P I K

POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Towards a Low Carbon Energy System: the Potential Role of Methanisation

Sustainable methanol:
An Alternative Green Fuel for the Future

Brainstorming Workshop IASS, 24th November 2011

Prof. Dr. Ottmar Edenhofer / Eva Schmid

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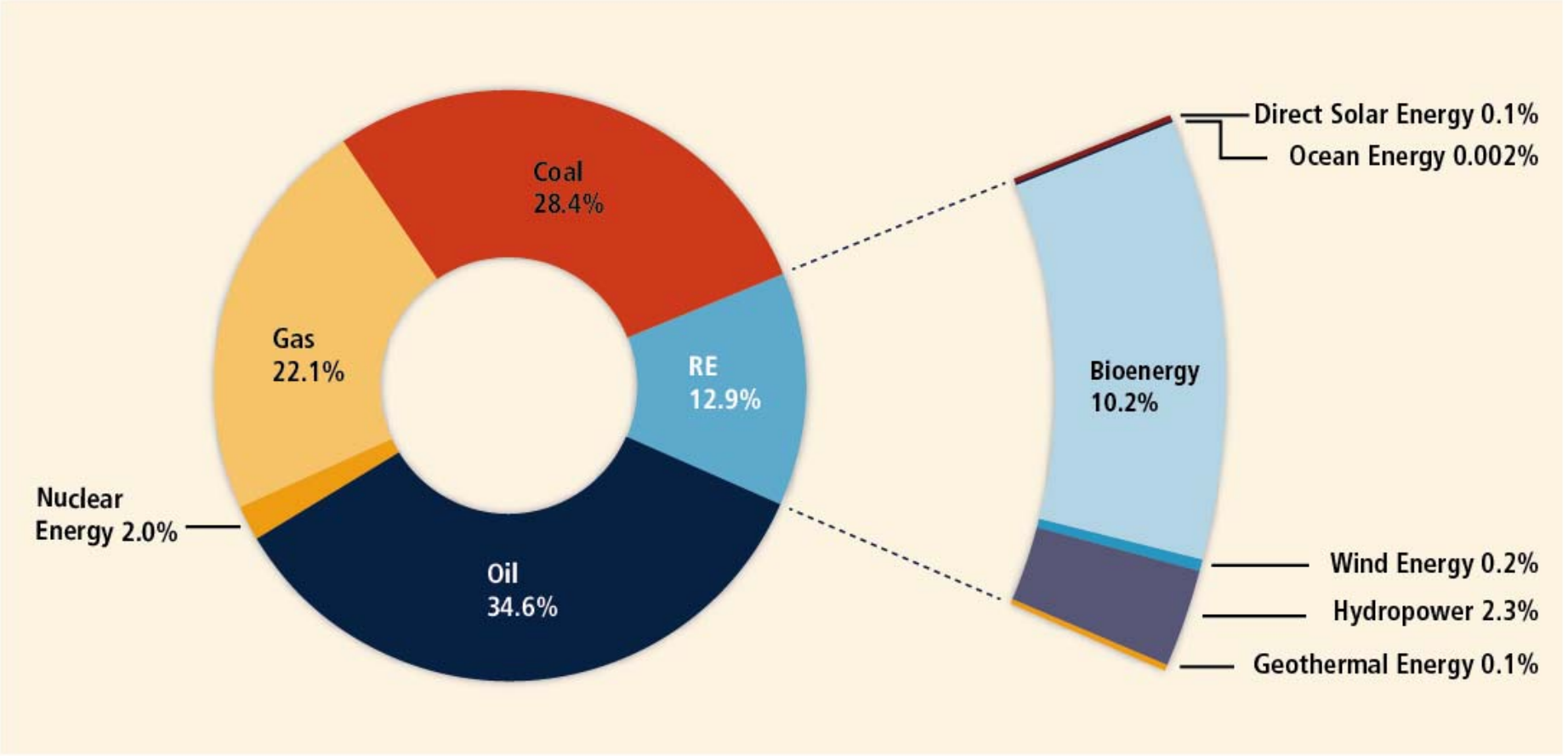
ipcc INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

berlin

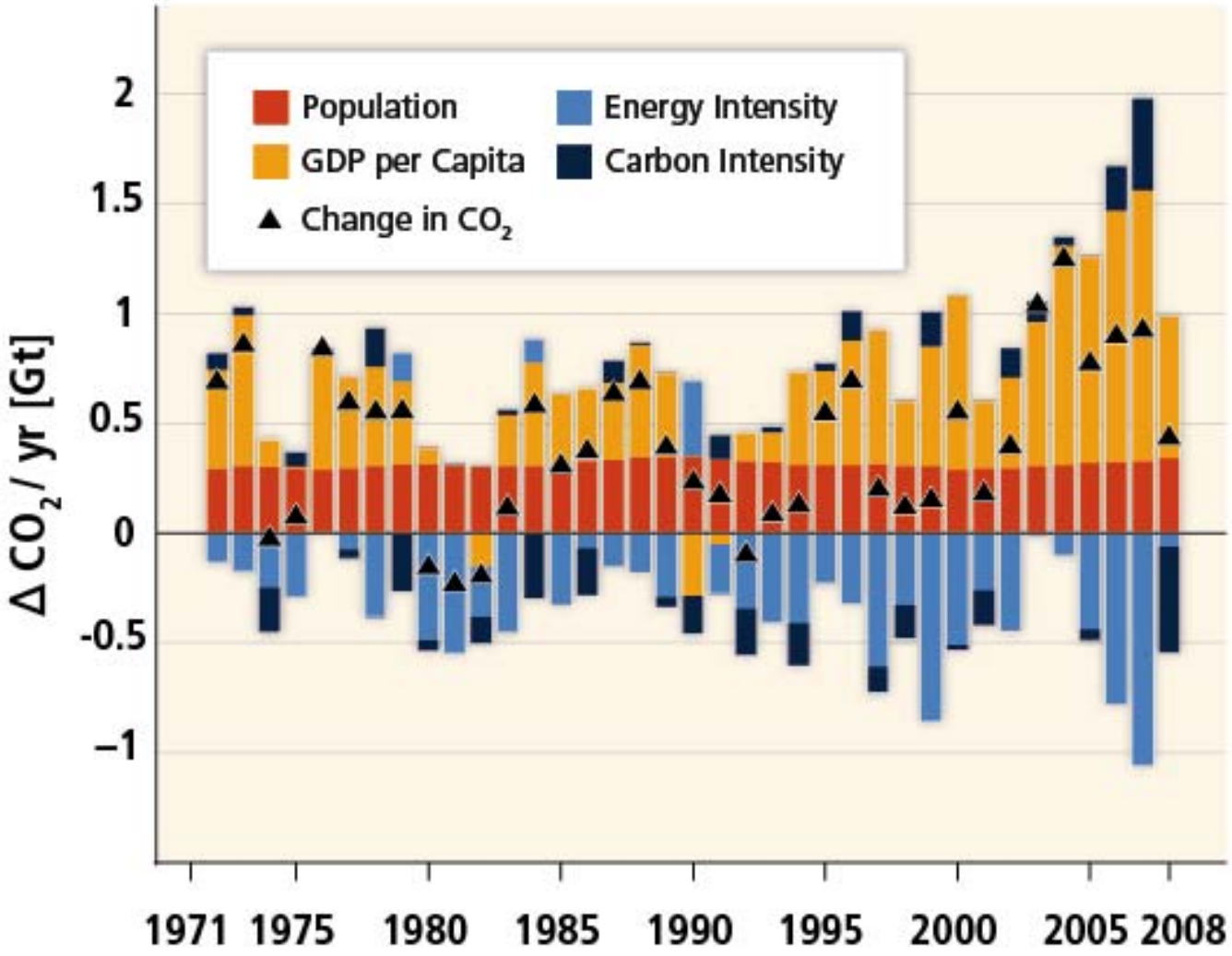
The Current Global Energy System is Dominated by Fossil Fuels



Shares of energy sources in total global primary energy supply in 2008.

SRREN (IPCC, 2011)

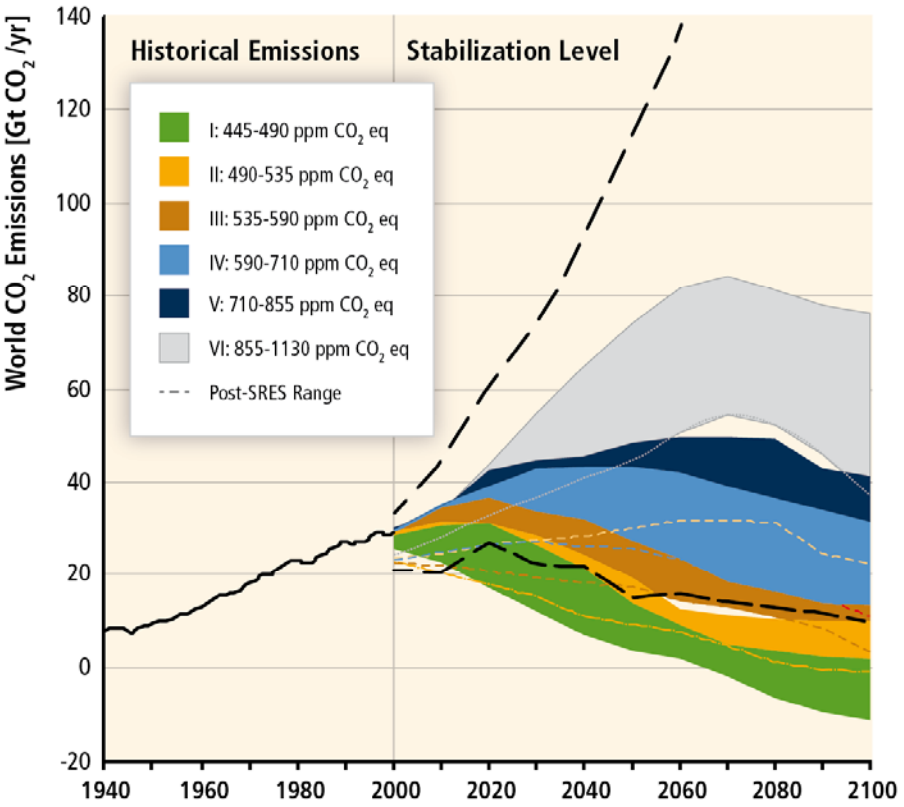
We Are Not on Track – Renaissance of Coal!

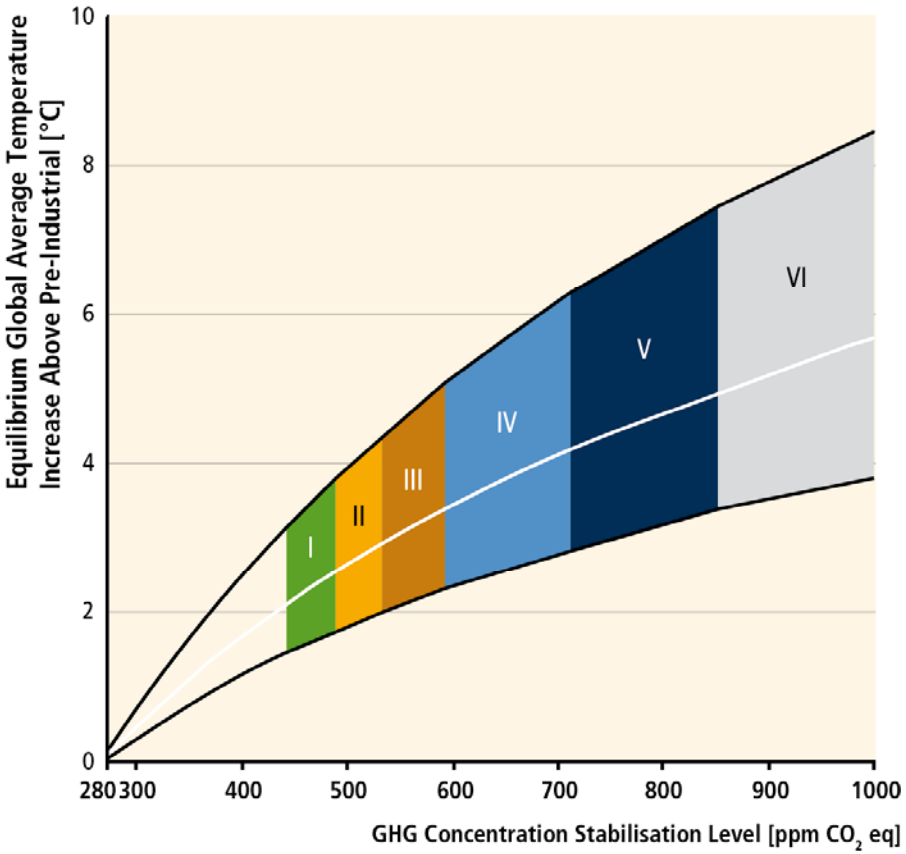


Kaya decomposition of global CO2 emissions.

SRREN (IPCC, 2011)

Climate Policy as an Insurance

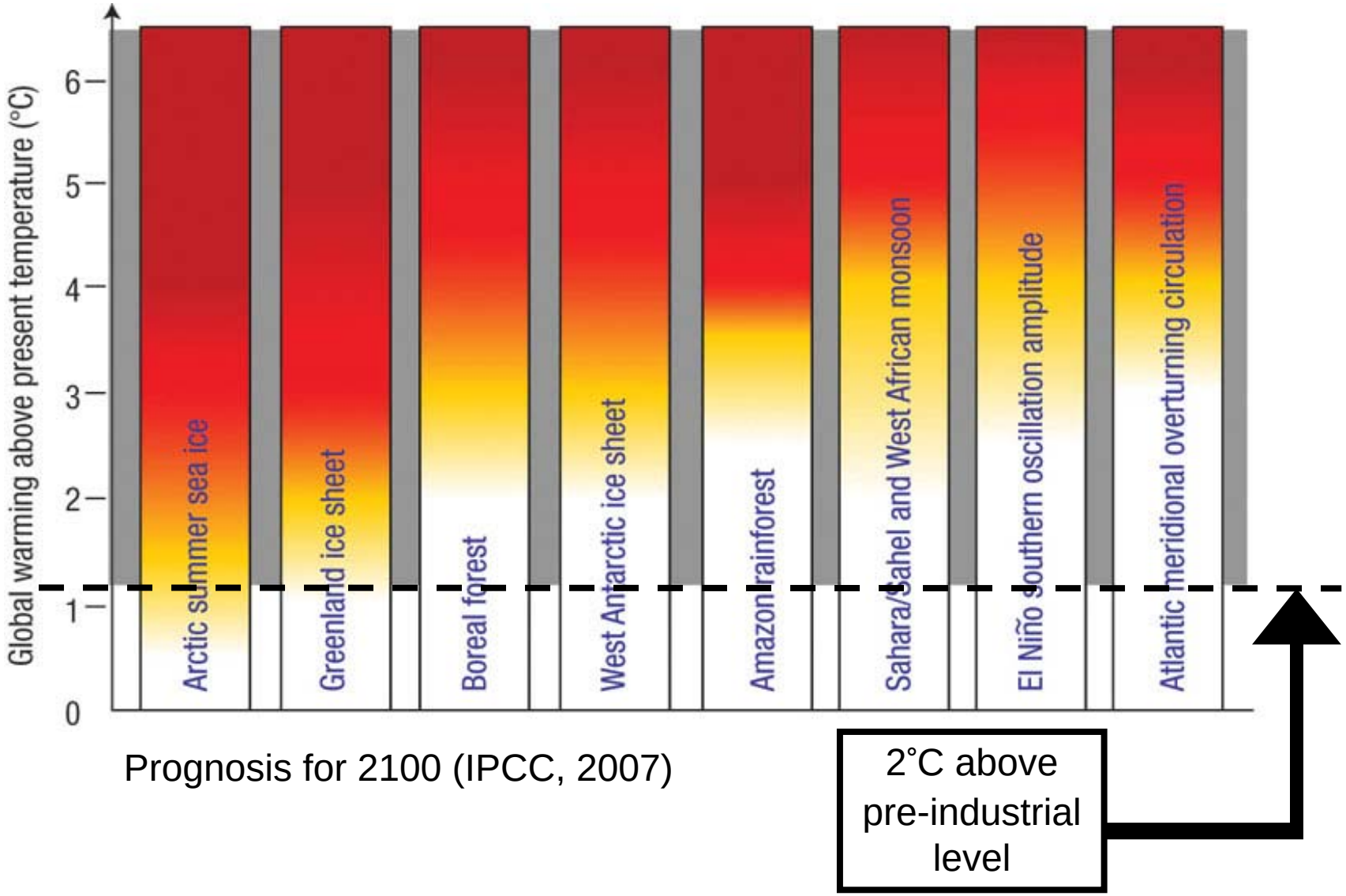




GHG emissions resulting from the provision of energy services contribute significantly to the increase in atmospheric GHG concentrations.

SRREN (IPCC, 2011)

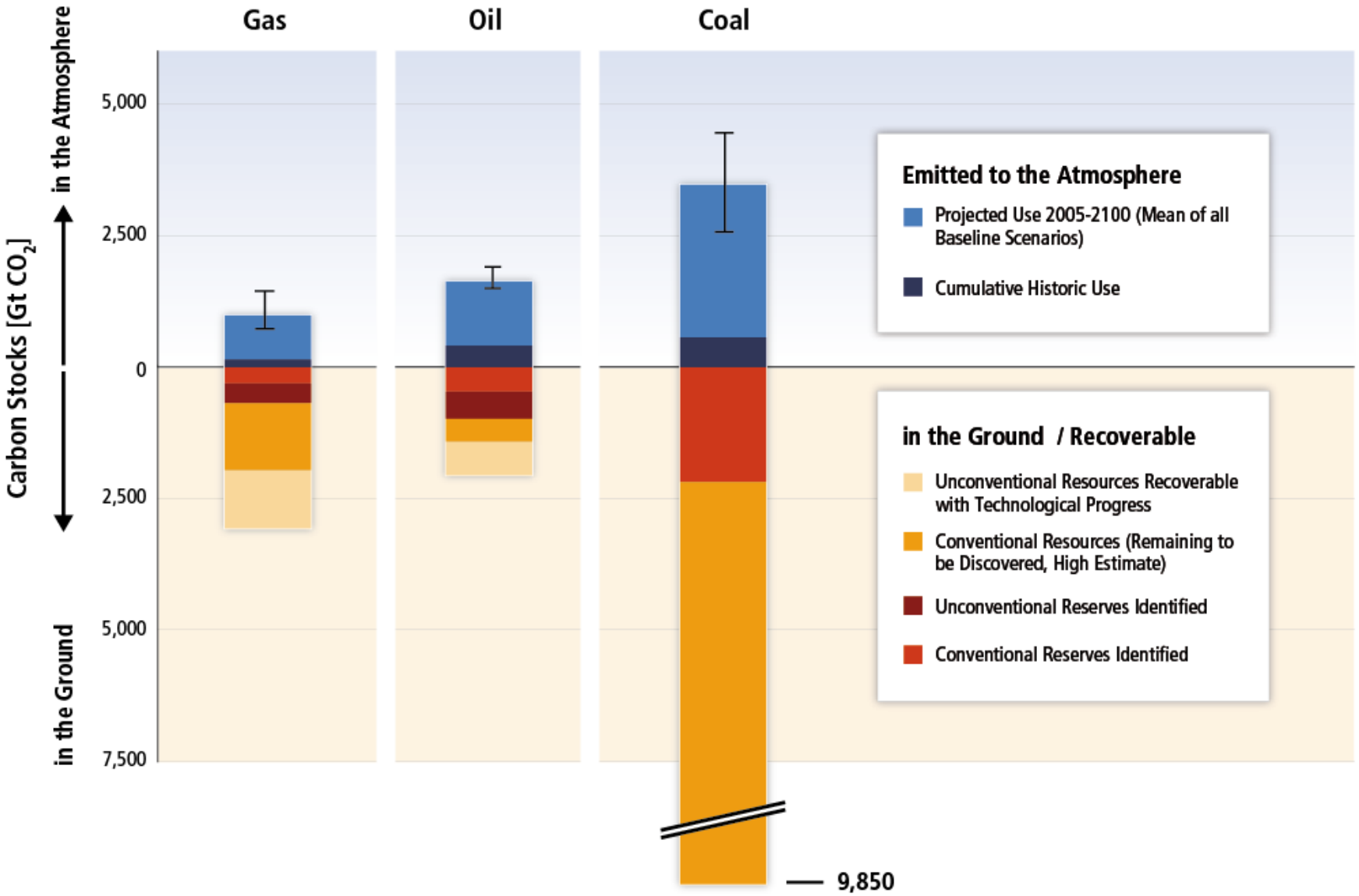
Burning Embers Diagram



Prognosis for 2100 (IPCC, 2007)

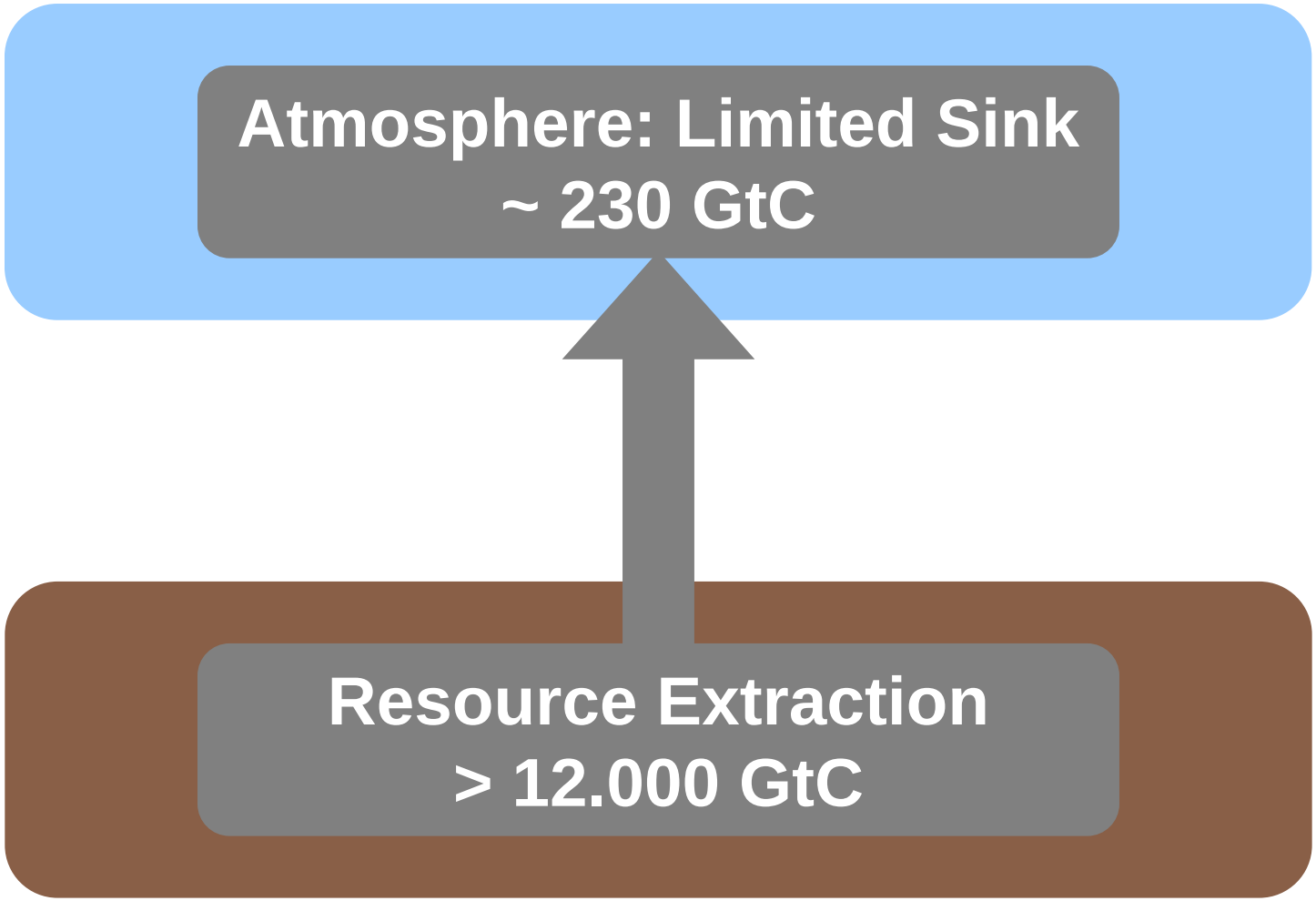
T. M. Lenton & H. J. Schellnhuber (Nature Reports Climate Change, 2007)

The BAU Scenarios Could Exceed the Level of Greenhouse Gas Concentration of 600ppm (~4° C Temperature Increase)

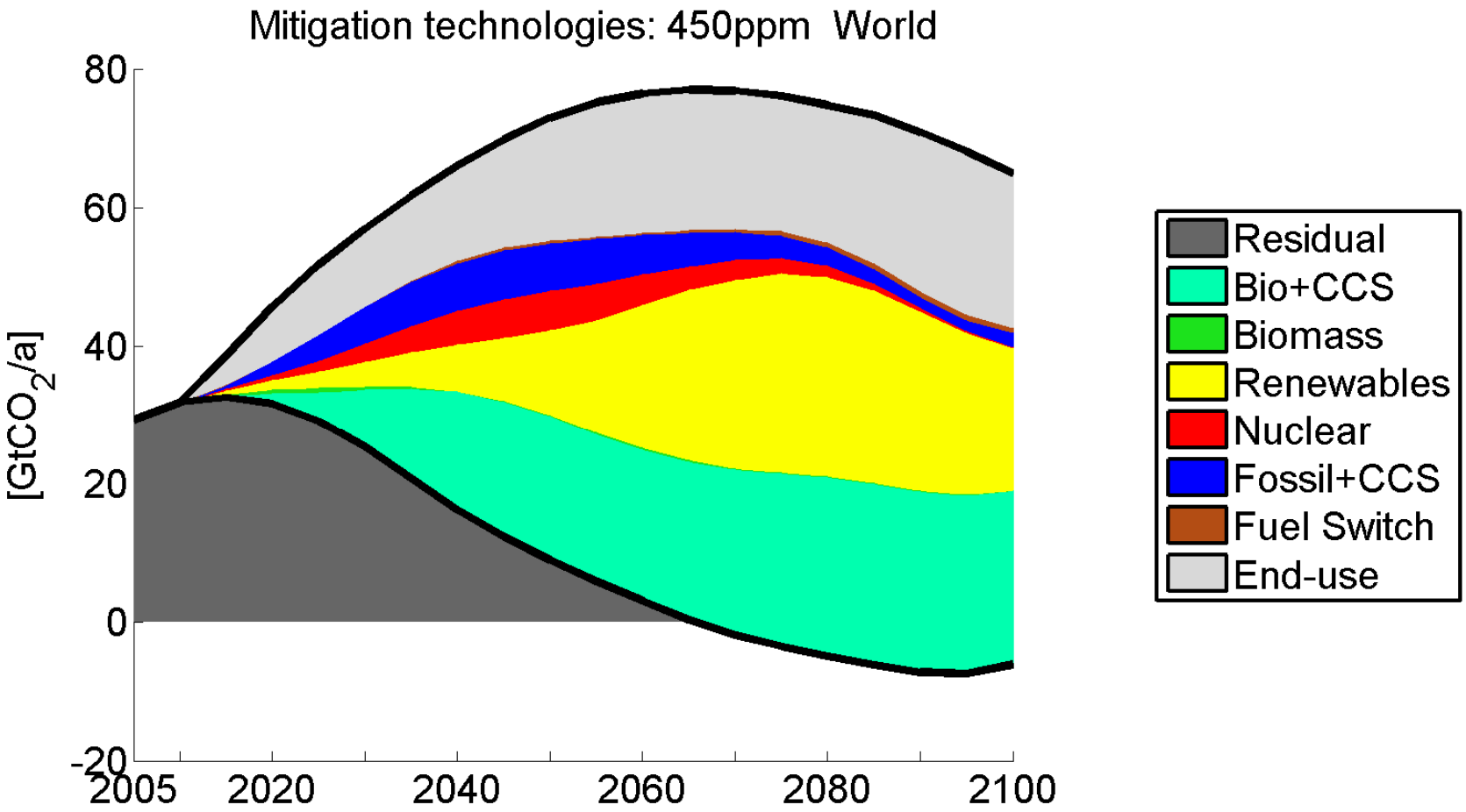


SRREN (IPCC, 2011)

The Atmosphere as a Global Common

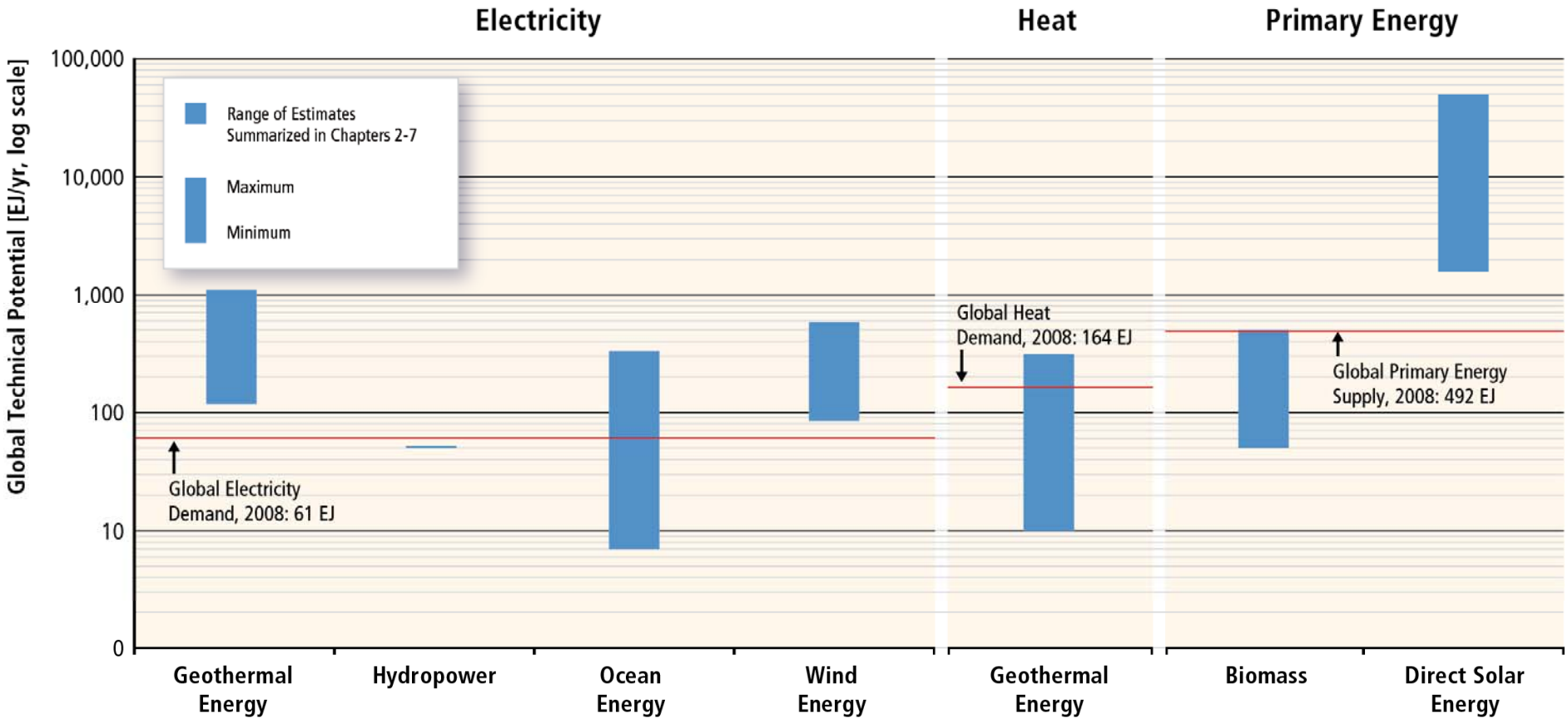


The Great Transformation – Mitigation Shares:



Three pillars: End-use Efficiency / Renewables / Biomass + CCS

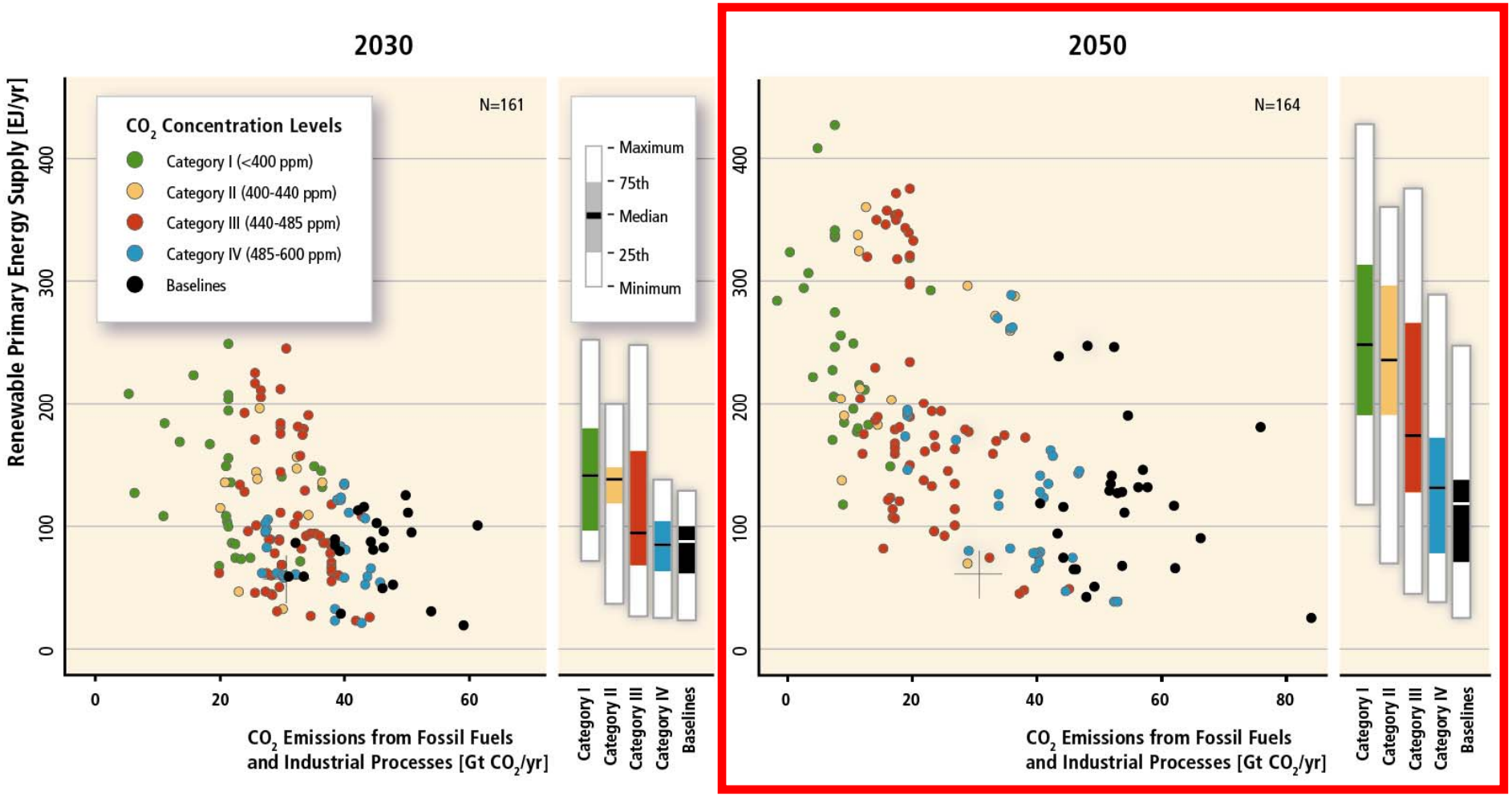
The Technical Potential of Renewable Energies



Range of Estimates of Global Technical Potentials

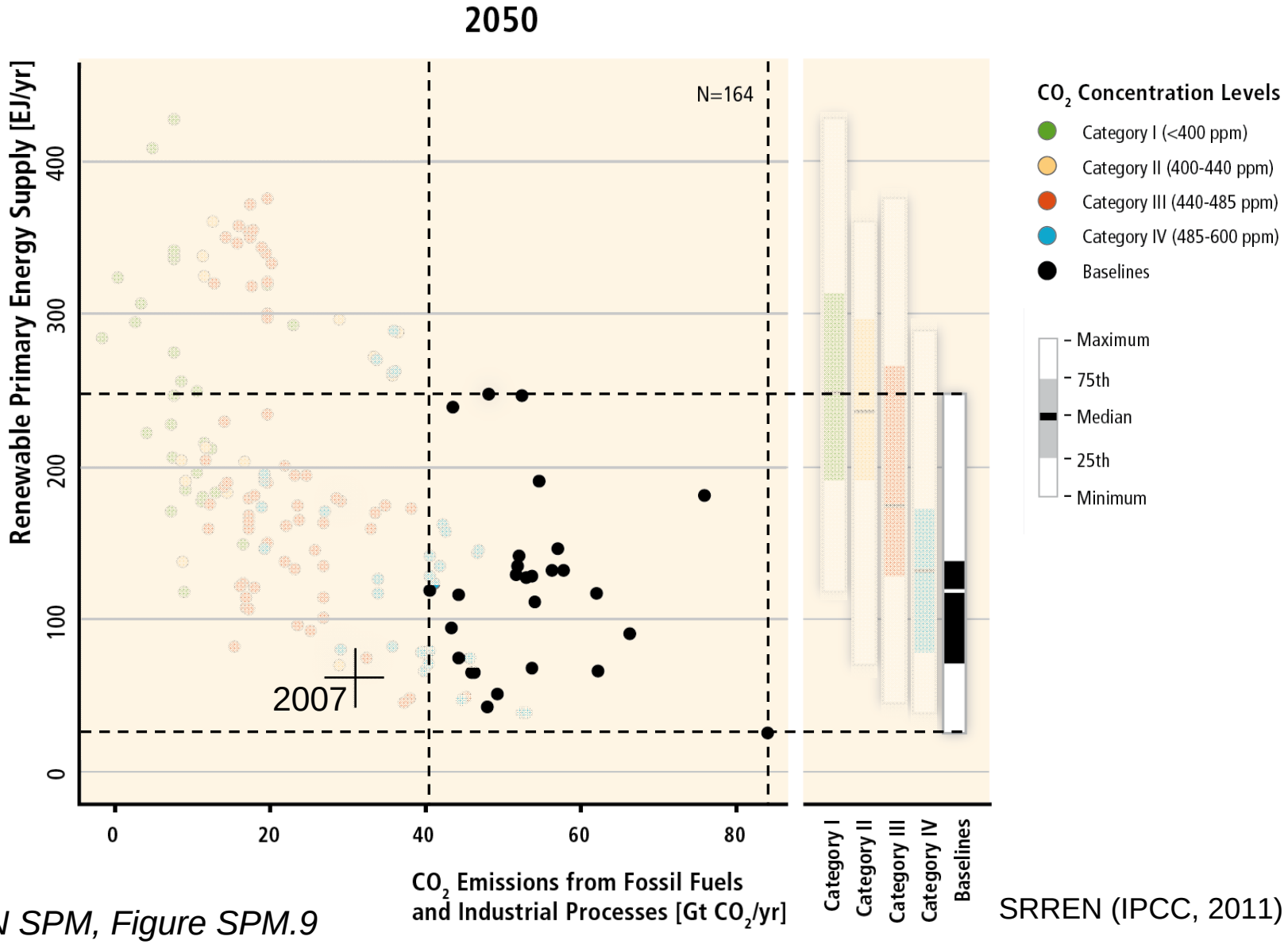
Max (in EJ/yr)	1109	52	331	580	312	500	49837
Min (in EJ/yr)	118	50	7	85	10	50	1575

Global RE Primary Energy Supply from 164 Long-Term Scenarios versus Fossil and Industrial CO_2 Emissions



SRREN SPM, Figure SPM.9

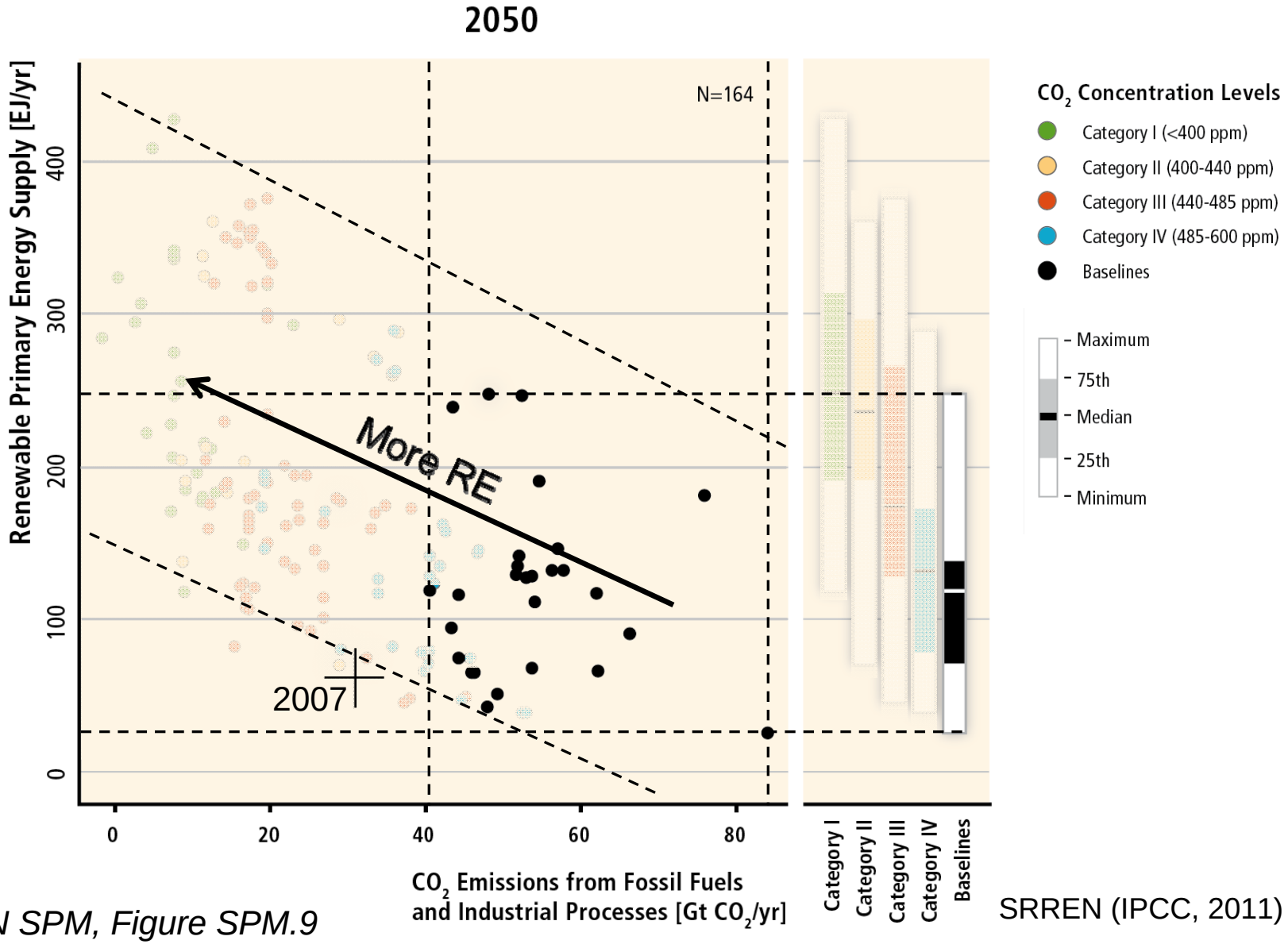
Global RE Primary Energy Supply from 164 Long-Term Scenarios versus Fossil and Industrial CO_2 Emissions



SRREN SPM, Figure SPM.9

SRREN (IPCC, 2011)

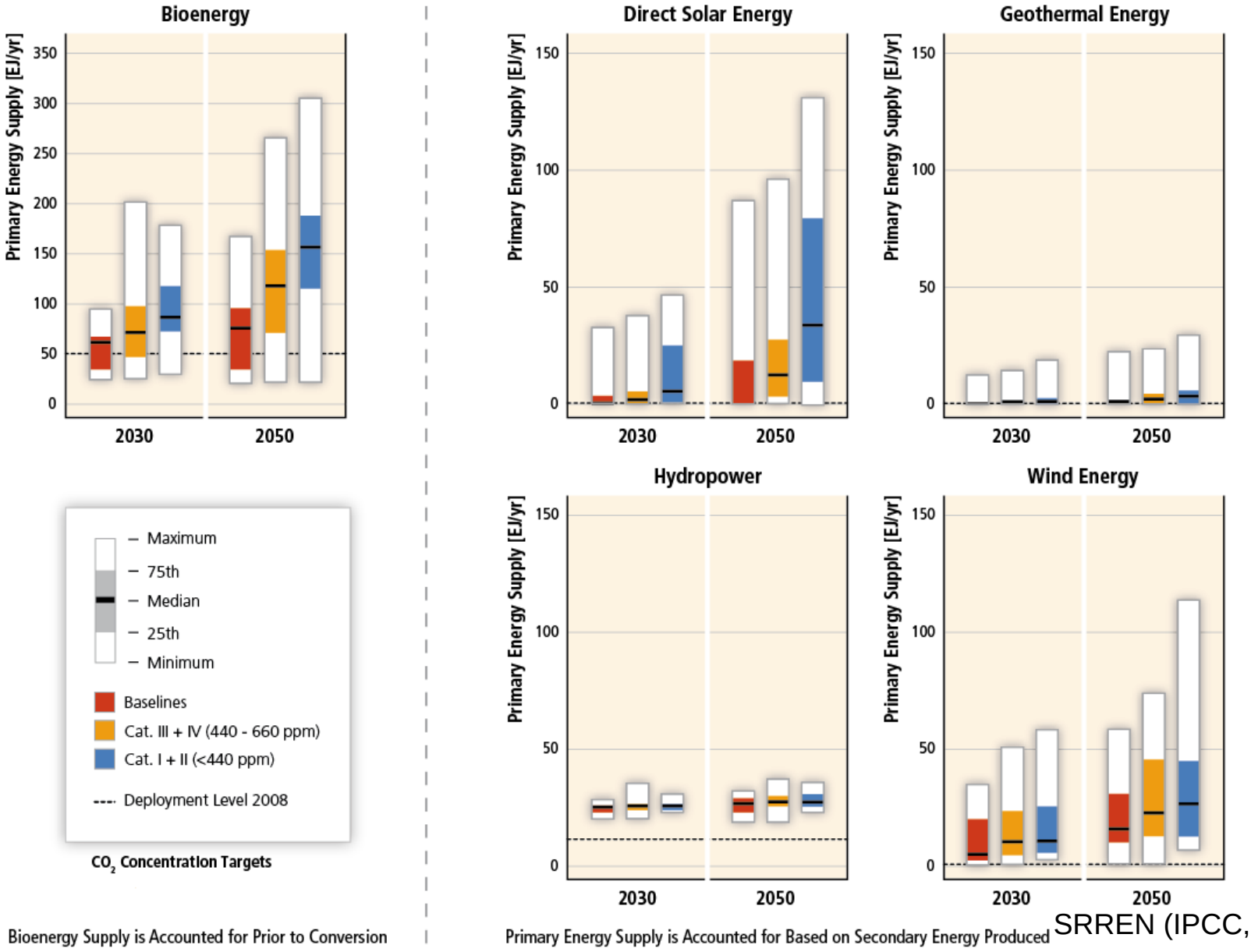
Global RE Primary Energy Supply from 164 Long-Term Scenarios versus Fossil and Industrial CO_2 Emissions



SRREN SPM, Figure SPM.9

SRREN (IPCC, 2011)

Potential Role of Renewables



SRREN (IPCC, 2011)

Numerical Limitations of Integrated Assessment Models

Time resolution:
Time steps of several years

→ Fluctuations of renewables neglected

Geographical resolution:
Aggregate world regions

→ Infrastructure neglected (e.g. grids)

Technological challenge with large shares of fluctuating renewables:

The electricity grid requires an exact match of supply and demand at **any time** and at **any place**.

Integration Options for Renewables

- **Improved weather forecast**
  → Better planning of renewable electricity feed-in

- **Demand side management**
  → Adjust demand to renewable electricity feed-in

- **Flexible power plants**
  → Provide residual load

Important Supply Side Options

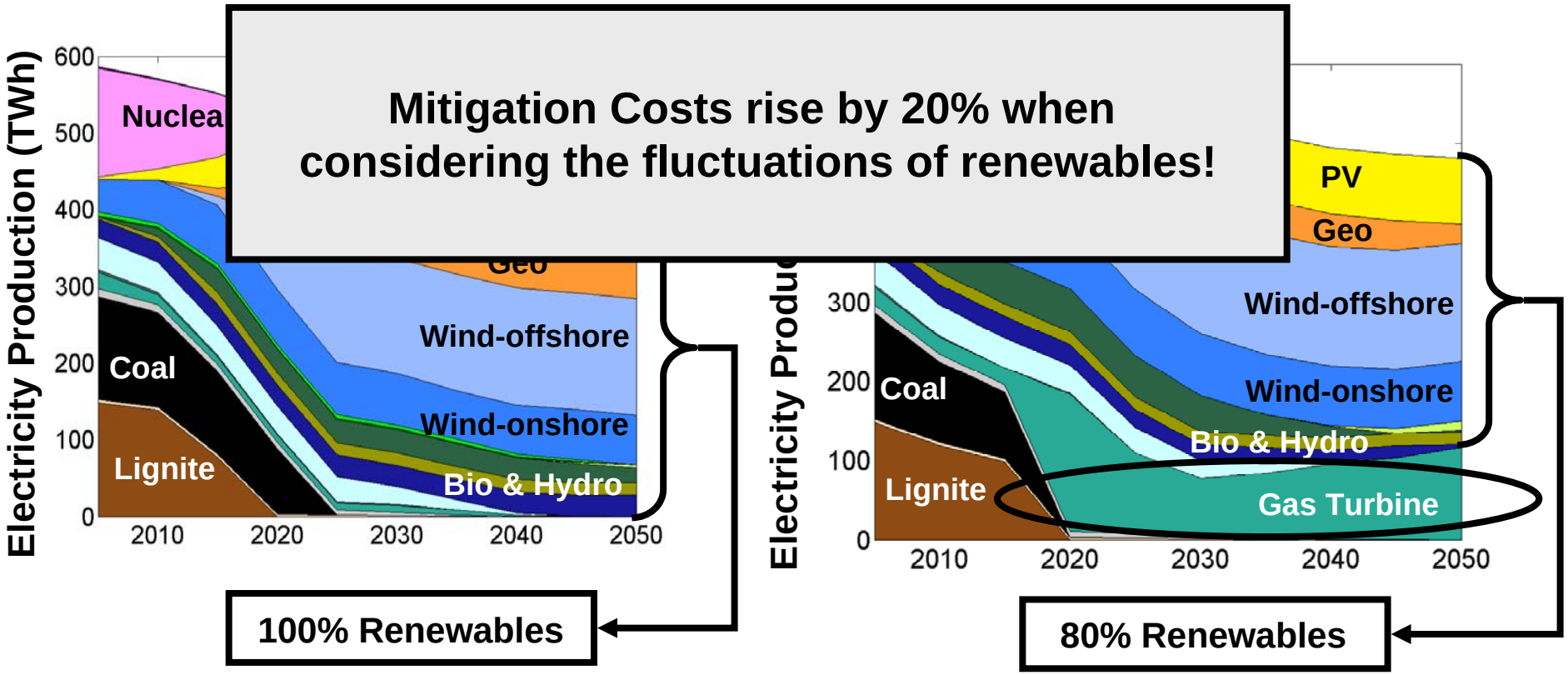
- **Grid extension**
  → Large area pooling of uncorrelated fluctuations (>300km): Import / Export between countries

- **Energy storage**
  → Remove electricity from the grid in times of high renewable generation and feed-in electricity in times of low generation

Impact of Considering Fluctuations in an Energy System Model of Germany

Most models do not take into account fluctuations explicitly:

Same scenario with consideration of fluctuations:



Scenario: 80% domestic CO_2 emission reduction in 2050 vs. 1990

(Ueckerdt et al., 2011)

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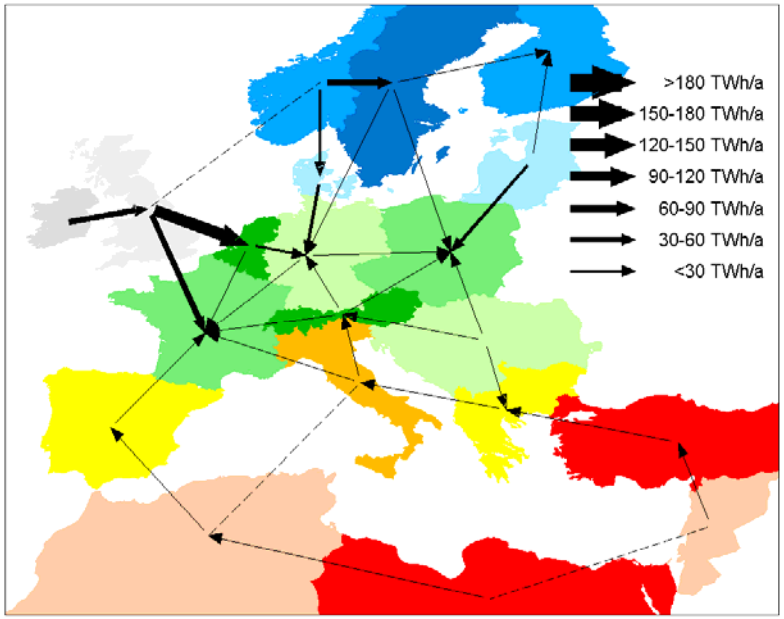
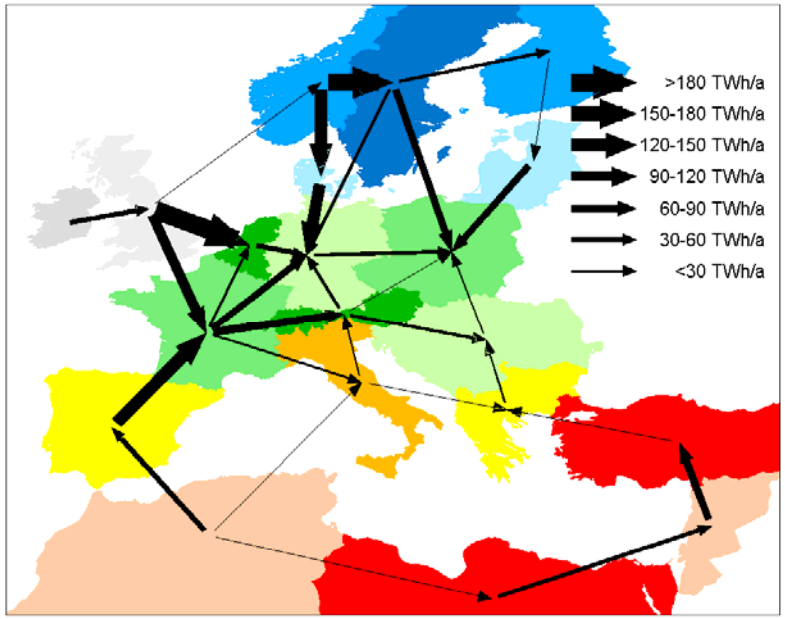
Aggregate Transmission in 2050 in an Electricity Sector model of Europe

Baseline,
no climate policy:



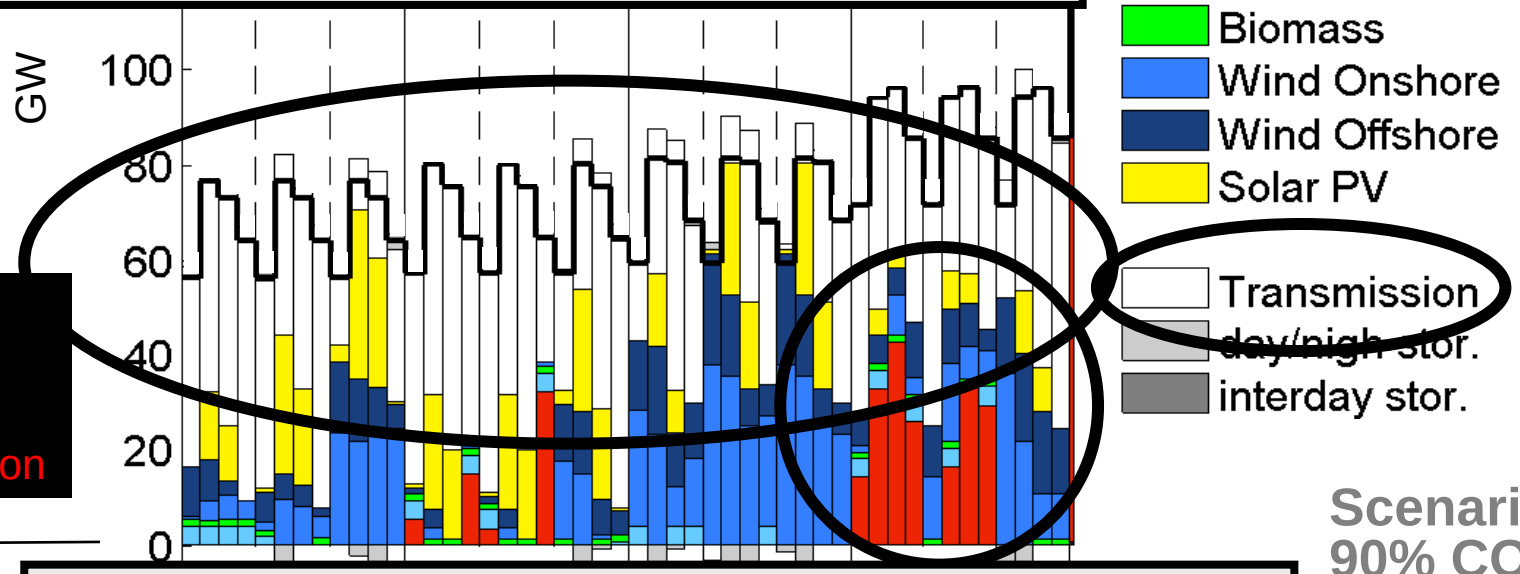
90% CO_2 reduction
in electricity sector:



(Haller et al., 2011, submitted)

Germany 2050: Electricity production with network expansion (European Interconnectors)

About 50% of demand covered by imports



- Storage outflow
- Import
- Production

- Export
- Storage inflow

Large capacities of natural gas power plants required, especially in winter

Scenario: 90% CO_2 emission reduction in electricity sector

(Haller et al., 2011, submitted)

Integration Options for Renewables

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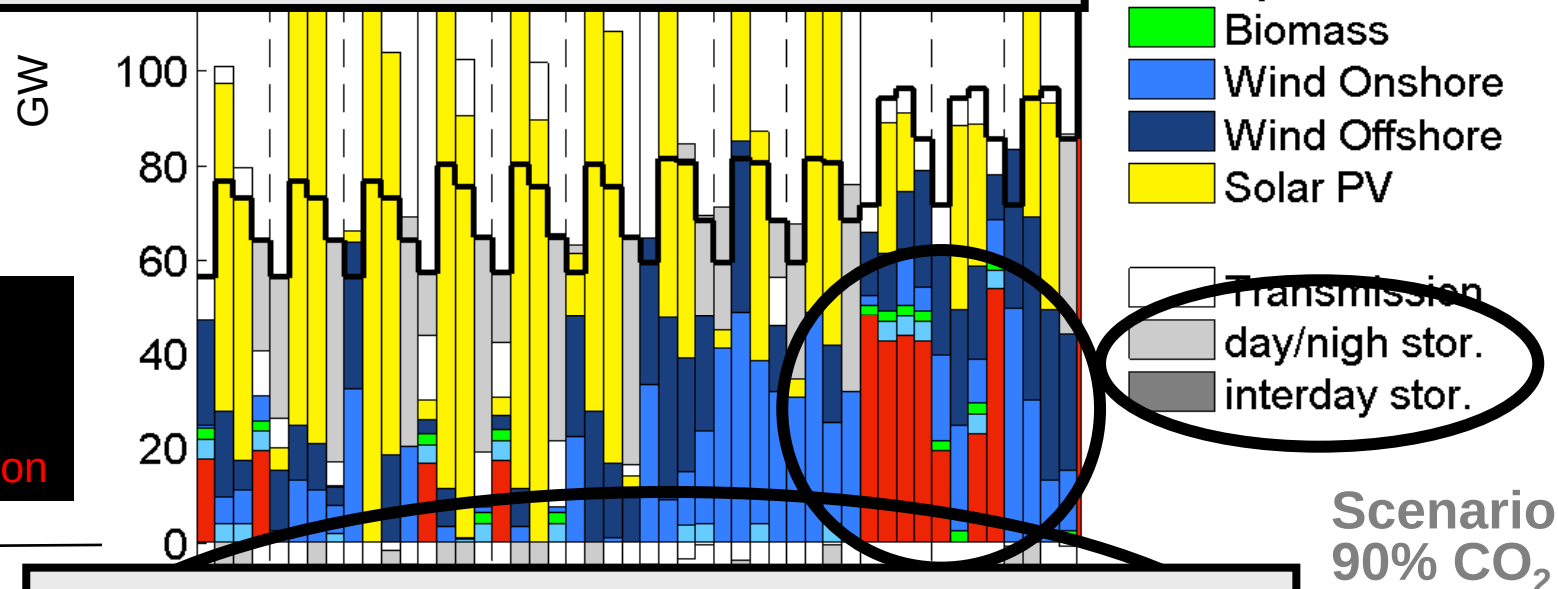
Germany 2050: Electricity production without network expansion (Autarkic Germany)

Large storage capacities required



- Storage outflow
- Import
- Production

- Export
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Large capacities of natural gas power plants required, especially in winter

Scenario: 90% CO_2 emission reduction in electricity sector

(Haller et al., 2011, submitted)

Interim Synthesis

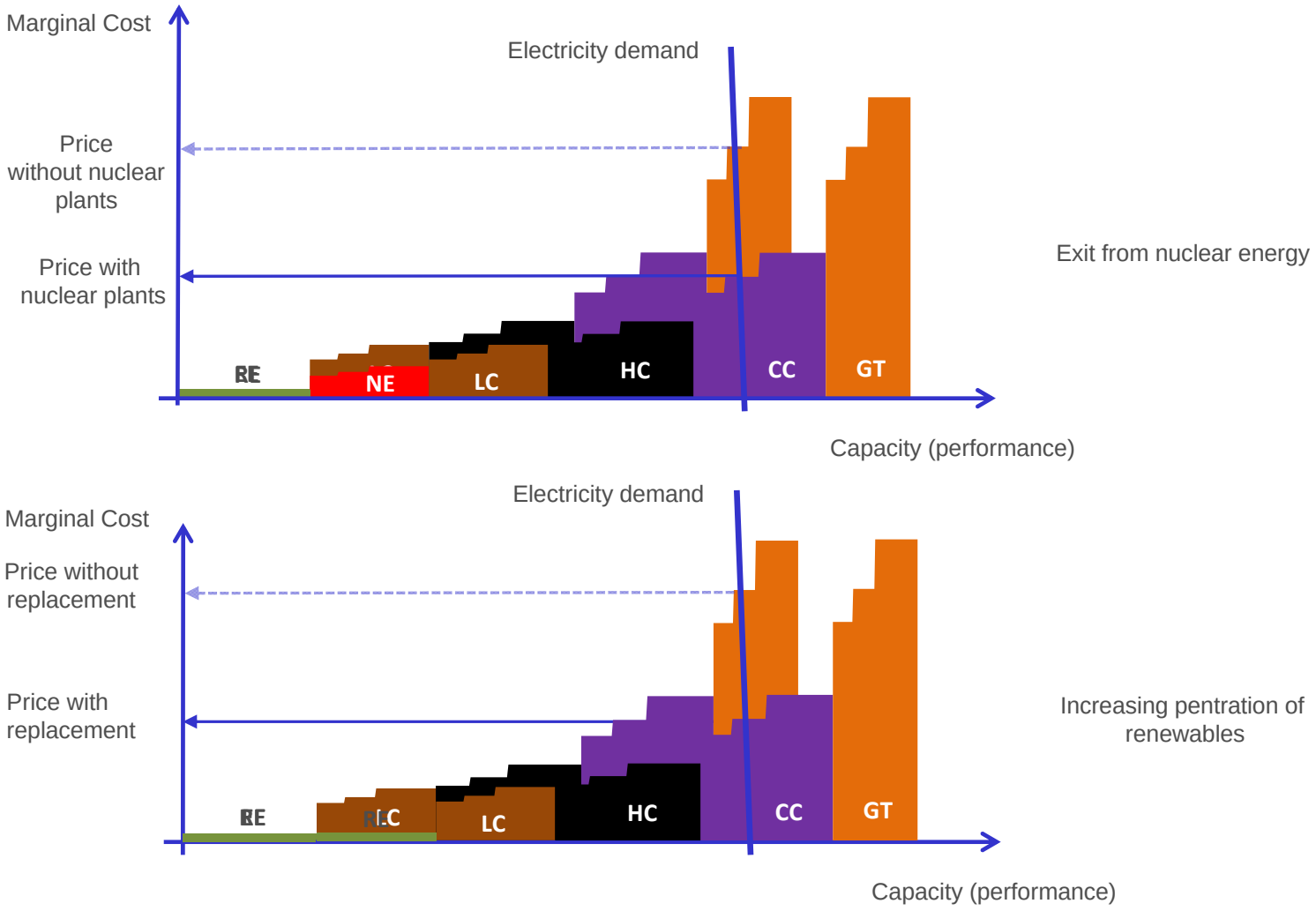
Large back-up capacities of flexible gas power plants are required to provide residual load in extended times of low renewable electricity generation (European winter)…

…even with a European integrated electricity grid

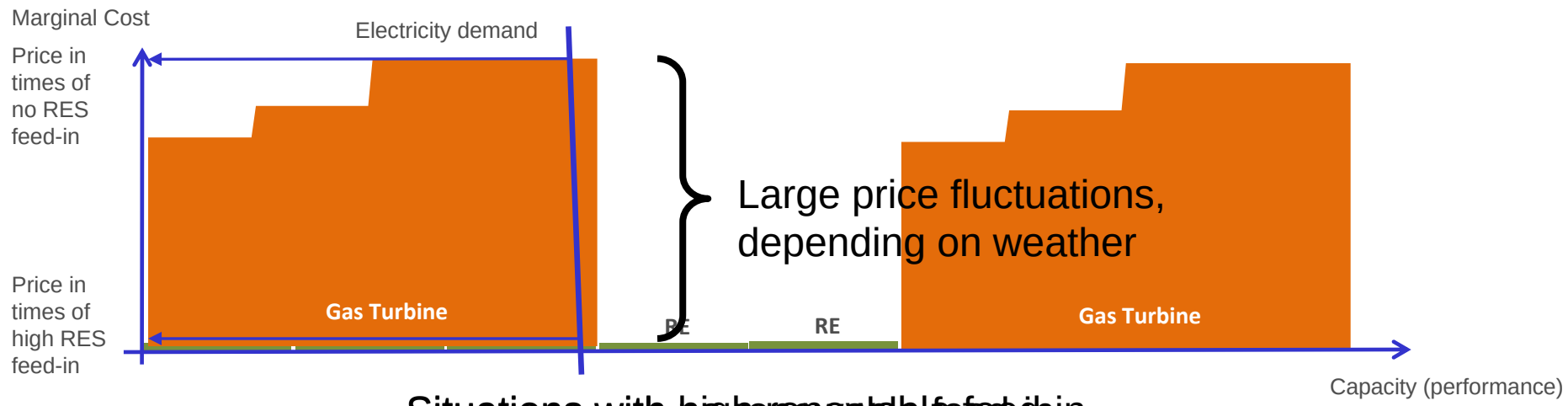
…even with large day/night or medium-term storage capacities (e.g. pumped hydro)

What are the implications for the electricity market, CO_2 emissions of the electricity sector, and what is the potential role of methanisation?

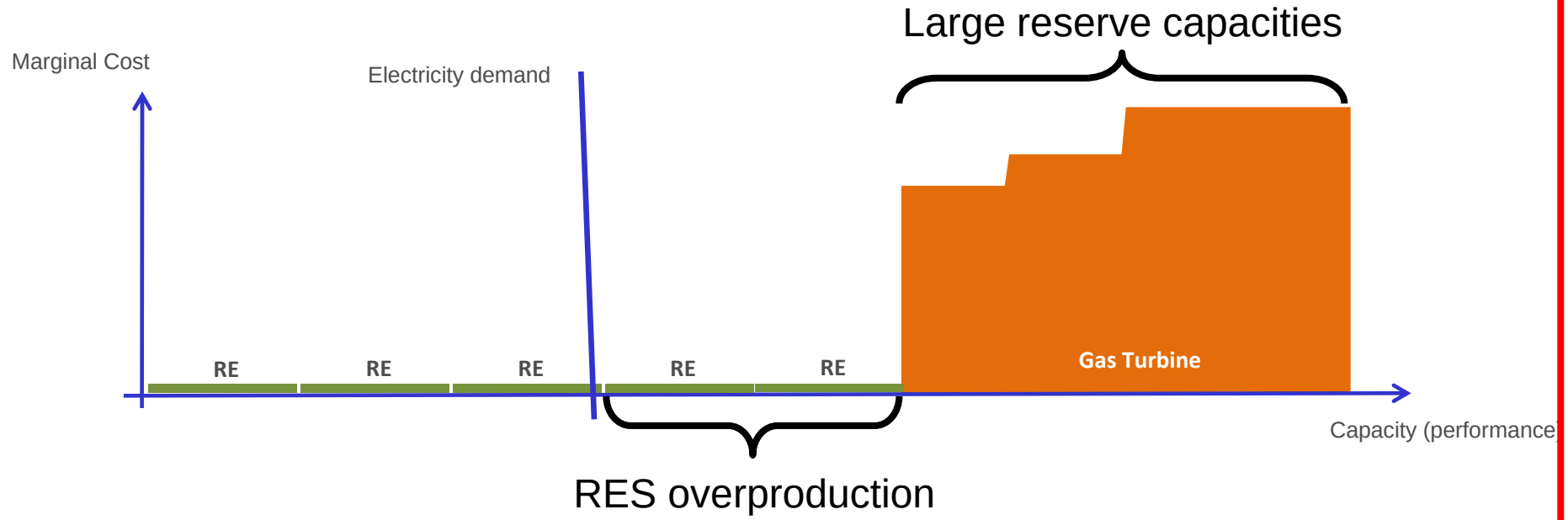
The Current Market System: Merit Order Pricing



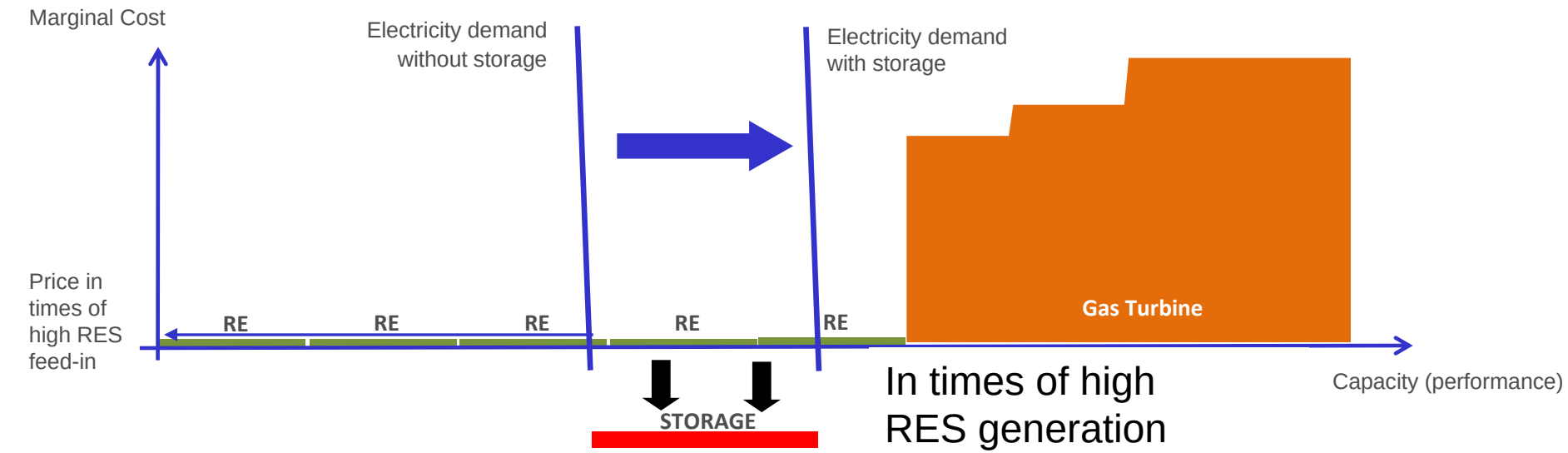
The Future Market System? Merit Order Pricing with high Renewable Shares and Flexible Gas Plants Only



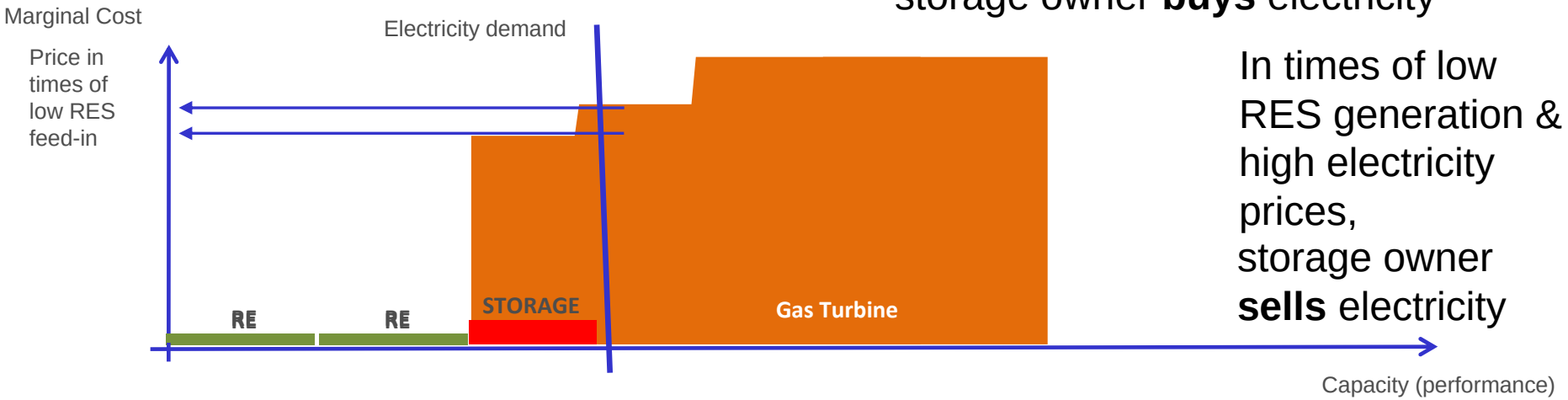
Situations with high renewable feed-in



The Role of Classical Storage (e.g. Pumped Hydro)

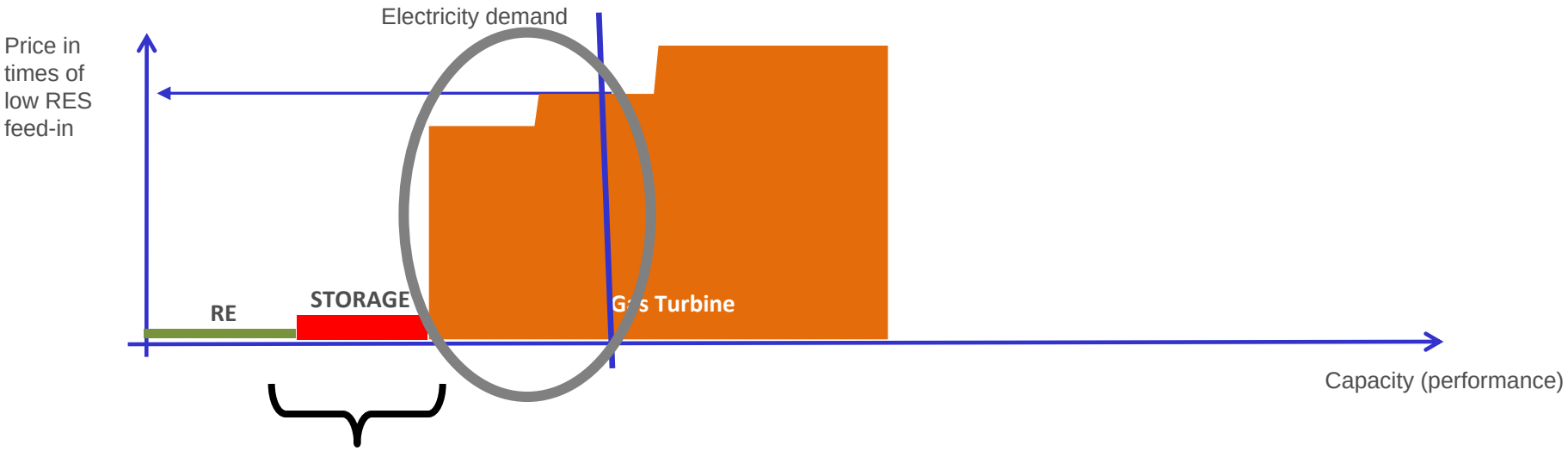


In times of high RES generation & low electricity prices, storage owner **buys** electricity



In times of low RES generation & high electricity prices, storage owner **sells** electricity

Insufficiency of Pumped Hydro Storage in Europe



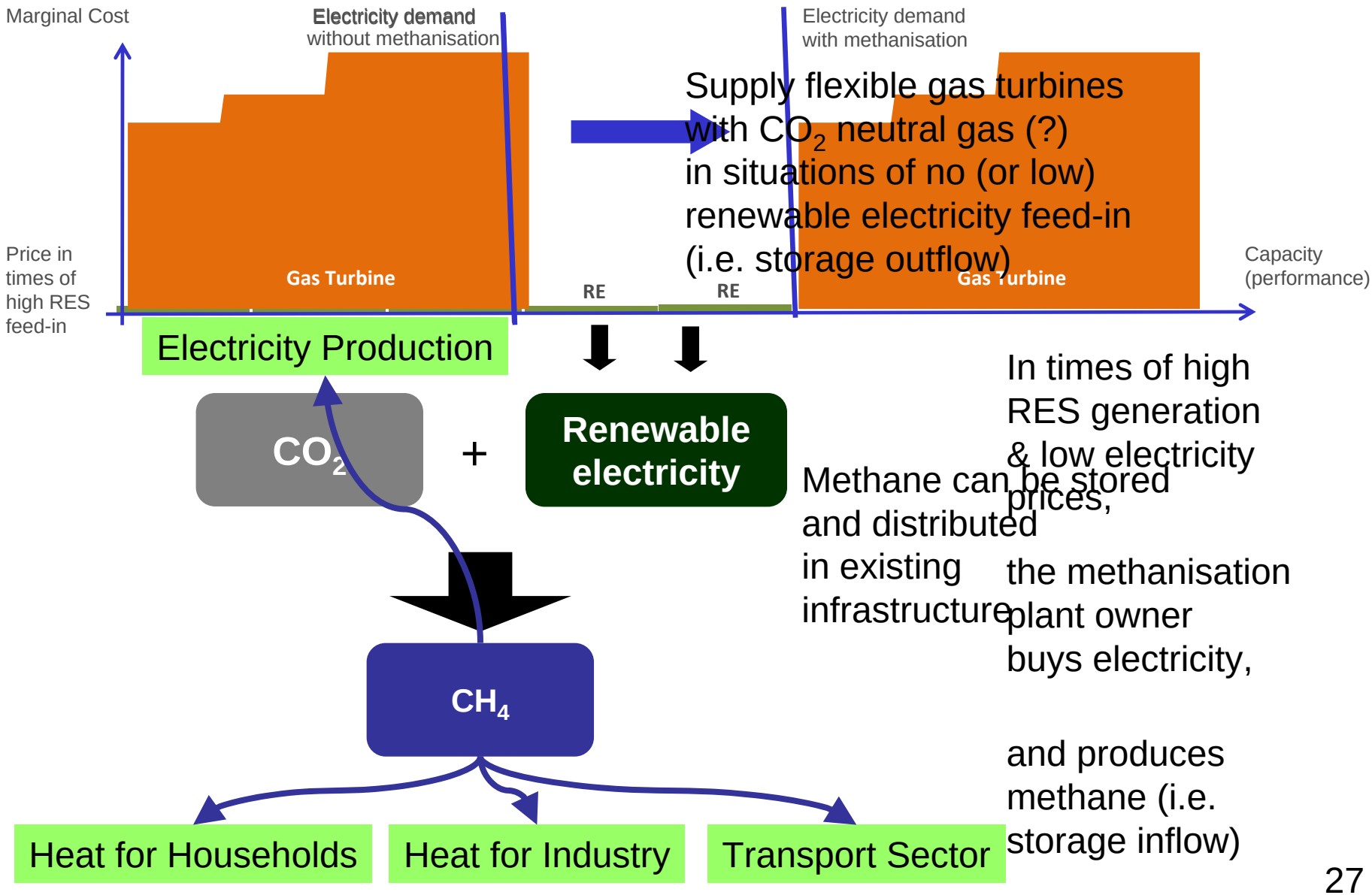
Pumped hydro storage is very limited in Europe

Gas turbines need to provide residual load, whenever renewable generation is insufficient to meet demand

→ Natural Gas incurs CO_2 Emissions

→ Natural Gas is a scarce resource and may be subject to severe price increases in the future

The Potential Role of Methanisation



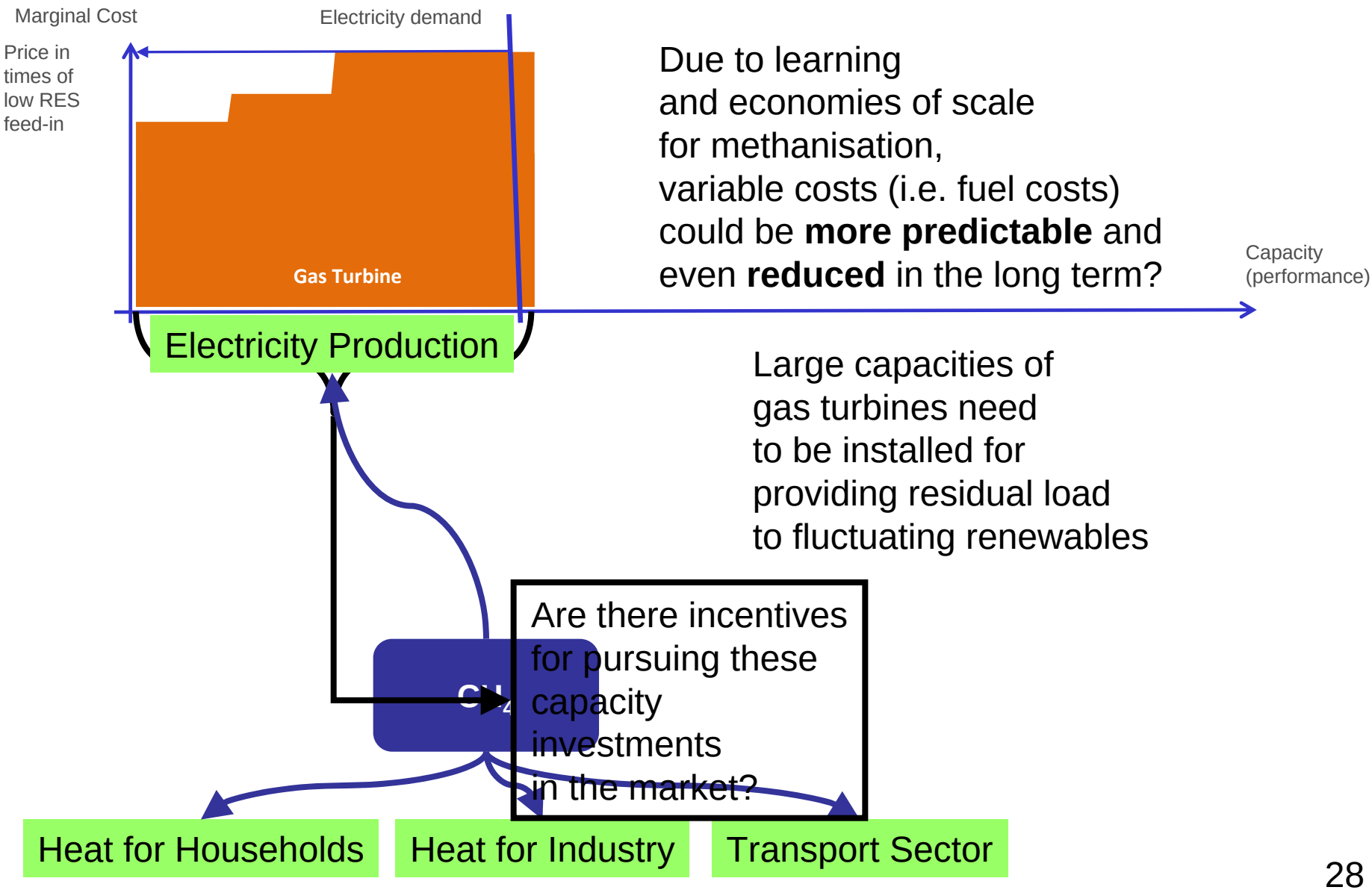
In times of high RES generation & low electricity prices,

Methane can be stored and distributed in existing infrastructure

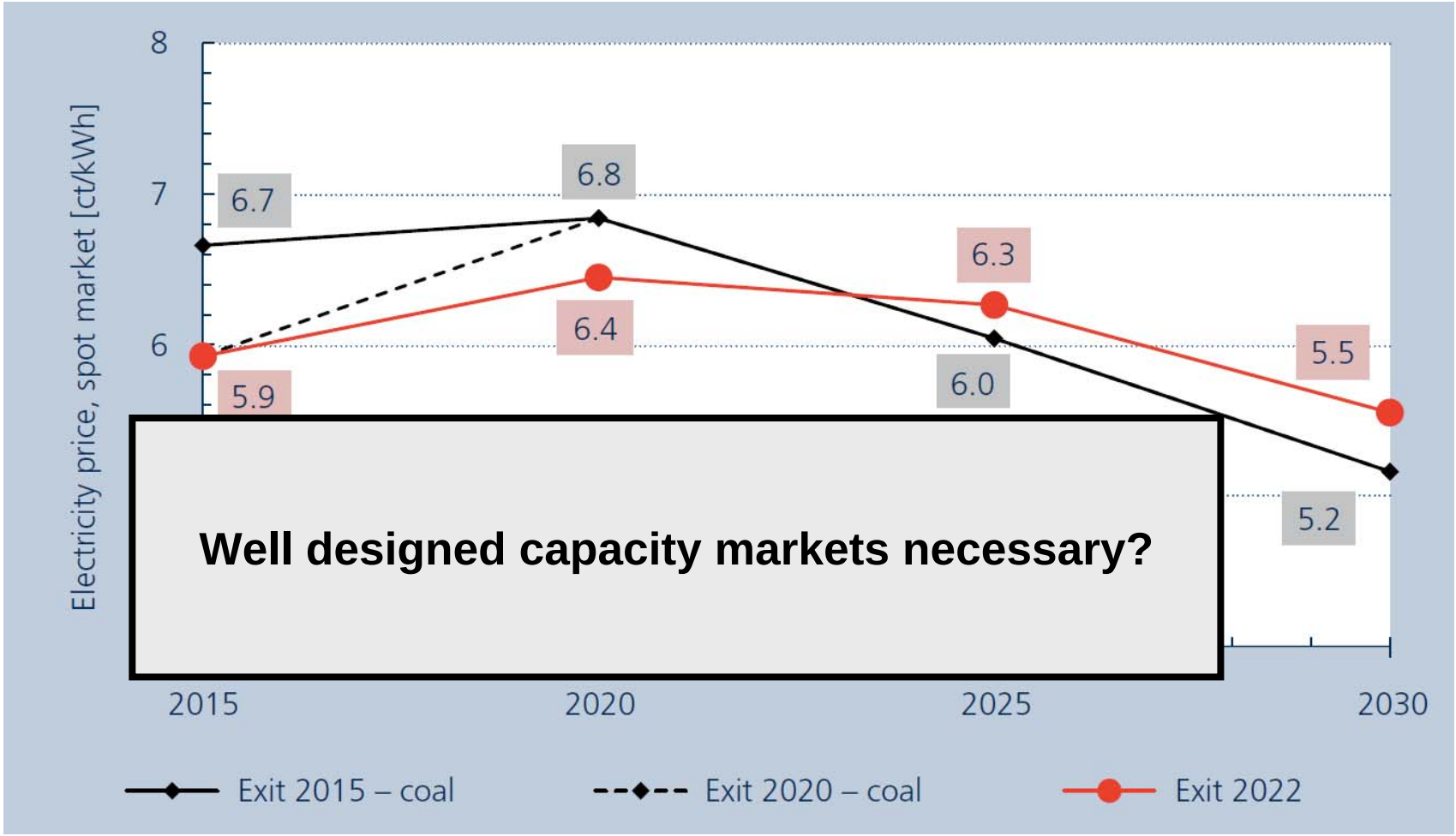
the methanisation plant owner buys electricity,

and produces methane (i.e. storage inflow)

The Potential Role of Methanisation



Wholesale Market Prices



Merit-Order effect of increasing shares of renewables:
Decreasing power prices

(Knopf et al. , 2011)

Methanisation could be a major game changer

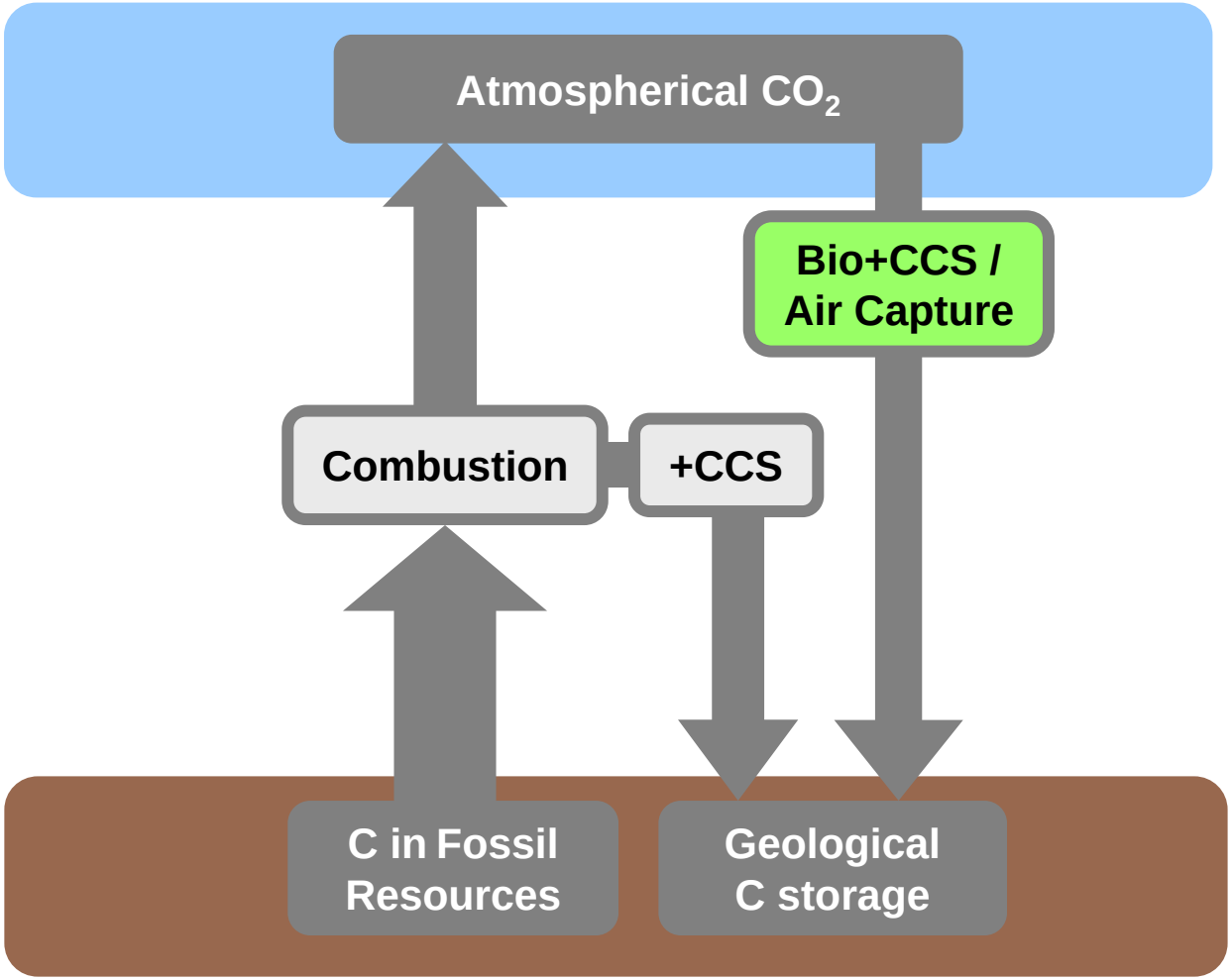
What is the price of methanisation?

Is it feasible on global scale?

How is the emission balance?

Carbon Capture and …

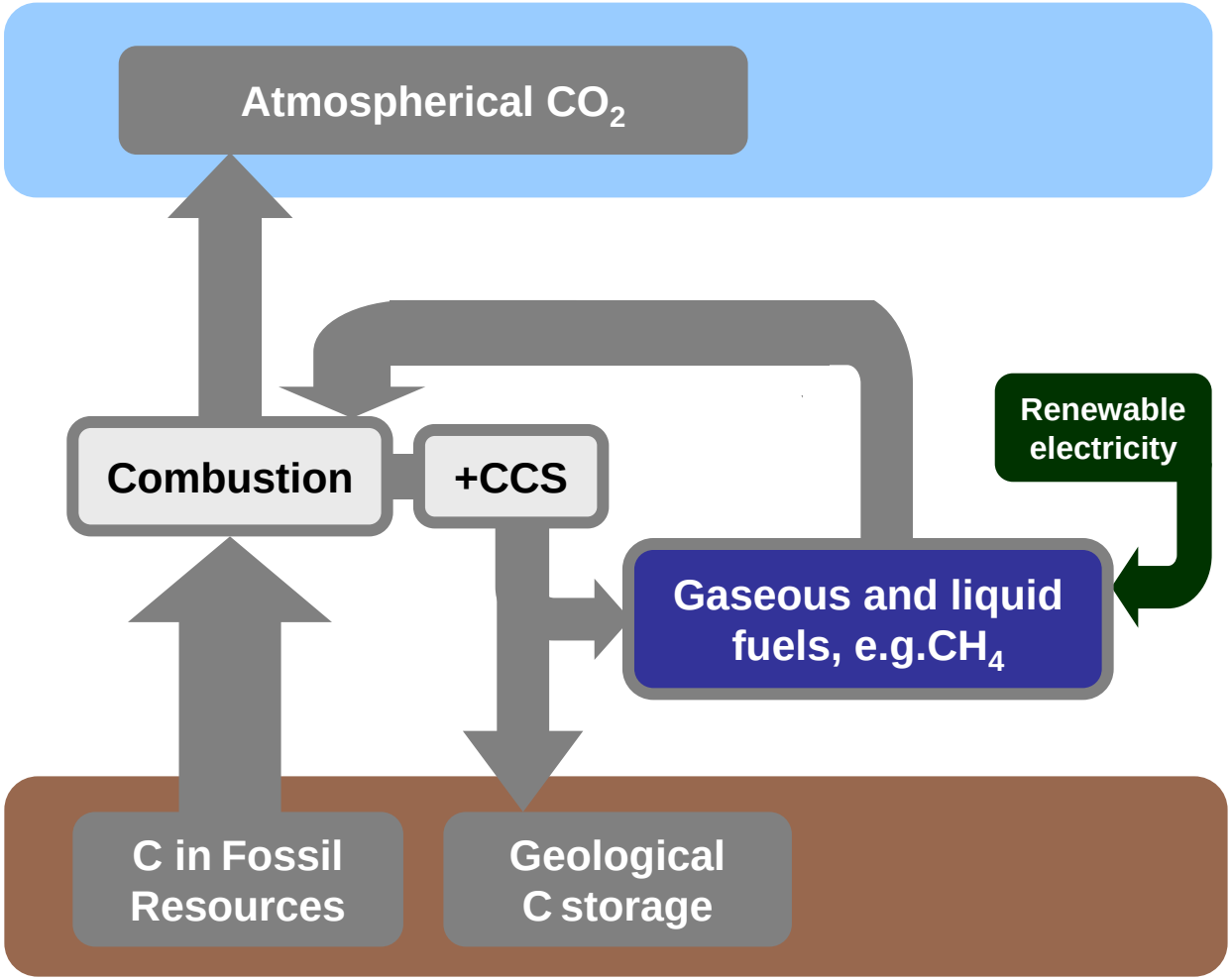
…storage (CCS)



Not fully sustainable

Carbon Capture and …

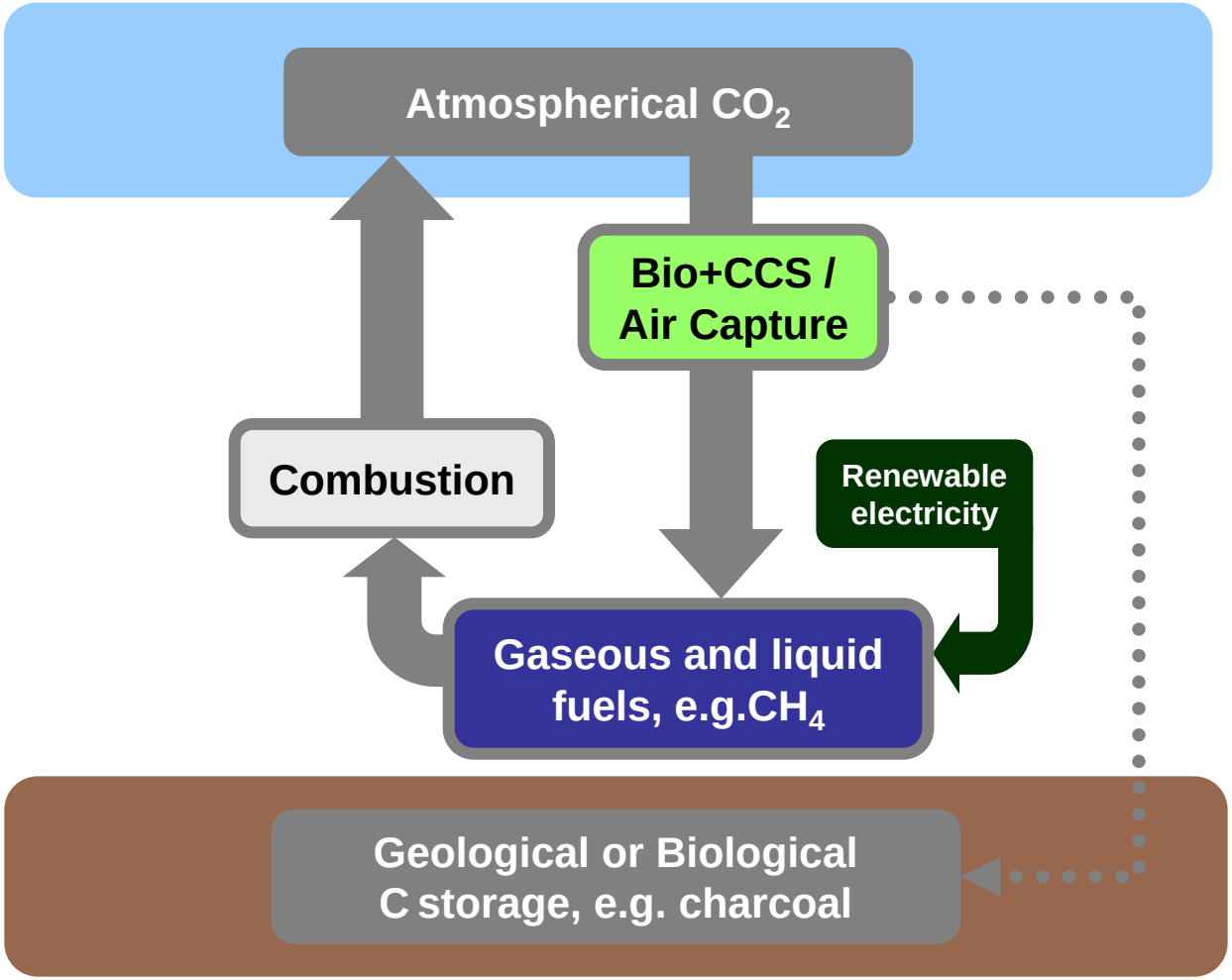
…use (CCU)

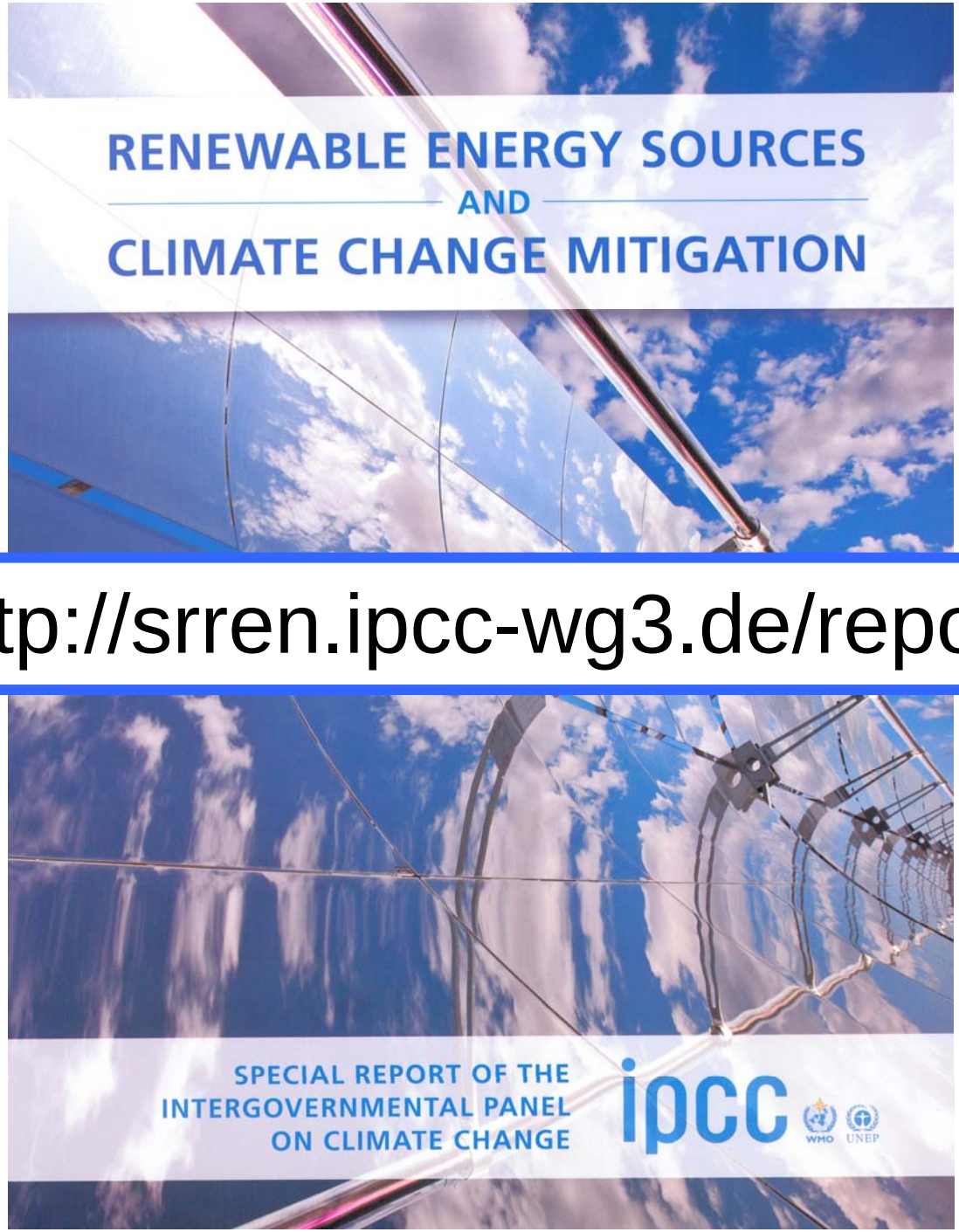


Transitional

Carbon Capture and …

…cycling(CCC)





http://srren.ipcc-wg3.de/report