What is the Energy of the Future?

Nicolas Meilhan
Principal Consultant, Frost & Sullivan

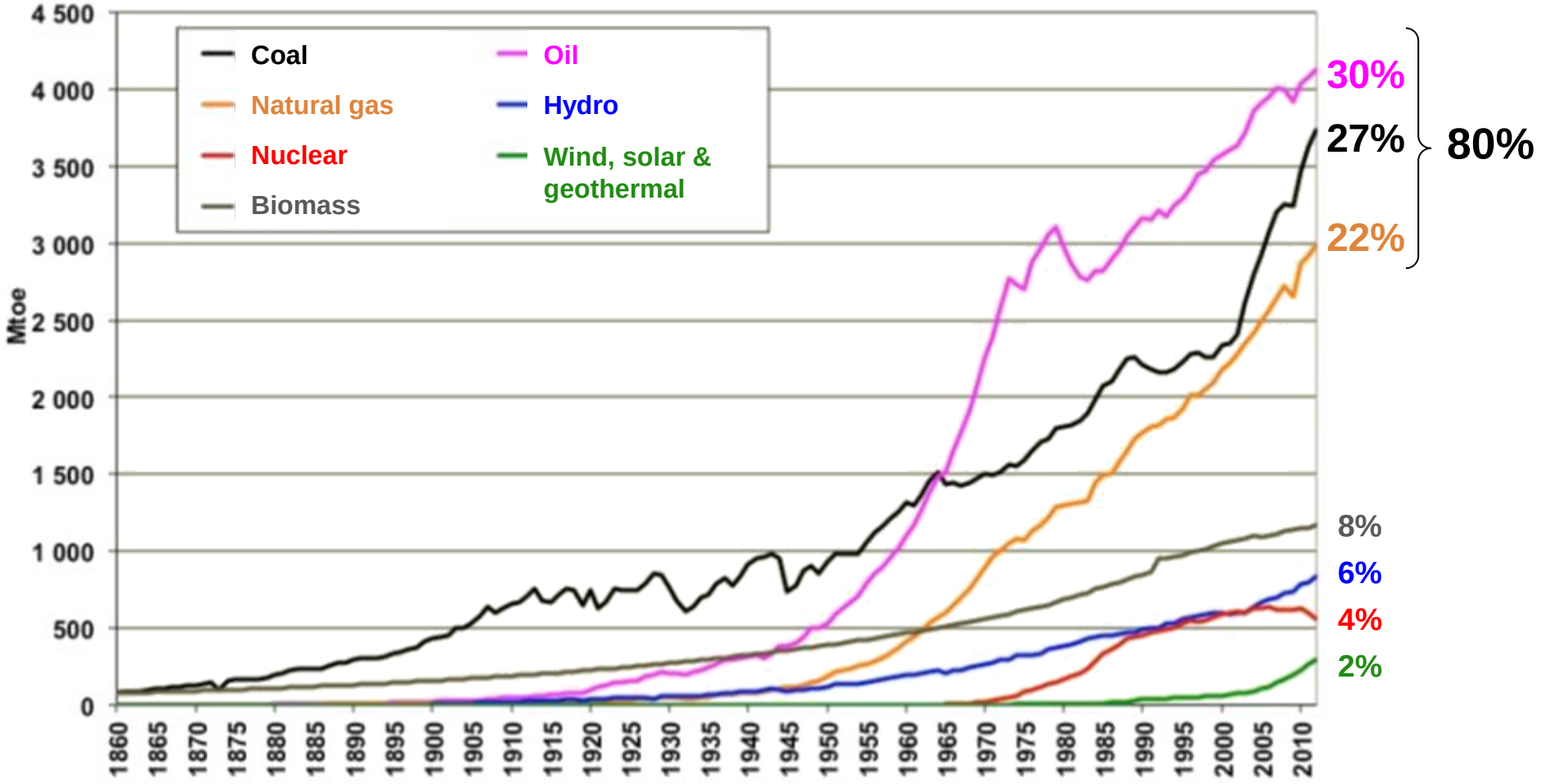
April 2015

What is the energy of the past?

Oil remains by far the main source of world energy, but has lost market share to gas and coal

Evolution of world primary energy consumption

- Million tons of oil equivalent , 1860 to 2012 -



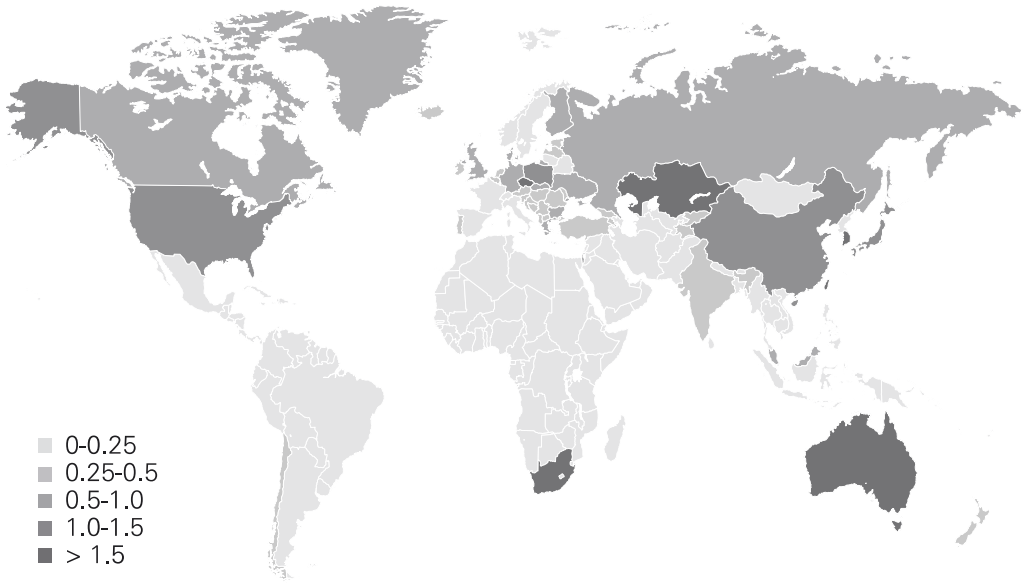
Sources: Shilling et al., 1977, et BP Statistical Review, 2013

Isn’t coal the energy of the past?

Yes it is as it fuelled the industrial revolution during the 18th century. But it might as well be the energy of the future as it could surpass oil as the most primary energy used by 2030

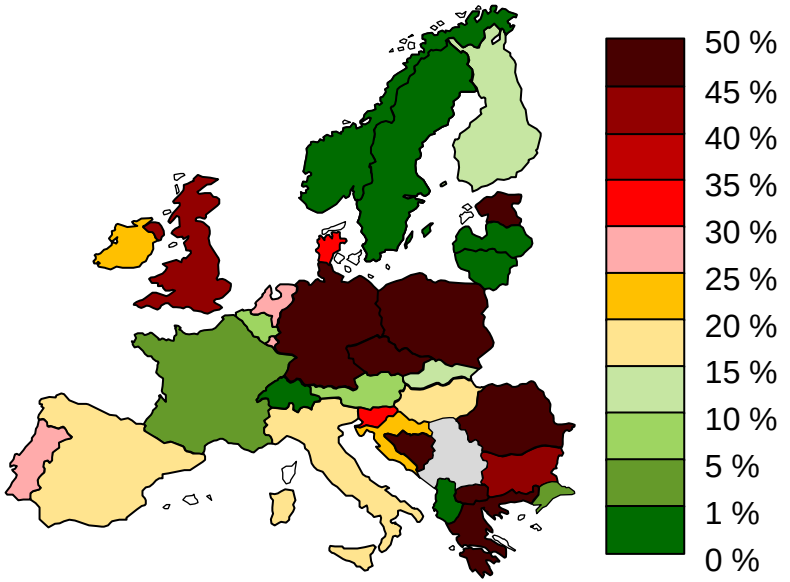
Coal consumption per capita

- Tons of oil equivalent, 2013 -



Electricity production from coal

- % of total electricity production, 2012 -



Coal currently provides 40% of the world's electricity needs, accounts for 40% of CO_2 emissions and as much as 60% of CO_2 emissions increase since 2000

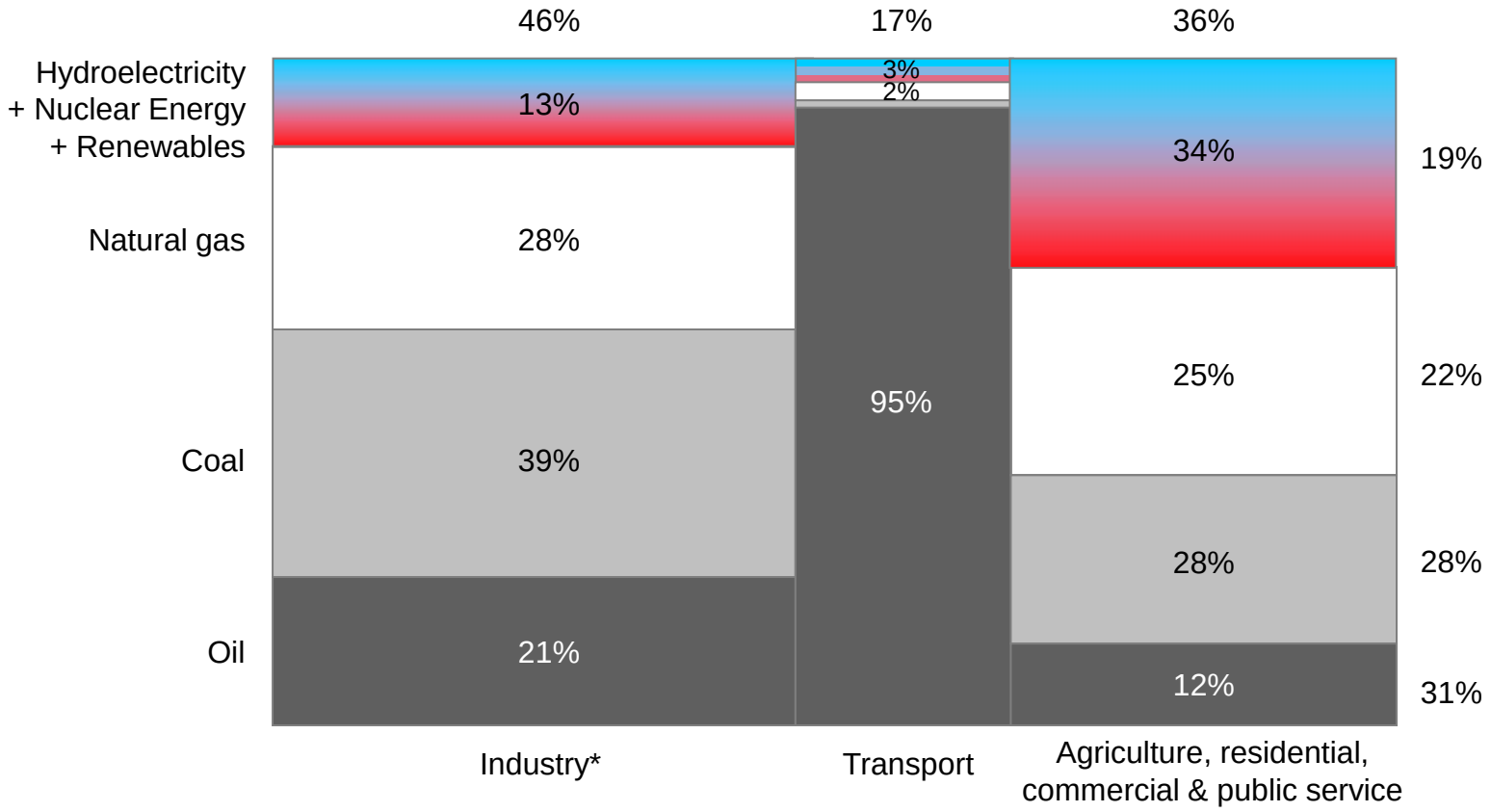
Source: World Bank, BP Statistical Review of World Energy 2014

What do we use this energy for?

Transport is almost exclusively based on oil, while industry relies on massive coal and gas usage

World primary energy consumption mix

- % of million tons of oil equivalent, 2013 -



** Including non-energetic use*

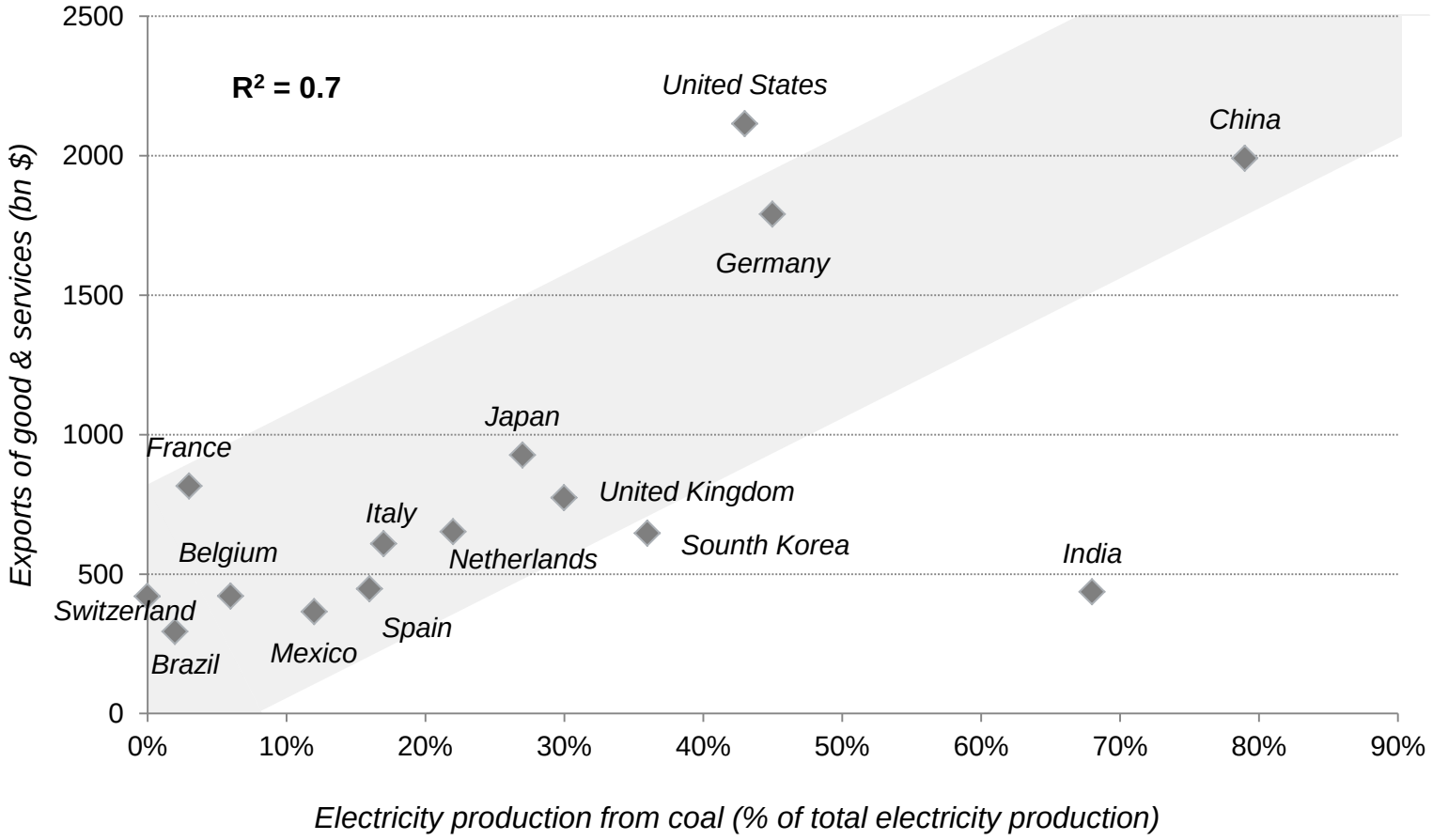
Sources: BP Energy Outlook 2035, IEA

Why do we use coal for industry?

Ask the top 15 exporting countries (who accounts for 80% of exports globally) – they probably know the answer

Exports vs. Electricity production from coal

- Top 15 exporting countries, 2011 -*



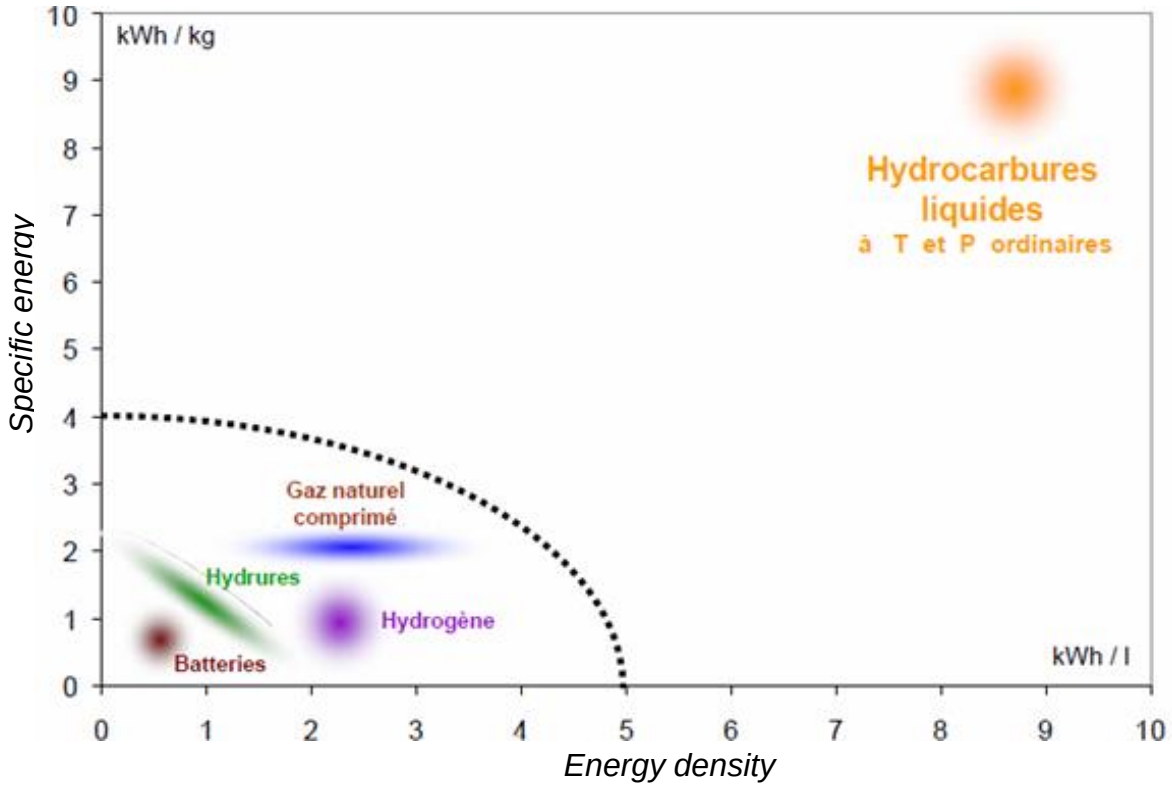
** Energy exports excluded*

Source: World Bank

Why do we use oil for transport?

1kg of oil contains as much energy as in 100 kg of batteries

Energy density of energy vectors used in transport



"If the building of the Great Pyramid required 10,000 people working for 20 years, then the petroleum based energy used in the US on an average day build 100 Great Pyramids"

Richard Heinberg

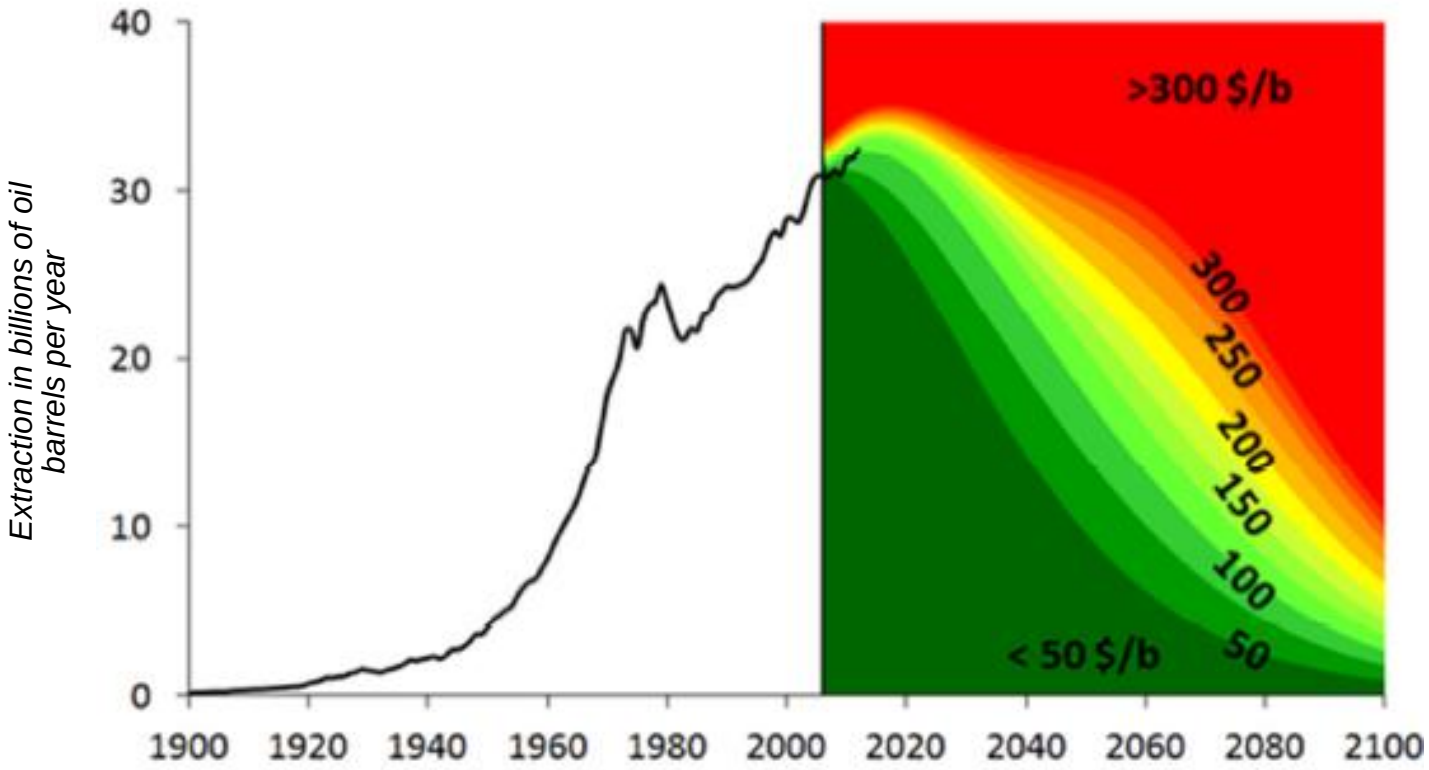
Source : Pierre-René Bauquis, Richard Heinberg

Are we really running out of fossil fuels?

Knowing whether we'll still have fossil fuels in 2100 is not the issue – the critical issue is for how long we will have affordable oil to fuel our economy (and our cars..)

Liquid fuels extraction simulation

- 1900 to 2100 -



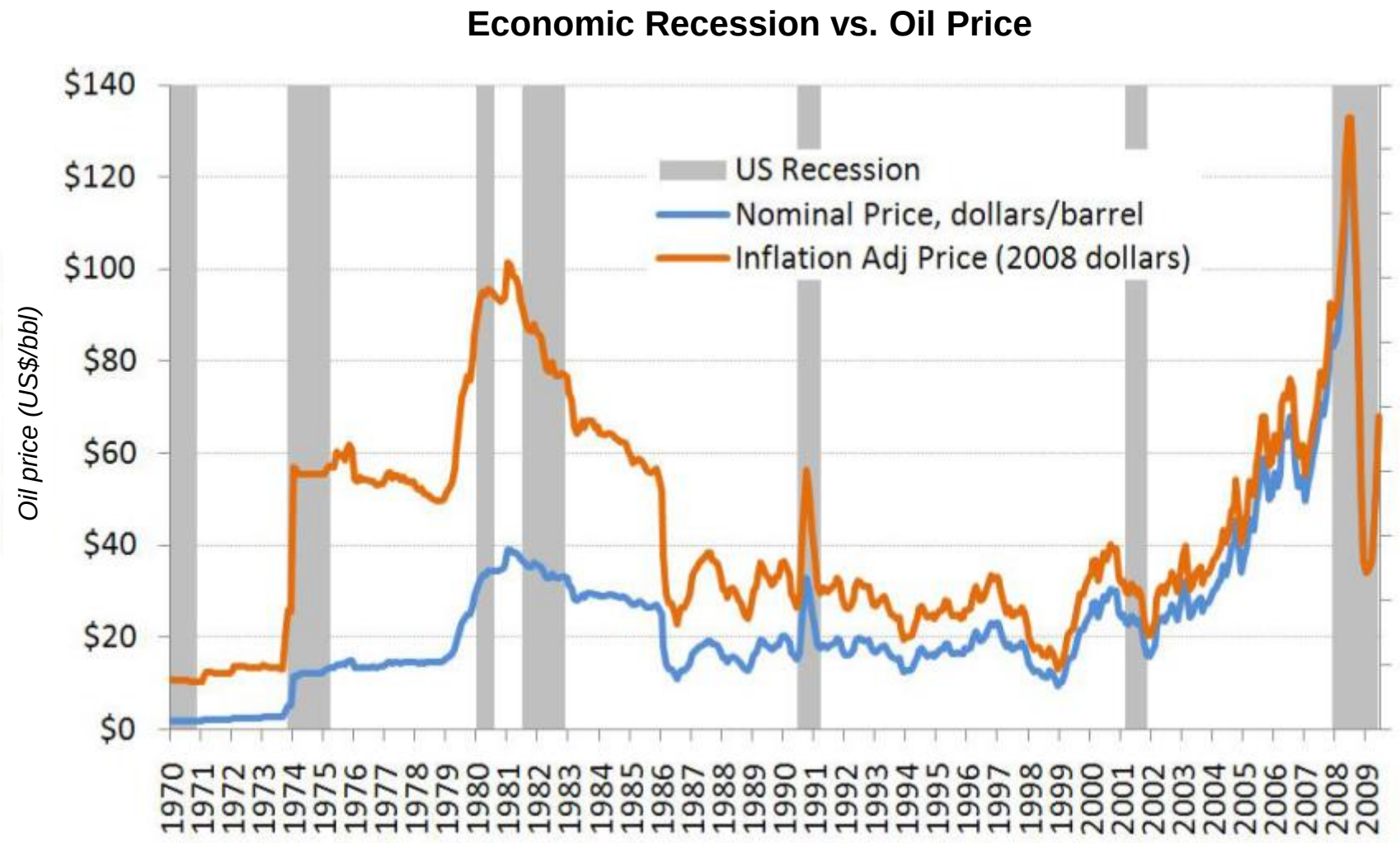
"It's not the size of the tank which matters, but the size of the tap"

Jean-Marie Bourdaire

Source : Jean-Marie Bourdaire, Patrick Brocorens

Do we really need affordable oil to fuel our global economy?

Four of the last five global recessions were preceded by an oil shock

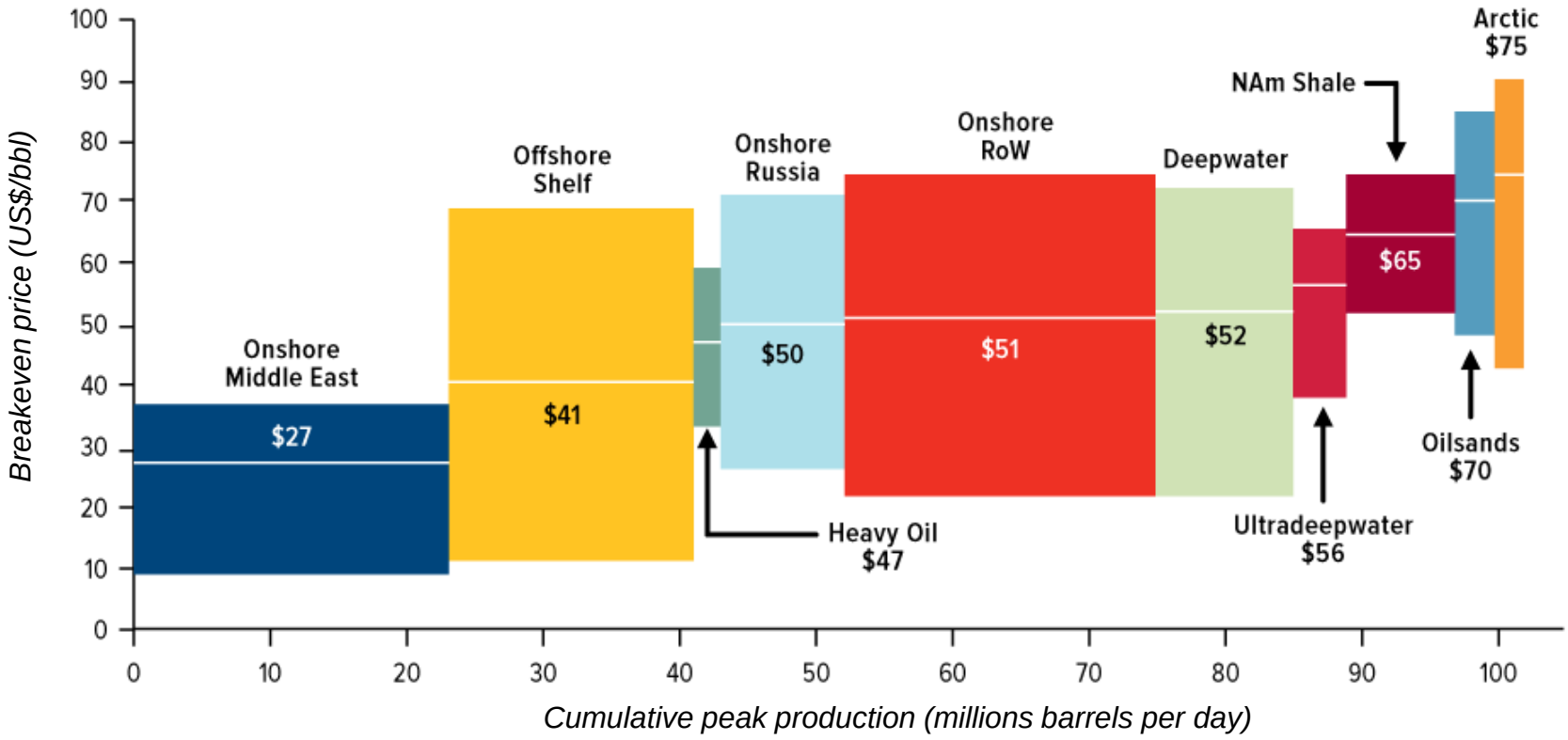


Source: Steven Kopits, June 2009, Douglas Westwood, Oil: What price can America afford?, EIA, NBER

Houston, we have a problem

Higher cost new oil projects require $80/bbl+ oil price to be profitable while oil demand (hence GDP per capita) contracts when oil price surpasses $100 in the US and $120 in China

Breakeven prices for non-producing oil fields



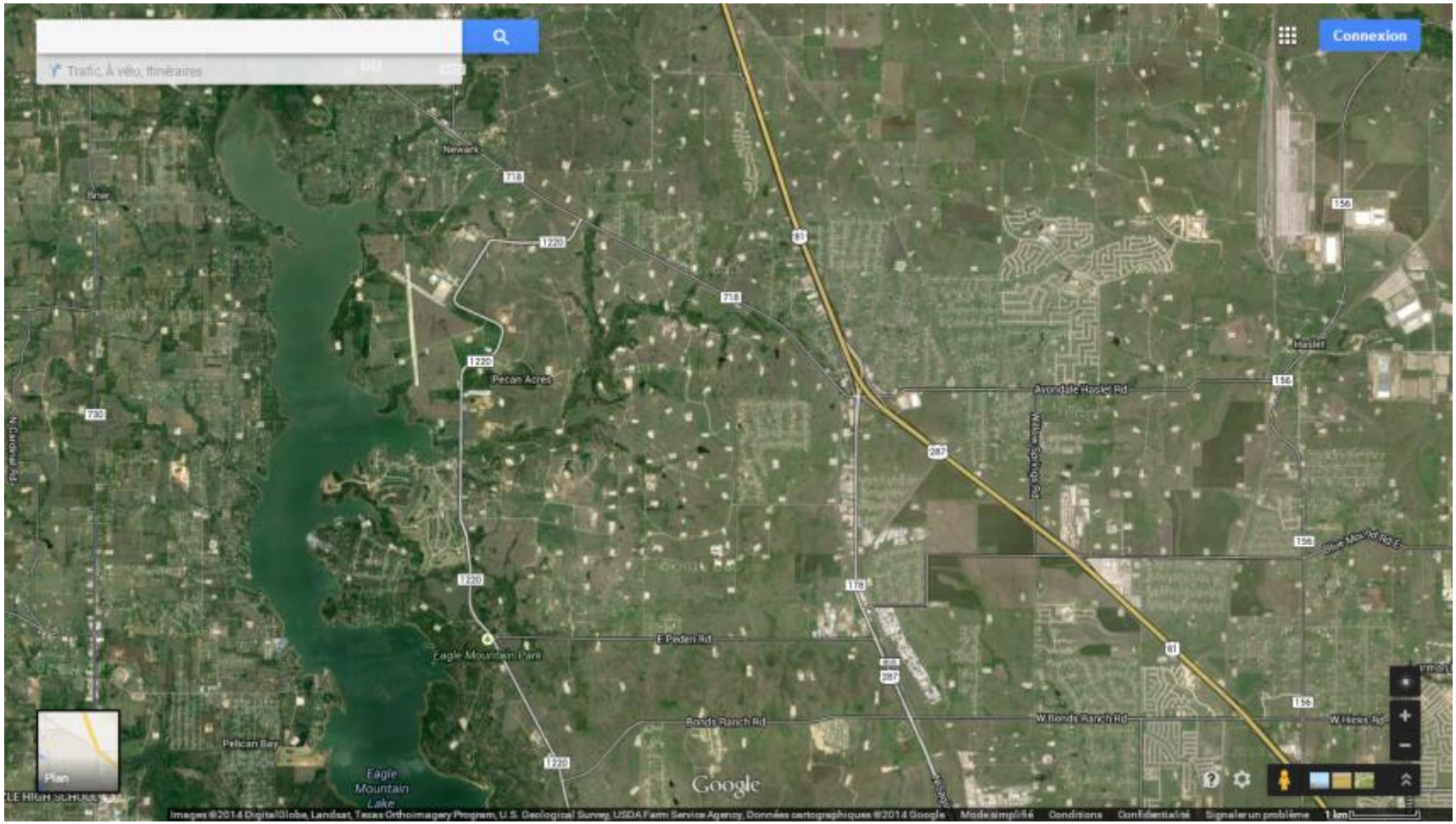
Source: Rystad Energy, Morgan Stanley, U.S. Global Investors

Is shale gas the energy of the future?

In the short term maybe in the US with as high as 40% of gas demand in 2013, in the longer term probably not in Europe with only 10% of gas demand in 2030

Bird's eye view of a Texas shale gas field

- Click on the image-

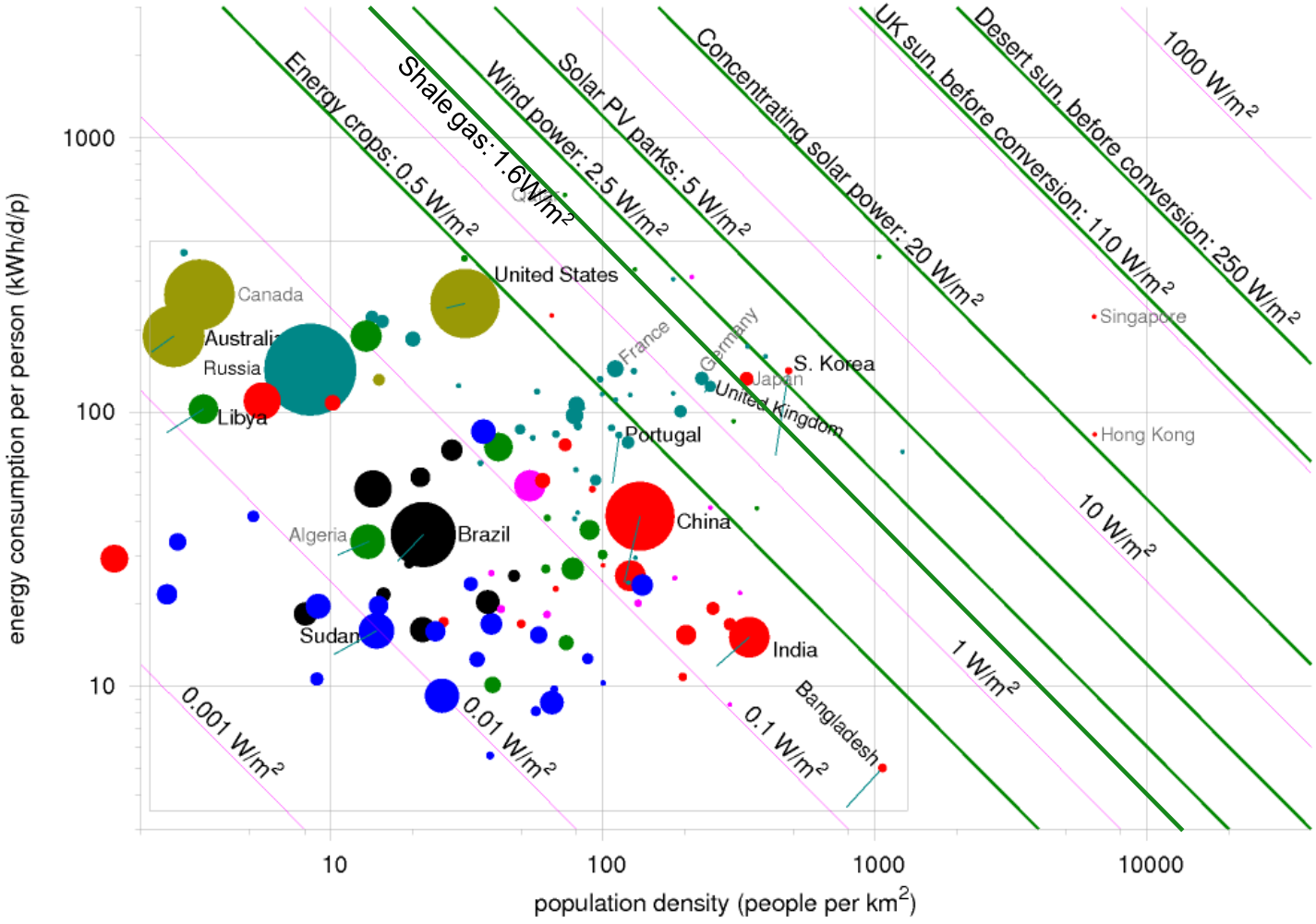


Source : [Google maps]

Is space that important when it comes to energy?

Energy surfacic density must be considered when looking at the energy of the future – The less space we have, the less choice we have!

Energy surfacic density



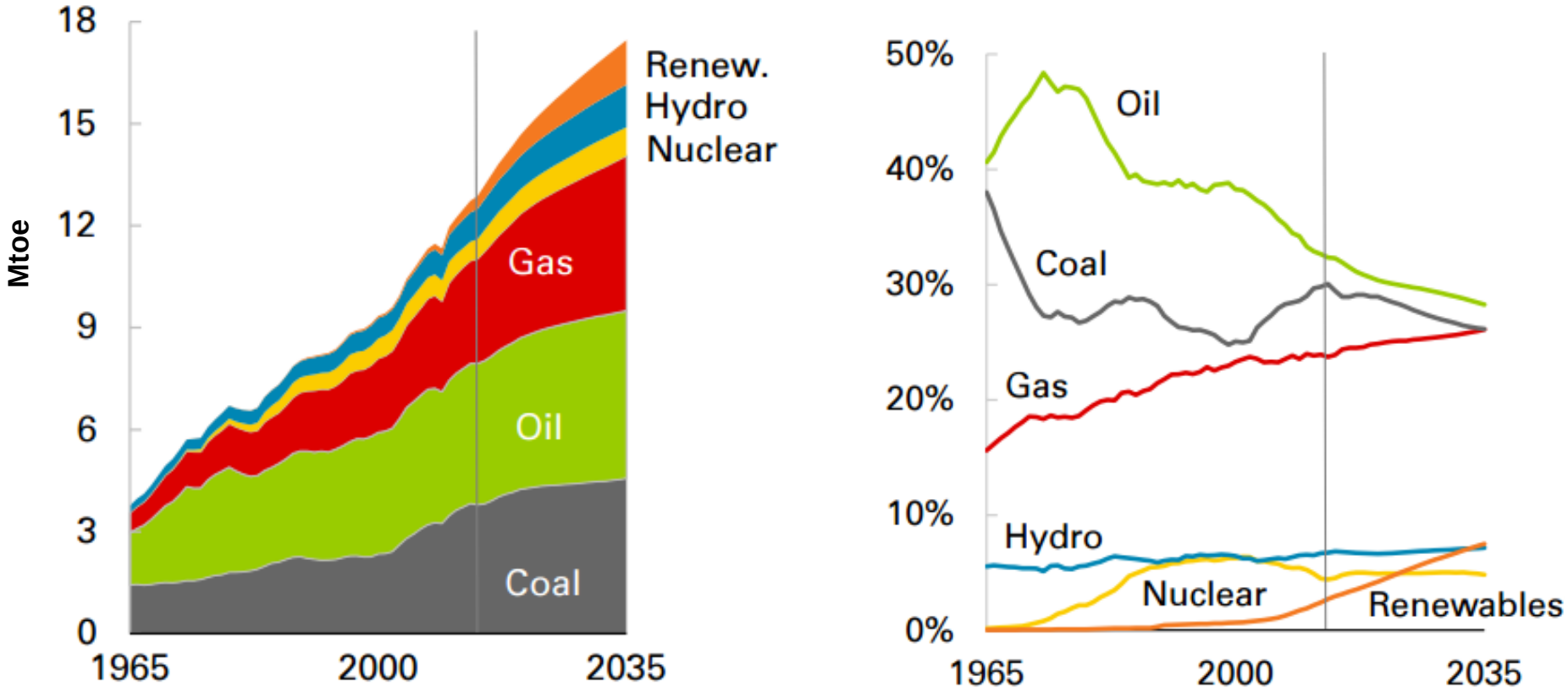
Source: *David MacKay, a reality check on renewables*

What could be the energy of the future then?

Fossil fuels share in primary energy mix will decrease only modestly, from 85% in 2013 to 80% in 2035, the new renewables share increasing from 3% in 2013 to 8% in 2035

Evolution of world primary energy consumption

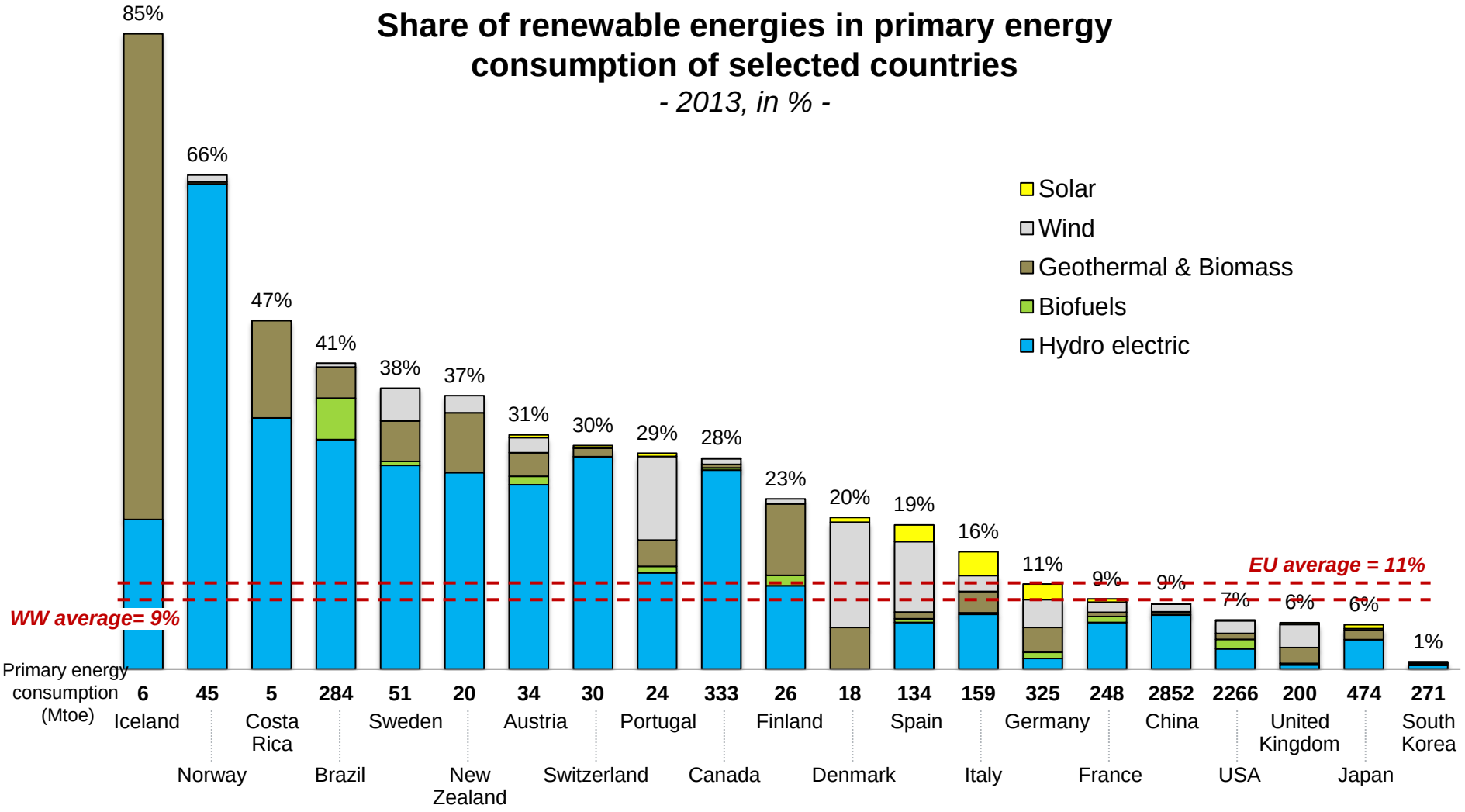
- Million tons of oil equivalent & % , 1965 to 2035 -



Source: *BP Energy Outlook 2035*

Can’t we just use renewable energies like our ancestors did in Middle Ages?

Countries which inherited large significant forests, hydraulic or geothermal potential might get close to it – for others, it will be much more difficult unless consumption significantly decreases



Mtoe figures for power generation are converted on the basis of thermal equivalence assuming 38% conversion efficiency in a modern thermal power station

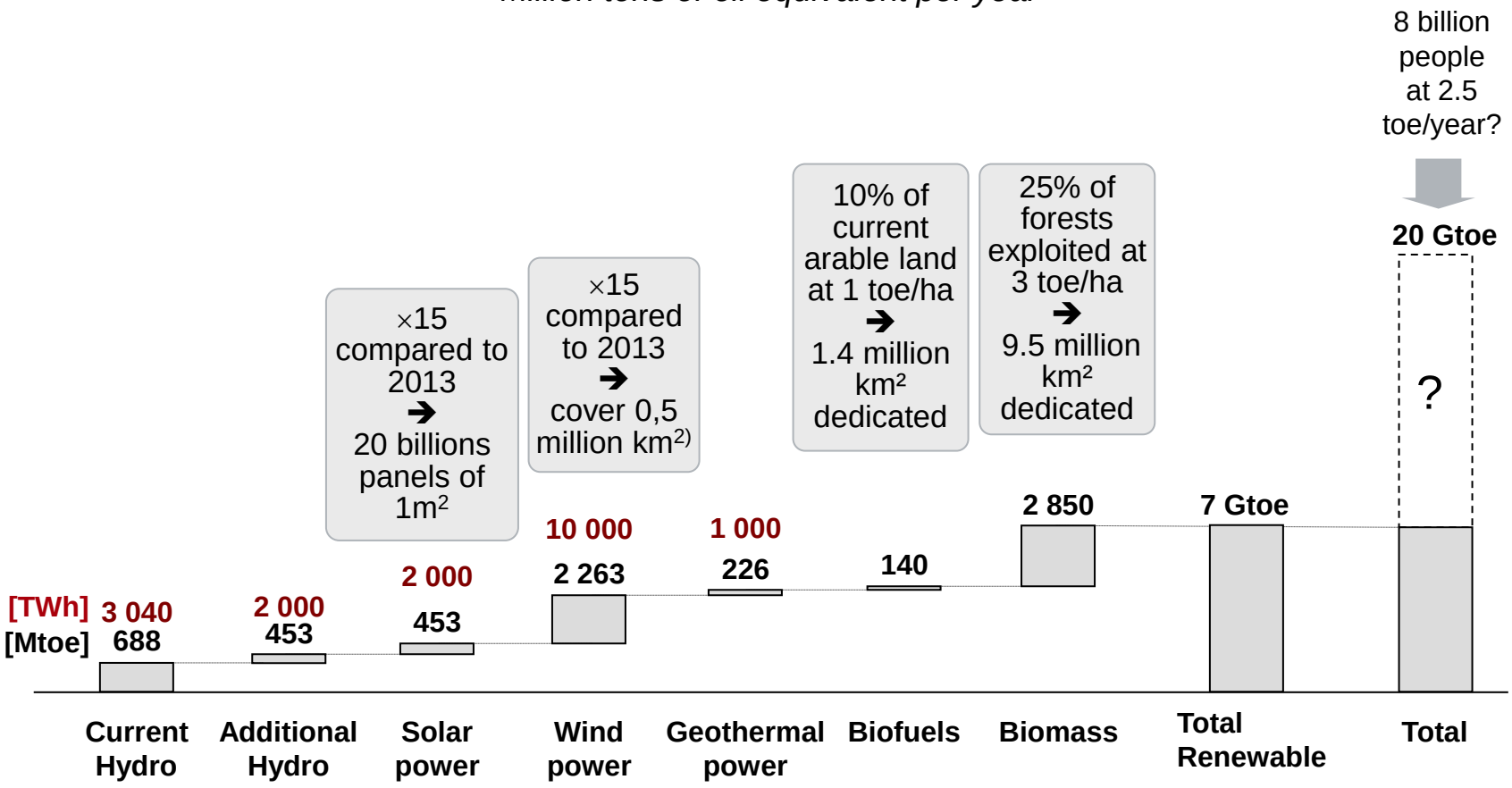
Sources: BP Statistical Review of World Energy 2014, Frost & Sullivan analysis

What will life after fossil fuels look like?

It will be pretty difficult without strong energy savings

Potential renewable energy production

- Million tons of oil equivalent per year -



Mtoe figures for power generation are converted on the basis of thermal equivalence assuming 38% conversion efficiency in a modern thermal power station

Source: Philippe Bihouix, BP Statistical Review of World Energy 2014, Frost & Sullivan

What is the real energy of the future then?

The one we will not use!

FROST & SULLIVAN

Nicolas Meilhan

Principal Consultant

Energy & Transportation Practices

(+33) 1 42 81 23 24

nicolas .meilhan@frost.com