

2°C: technologies and costs of meeting the target

Key results and personal comments

Alain Bucaille – Rabat – 8 May 2013

A difficult and unusual issue : at least 10 reasons! **(1/2)**

1/ **Proven or not proven?**

All the specialists agree; a matter to be definitely solved by 2020.

2/ **Too late or not too late?**

Many interests are in stake!

3/ **UN negotiations? G20 negotiations? G2 negotiations?**

Probably all of them are necessary.

4/ **Unavailability inside almost all the nations to think at the world level;**

A difficulty for every citizen to realize the changes due to populations, large cities growth and... TV.

5/ **Lack of transparency about carbon value through CCS.**

A difficult and unusual issue : at least 10 reasons! **(2/2)**

- 6/ The public opinions are not mobilised on the topic..., **lack of worldwide opinions polls.**
- 7/ The **NGO** don't play the role the people believe.
- 8/ **USA** seems not to study because **China** doesn't think to negotiate... and China doesn't want to negotiate because considering USA is not studying... : **an apparently vicious circle.**
- 9/ **India** and **Russia** in specific positions.
- 10/ **A very unusual problem** ; which leaders?...

The present Imperial College project report

- 1/ 18 professors.
- 2/ An academic report now available on the web.
- 3/ The key question: **is it realistic or not to aim at 3 or 3,5 GT C in 2050 without refraining economic growth?**
- 4/ Every important country can validate, challenge, recalculate... through universities or others...

Summary of approach

Objectives

How will the world's energy system look in 2050?

Low-mitigation scenario (LMS):

- No specific effort to cut carbon
- We avoid the term "business-as-usual"

Low-carbon scenario (LCS):

- CO₂ from energy use and industrial processes limited to ~15 Gt (4 GtC) per year 2050

What will the LCS cost?

- Additional annual cost compared to LMS in 2050
- Expressed in absolute terms and as share of 2010 and 2050 GDP

Approach

Develop a set of "bottom-up" models

- for each sector of the economy
- for each of 10 world regions

Power

Other energy conversion

Buildings

Transport

Industry

What technologies would be deployed in LMS and LCS?

What are the costs and resource constraints for these technologies?

Only consider technologies at current deployment or pre-commercial stage, including:

- Power (renewable sources, nuclear, CCS)
- Buildings (shell & appliance efficiency, low-carbon heat)
- Industry (efficiency, fuel-switching, CCS)
- Transport (efficiency, fuel cells, electrification, bio-fuels)

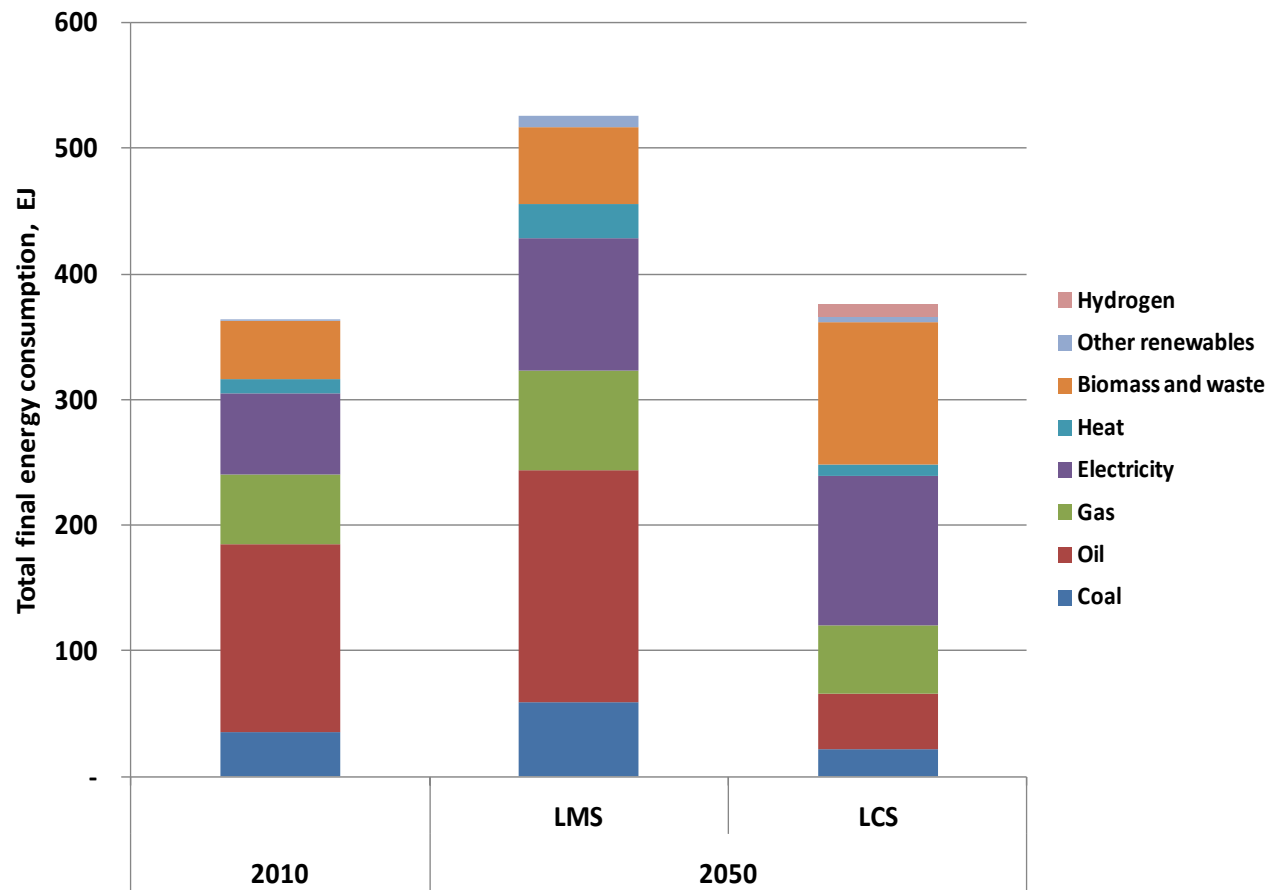
Conversion factors and precautions

General conversion factors for energy

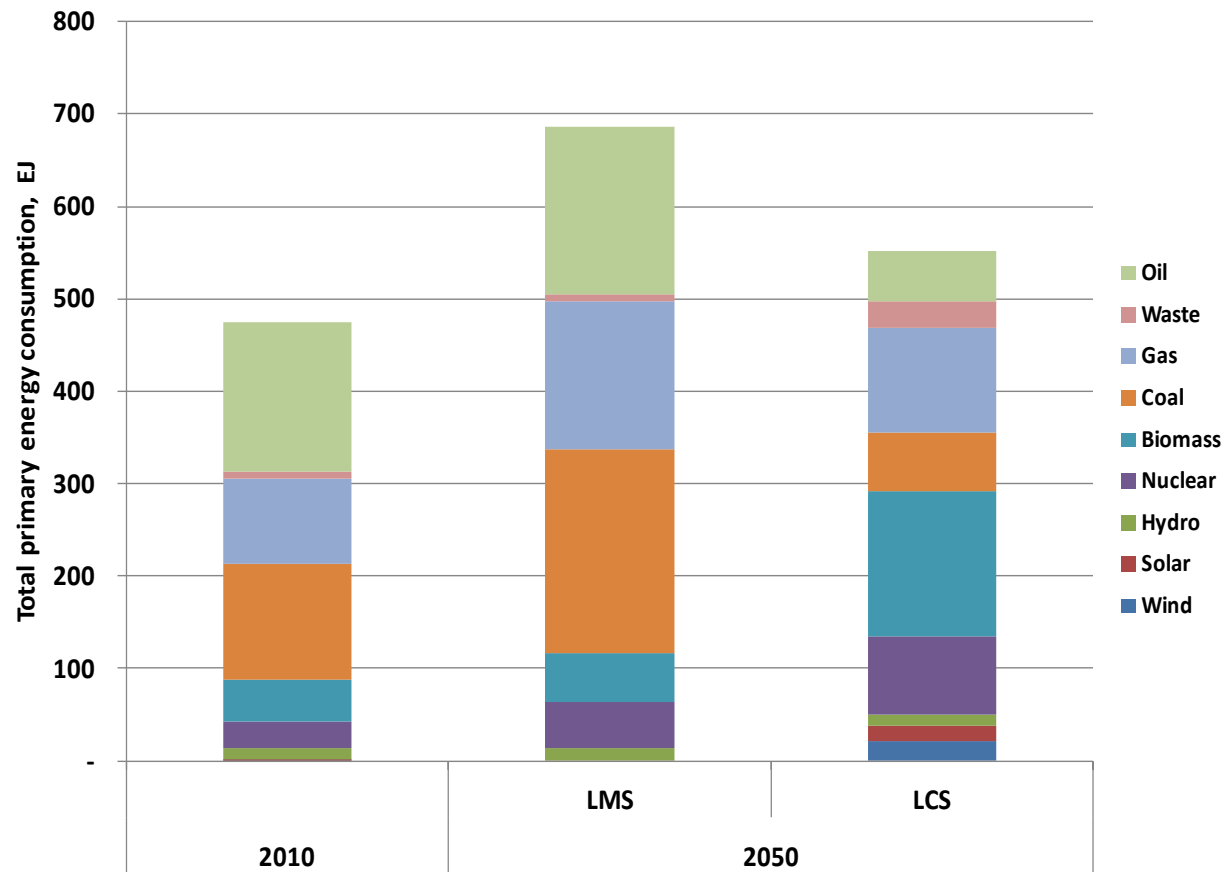
To:	TJ	Gcal	Mtoe	MBtu	GWh
From:	multiply by:				
TJ	1	238.8	2.388×10^{-5}	947.8	0.2778
Gcal	4.1868×10^{-3}	1	10^{-7}	3.968	1.163×10^{-3}
Mtoe	4.1868×10^4	10^7	1	3.968×10^7	11630
MBtu	1.0551×10^{-3}	0.252	2.52×10^{-8}	1	2.931×10^{-4}
GWh	3.6	860	8.6×10^{-5}	3412	1

- 1 Gtoe = 41,8 EJ
- The specific problem of cars, trains, trucks:
 - Electric motor efficiency is around 90%
 - Thermal motor (internal combustion) efficiency is around 25%
 - **Important in interpretation of energy demands when energy vectors change**

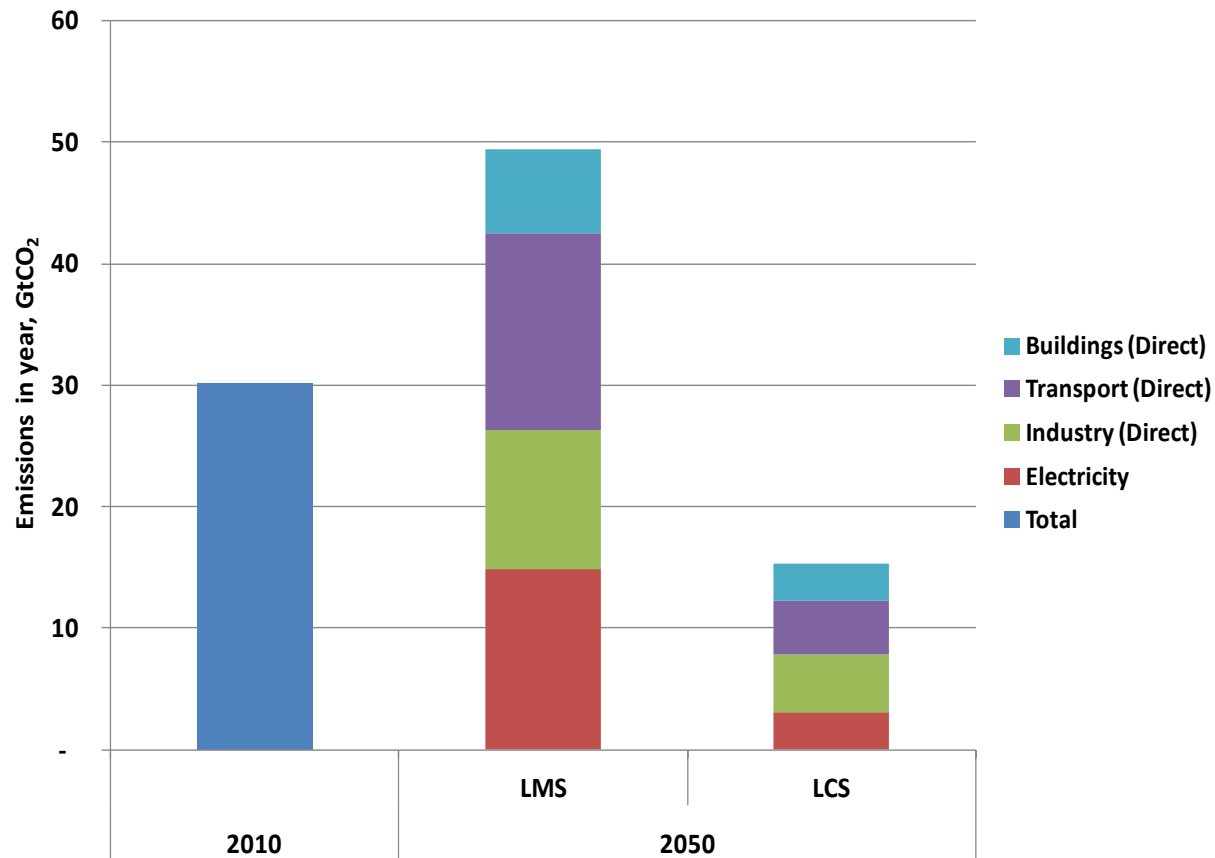
Final energy demand could remain almost flat



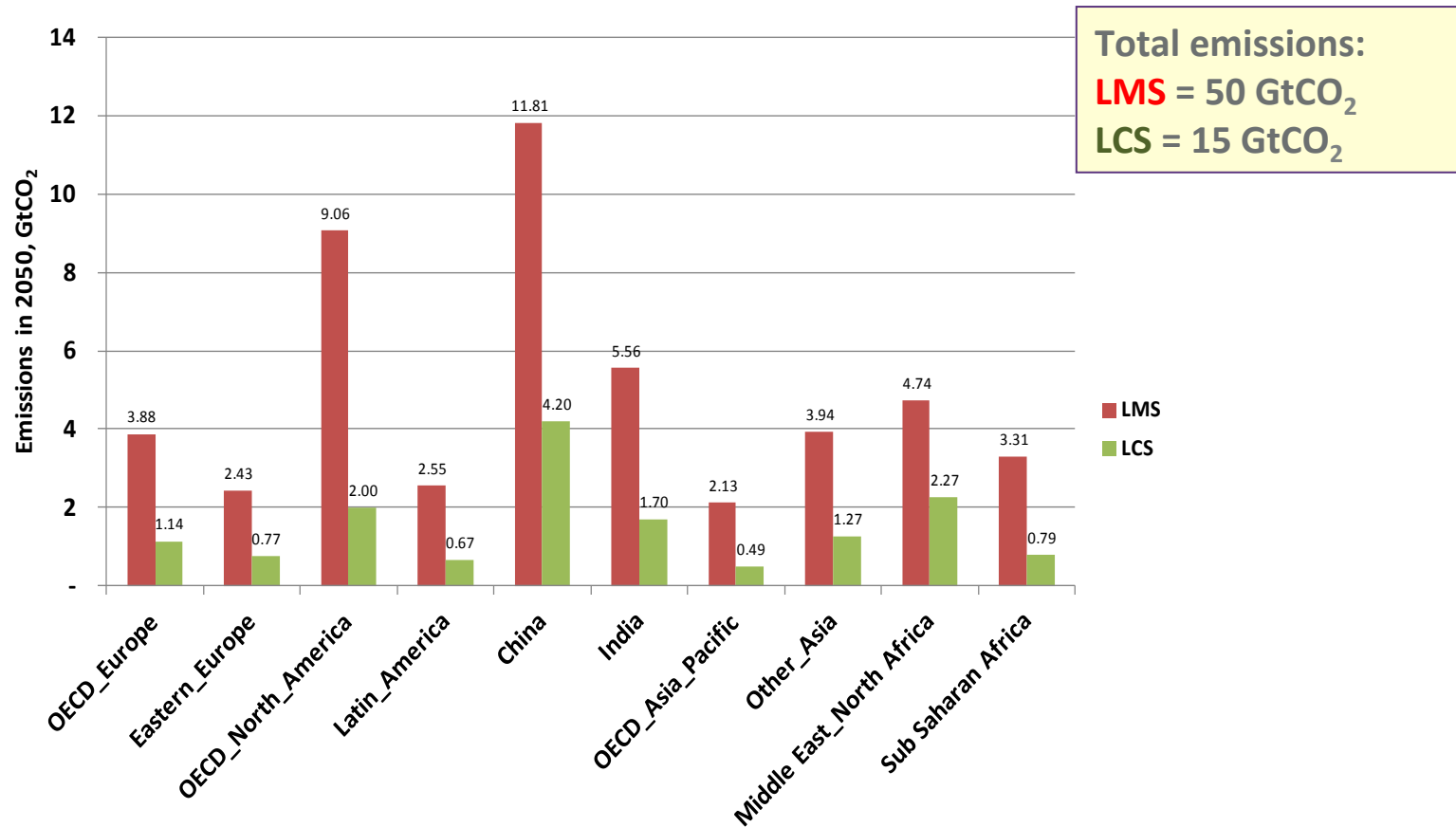
Primary energy



Emissions in all sectors could be cut dramatically

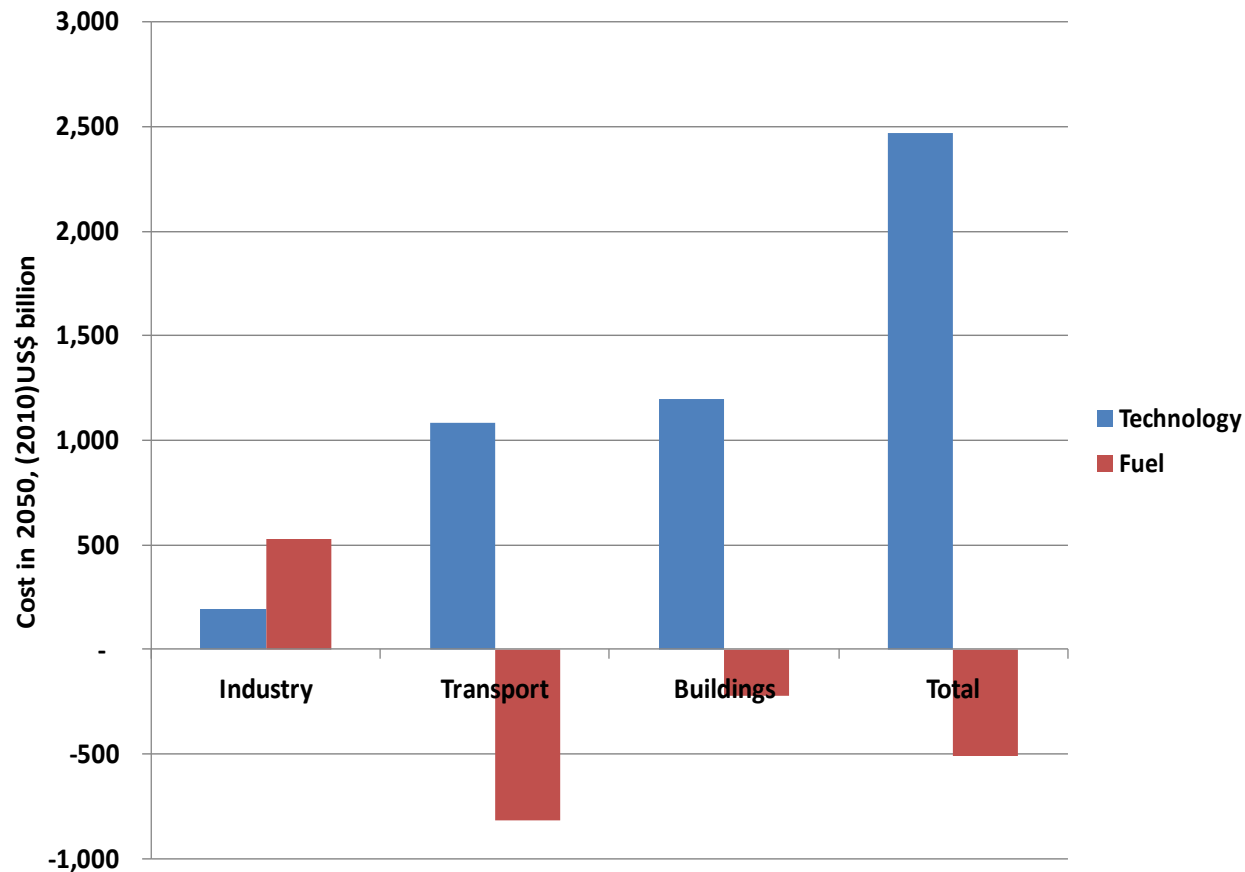


Every region contributes to emissions reductions



54% of total emissions reduction in
North America, China and India

Fuel savings significantly offset technology costs



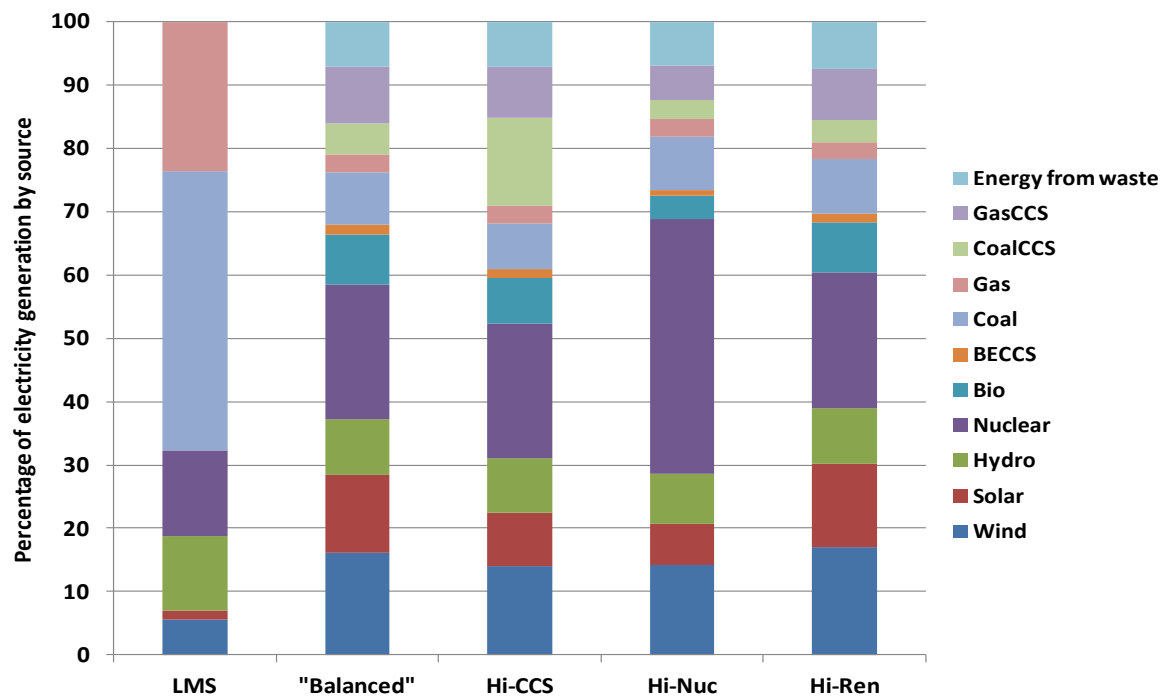
By 2050, annual energy and industrial process system cost of LCS is around \$2 trillion higher than LMS – compared to global 2050 GDP of \$111 trillion (exchange rates) to \$230 trillion (in PPP terms)

Sector findings – power (1)

- The power sector has the largest “responsibility” in decarbonising the global economy:
 - Delivered power almost doubles between 2010 and 2050 (annual growth rate of 1.7% globally)
 - CO₂ intensity reduces by 82% in 2050, from 508 (LMS) to 94 gCO₂/kWh (LCS)
 - Wholesale electricity cost up 33-73% worldwide in 2050, depending on fossil fuel prices
 - More significant increases in North America, China and India (60-80% increase)
 - CCS is an important component but there are large uncertainties attached to its development. Regional CO₂ storage constraints are included in our analysis

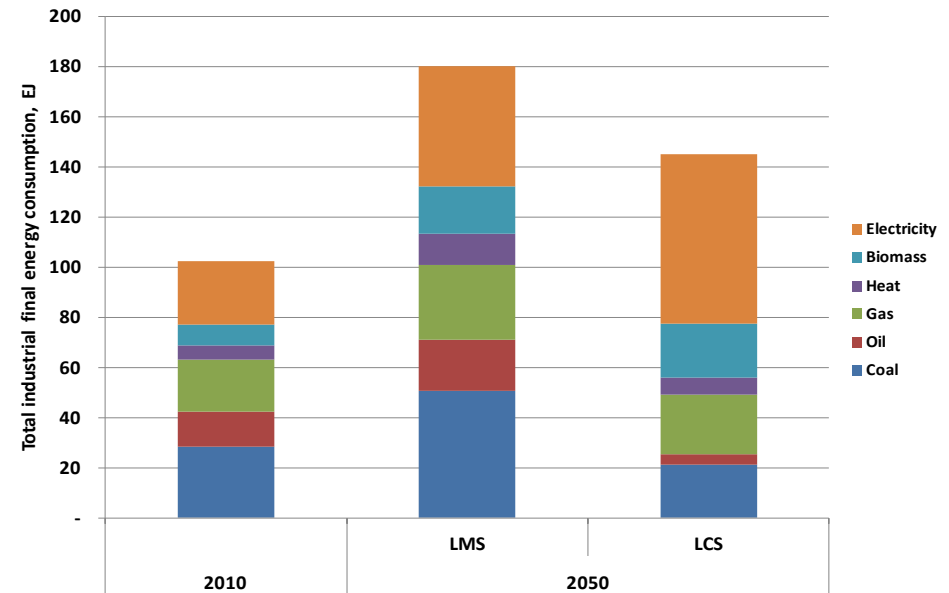
Sector findings – power (2)

- 4 scenarios are used to show different possibilities and reflect different stakeholder perspectives:
 - “Balanced”, High CCS scenario, High Nuclear scenario, High Renewable scenario
 - All LCS scenarios have average electricity cost of \$0.085/kWh except High Nuclear (\$0.077/kWh) – this follows from assumptions showing nuclear as relatively cost-competitive by 2050



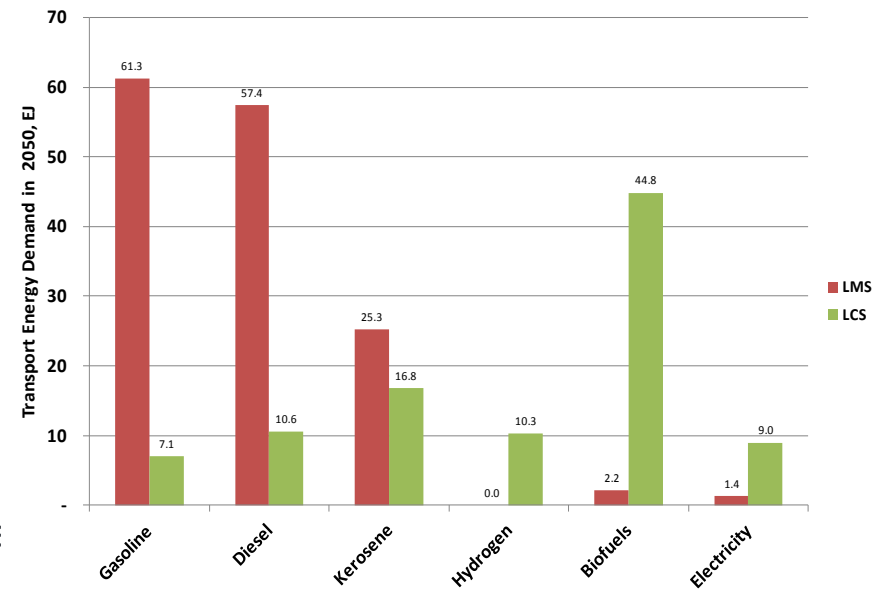
Sector findings - industry

- Total industrial energy demand could almost double if current production practices are continued.
- Energy efficiency reduces demand by 19% (LCS vs LMS) by 2050.
- Fuel switching will also play a major role in decarbonising industry processes:
 - away from coal (which makes up 28% of energy in LMS, versus 15% in LCS) to gas
 - increased supply from non-fossil fuels (4.6% heat (CHP), 14.7% biomass, 46.7% electricity) in LCS.
- CCS is an important component – captures 1.5 GtCO₂ in 2050.
- Cost increase in industry ~2.6% of industrial value added.



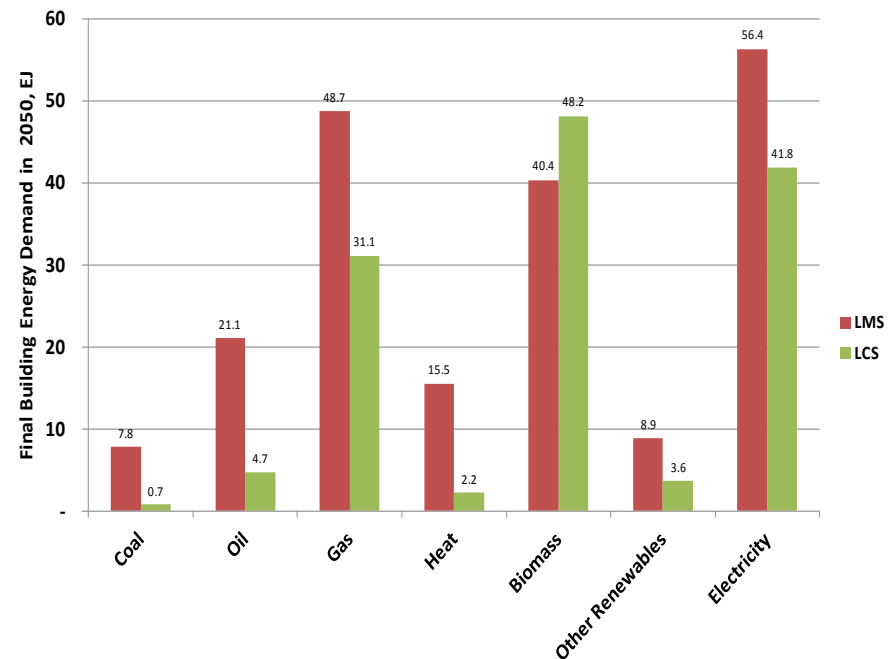
Sector findings - transport

- Our scenarios show a dramatic reduction in transport emissions:
 - Direct emissions are 72% lower in the LCS compared to the LMS, by 2050.
- This is driven by a fundamental shift away from oil:
 - To electric vehicles, hydrogen fuel cell vehicles and bio-fuels in road
 - To electrified rail, and to bio-fuels in marine and aviation.
- Energy efficiency, aided by more efficient combustion engines and increased share of hybrids, is also critical.
- As an illustration, in the LMS, light duty vehicle (car and van) emissions on a “well-to-wheel” basis are 26 gCO₂/km in LCS, versus 227 in the LMS
 - The transition could save costs:
 - LCS cost per passenger-km is 3.6% *higher than LMS* for low FF prices
 - But 7.3% *lower than LMS* for high FF prices



Sector findings - buildings

- Direct buildings emissions are 56% lower in the LCS versus the LMS by 2050, and overall emissions 72% lower.
- This is driven by:
 - A shift away from traditional fossil fuel heating to low carbon sources such as biomass and less carbon-intensive electricity
 - Significant improvements to the thermal envelopes of buildings through better glazing and insulation
 - More efficient lighting, cooking, and appliances
- Global carbon intensity of heat decreases from 255 gCO₂/KW_{th} to 129 CO₂/KW_{th} ;
- The costs are considerable at \$1.2 billion per annum by 2050, but fuel savings of \$0.4 billion bring this figure down to about \$200 per household.



Additional remarks (1/2)

If you look more precisely at the report:

1/ **Electricity's share would be over 60%** on a primary energy basis in the LCS scenario. CO₂ emissions would decrease from 508g CO₂/KWh in the LMS scenario to around 94g CO₂ /KWh in the LCS scenario.

Total electricity demand is 60 EJ in 2010, it would be 117 EJ in the LMS scenario, 147 EJ in the LCS scenario.

2/ **Energy efficiency plays its role in any sector:** 526 EJ in the LMS scenario, 376 EJ in the LCS scenario, in addition to already sure progresses for transport.

Half of this decrease could come from residential heat demand and industrial progress.

3/ **Light-duty vehicle emissions** would amount at **26 g CO₂/km**, in contrast with **181g CO₂/km** in the LMS scenario.

It has a lot of consequences: in the 2050 LMS scenario total of petroleum products would be 185 EJ in terms of final demand, while in the LCS it would be 44 EJ !

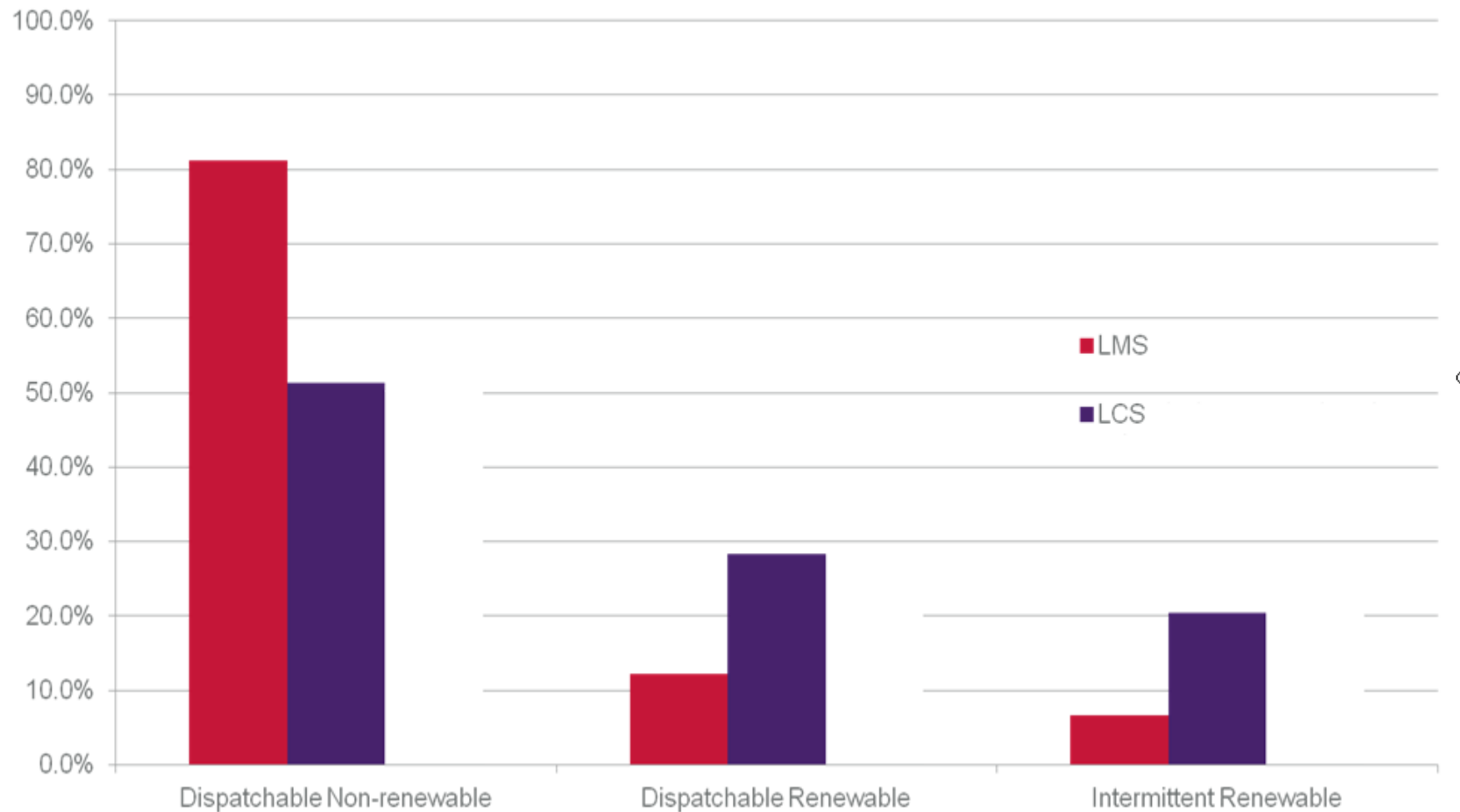
4/ **Bio-energy** could account for 20% of the energy mix (biogas, bio fuels, heat) and use **8,8% of the global arable and pasture land.**

5/ The cost of decarbonisation between the two scenarios would be around **2,6%** of the gross value added of the industry.

6/ In the buildings sector **residential heat demand** would be reduced from **66,5 EJ/year to 24,8 EJ/year.**

Power – Renewables share (2/2)

Generation - Share of Renewables



Conclusions (1/3)

1. The transition would be theoretically affordable.
2. It would cost less than 2% GDP based on exchange rates, less than 1% based on purchasing power parity basis.
3. At 150\$ / barrel, it doesn't cost any more money.
4. Impossible to do it without a strong move towards electricity.
5. Even industry should strongly move towards electricity.

Conclusions (2/3)

6. Biomass is a key issue, especially inside countries where there are a lot of unused space (8% of arable spaces could be concerned... which is a lot!).
7. As long as the G20 countries are not speaking about CO₂ emissions targets for electricity (250 g CO₂ /KWh) and CO₂ emissions for cars (70 g CO₂ /Km)... they are probably speaking in the air.
8. CCS is necessary, it is not an option !
9. In any realistic scenario, nuclear represents more than 15% of the energy landscape.
10. Stupid to oppose renewables and nuclear. Both are necessary.

Conclusions (3/3)

11. Hydrogen will probably be a new energy source, at least inside the G20 countries.
12. Oil producer countries should think about... all that.
13. The value for money is not surprisingly a key element. At present levels required from the companies, our economic development is likely to be not sustainable.
14. AFRICA is not a detail... it is not only a G2 or a G20 issue!

So what...

If there would be an consensus around such results, once the financial and economic crisis being behind us..., **the topics to be discussed on the top of the agenda could be the followings** :

- Stabilisation before 2030... or not...?
- Targets to be defined: less than 250g CO₂/KWh for electricity, less than 75g/ CO₂/Km for within at least G20.
- Feasibility of CSC proven or not by 2025...
- Biomass issue to be assessed and discussed... before 2020
- Heat promotion as a substitute to fossil fuels...
- Common opinion polls...
- A fiscal framework to prompt private large firms to adhere or not to a global worldwide pact...?...