic to go above 25% electricity with renewables.
- ◆ Industry needs to shift gradually to electricity .

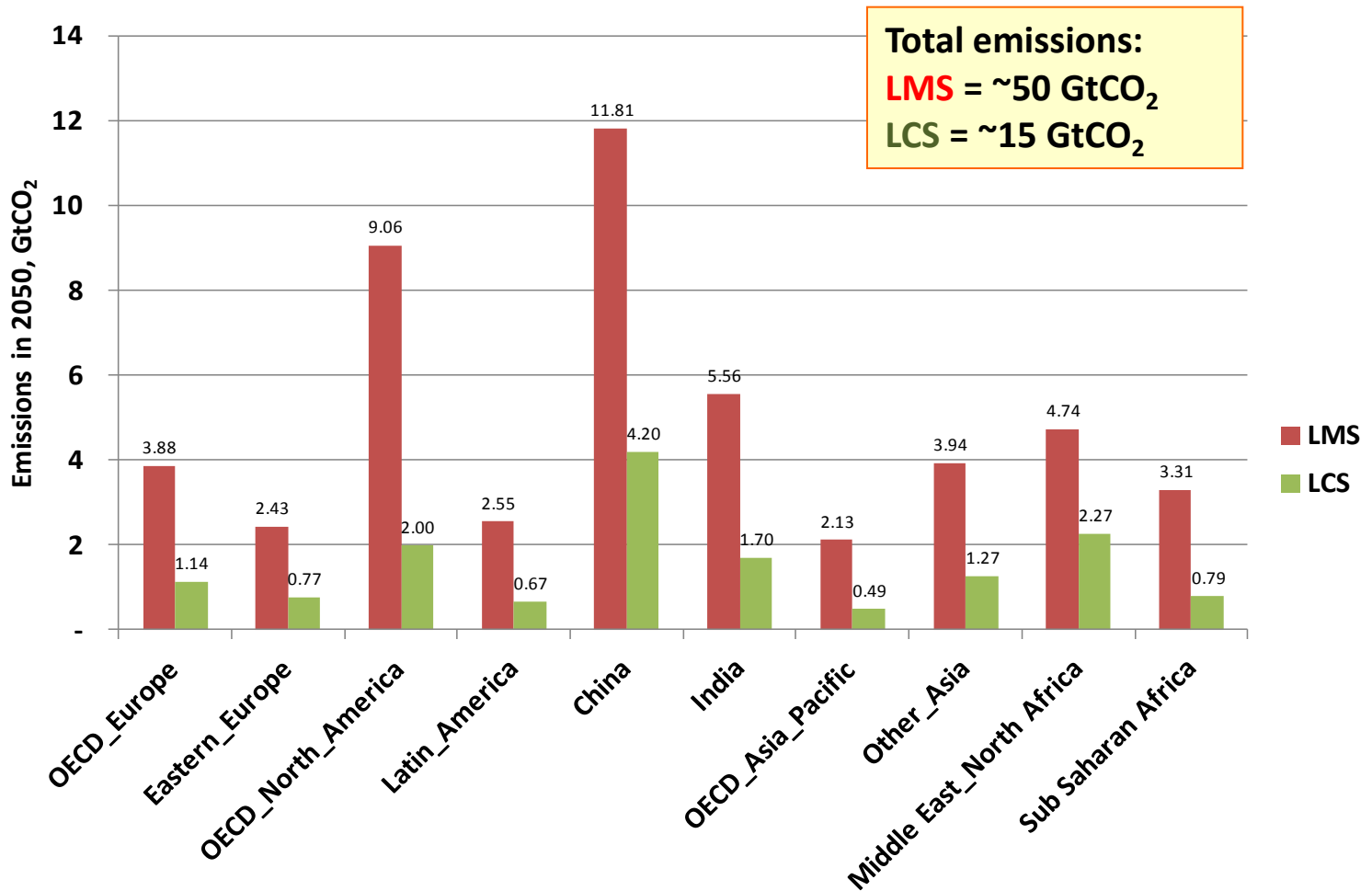
5. Transportation: Develop EV and plug-in Hybrid as well as liquid synfuels from biomass and carbon-free produced Hydrogen.

6. Two main targets need to be agreed upon : gCO_2/kWh for power generation and gCO_2/km for cars by 2030 and 2050 inside G20 countries.

Economically speaking: 10 main results... (3/4)

- 7. Investigate hydrogen generation as a way to store excess power from renewables or to generate biofuels.**
- 8. Crude Oil prices should be high enough to promote alternatives and feed the development of Middle East countries but low enough not to impair the world economy. Price bracket could be 100 to 140 US\$₂₀₁₀/barrel.**
- 9. No possibility to regulate without an agreement inside the G20 countries and an open system for the others.**

Every region has to contribute ... (4/4)



Conclusions

- ▶ **Three major conclusions:**
 - ◆ **We can meet the challenge for less than 1,5% GNP**
 - ◆ **Decarbonized electricity is key for doing it**
 - ◆ **This bill would be reasonable if we aim at limiting oil bill inside the GNP, and would be higher if we are not able to do it.**

- ▶ **The way China will position itself will be absolutely critical for any kind of process... and naturally therefore the talks between USA and China will be of utmost importance.**