



Technology Options in Power Generation



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Setting

CO₂ emissions in power sector are about 40% of energy-related emissions in 2011 (IEA, 2013).

2011 global shares of generation: Coal – 41%; Natural Gas – 22%; Hydro – 16%; Nuclear – 12%; Oil – 5%; Renewables – 4%.

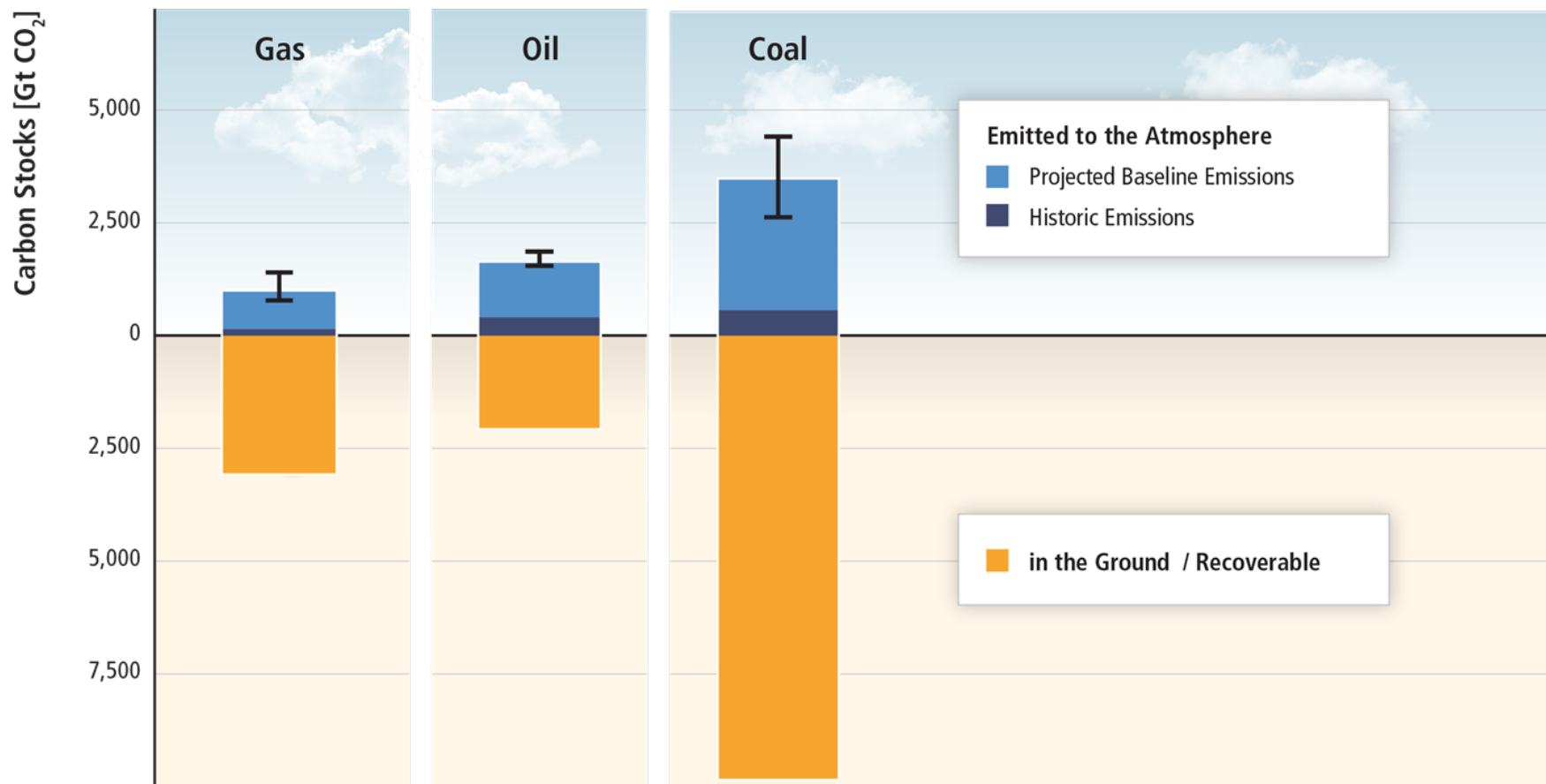
2011 global shares of CO₂ emissions in power generation: Coal – 73%; Natural Gas – 20%; Oil – 7%.

Low-Carbon Options:

Nuclear, Hydro, Wind, Solar, Biomass, CCS



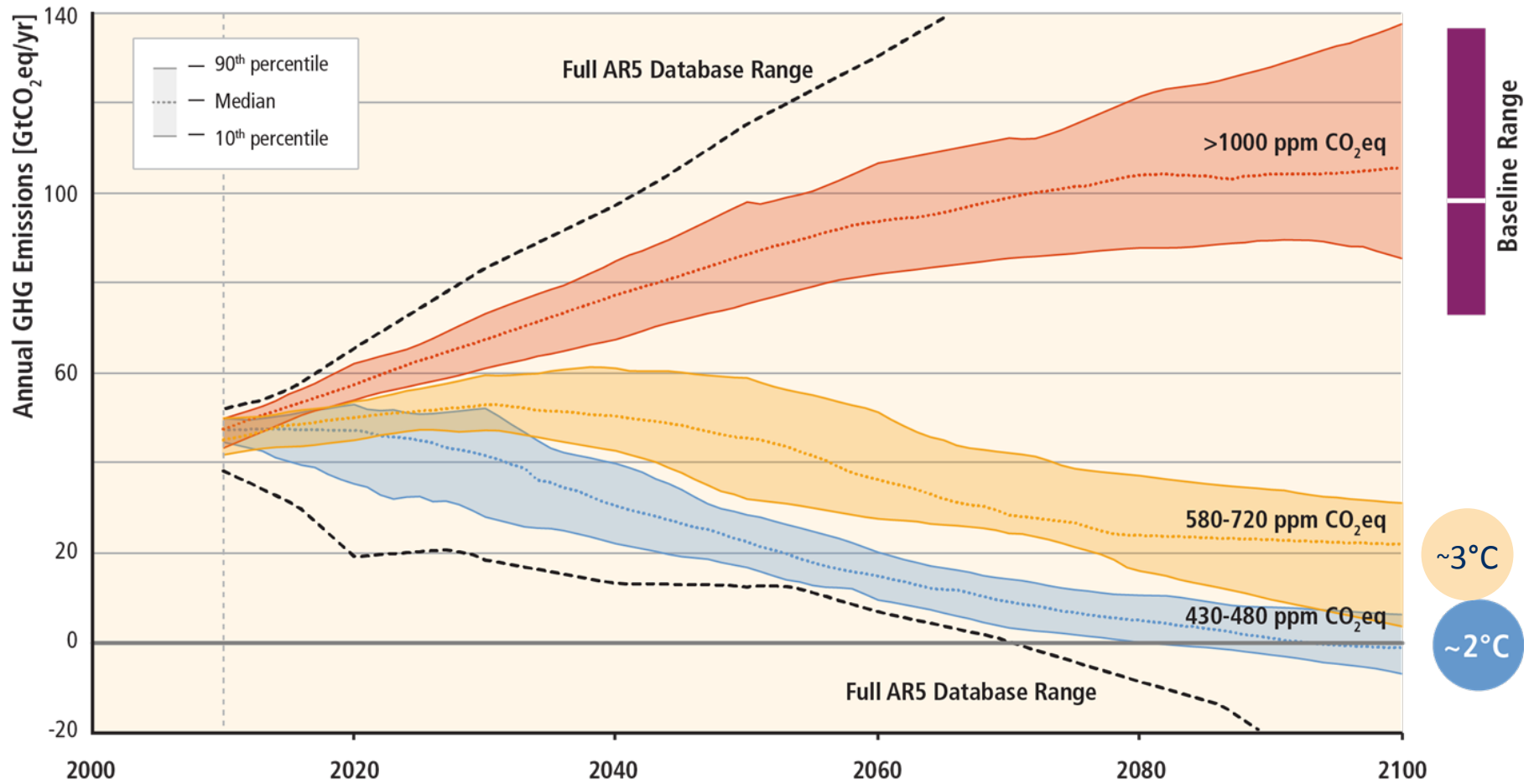
Plenty of carbon in the ground



Based on SRREN Figure 1.7



Move to low-carbon energy

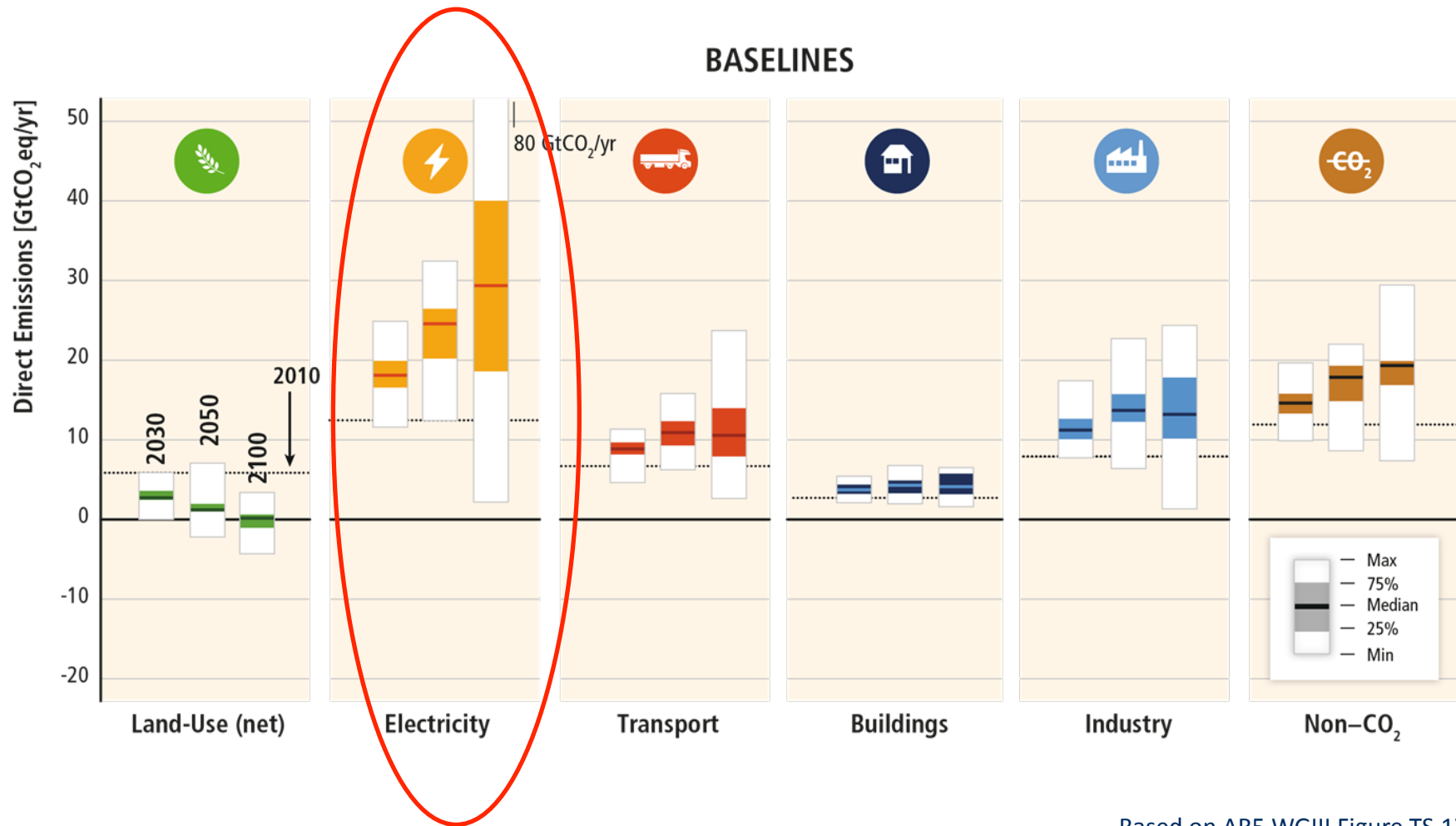


Low climate stabilization scenarios are dependent on decarbonization

Based on AR5 WGIII Figure 6.7

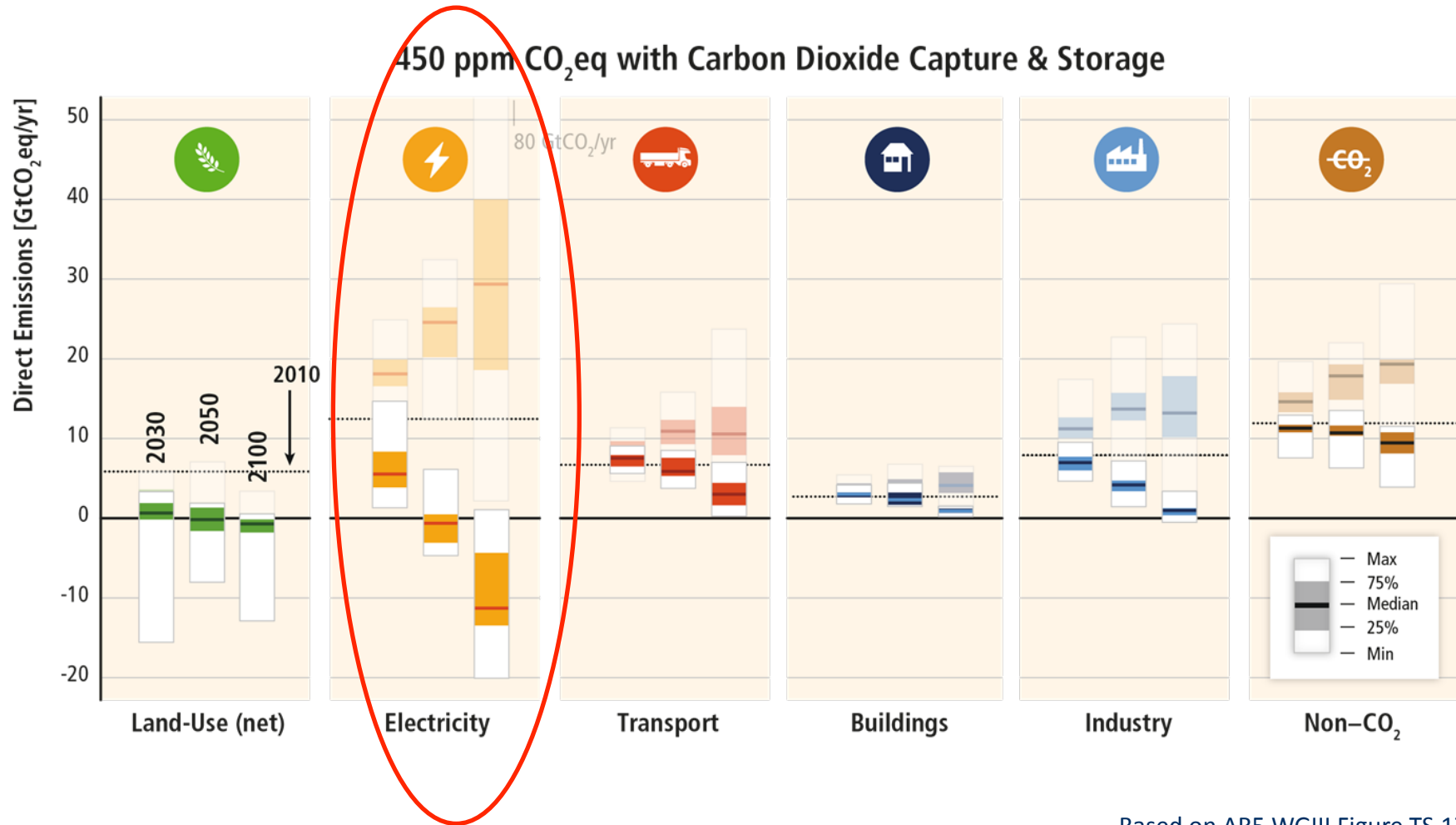


Rising GHG emissions in no-policy scenarios



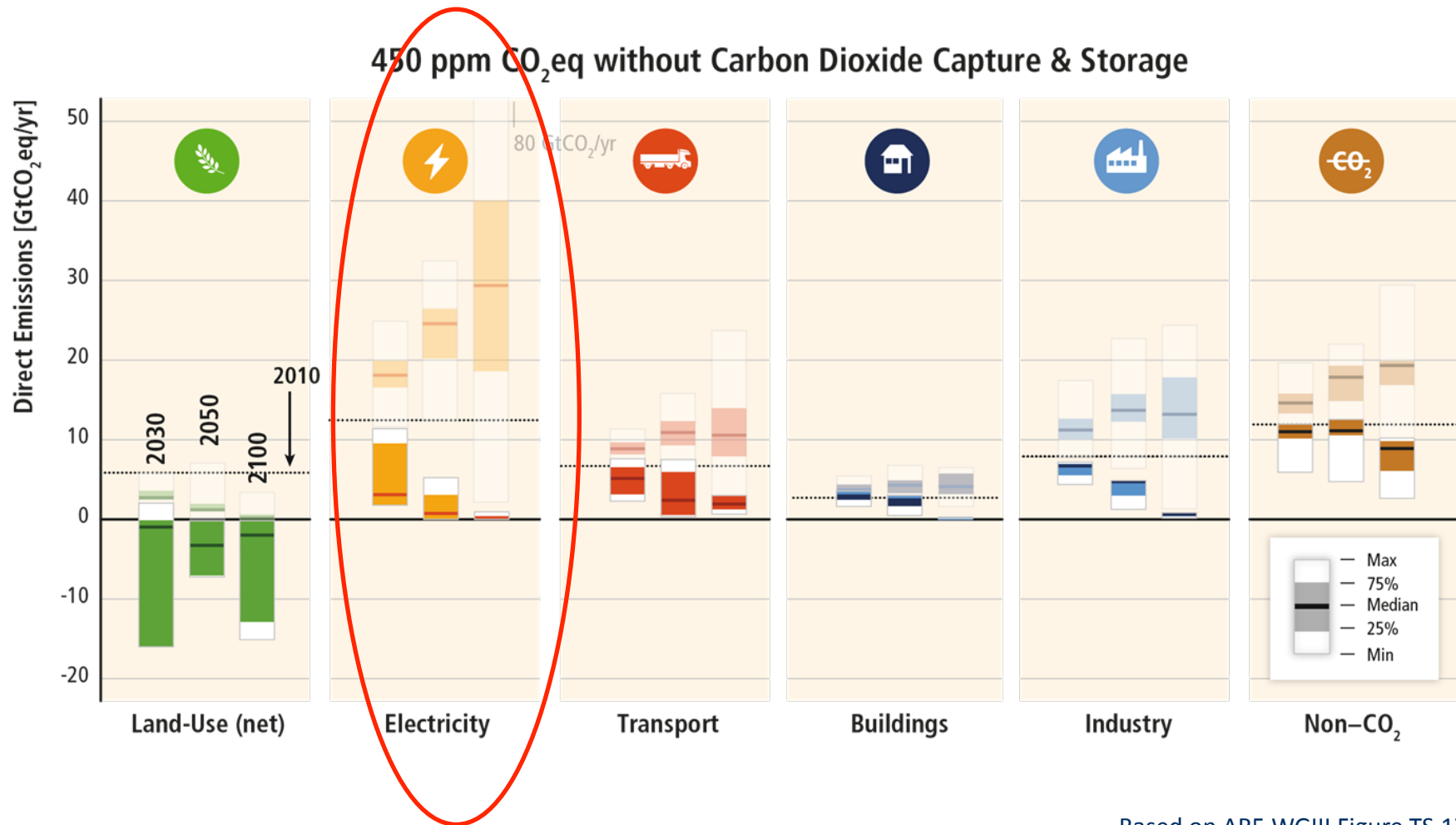
Based on AR5 WGIII Figure TS.17

Mitigation requires dramatic changes



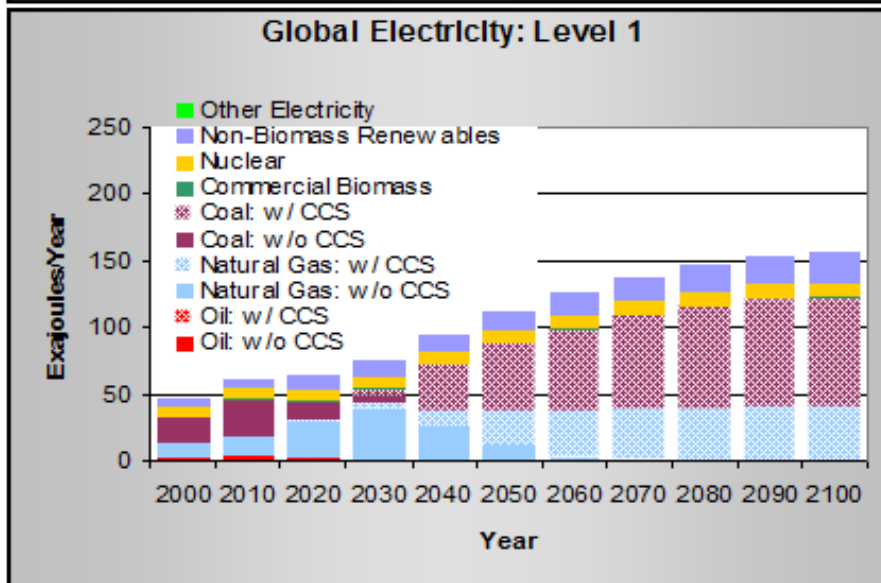
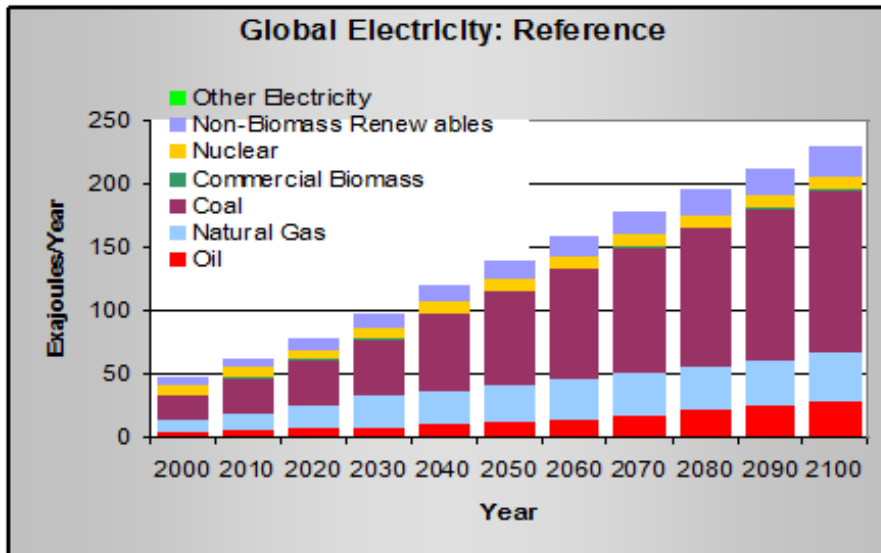
Based on AR5 WGIII Figure TS.17

No negative emission technologies in power sector imply more effort in other sectors



Based on AR5 WGIII Figure TS.17

Technology options are affected by policy instruments and cost assessments



2004 – 2007 Optimism about CCS

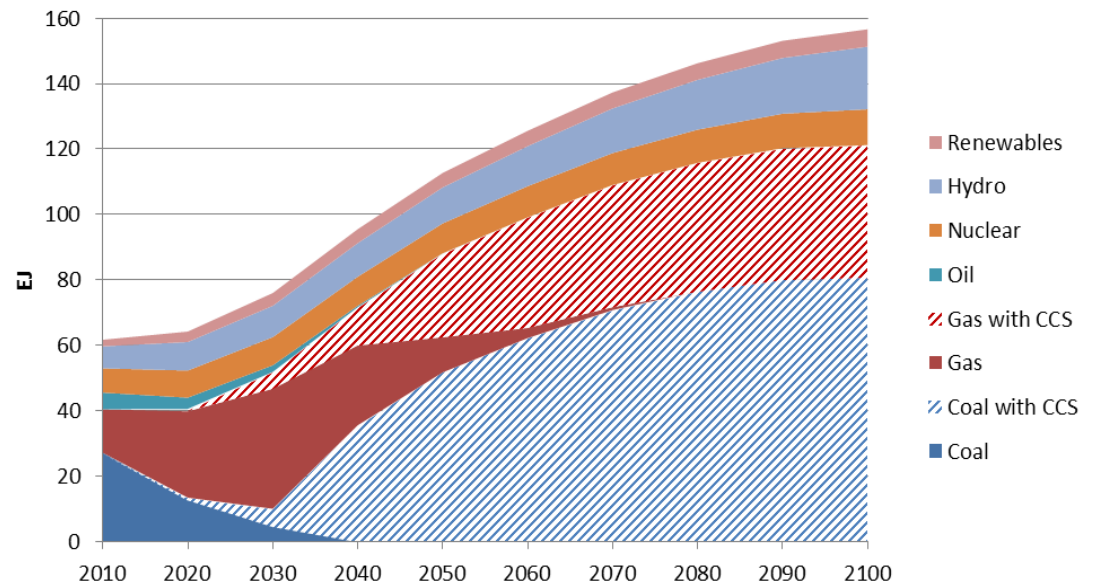
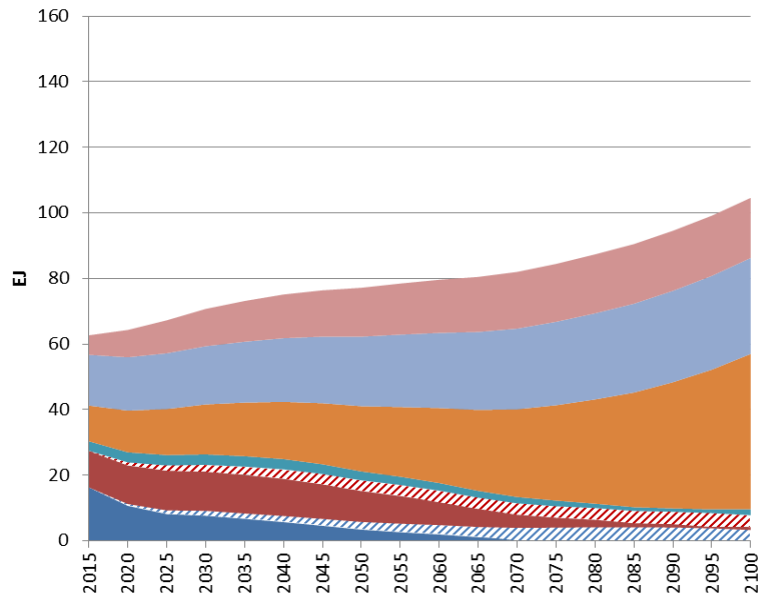
Short-term increase in gas

By 2100 coal and gas with CCS
and
Renewables

Based on EPPA results for US CCSP (2007)



Technology options are affected by policy instruments and cost assessments



2014 – Less optimism about CCS,
More optimism on nuclear,
renewables and energy efficiency

Based on EPPA results for US
CCSP (2007)

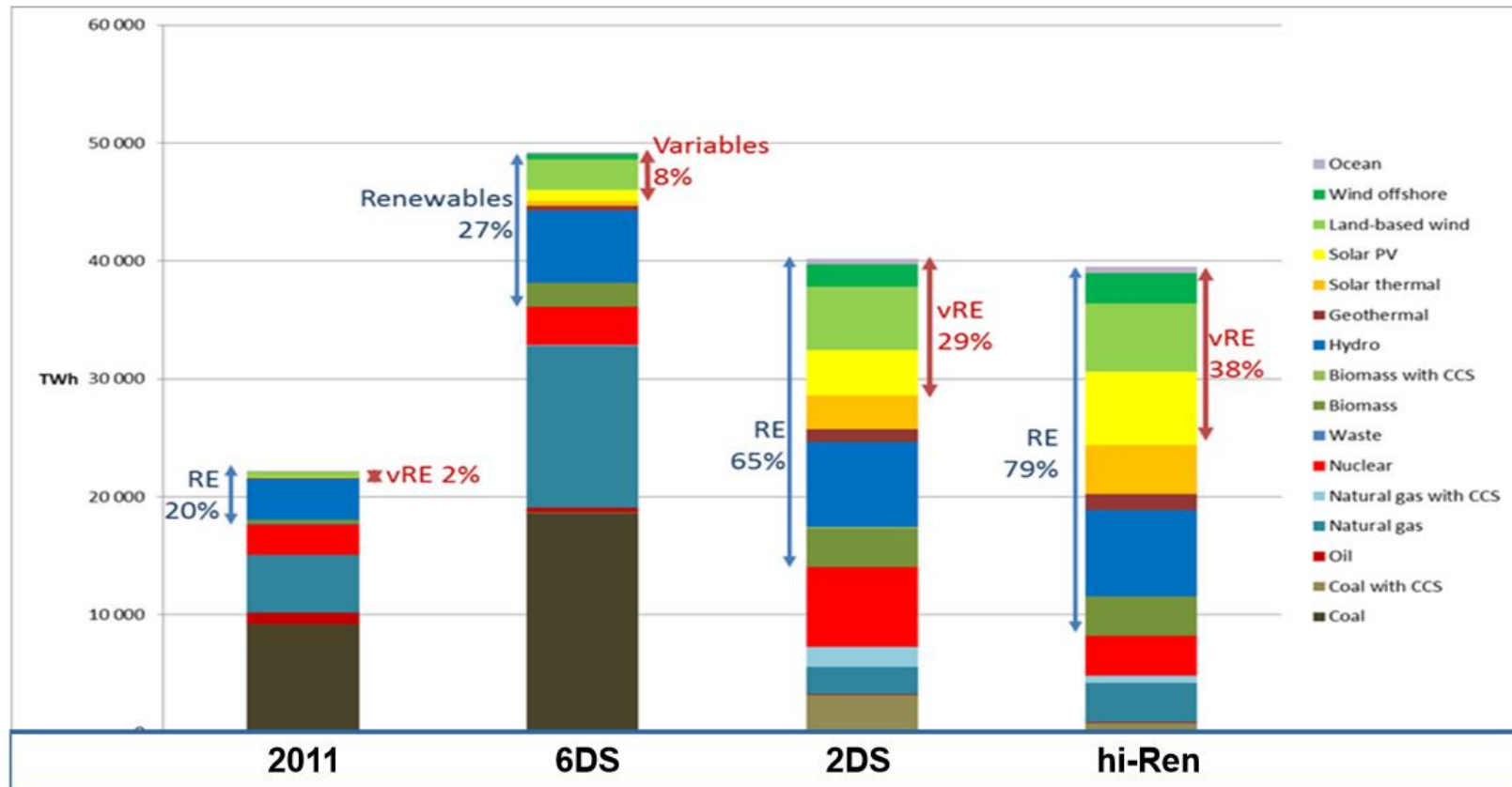
2050 global shares of generation:

2007 study -- fossil – 75%, renewables – 15%

2014 study -- fossil – 30%, renewables – 50%



Technology options are affected by policy instruments and cost assessments



■ Generation today:

- Fossil fuels: 68%
- Renewables: 20%

■ Generation 2DS 2050:

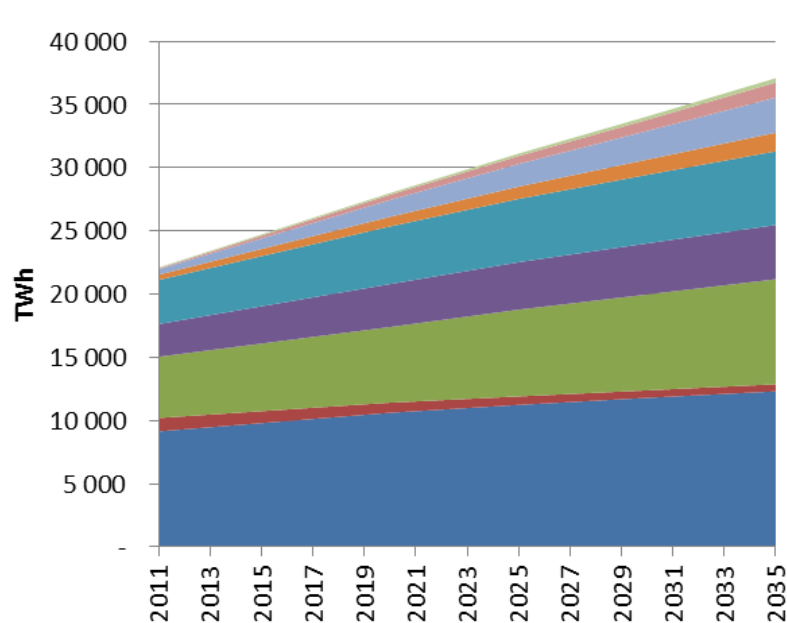
- Renewables: 65 - 79%
- Fossil fuels: 20 - 12%



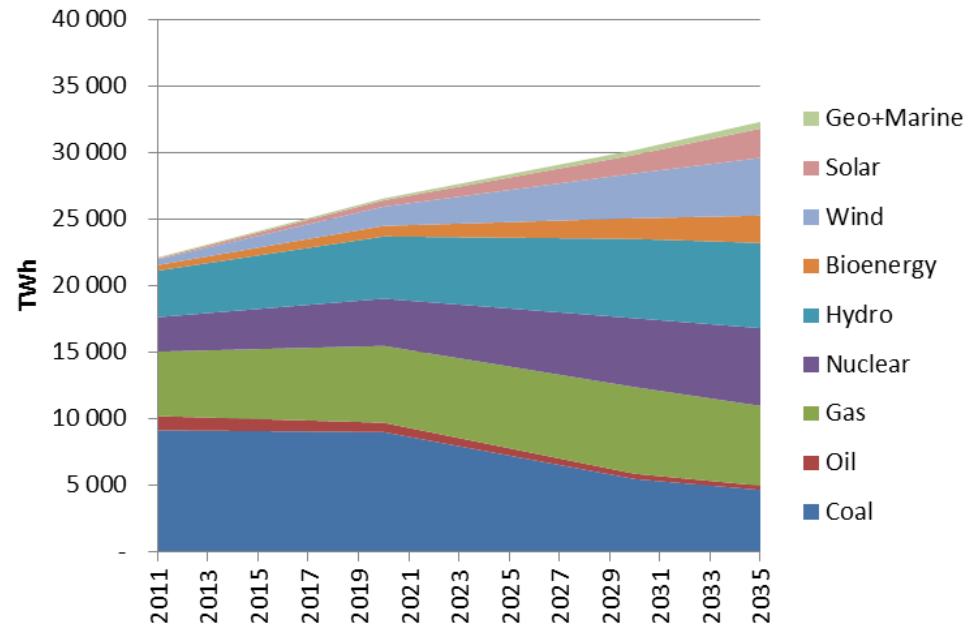
© OECD/IEA 2013



Technology options are affected by policy instruments and cost assessments



New Policies Scenario



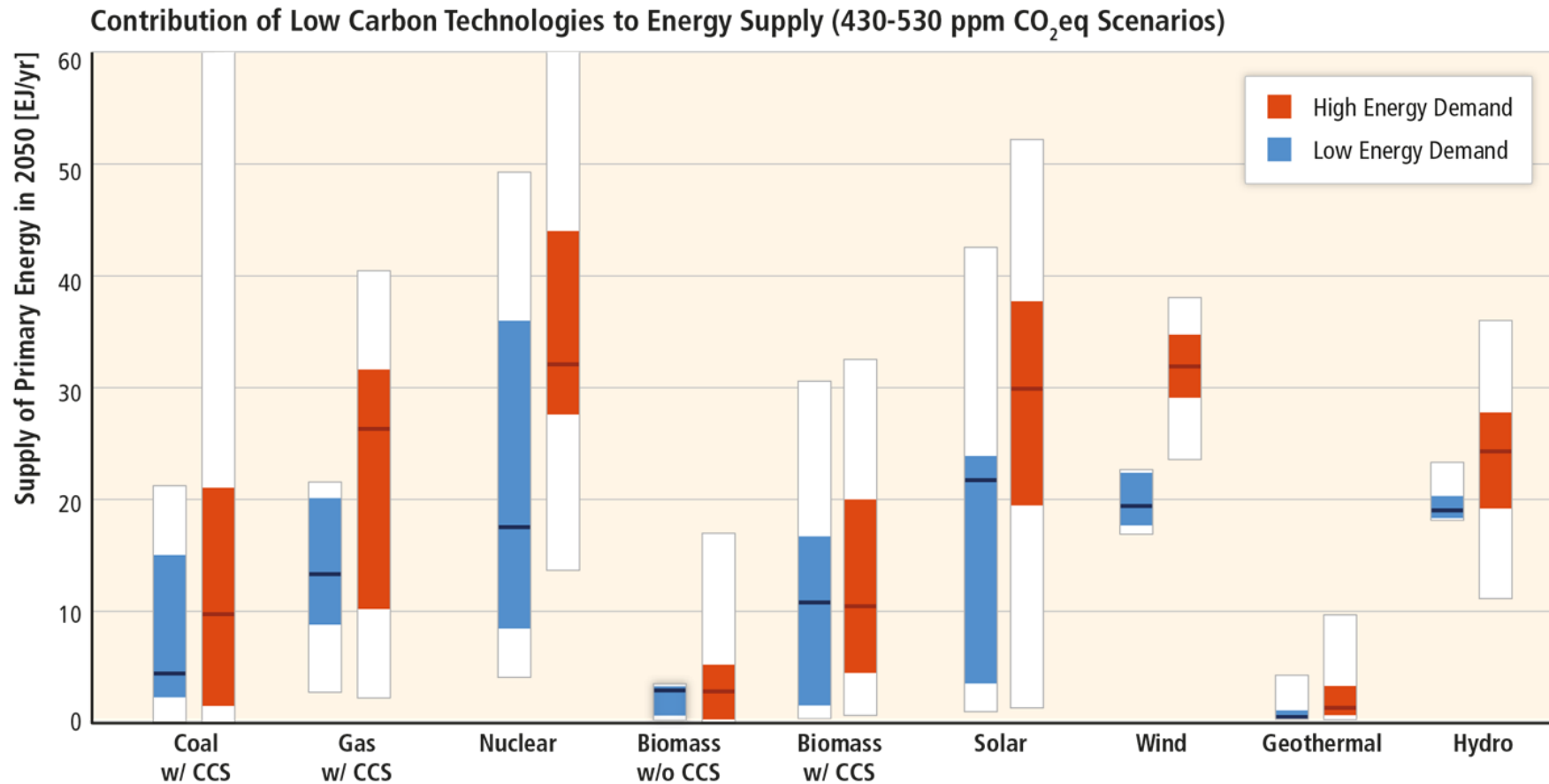
450 Scenario

2035 global shares of generation in 450 scenario: Coal – 14%; Natural Gas – 19%; Hydro – 20%; Nuclear – 19%; Oil – 1%; Renewables – 28% (including wind – 13%, solar – 7%, bio – 6%).

Based on IEA (2013)



Different modeling groups - no dominant technology for de-carbonization

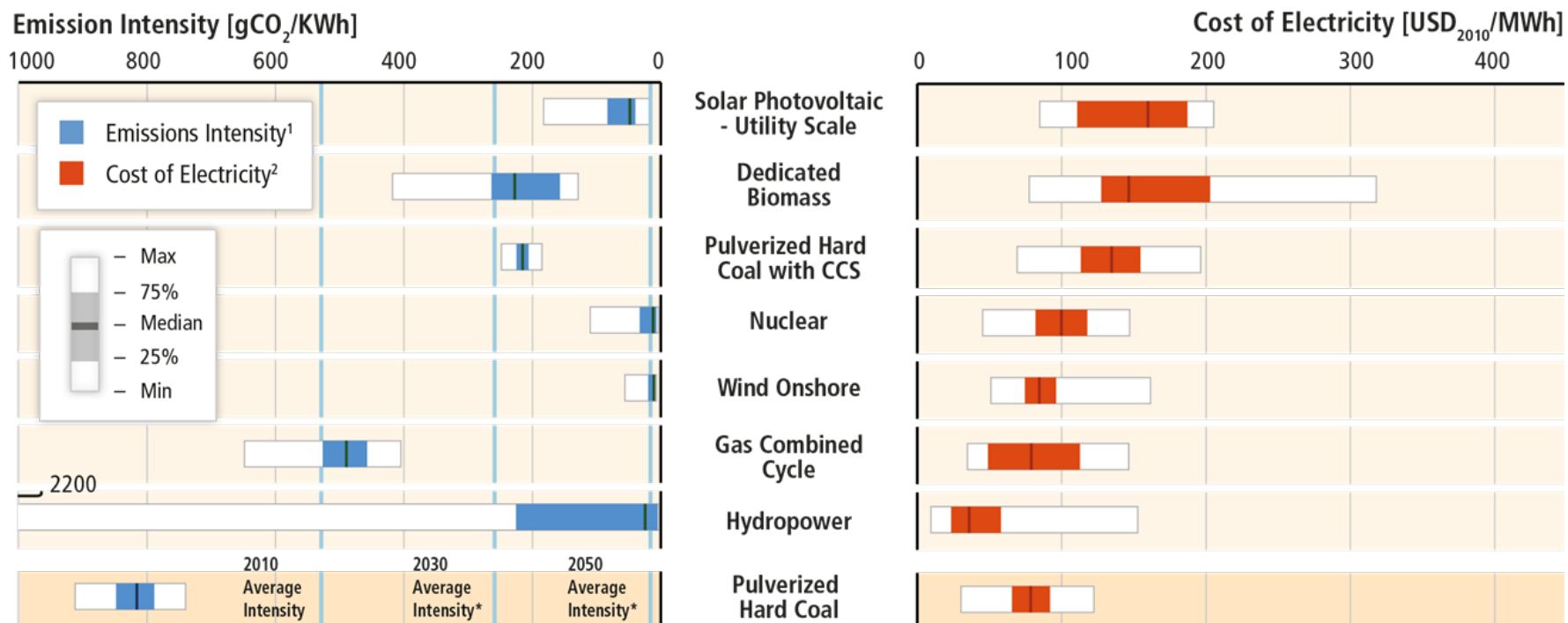


Based on AR5 WGIII Figure 7.11



Some low-carbon technologies can compete with conventional

Some Mitigation Technologies for Electricity Generation



* Median Value in Mitigation Scenarios (430-530 ppm CO₂eq by 2100)
¹ In gCO₂/kWh; Based on Lifecycle Emissions
² Levelized Cost of Electricity in USD₂₀₁₀/MWh; Based on High Full Load Hours

Based on AR5 WGIII Figure 7.7



Levelized Cost and Benefits Calculations are challenging...

Gas not wind

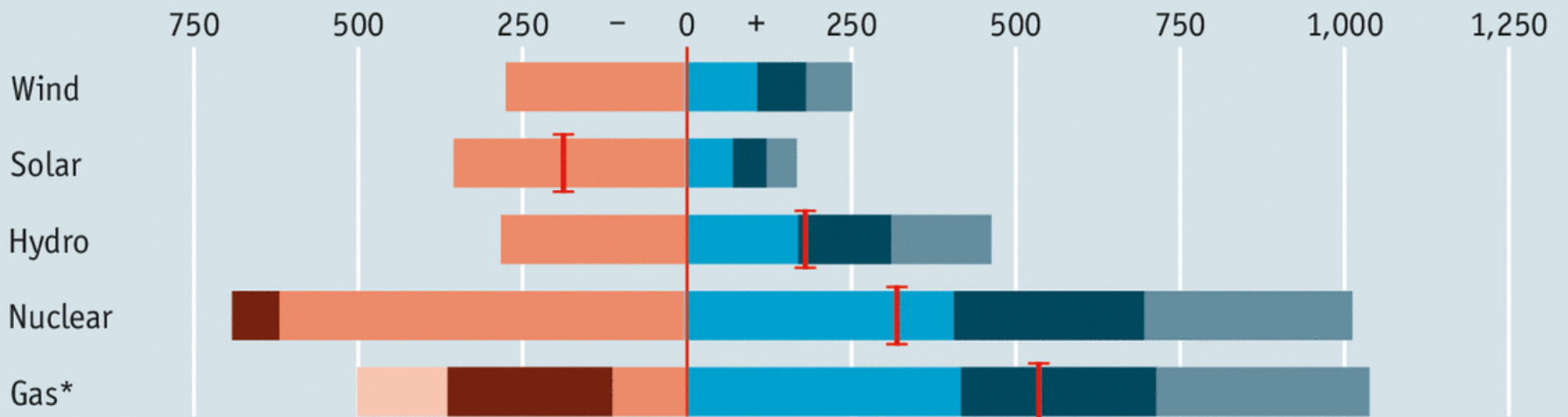
Net costs and benefits per year per MW compared with coal baseload generation
United States, \$'000

Costs

- New emissions
- New energy costs
- Capacity costs
- Other

Benefits

- Avoided emissions
- Avoided energy costs
- Avoided capacity costs



Source: Brookings Institution

*Combined cycle

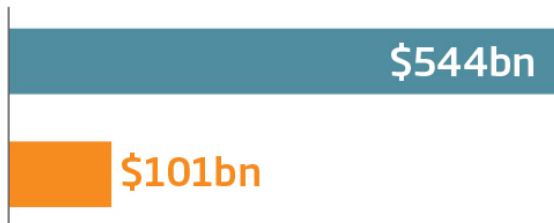
The Economist (2014) based on Frank (2014)



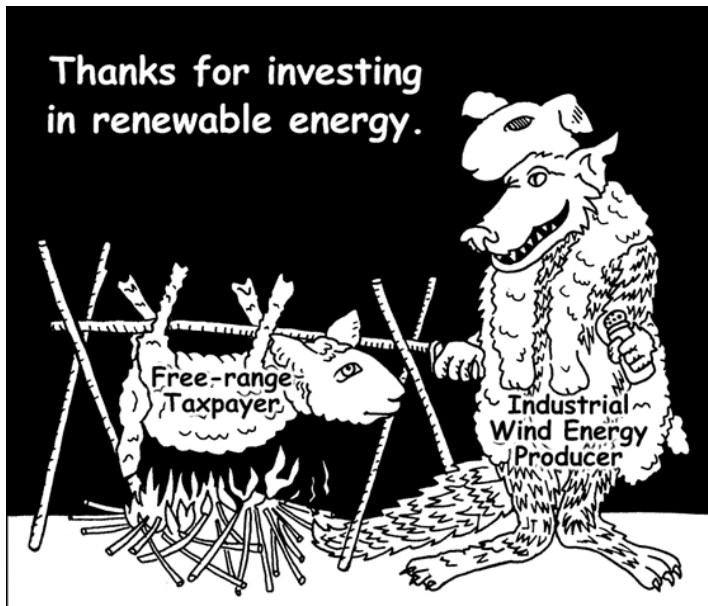
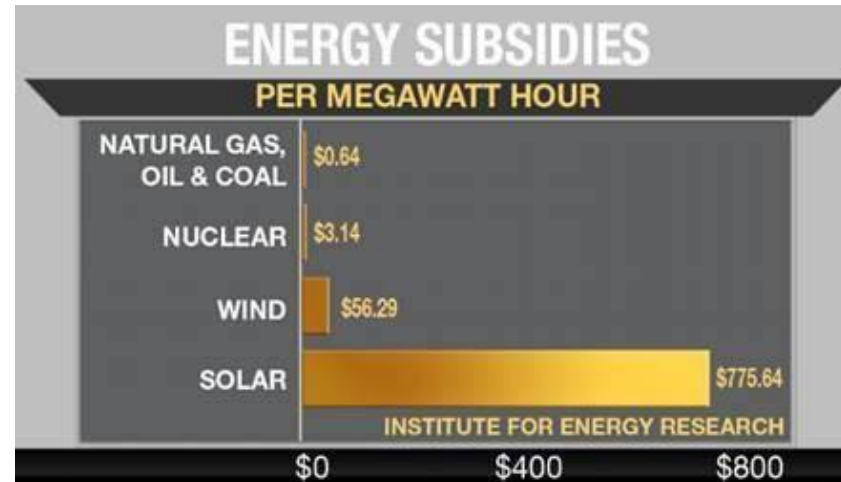
How to move to low-carbon energy?

Global subsidies

In 2012 **fossil fuel** subsidies far outweighed those for **renewables**



SOURCE: IEA 2012



Conclusions

Aggressive climate stabilization targets (2-3C) require drastic changes in power generation technology options

Future costs and the resulting technology mixes are uncertain

Policy: Target emissions reductions from any source, rather than focus on boosting certain kinds of renewable energy.



Thank you

Questions or comments?
Please contact Sergey Paltsev at paltsev@mit.edu.



<http://globalchange.mit.edu/>