Energy Academy Europe

Energievoorziening en de transities daarin.

NWG Jaarvergadering, Assen, 14th November, 2016.

rijksuniversiteit groningen

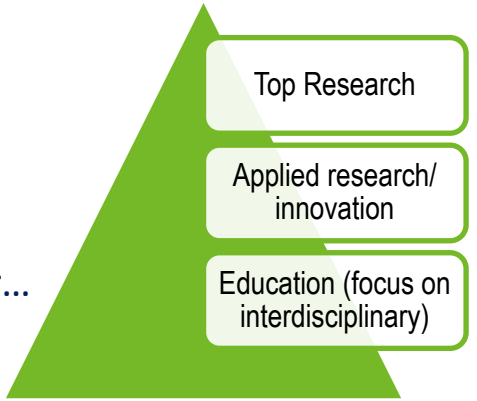
Prof. Dr. André P.C. Faaij

Academic Director - Energy Academy Europe

Distinguished Professor Energy System Analysis – University of Groningen

The EAE "initiative"

- **Center of excellence** in energy education / research / innovation
- **Focus on transition** to sustainable, reliable and affordable energy
  - Renewables (wind, biobased, solar etc.)
  - Energy efficiency (including energy water and food)
  - Gas in transition (including biogas, green gas)
  - Biobased Economy
  - CO_2 reduction (including CCS)
  - Built env/Smart grids/households
  - Governance, policy, law, energy markets, human behavior…

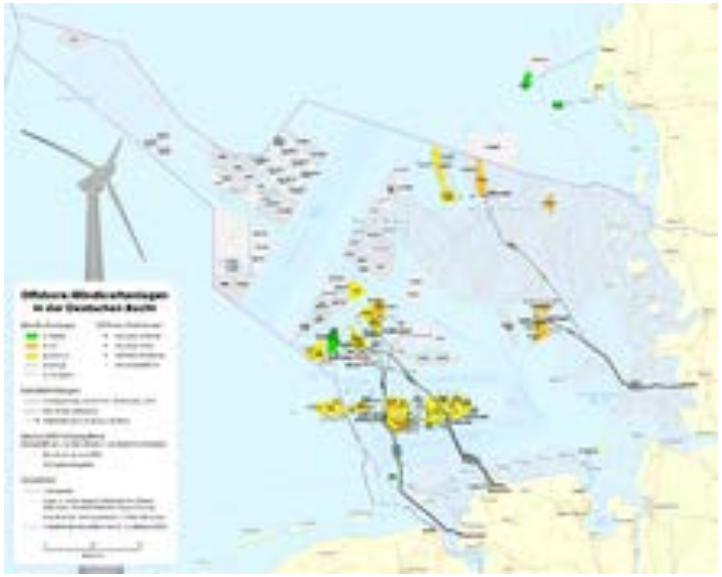


- **Open** to all interested students, organisations and businesses
- **OPEN Public / Private initiative** of: University of Groningen (UoG), Hanze University of Applied Sciences (HUoAS), Gasterra, Gasunie, Energy Valley, EBN (+NAM/Shell and counting…), TNO, ECN…
- Some **500 scientists** from many different disciplines involved. Towards **3000 ''energy students"** from vocational to post academic level.

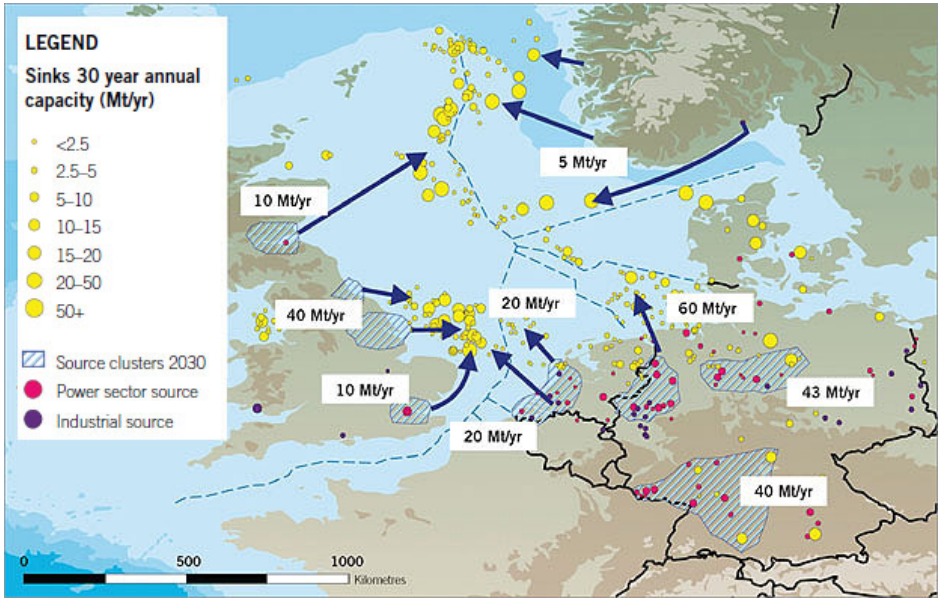
North NL = Energy region

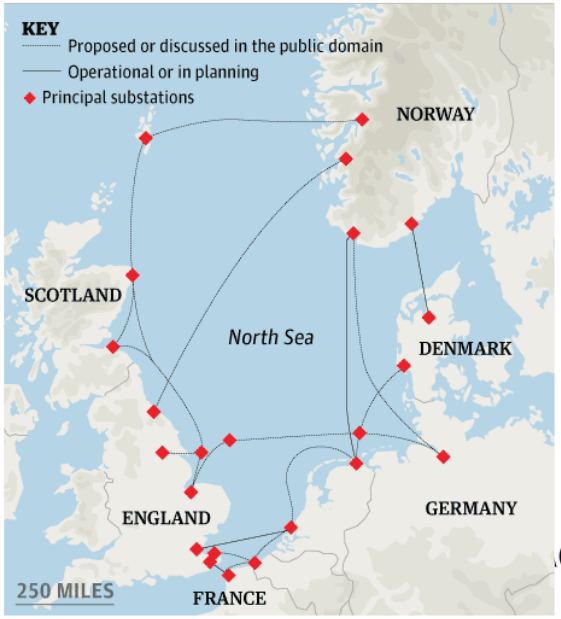
university of groningen
Hanze University of Applied Sciences Groningen
energy valley
GasTerra
ebn
gasunie

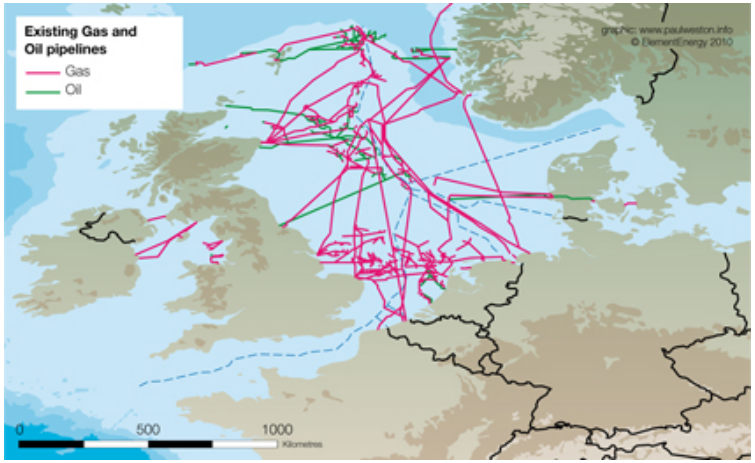
North Sea Region…



High voltage grid







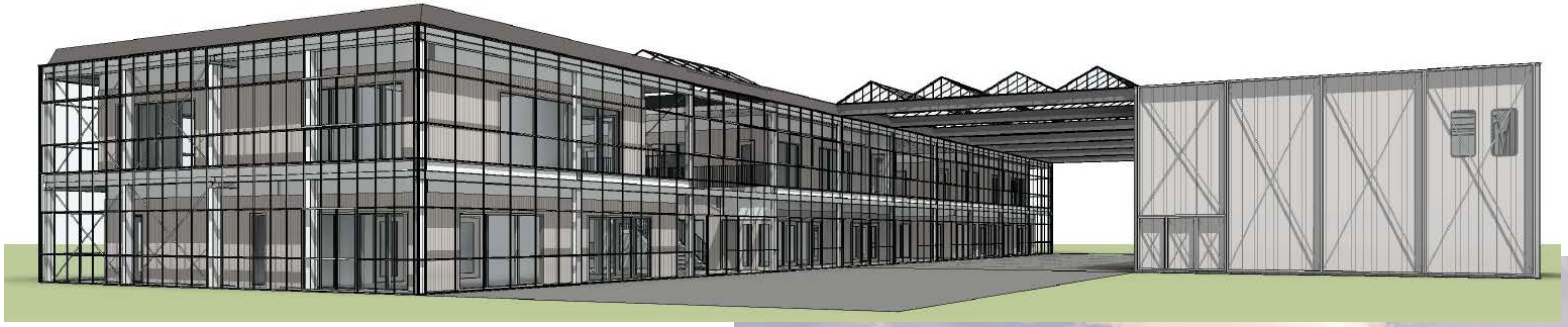
cademy **Europe**

ebn

Societal needs and relevance

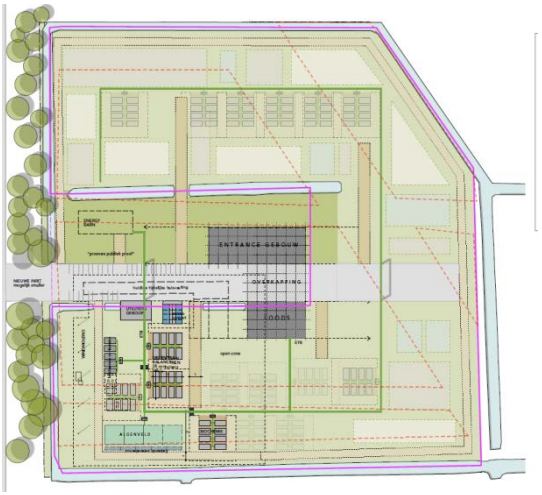
- Massive investments needed and changes in investment portfolio.
- Energy business is changing
- New professionals needed from vocational to academic (and post-academic) level.
- Research to support innovation and implementation; increasingly interdisciplinary.

Building the Energy Academy



EnTranCe

Building 2000 m2 realized in 2015
5ha terrain for range of energy technologies & infrastructure.



10.000 m2, completed first half 2016

DEFINITIEF ONTWERP
ENERGY ACADEMY EUROPE

broekbakema dvnb architecten

energy

university of groningen

Hanze University of Applied Sciences Groningen

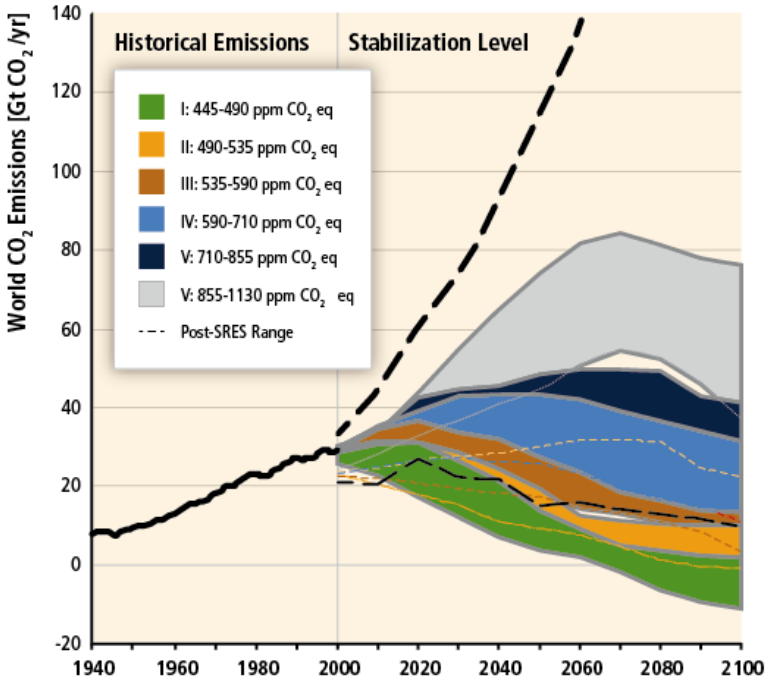
energy valley

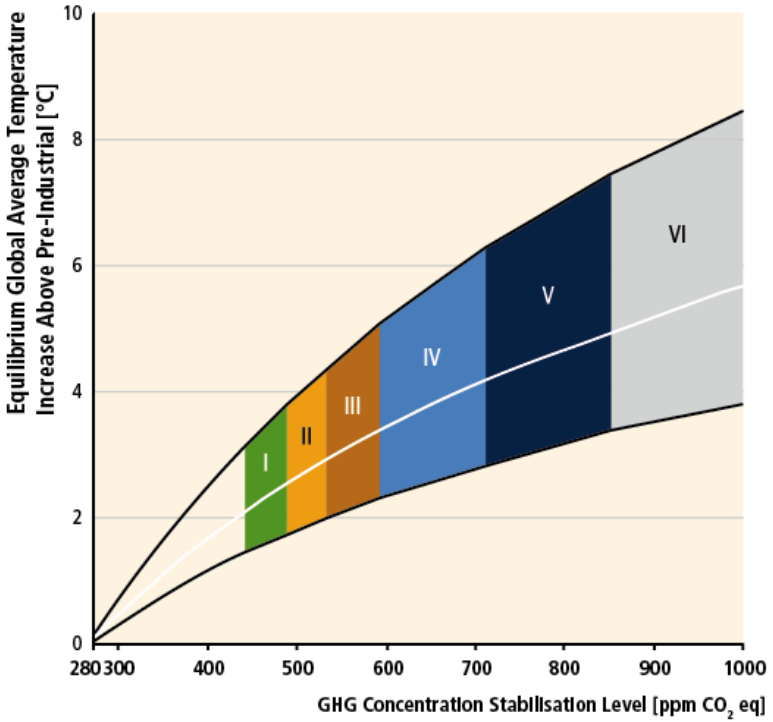
GasTerra

ebn

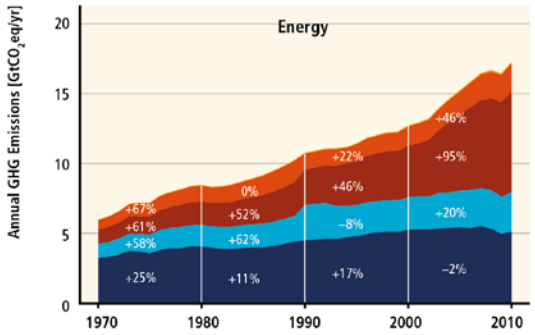
gasunie

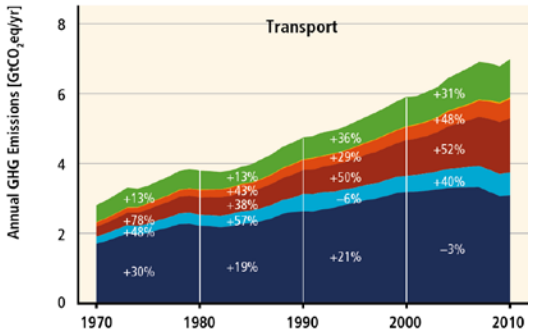
Energy demand, GHG emissions and climate change…

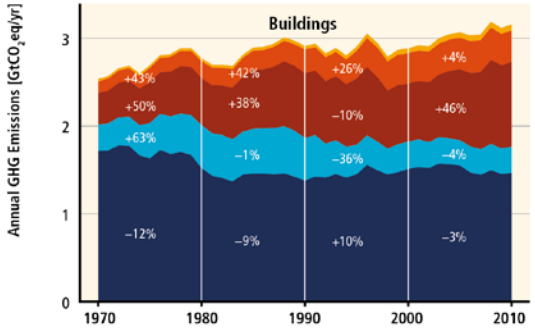


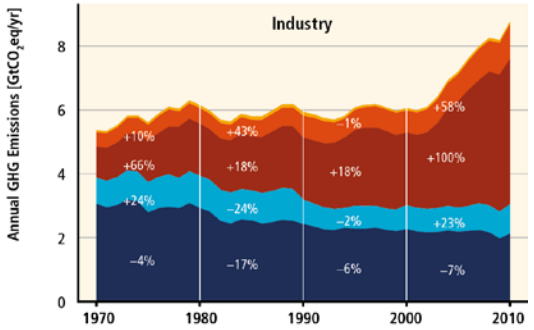


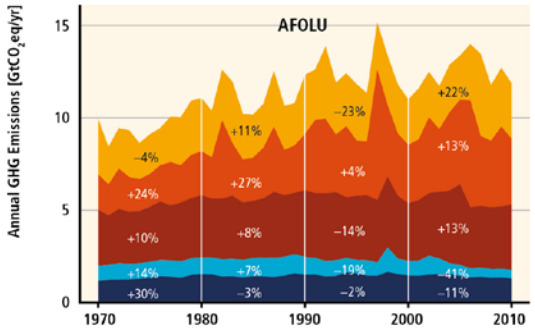
[IPCC, AR5]

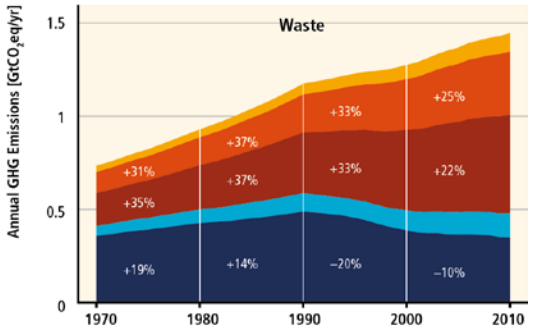


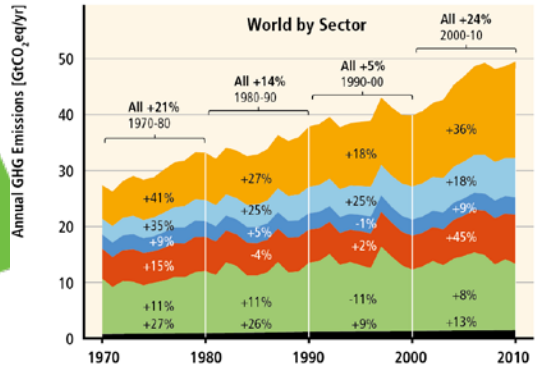


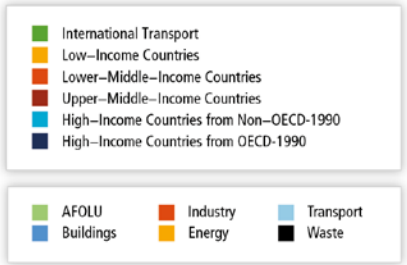












Breakdown of global GHG emissions.

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energy valley
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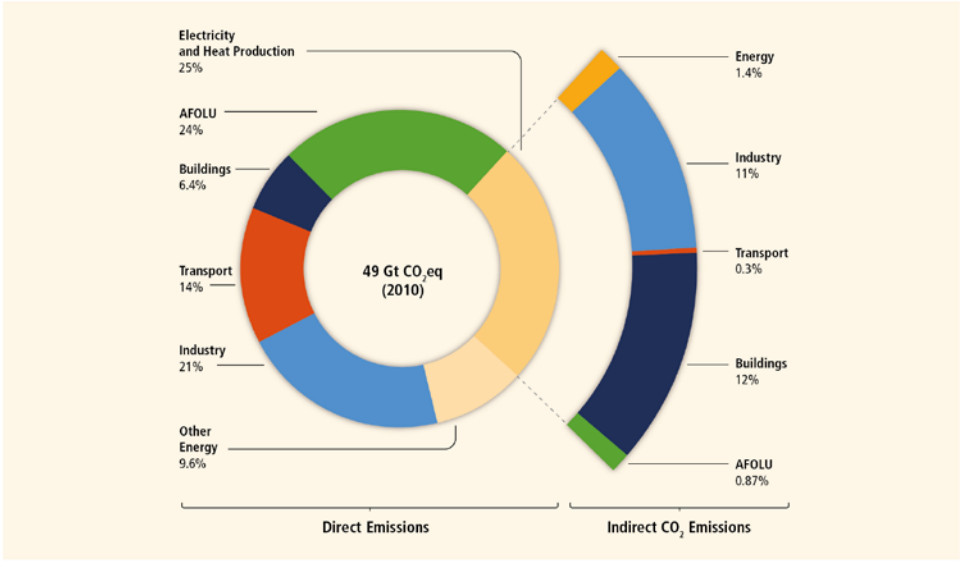
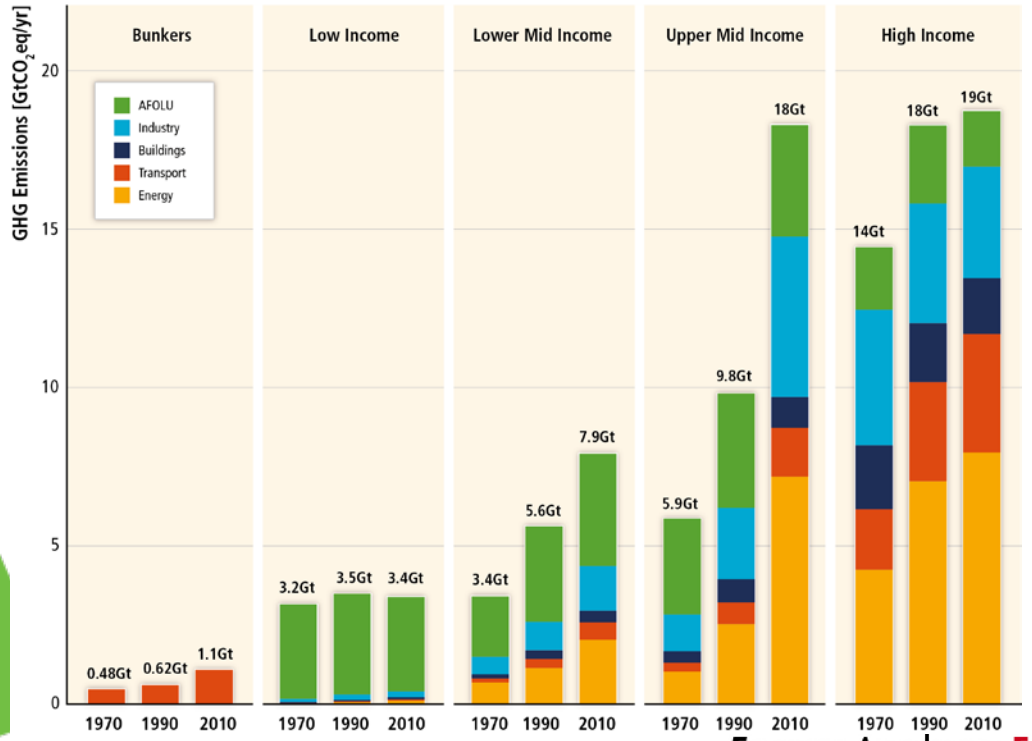
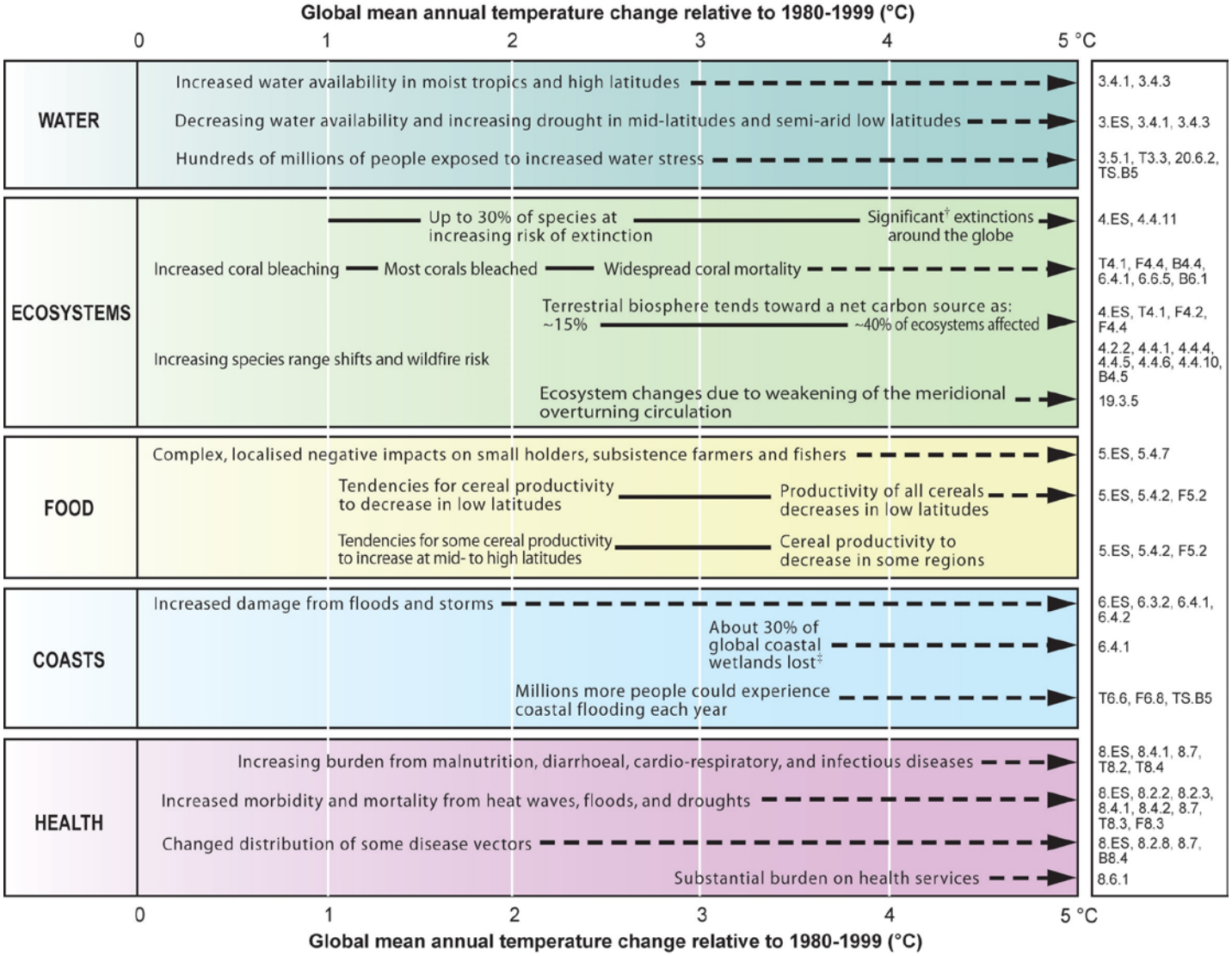
Greenhouse Gas Emissions by Economic Sectors





GHG emissions per key economic sector and related to income/development levels.

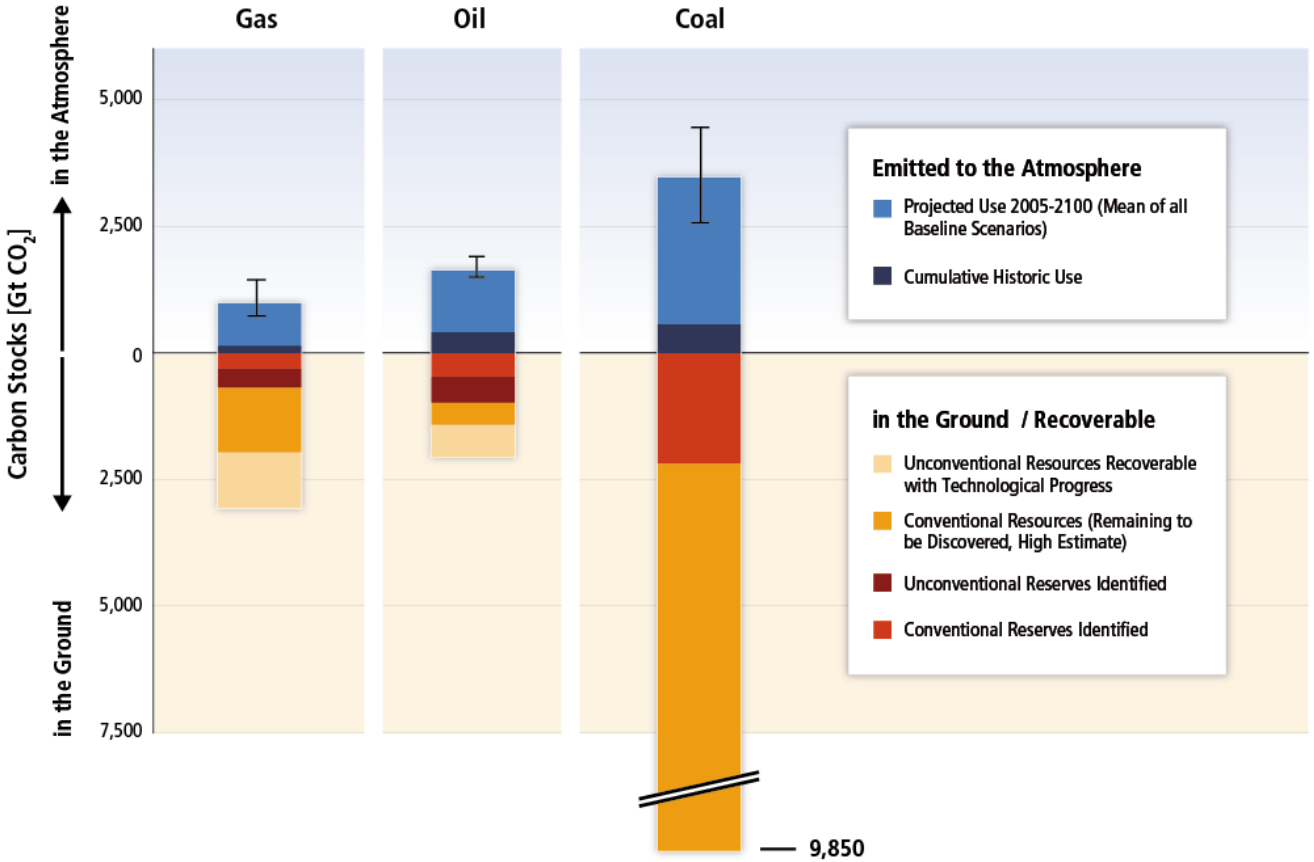
IPCC AR4 (2007); temperature change vs. expected impacts



† Significant is defined here as more than 40%.

‡ Based on average rate of sea level rise of 4.2 mm/year from 2000 to 2080

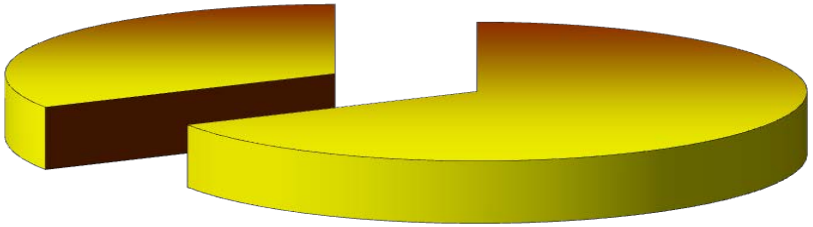
Potential emissions from remaining fossil resources could result in GHG concentration levels far above 600ppm.



CO_2 budget approach

If we want 2/3-3/4 probability to stay below +2°C, global CO_2 emissions should stay below 1000 Gton (from the year 2000).

2000-2009: 33%



2010-2050: 67%

→ At current consumption the budget will be exhausted in 2030.

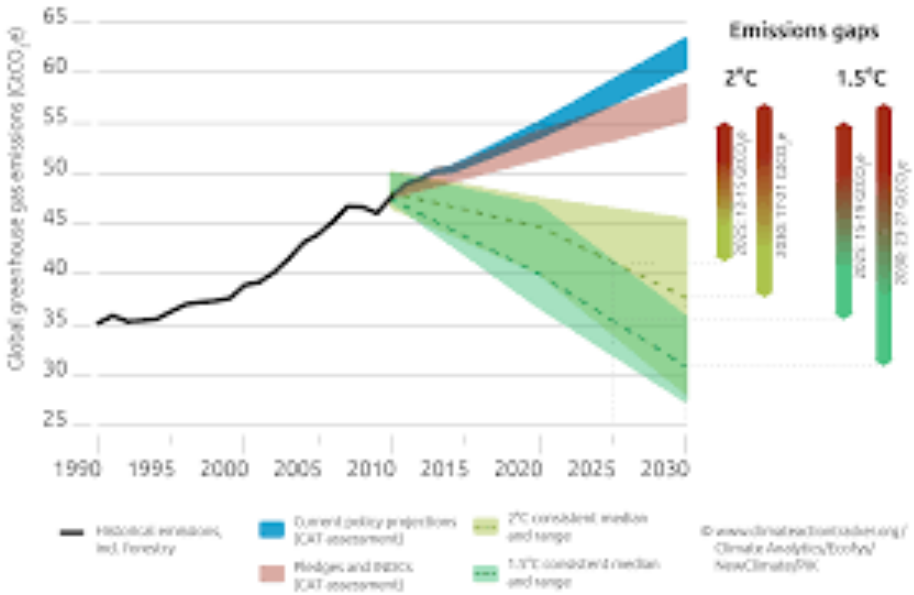
Sources: M. Meinshausen et al., Nature, 30 April 2009;
A. Levermann, GHGT-10, 19-23 Sept. 2010

→ Without CCS less than 1/3 of fossil fuel reserves (and only a fraction of fossil fuel resources) can be utilized .
→ Minister Maria van der Hoeven (NL, 2010): "Without CCS no fossil fuels; without fossil fuels no energy security".
***→ Also attention needed for* NG & CCS *and for* Biomass & CCS.**

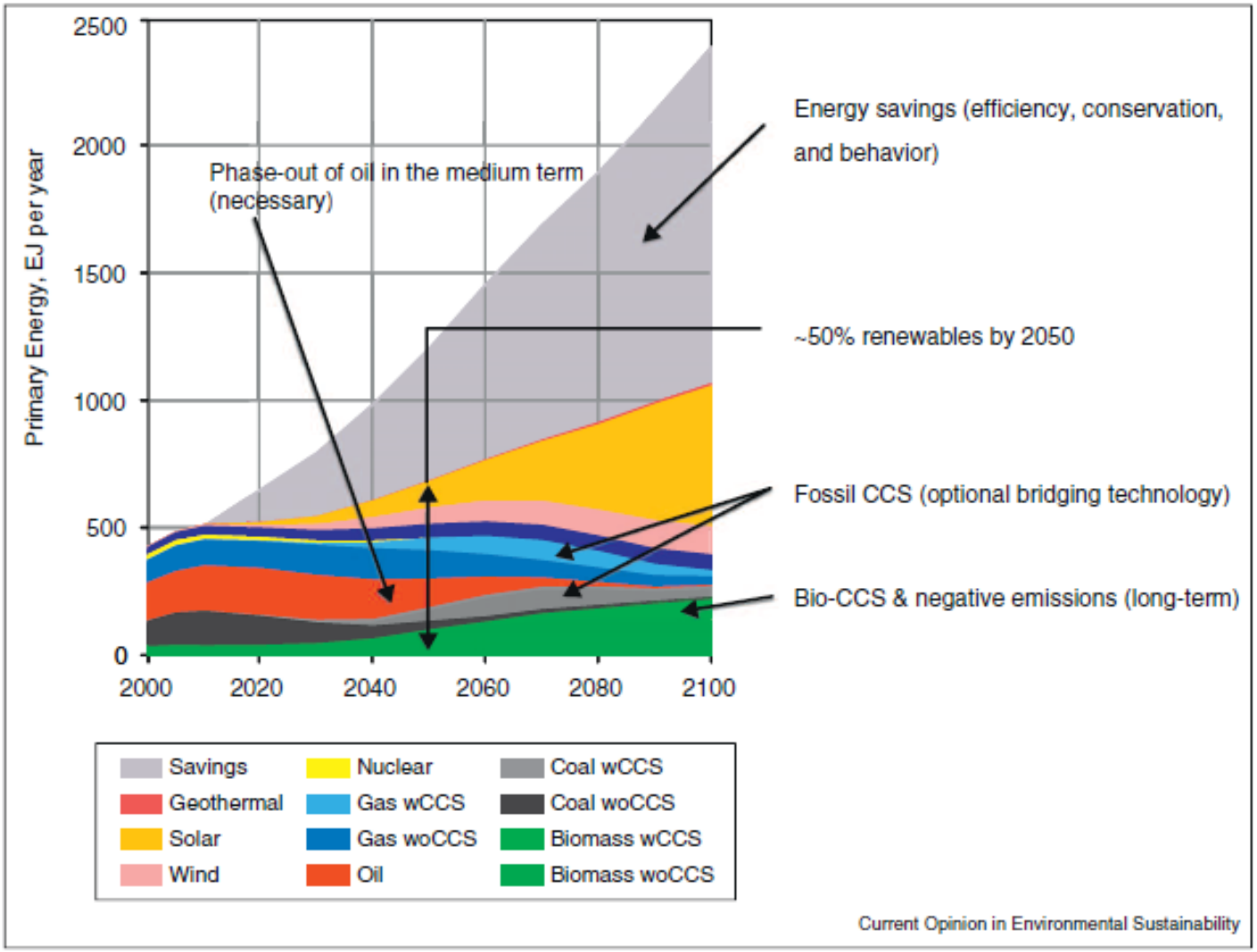
PARIS2015

UN CLIMATE CHANGE CONFERENCE

COP21·CMP11



Energy system transformation…



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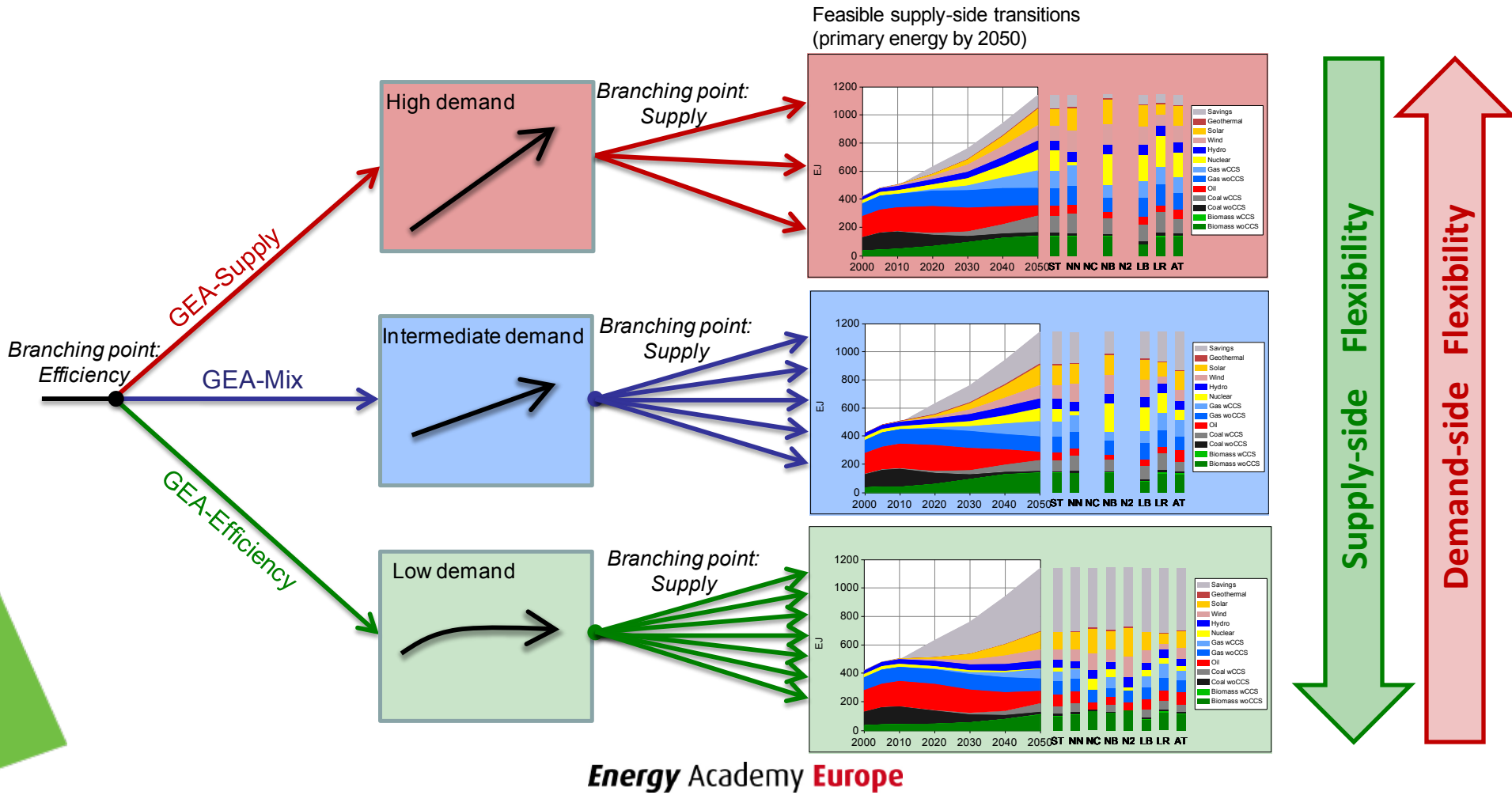
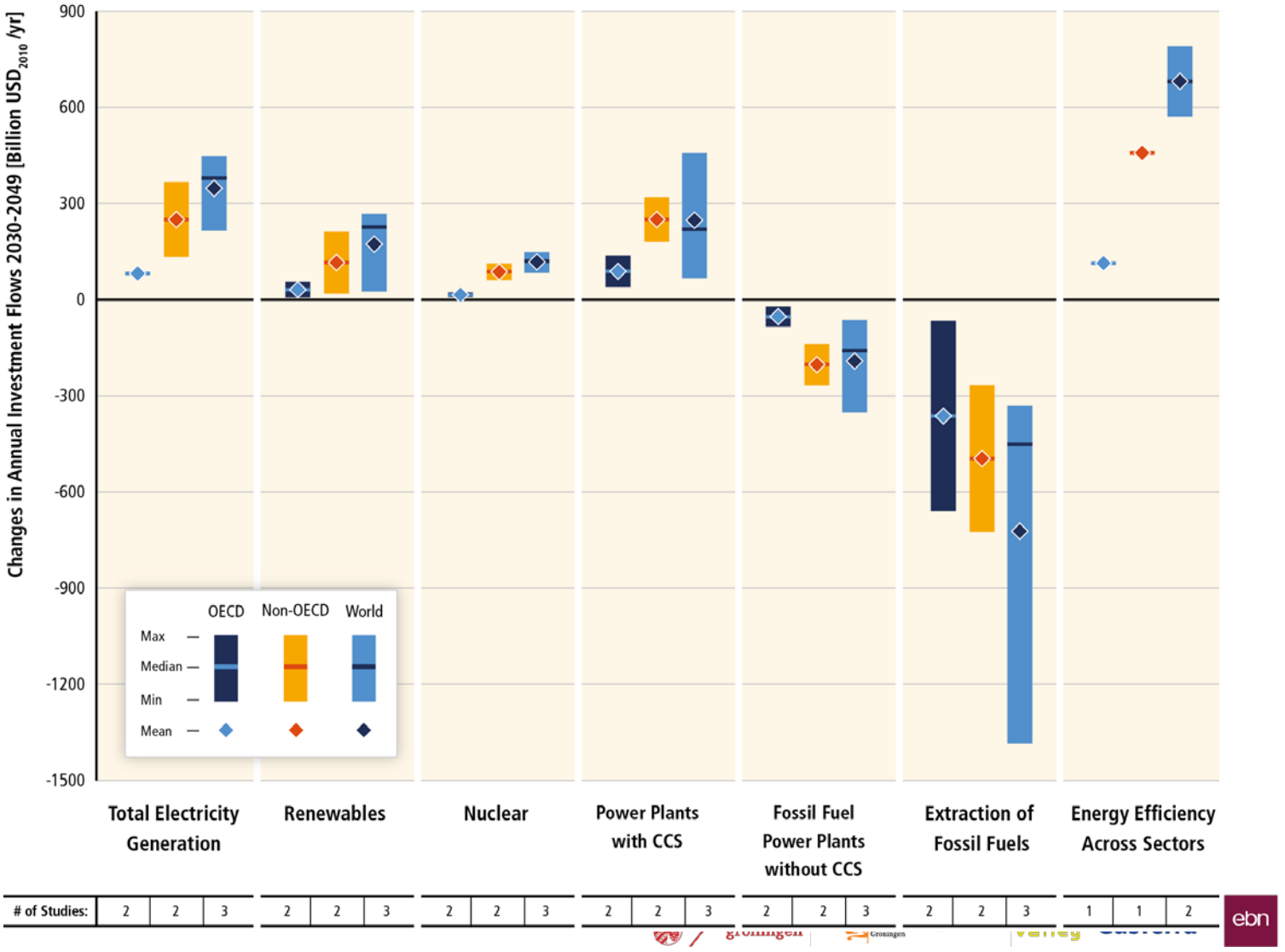
[GEA/van Vuuren et al CoSust, 2012]

Global Energy Assessment (GEA)
Pathways depend on many factors



(Required) changes in annual investment flows to enable the global energy transition.



IPCC, AR5

Economic importance:

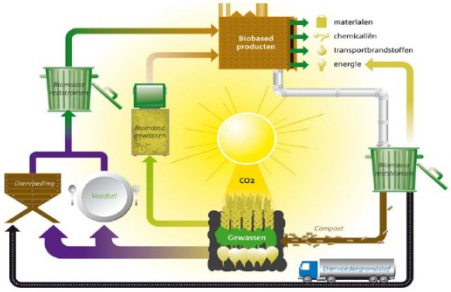
New industry & employment?

Decline overall employment since 2008
But (RET & Eff.) energy sector grew some 60% and expected to continue.

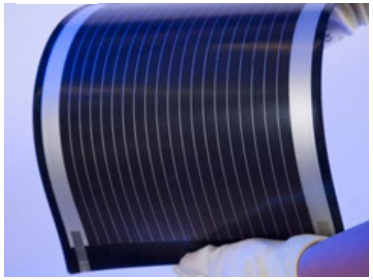
Wind Off shore?

Gasroundabout Europe?

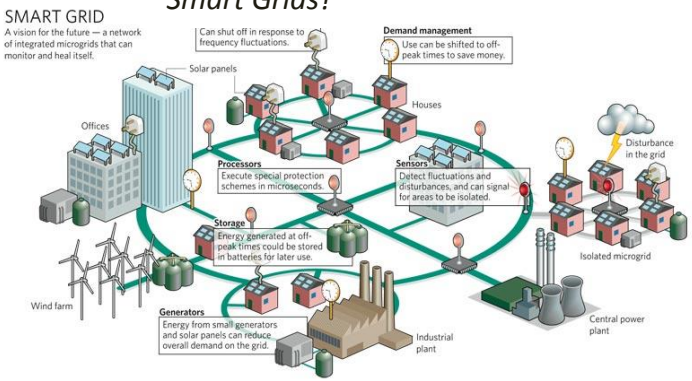
Biobased economy?



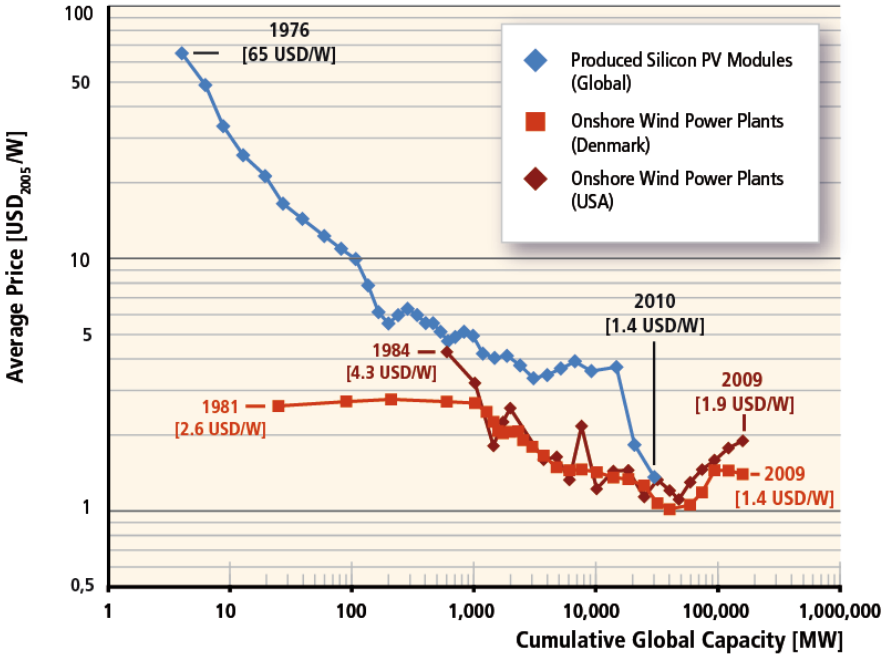
PV



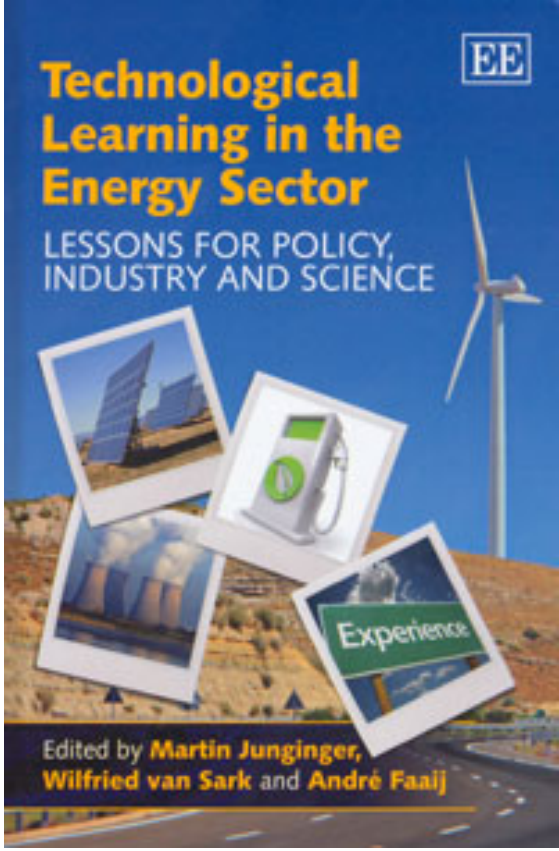
Smart Grids?

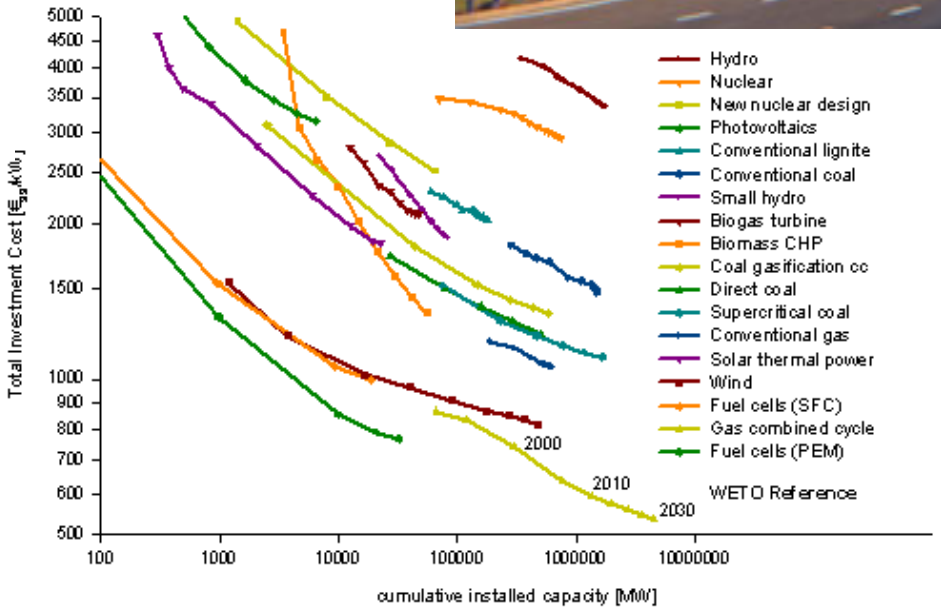


RE costs have declined in the past; further declines expected in the future



[IPCC-SRREN, 2011]

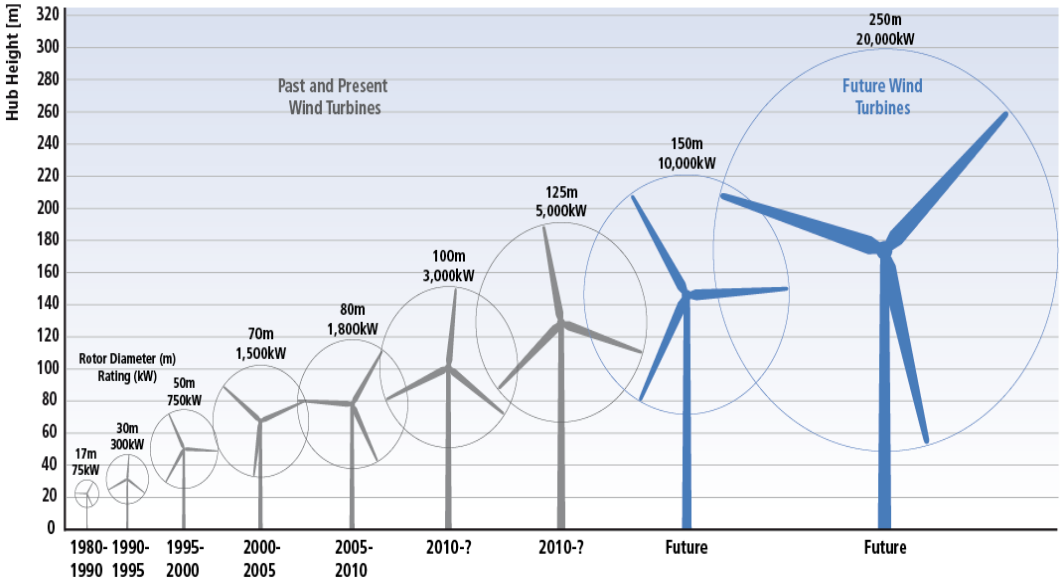




Learning curve for power generation technologies, historic data and POLES WETO reference projection up to 2030.

Factors influencing learning/ unit costs

Example for onshore wind farms:



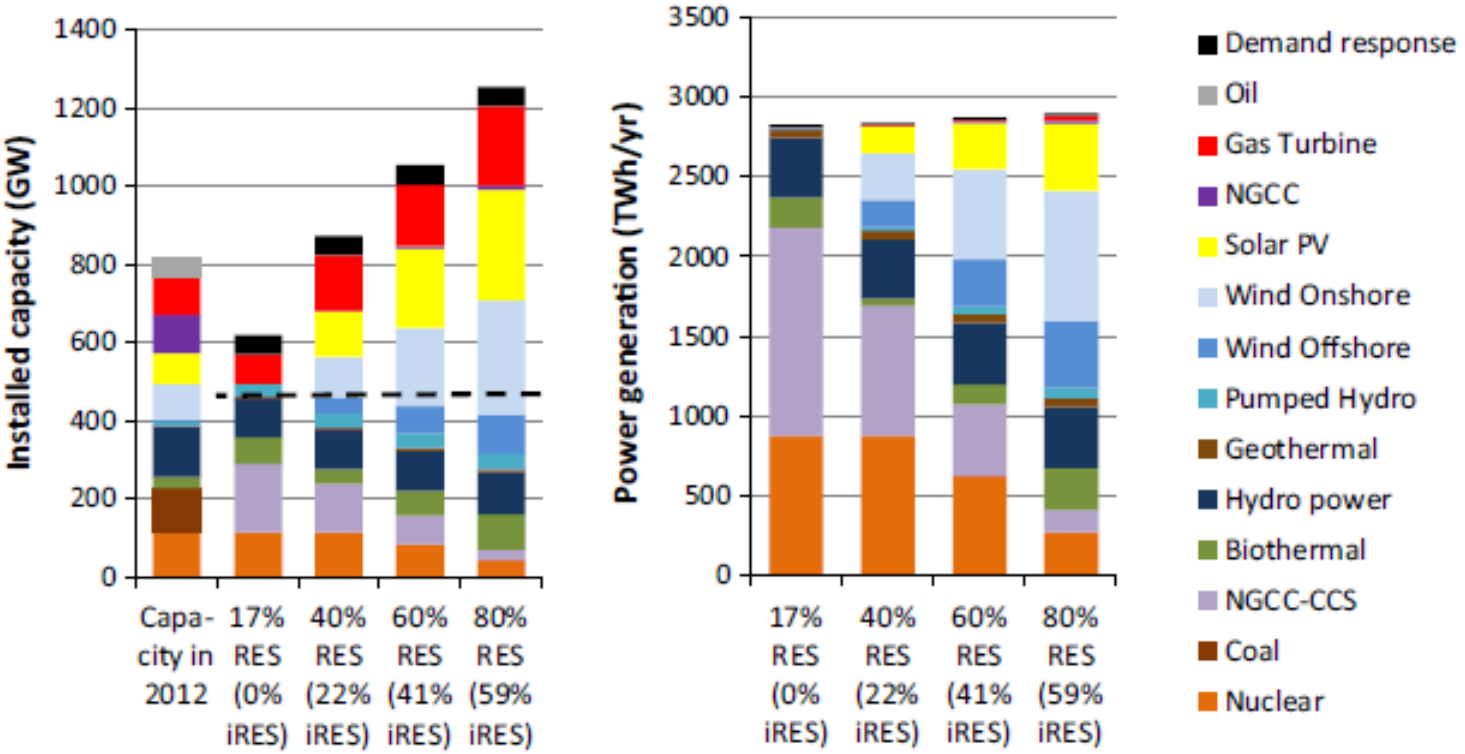
- Improved siting of wind farms (Learning by doing)
- Development of specific components (gear boxes, generators) and regulating mechanisms (stall/ pitch regulation) (R&D)
- Mass production of wind turbines (economies-of-scale)
- Upscaling of wind turbines (upscaling)

Indicative Contribution of R.E. options

Source	2013	2020	2023
Wind on off-shore	3,1	27,0	60,0
Wind on -shore	20,6	54,0	63,0
Solar PV	0,9	11,6	12,4
Cofiring	6,1	25,0	25,0
Waste Incineration	13,3	11,7	12,0
Biomass CHP	3,5	13,6	18,0
Biomass Heat	19,0	31,6	34,1
Biofuels	18,0	35,6	34,6
Renewable Heat	6,1	36,3	46,3
TOTAL	105,5	261,6	335,4
Percentage R.E.	4,4%	14%	16%

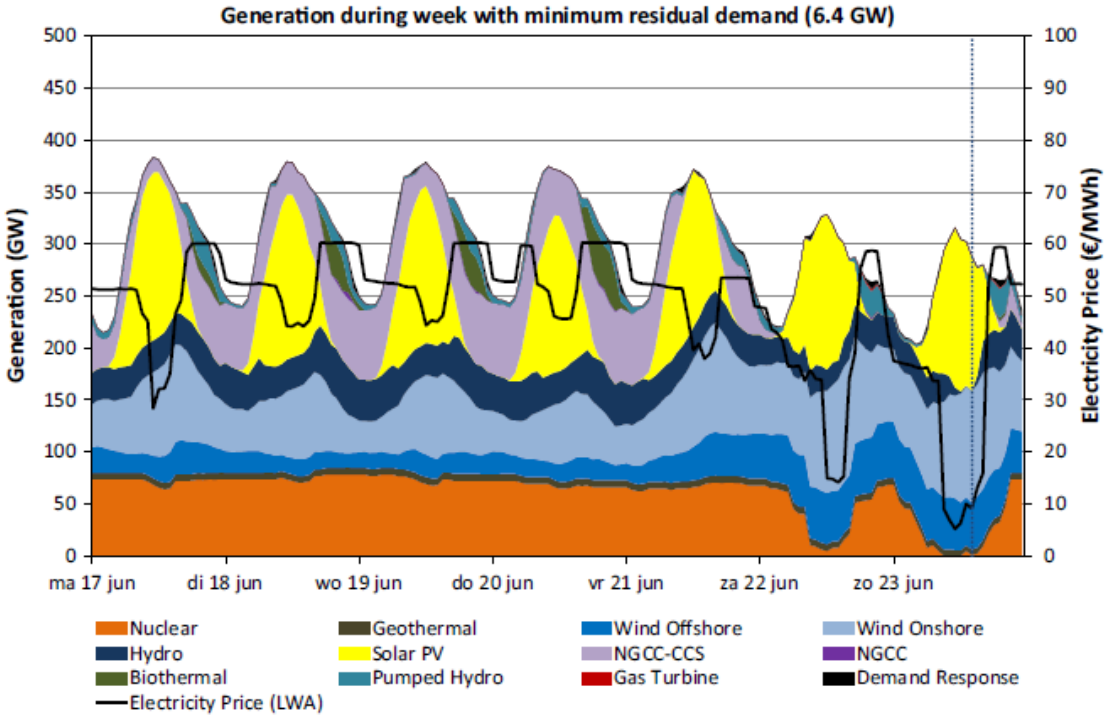
Compared to 2013:
- Doubling the amount of biomass in 6 years
- Tripling wind on-shore
- 20 fold wind off-shore (equal shares).

Possible RET deployment NW Europe 2050 for low GHG pathways (electricity only!).



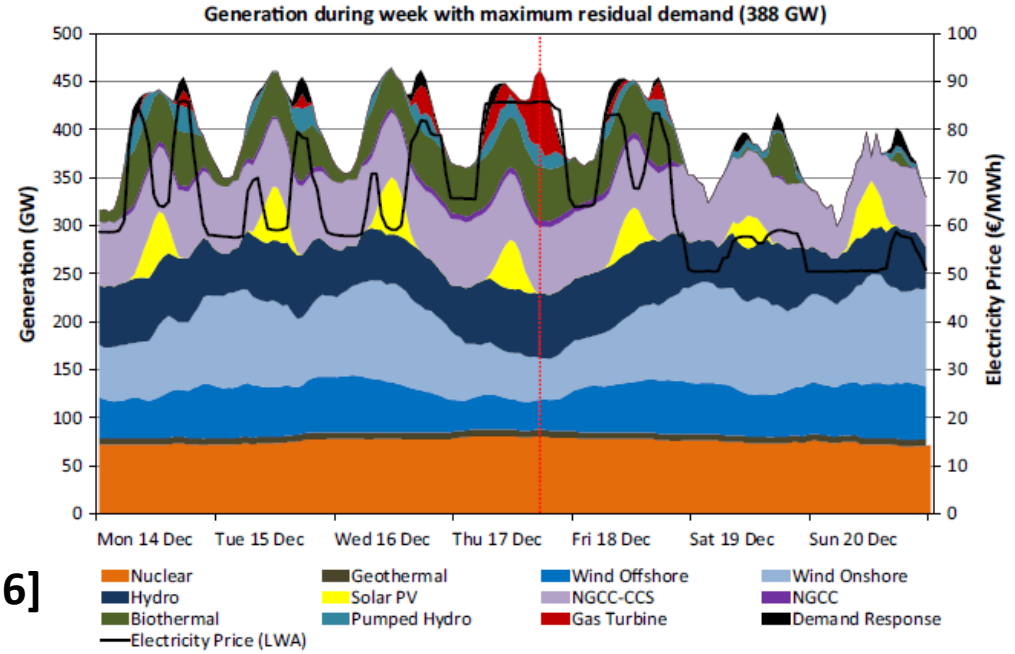
Breakdown of installed capacities and power generation in the core scenarios in the year 2050. The dashed line depicts the peak load in 2050.

[Brouwer et al., Applied Energy, 2016]



System implications!

Electricity system simulations
NW Europe 2050 with 60% iRES
Weeks with maximum and minimum residual loads during the year.



[Brouwer et al., Applied Energy, 2016]

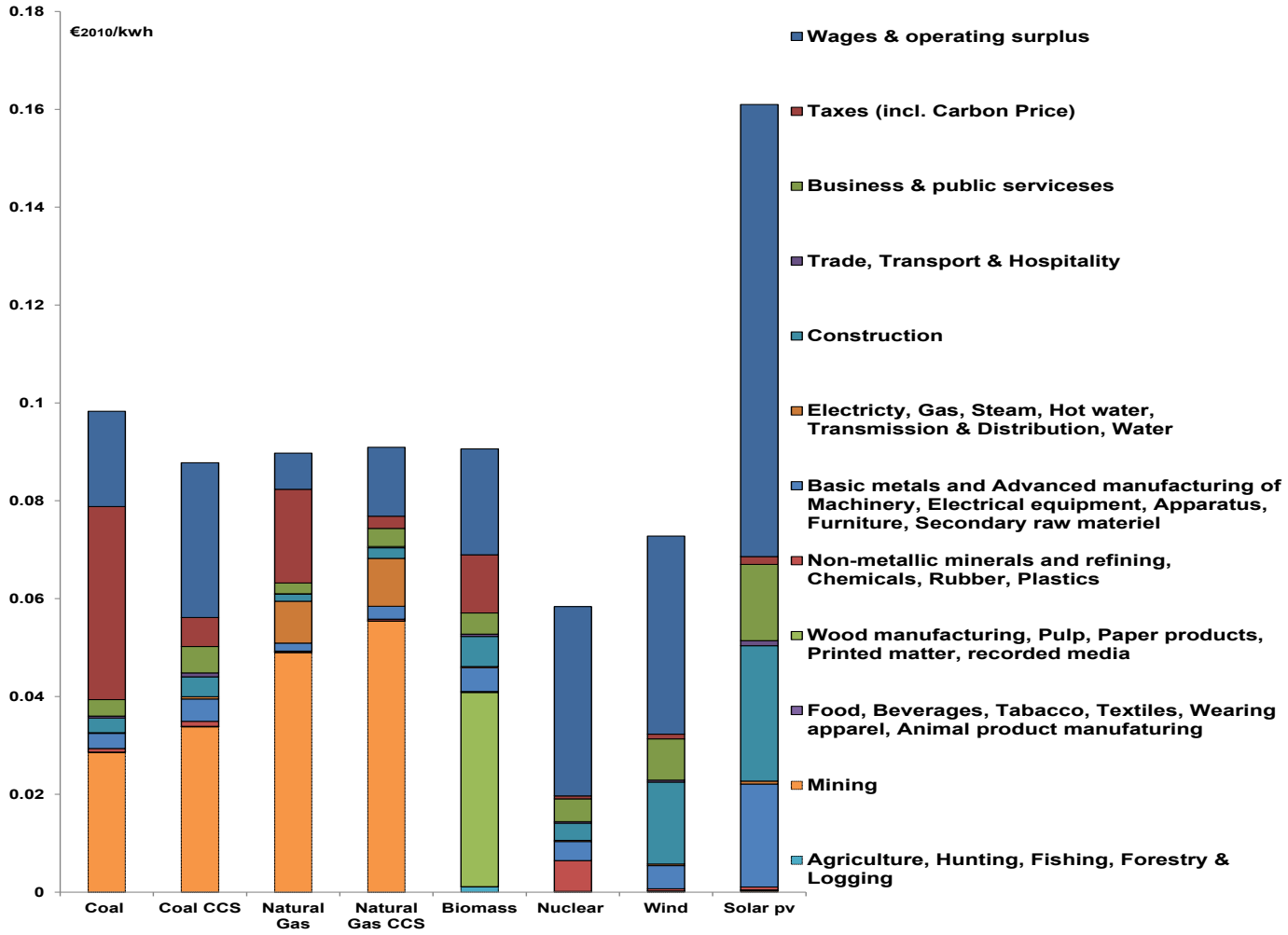
Die turbines moeten ergens staan…

[Ontwerp structuurvisie wind op land]

Ruimte voor energievoorziening
Structuurvisie Infrastructuur en Ruimte

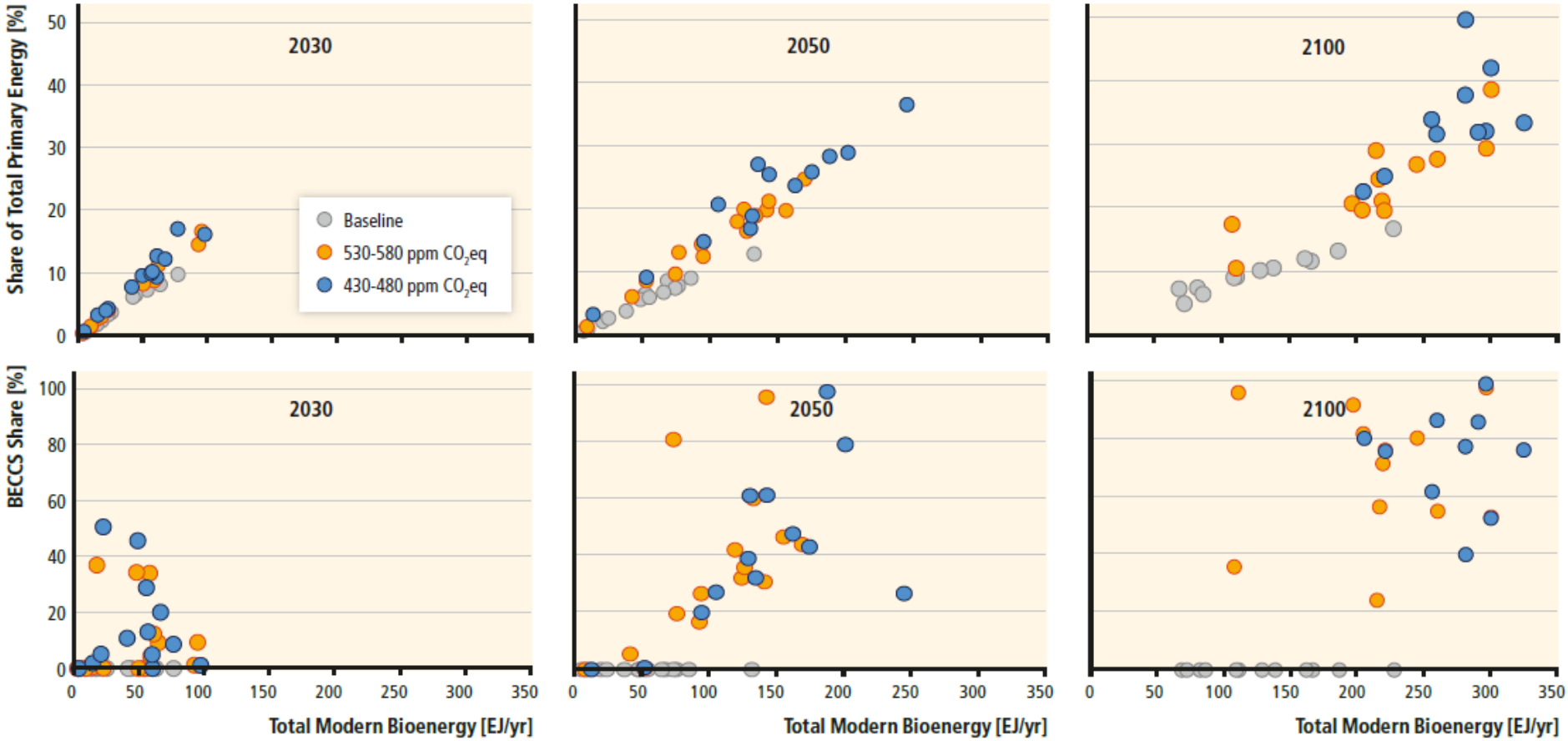
- (Mogelijke) vestigingsplaats kerncentrale
- (Mogelijke) vestigingsplaats elektriciteitsproductie > 500MW
- Hoogspanningsverbinding 220 kV
- Hoogspanningsverbinding 380 kV
- Hoogspanningsverbinding 450 kV
- Nieuwe hoogspanningsverbinding (indicatief)
- Gerealiseerd windturbinepark op zee
- Aangewezen windenergiegebied op zee
- Kansrijk gebied windenergie (illustratief)
- Eems Dollardverdraggebied

Aggregated cost factors for power production technologies in 2030



Energy Academy Europe [Koebl et al., 2016 (forthcoming)]

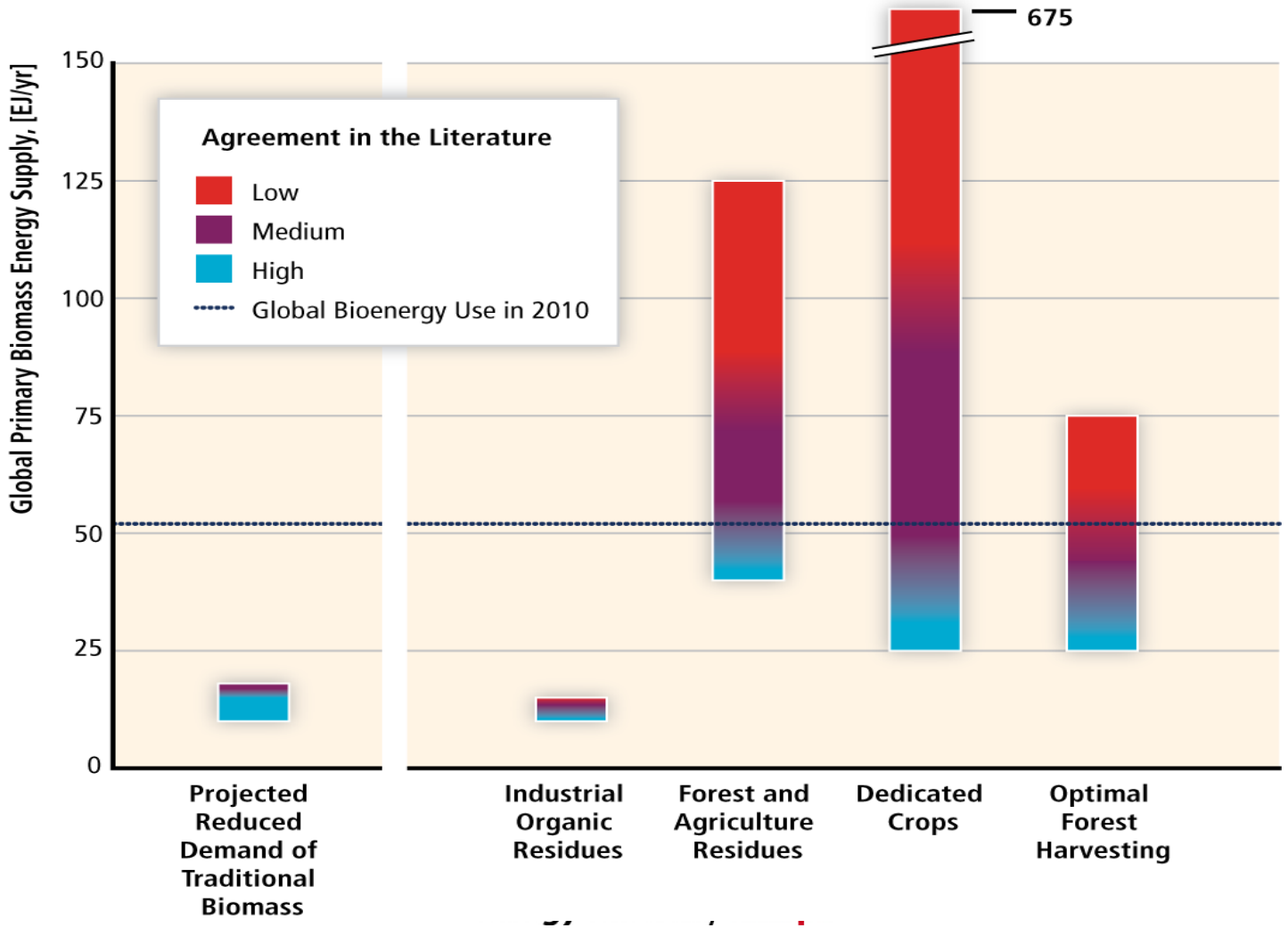
Global biomass deployment in relation to GHG mitigation (IPCC AR 5, 2014)



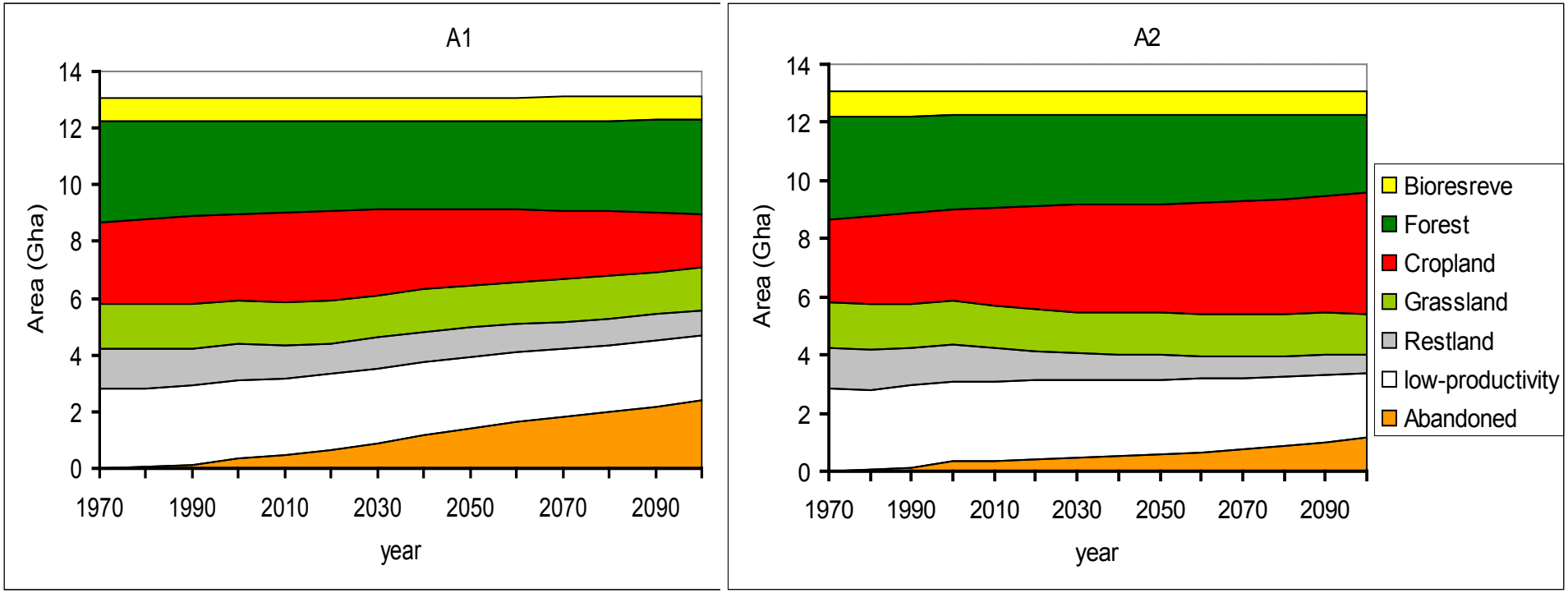
But, BBE faces key hurdles…

- Negative perception on biomass use for energy (and materials) in key markets (including EC; RED now EXCLUDES iLUC mitigation…).
- Policy arena is divided and fails to combine key priorities (agri, energy, climate, development).
- Uncertain investment climate stalls essential technological learning of advanced BBE-options.
- Too limited attention for synergy between sustainable agriculture, forestry, land use and biomass production.

Bioenergy potentials [2050] (colors based on expert opinion). (IPCC – AR5 WGIII, 2014)



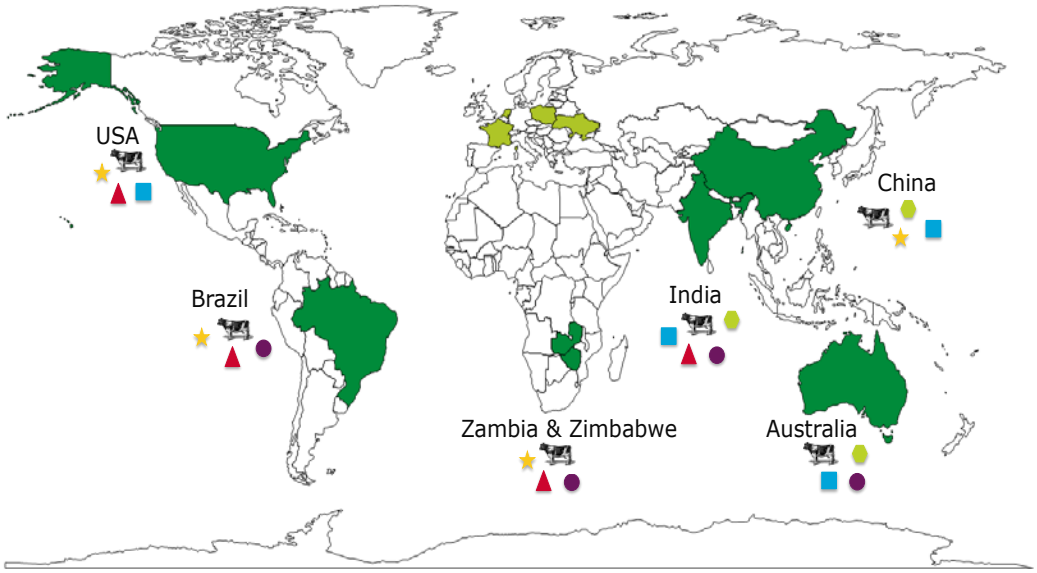
Potential land-use pattern changes (integral update under final review)



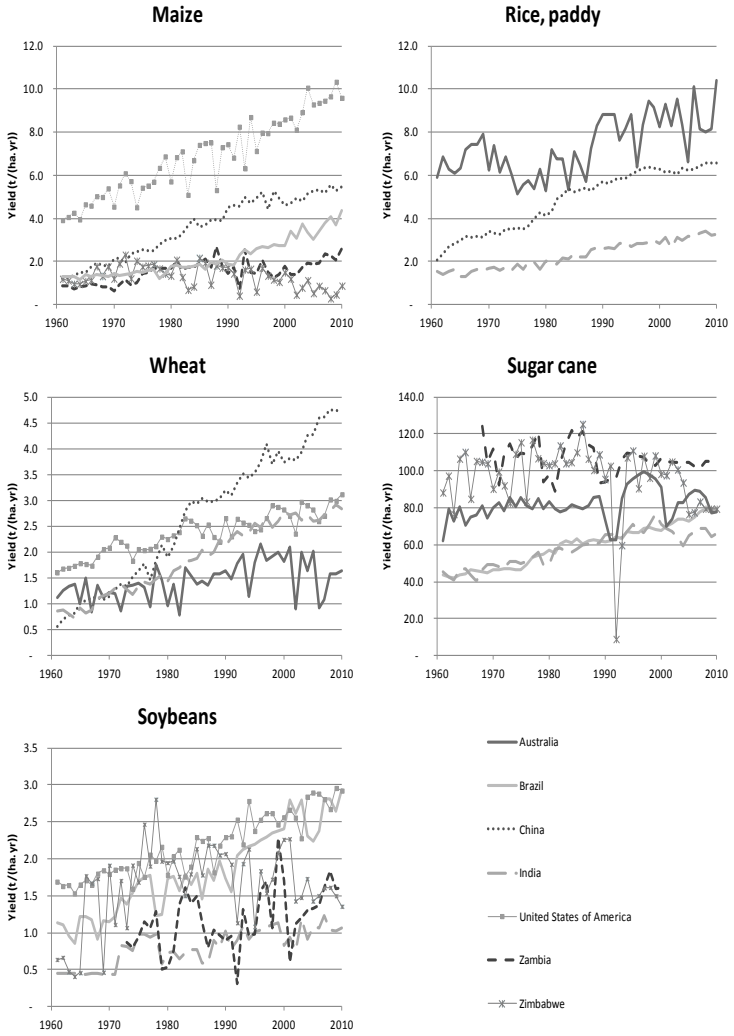
[Hoogwijk, Faaij et al., 2006]

Further investigations yield gaps…

Livestock footprint per unit of meat of milk may Improve a factor 2-20+ depending on setting



Legend:
- Countries assessed in this study
- Countries assessed by De Wit et al. [1]
- Maize
- Wheat
- Rice
- Sugarcane
- Soybean
- Beef and milk



Key options such as intercropping, agro-forestry and multiple harvests poorly included (e.g Camelina).

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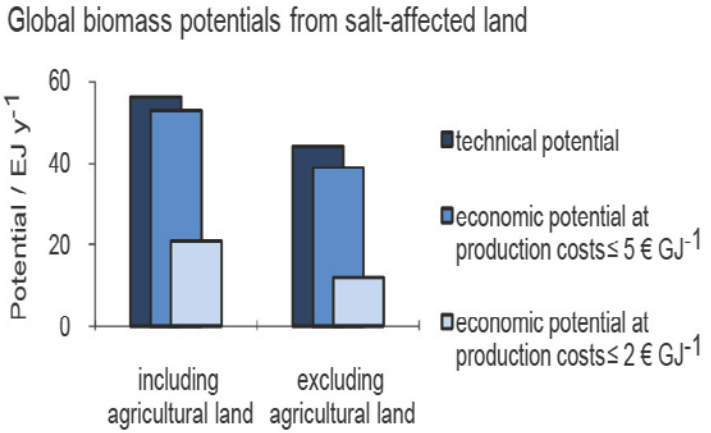
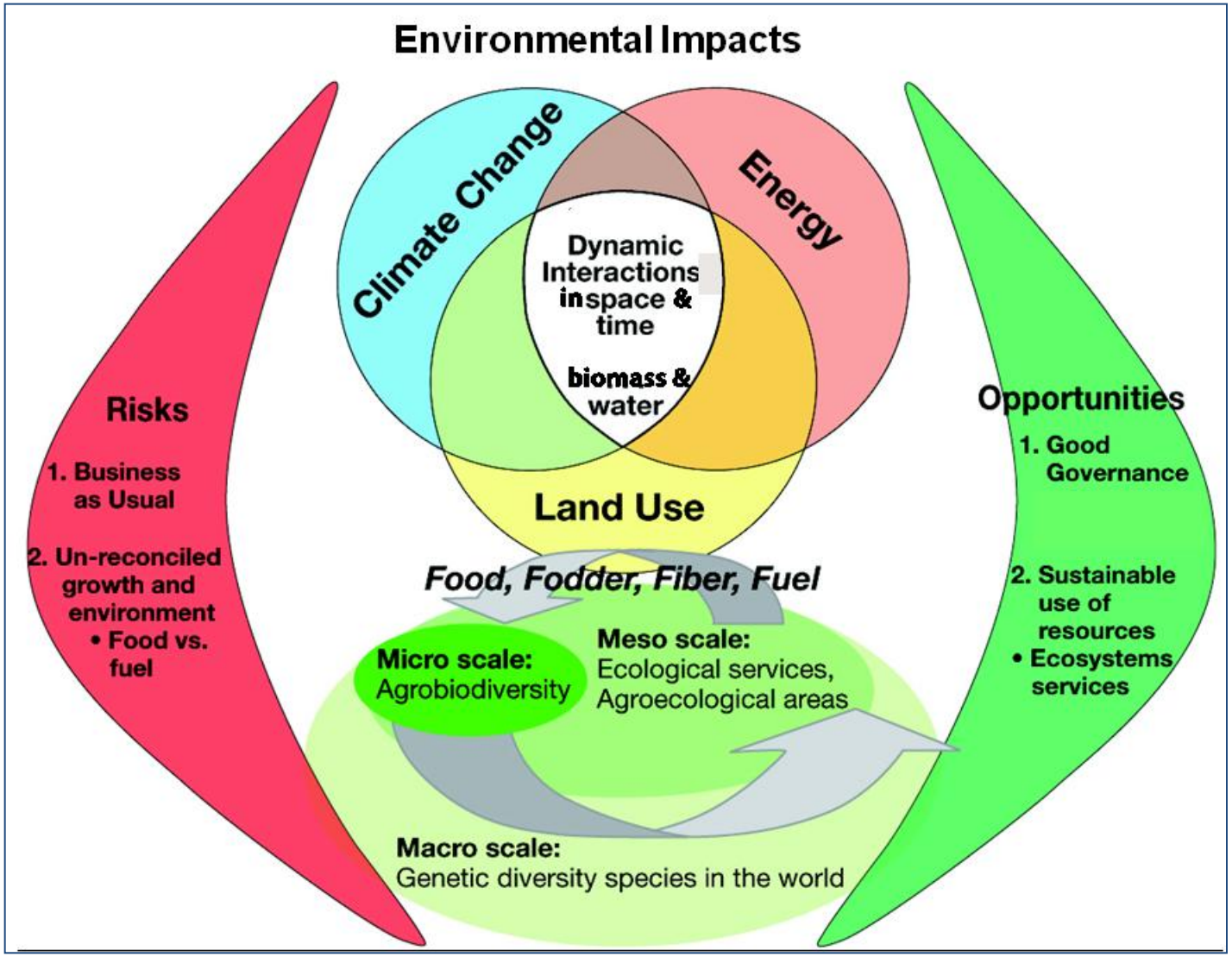
[Gerssen-Gondelach, et al., Food & Energy Security, 2015]

Potential biomass production on saline soils.



[Wicke et al, Energy & Environmental Science, 2011]



[IPCC-SRREN, 2011]

Summary Biobased Economy

- BBE deployment ~300 EJ required post 2050 (mix of advanced fuels, power, heat, biomaterials + bio-CCS) for essential GHG mitigation effort (BBE may take up to 40%).
- **Potentials** (technical, economic, sustainable) **suffice** when combined with modernization of agriculture and good land management.
- Realize the **synergies** with more resilient food production, more **efficient use of natural resources, increased carbon stocks.**
- …and **rural development** + (shift of fossil fuel expenditures to rural areas can amount several trillion U$/yr).
- Logical and efficient pathways and **gradual development of (biomass) markets, infrastructure and technologies**; intersectoral approaches.

Concluding remarks (I):

- Transition of the energy system does not allow for further delays; 2050 targets require considerable **acceleration.**
- Not only because of climate change (and other ecological concerns) but also because of **economic reasons.**
- Technical possibilities known; ***potentials suffice.***
- Implementation and governance major bottlenecks.
- Innovation and new business creation crucial.
- ***Implications*** for the energy system, deployment over time and minimization of costs poorly understood
- as are the extent to which economic benefits can be maximized.
- ***System perspective***, integral view of impacts and analysis of governance and business models.
- Analysis ***parallel*** to implementation.

Concluding remarks (II)

- Sustainable energy system will generate substantially more jobs, especially indirect and in construction/maintenance, than the current system (high capital intensity).
- Trade balance impacts become very important with declining gas production (in favor of renewables and efficiency).
- Will affect many sectors (e.g. ICT, manufacturing)
- Also various current sectors and activities will decline (O&G).
- Benefits from improved export positions and trade balance strongly depend on RDD&D investments and ability to take frontrunner position(s).
- Hard to predict impacts due to path dependency, variable energy & CO2 prices; analyses could however be produced.
- Warrants clear governance (winners vs. losers and timely investment in education; vocational – post-academic).

Thank you very much for your attention