The energy transition

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Chairman and CEO

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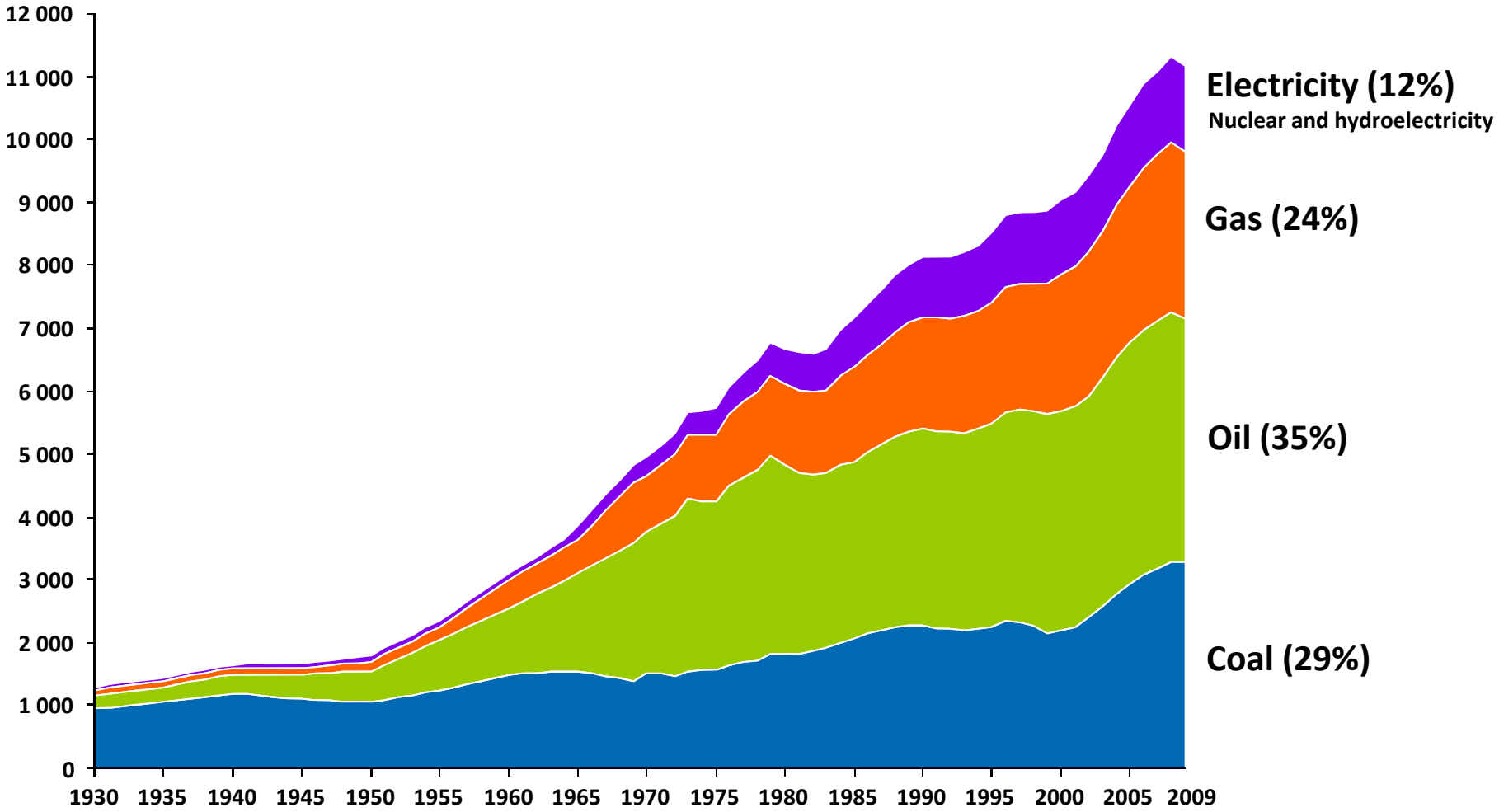
IFP Energies nouvelles

The energy transition

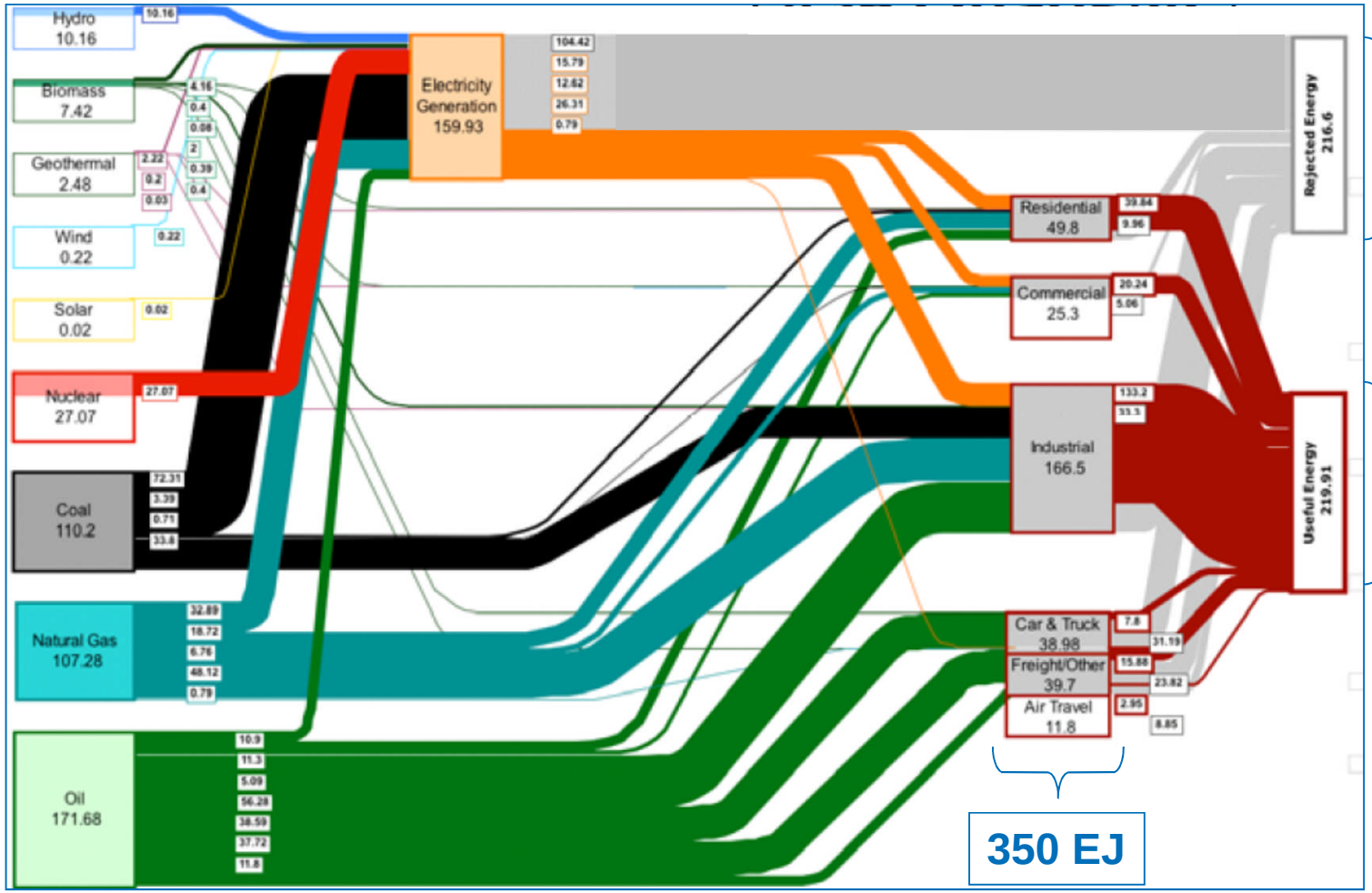
- **The energy scene**
- **The environment challenge**
- **The future of oil and gas**
- **The transportation sector**
- **The energy transition**

World commercial primary energy consumption



Source : BP Statistical Review/WEO

2005 World Energy Flow Diagram



Primary Energy

461 EJ

Rejected Energy

229EJ

Useful Energy

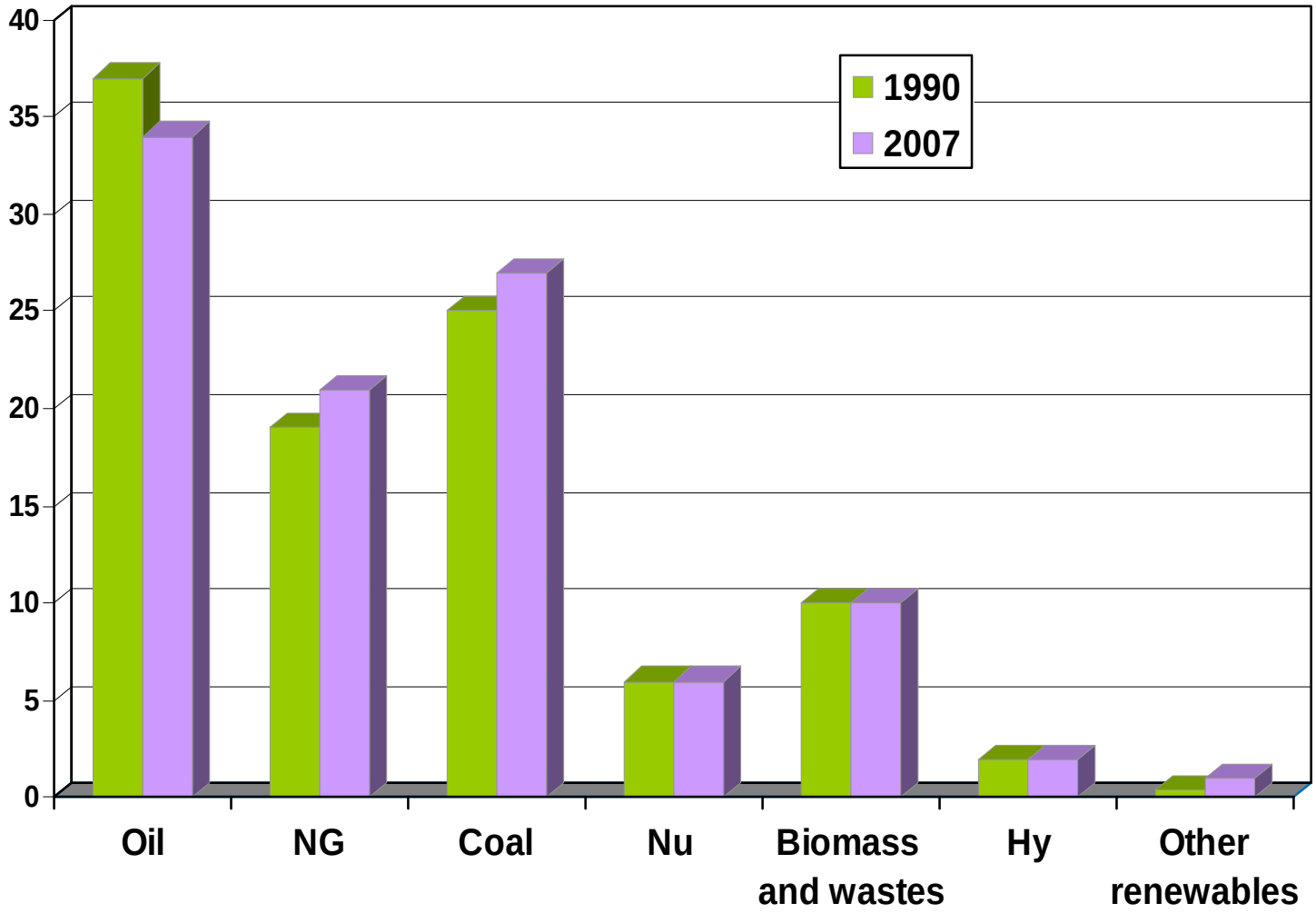
232EJ

350 EJ

Final Sector

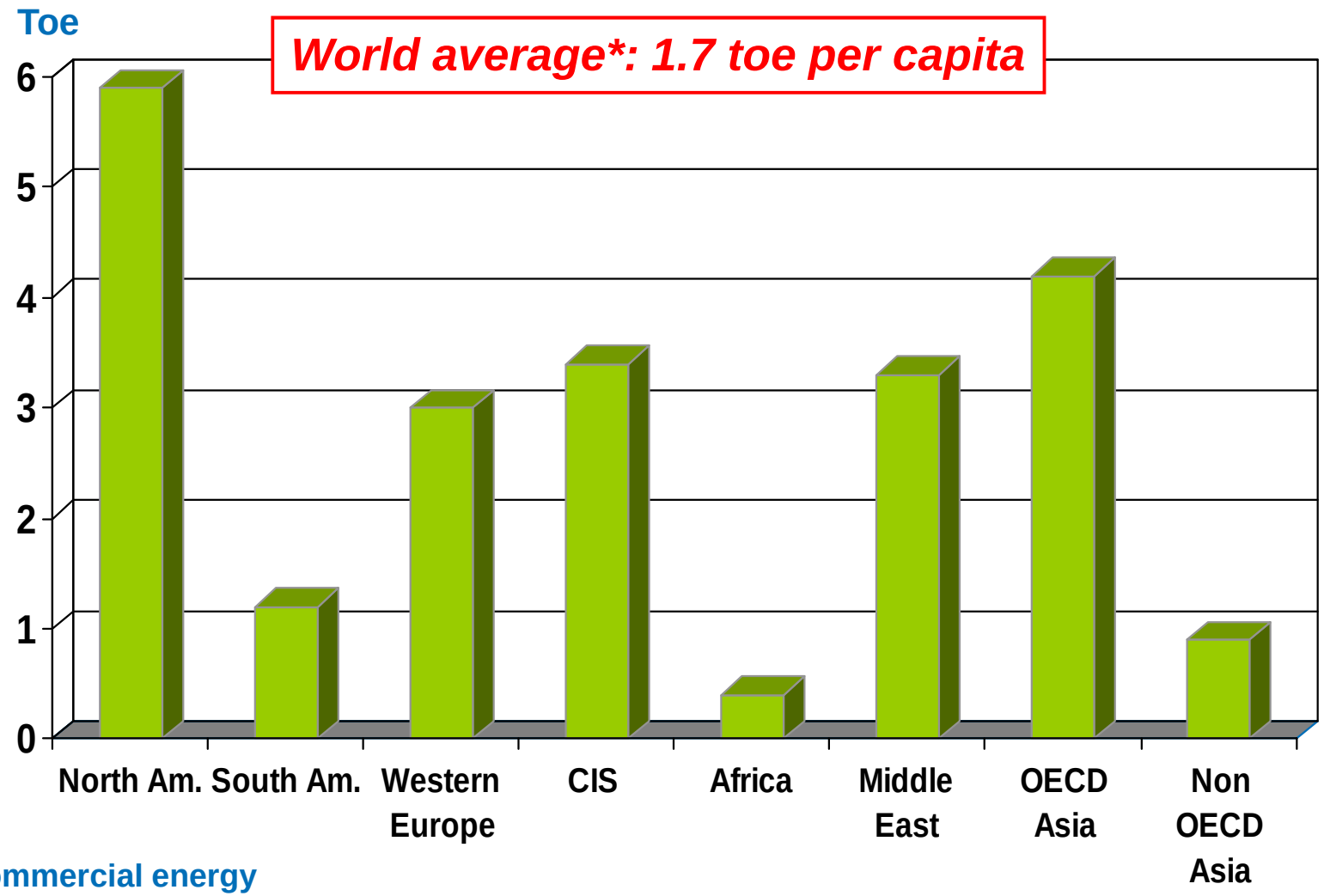
Source: Lawrence Livermore National Laboratory
chart figures in quads – 1 quad=1.05 EJ

A slow evolution of the global energy balance



Source : WEO 2009

Consumption per capita* - 2009, by region

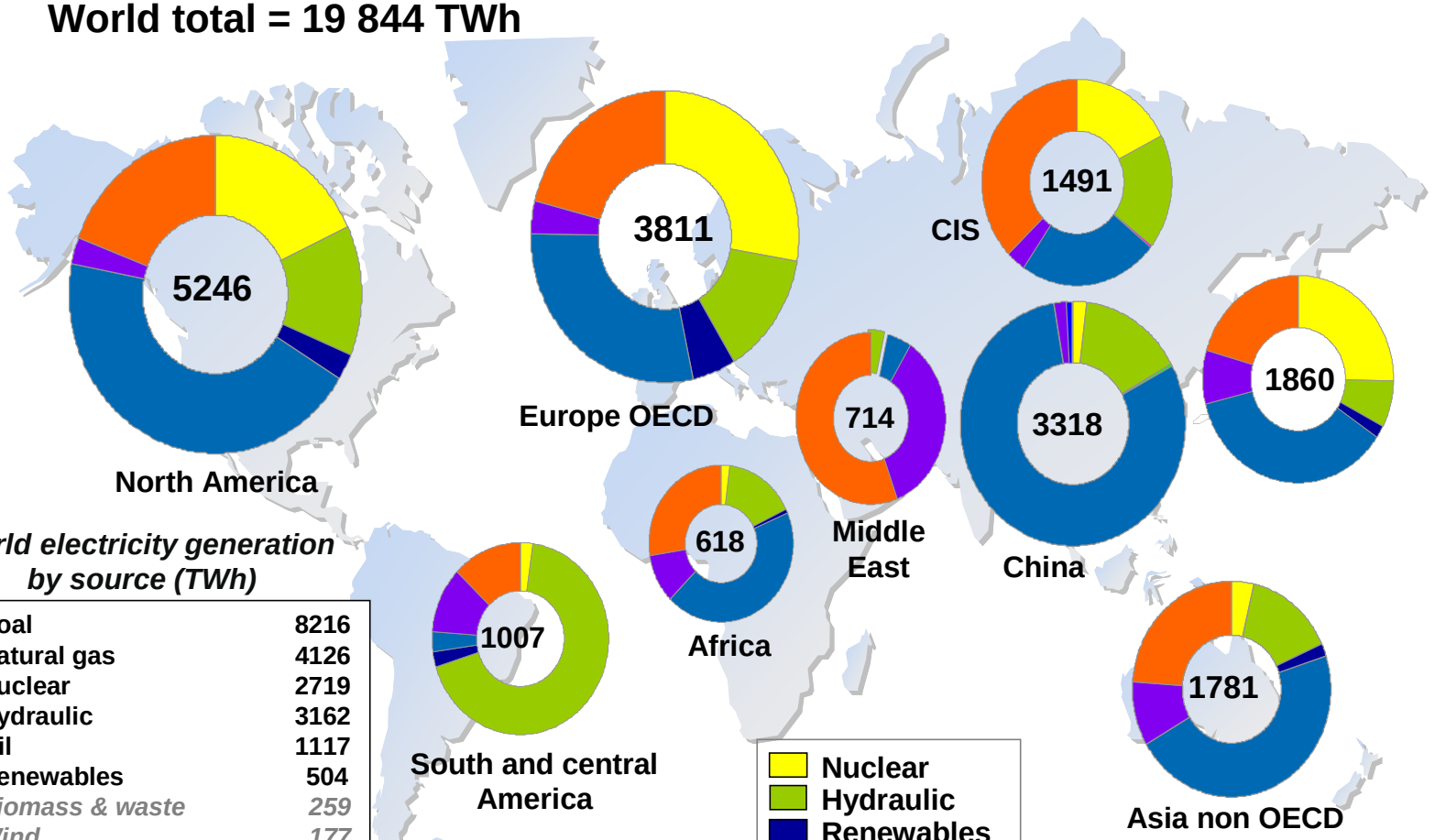


* Commercial energy

Source: BP Statistical Review and UN

World electricity generation 2007

World total = 19 844 TWh

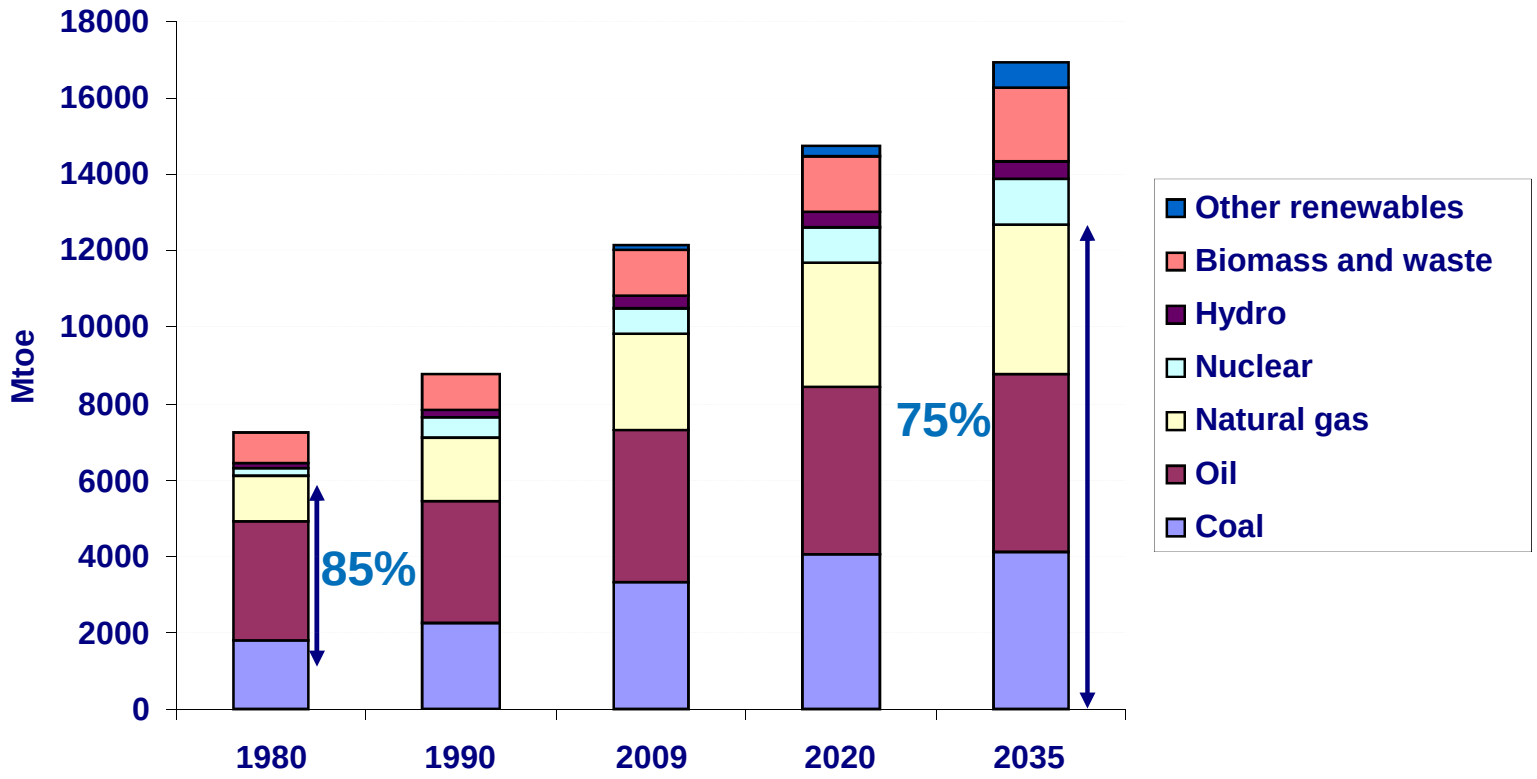


World electricity generation by source (TWh)

Coal	8216
Natural gas	4126
Nuclear	2719
Hydraulic	3162
Oil	1117
Renewables	504
Biomass & waste	*259*
Wind	*177*
Geothermal	*62*
Solar	*5*
Tide & Wave	*1*

Source : IEA

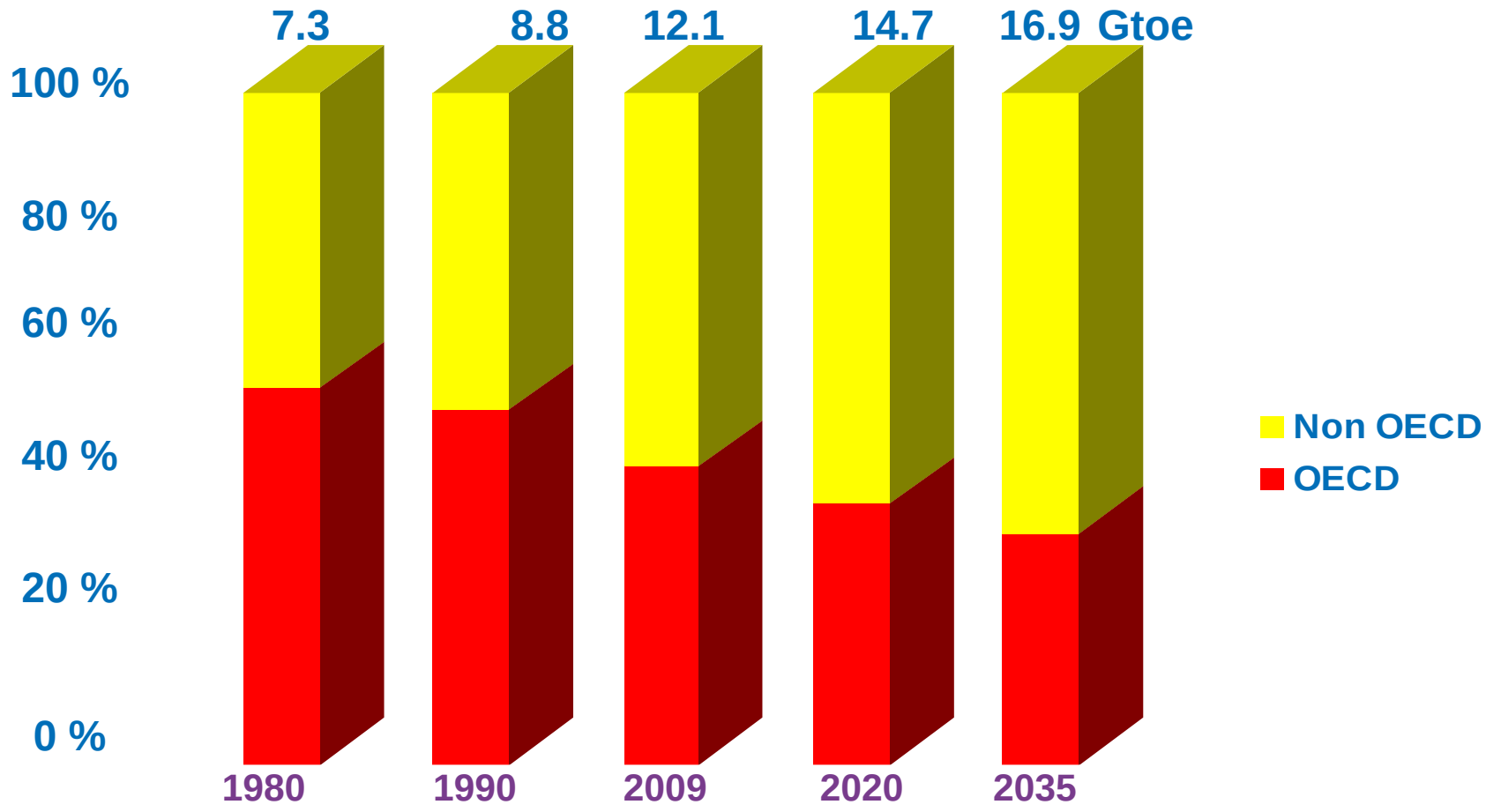
Primary Energy Demand (Mtoe)



+ 40 % between 2009 et 2035

Source : IEA WEO 2011 "New policies"

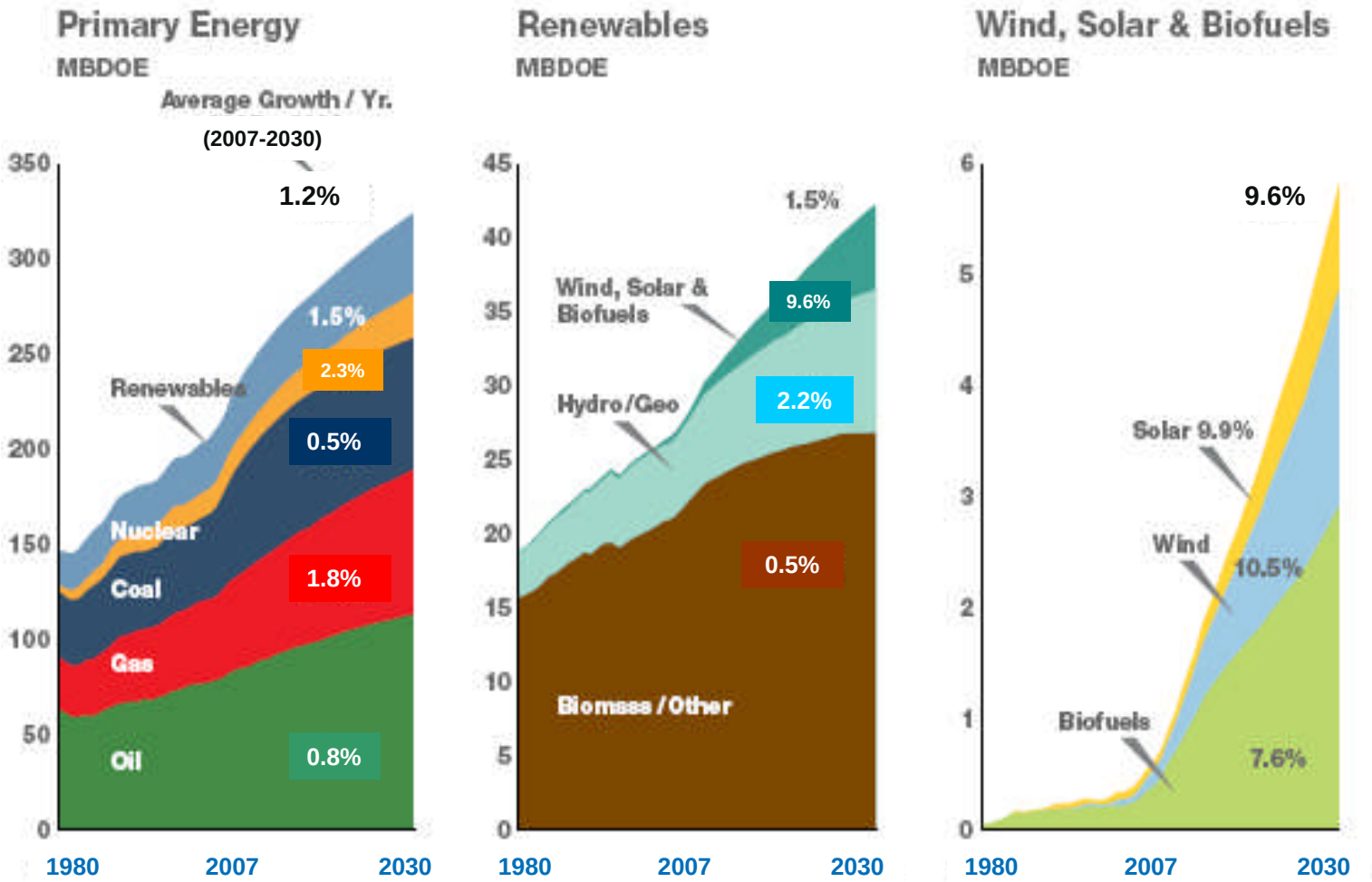
Energy demand by region



Growing non OECD share:
1980 43% 2035 66%

Source : IEA WEO 2011 "New Policies"

Global energy demand (Exxon Outlook)



Source : Exxon World Energy Outlook 2009

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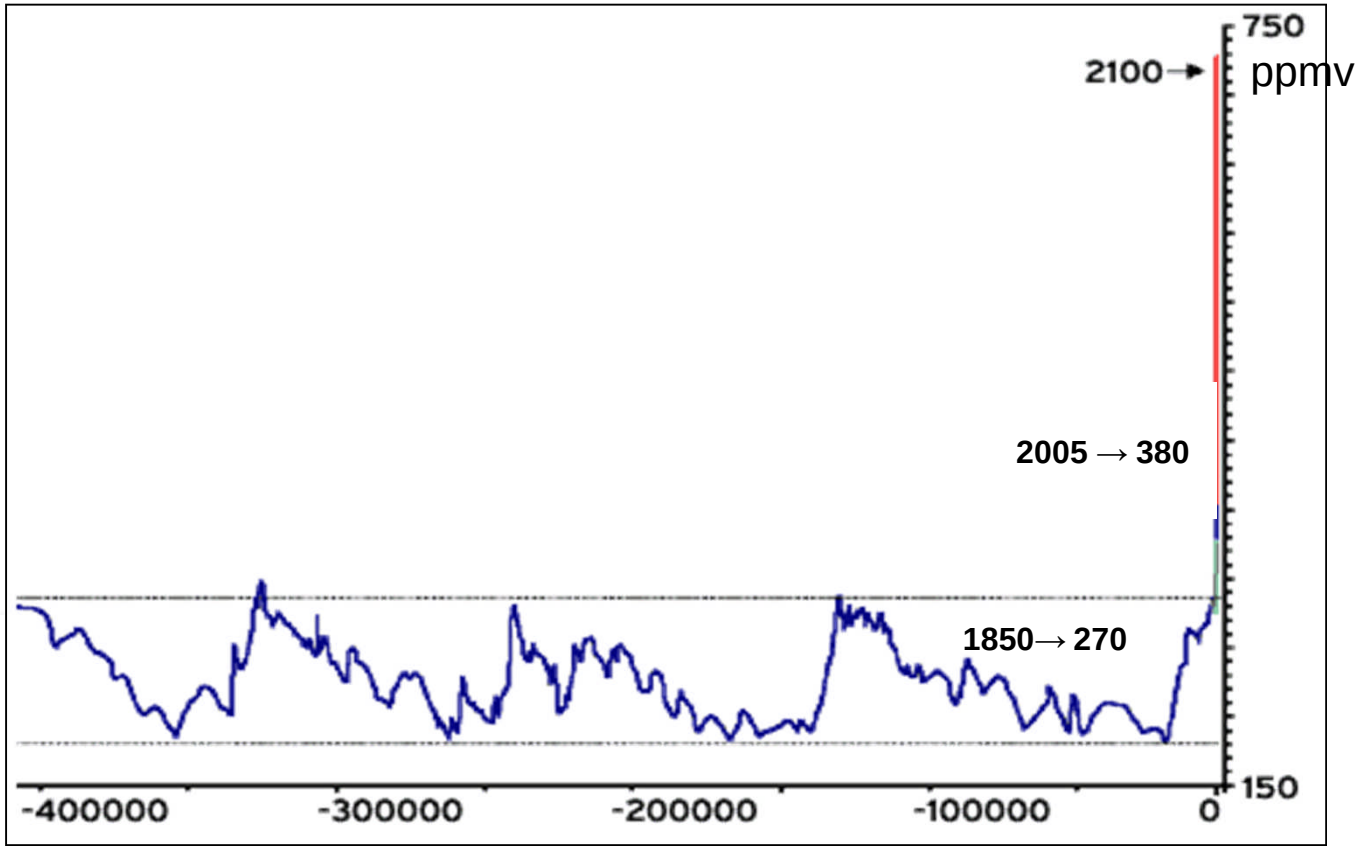
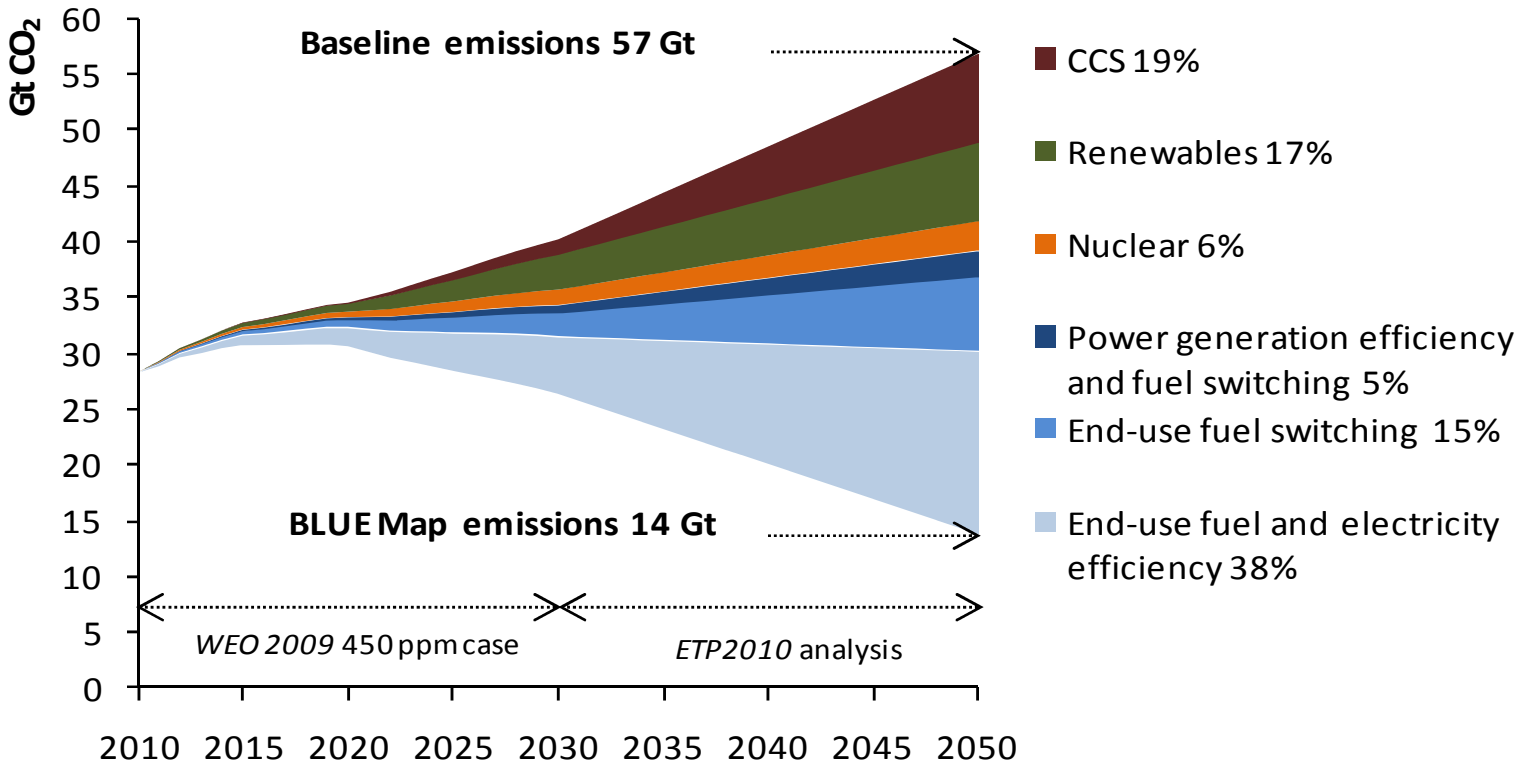
Challenges:
CO_2 concentration in the atmosphere



Key technologies for reducing global CO_2 emissions



A wide range of technologies will be necessary to reduce energy-related CO_2 emissions substantially.

Source : IEA ETP 2010

Evolution of CO_2 emissions

To save 1 billion tons of CO_2 per year

- CO_2 storage : 1000 x Sleipner
- Wind energy : 5 x world capacity
- Solar energy : 50 x world capacity
- Nuclear energy : 150 x 1GW reactors (40% of world capacity)
- Lighting : replace 95% of light bulbs worldwide
- Coal : 300 x 500 MW power stations with CCS

Source AIE, other

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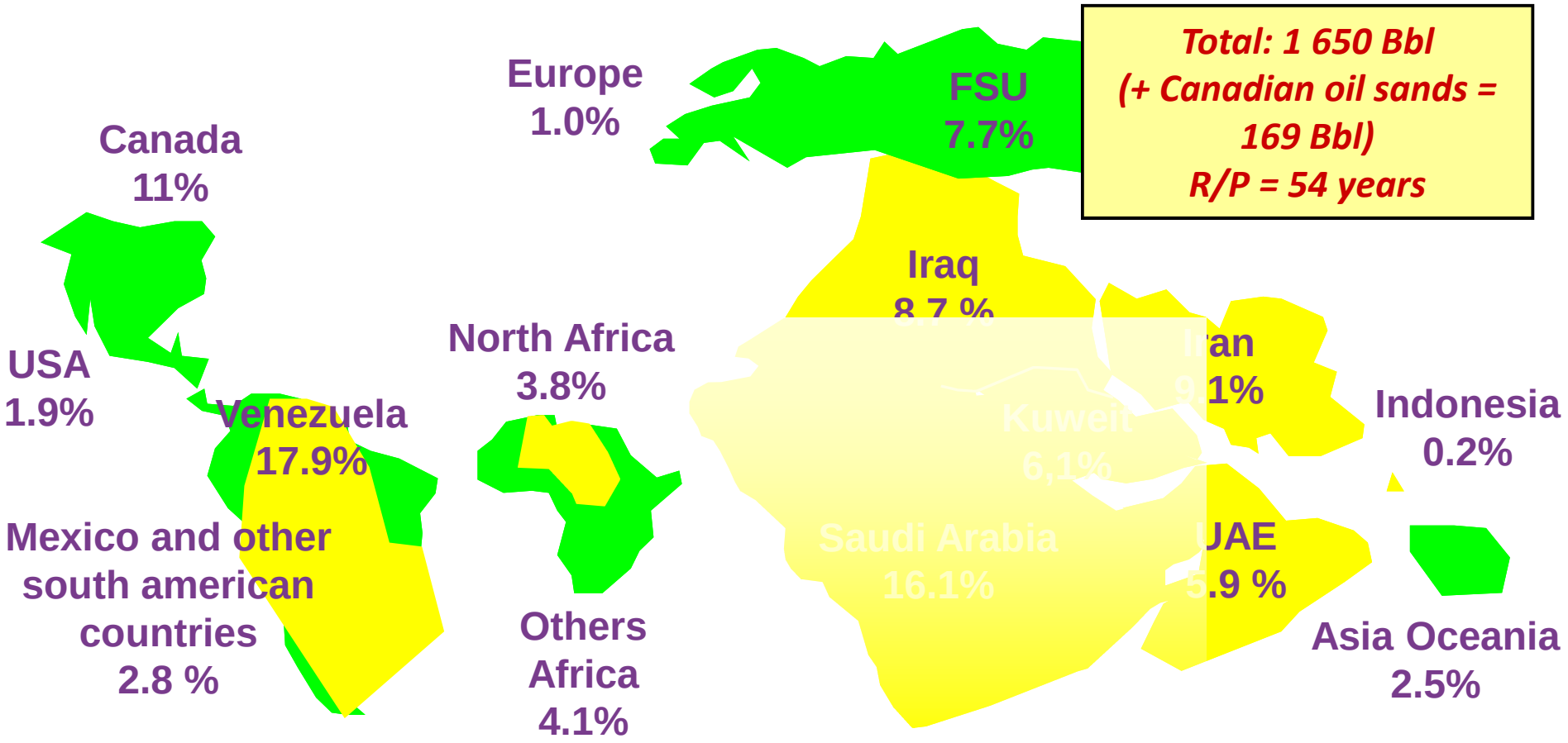
Oil proved reserves by zone

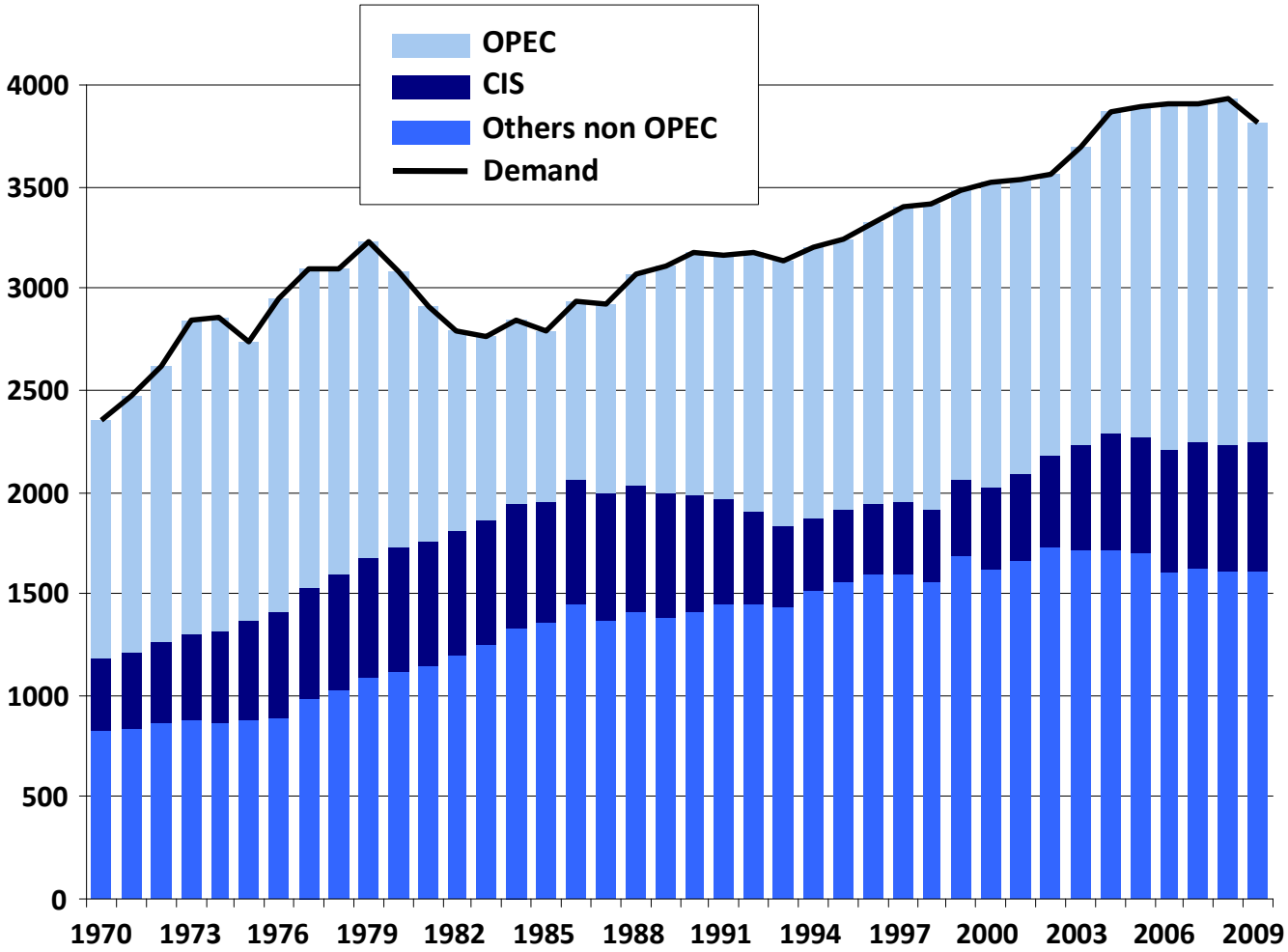


Total: 1 650 Bbl
(+ Canadian oil sands = 169 Bbl)
R/P = 54 years

OPEC 72 %

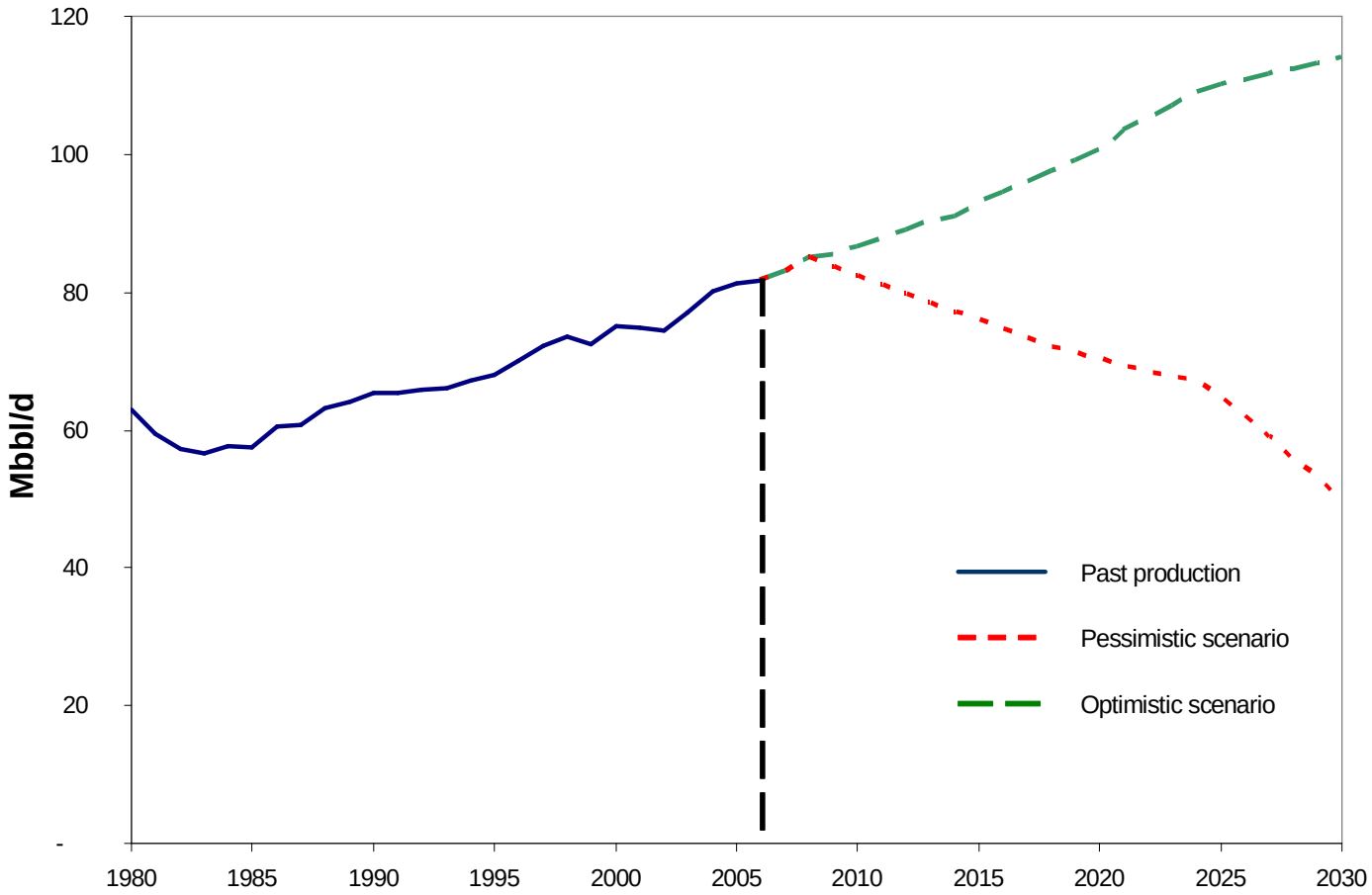
Source: BP Statistical 2012

Crude oil production - Mt



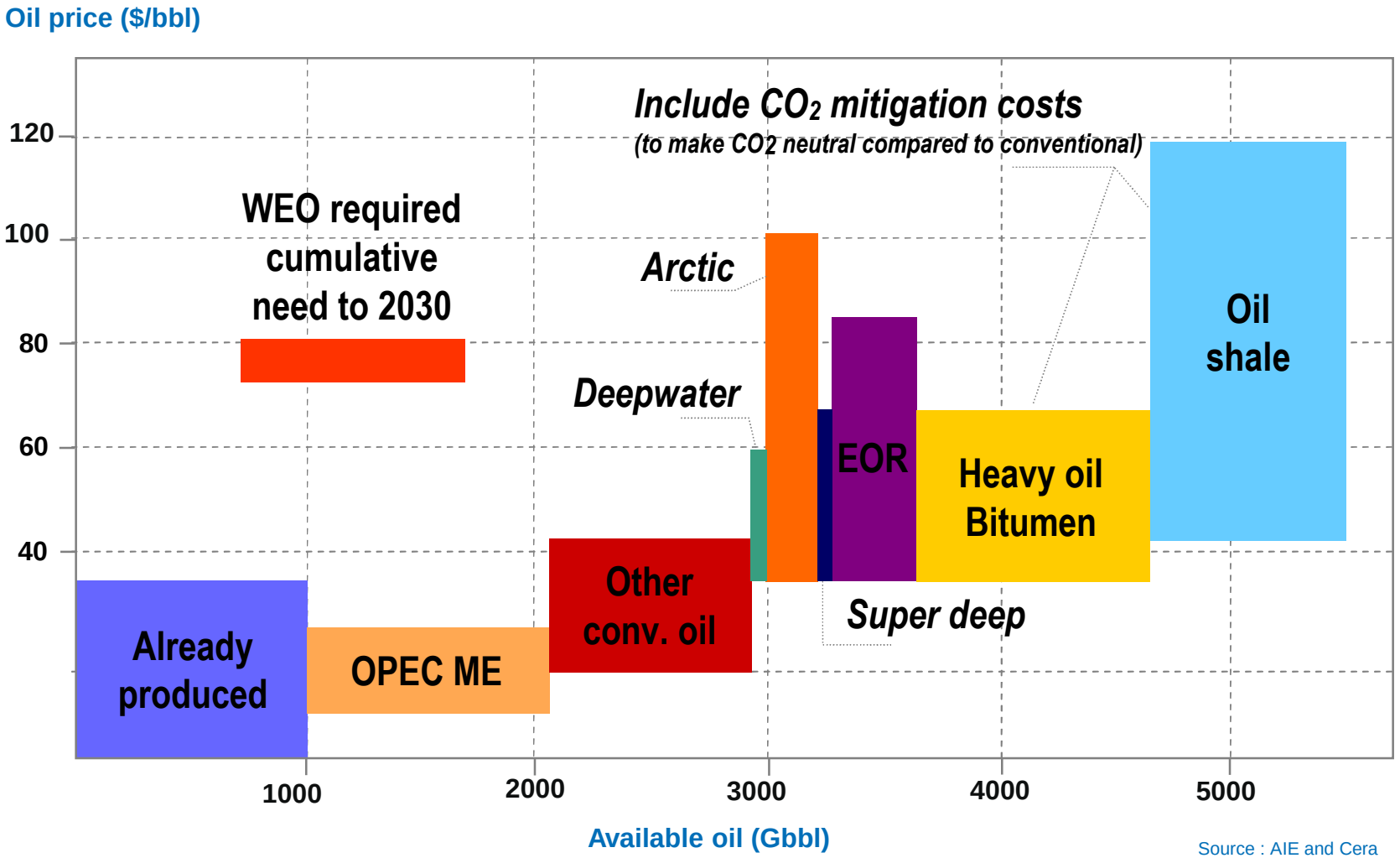
Source : BP Statistical Review

The future of oil production : possible scenarios



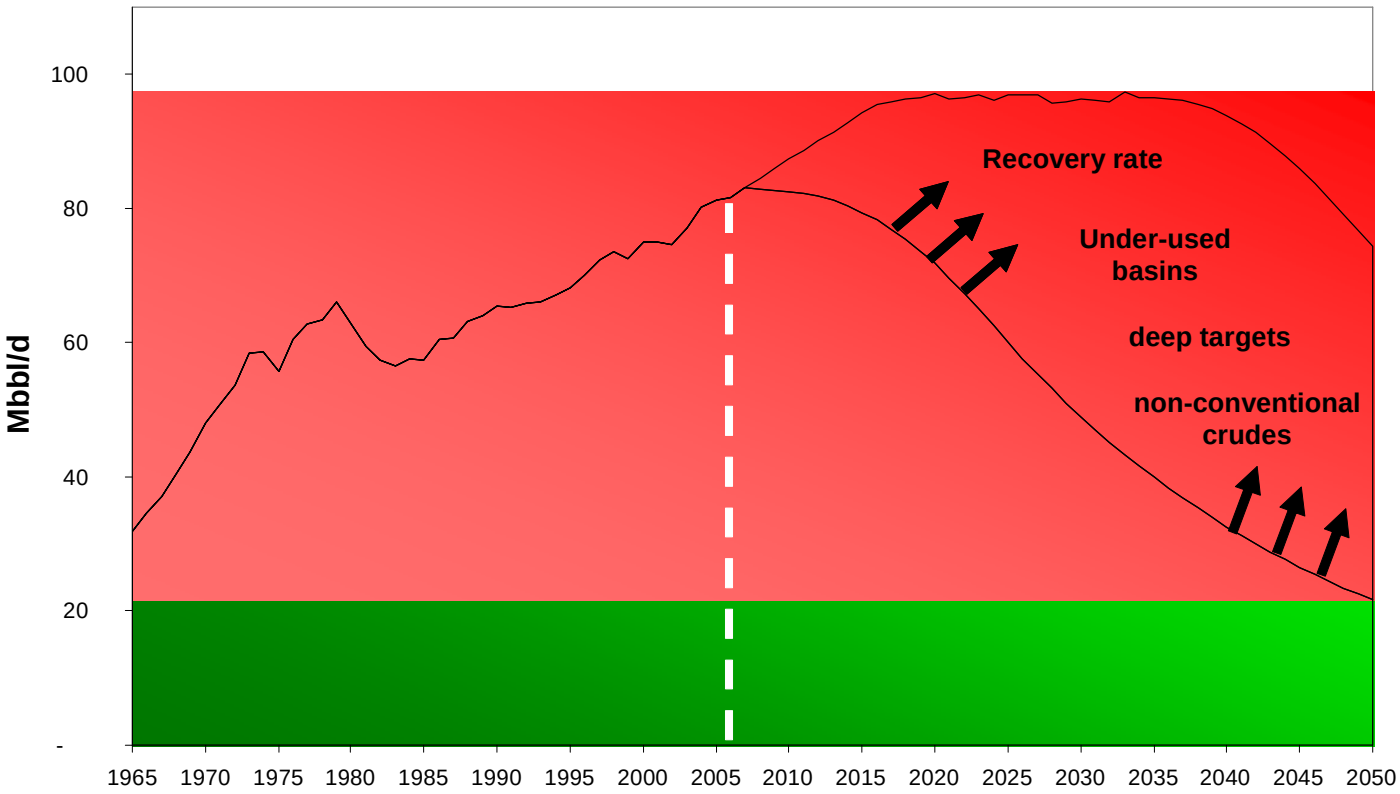
Source : National Petroleum Council & ASPO 2007

Economics of oil resources



Source : AIE and Cera

Oil production and plateau @



Oil produced from current deposits (natural depletion)

Additional oil production thanks to modern exploration-production technologies

Source : IFPEN 2007

The future of gas

- **Current gas glut due mainly to the economic recession**
- **Current low prices as compared to oil**
- **Conventional gas reserves equivalent to that of oil**
- **Unconventional gas (shale, tight, CBM)**
  - a game changer in the US: 50% of current production
  - many uncertainties elsewhere but huge potential
- **Important role for electricity generation**
  - highly efficient technology (CCGT)
  - ideal complement to renewables
- **Is gas a transition fuel or a destination fuel?**

" Natural gas could "change the world's energy landscape for the better" Peter Voser, CEO, Shell, September 2010

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World energy consumption in transport sector in 2009

Transport :

2280 Mtep

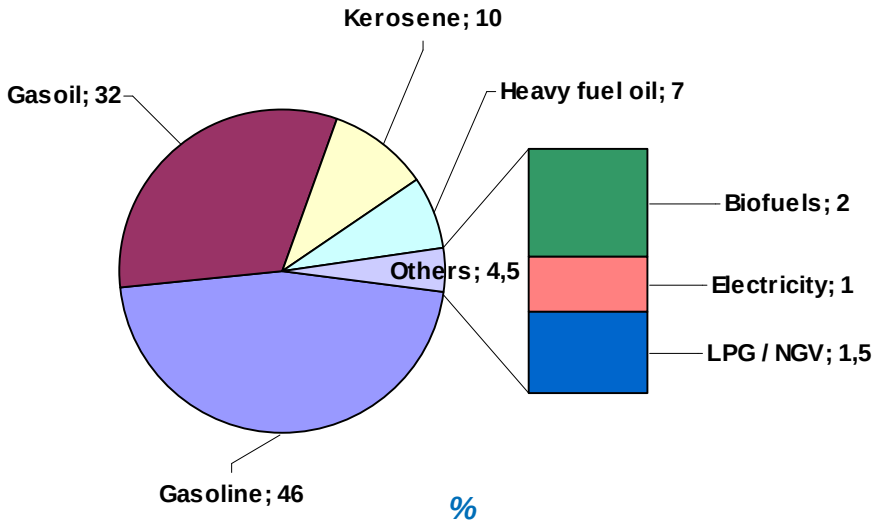
27 %

global

final consumption

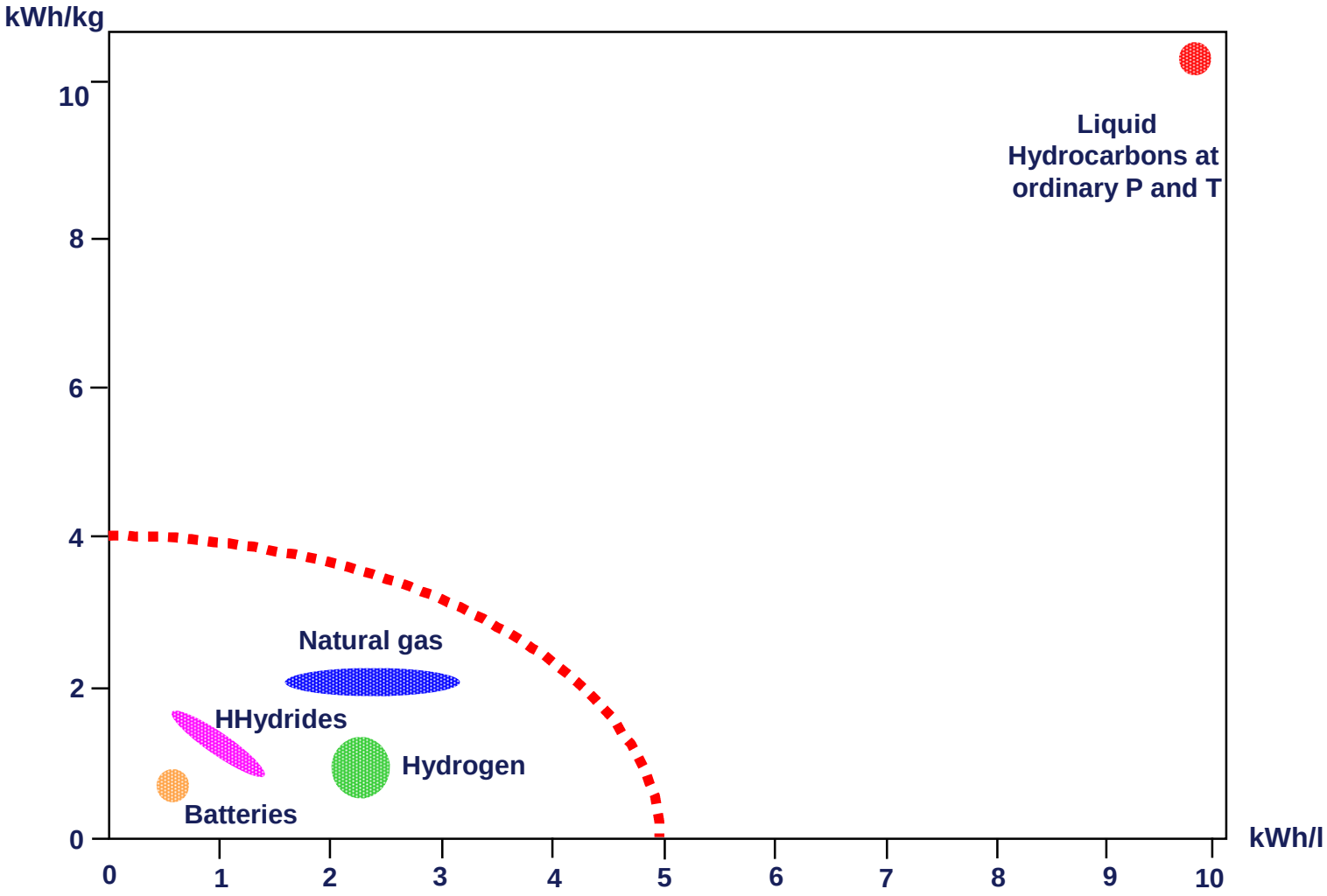
Petroleum Products

94 %



Source : World Economic Forum "Repowering Transport" 2011, AIE WEO 2011

Liquid hydrocarbons : A cutting edge energetic intensity



Source : PR Bauquis – Revue de l'énergie - 2004

Context - The future of automotive is in BRIC & Asia...

Adapted from Ducker Worldwide
(Source IRIS Strategic yearbook 2010)

The automotive propulsion Vision of the future

- **Short term:**
  - Further improvements of the efficiency of existing thermal engines technology (direct injection, turbo charging, variable valve actuation, CAI & HCCI combustion,...)
  - Progressive introduction of a light electrification (stop & start)
- **Medium term:**
  - Towards the decrease of the size of the thermal engines (reduction of the engine displacement and number of cylinders)
  - Increased electrification and hybridization
- **A long term worldwide vision:**
  - Different electric solutions to cover specific uses
  - And smaller and smaller thermal engines for:
    - Ultra low cost small vehicles,
    - Plug-in hybrid vehicles,
    - "Range extender" for electric vehicles

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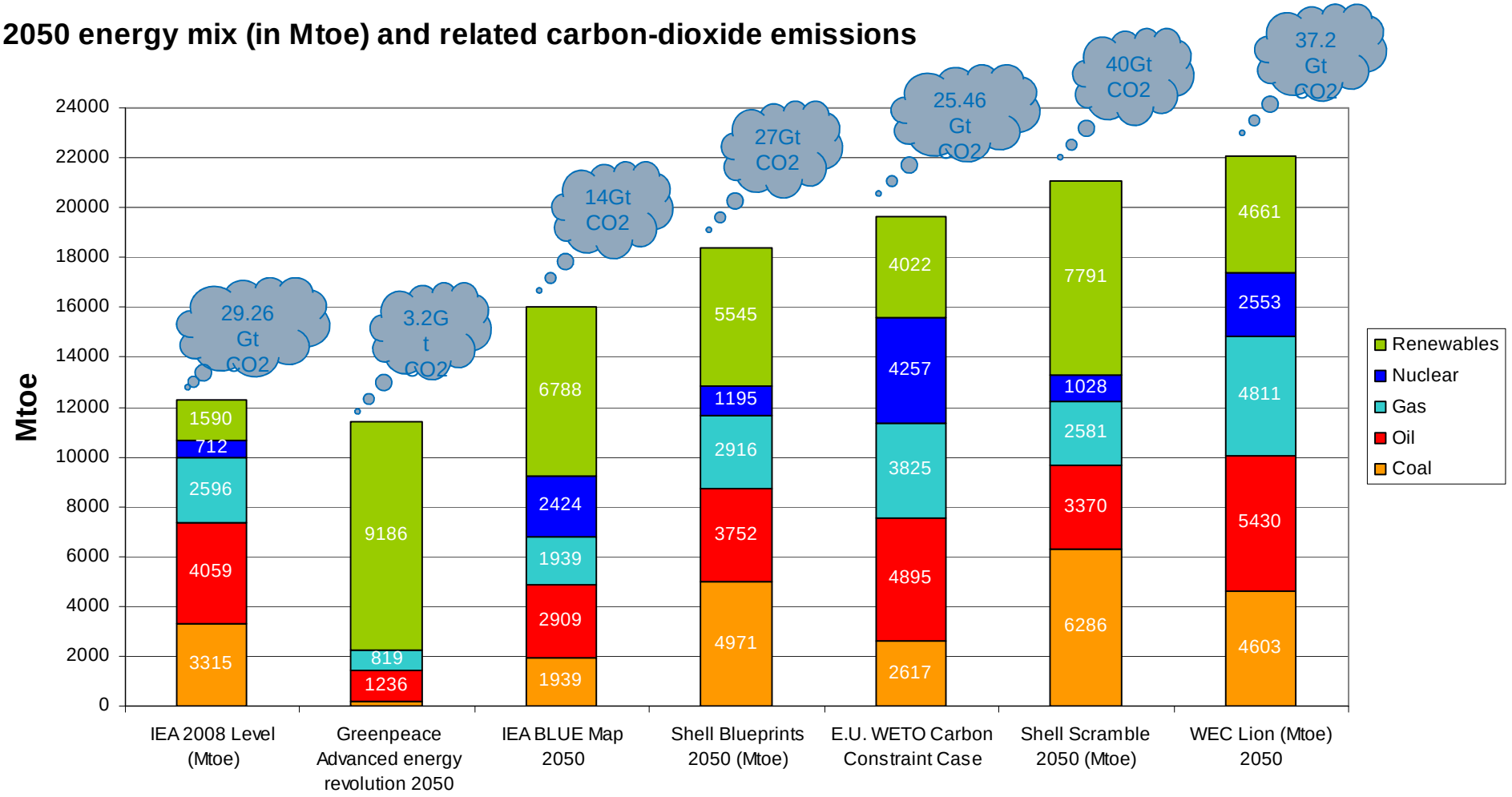
2050 scenarios – future is still to be shaped

2050 energy mix (in Mtoe) and related carbon-dioxide emissions



sources: World Energy Outlook 2010 ; Shell energy scenarios to 2050 ; Greenpeace energy [r]evolution ; Energy scenario Development Analysis: WEC Policy to 2050; World Energy Technology Outlook 2050 – Energy Technology Perspectives 2010

The energy transition

- **12 points to keep in mind:**
  - So far growth of demand is related to population and GDP
  - Today fossil fuels represent 80% of the world energy demand
  - Fossil fuels are cheap and easy to use, but non renewable and emit CO_2
  - Energy density favours liquid fuels, especially for transportation
  - Renewables are clean, secure, but still expensive, capital intensive and intermittent (problems of storage)
  - Changes in the global energy balance are very slow and the energy transition towards a low carbon economy will take decades
  - Risks of climate change require urgent actions because behavourial changes are needed
  - Energy efficiency is a must
  - Reserves of fossil fuels are not the problem but oil production capacity may be the main constraint very soon
  - Scientific and technological lockings require lots of innovation
  - >>> Huge need of competencies in the energy field
  - Energy security will remain a major concern.

Conclusions

- Two main challenges:
  - Access to energy for all at a reasonable price
  - Climate change
- It is necessary to operate an energy transition
- There is not immediate single alternative
- We need everything: energy efficiency, CCS, nuclear, renewables
- We still need a lot of oil, gas and coal
- Adequate answers can be provided, but require innovation

Innovating for energy

www.ifpenergiesnouvelles.com