The IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation

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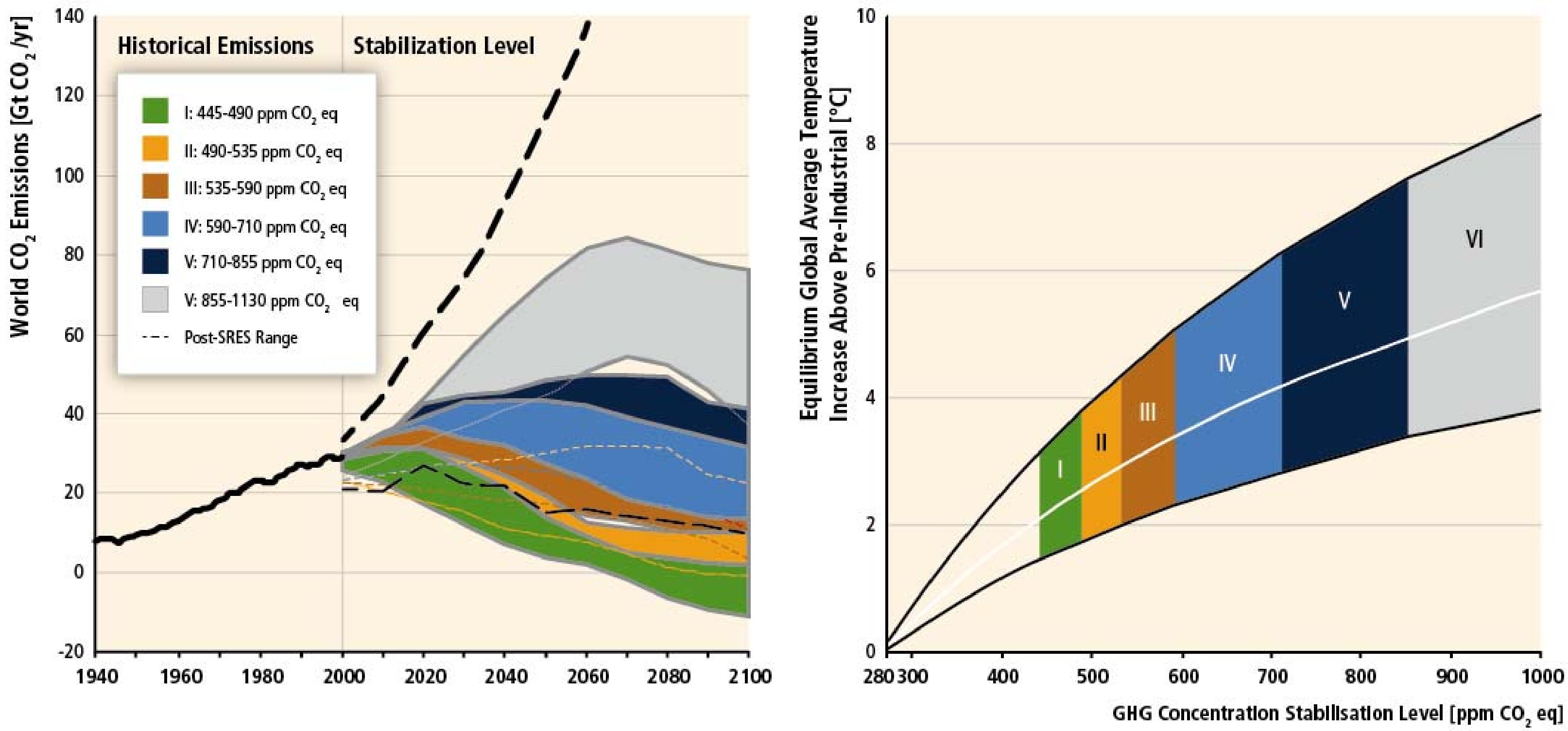
Demand for energy services is increasing.



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

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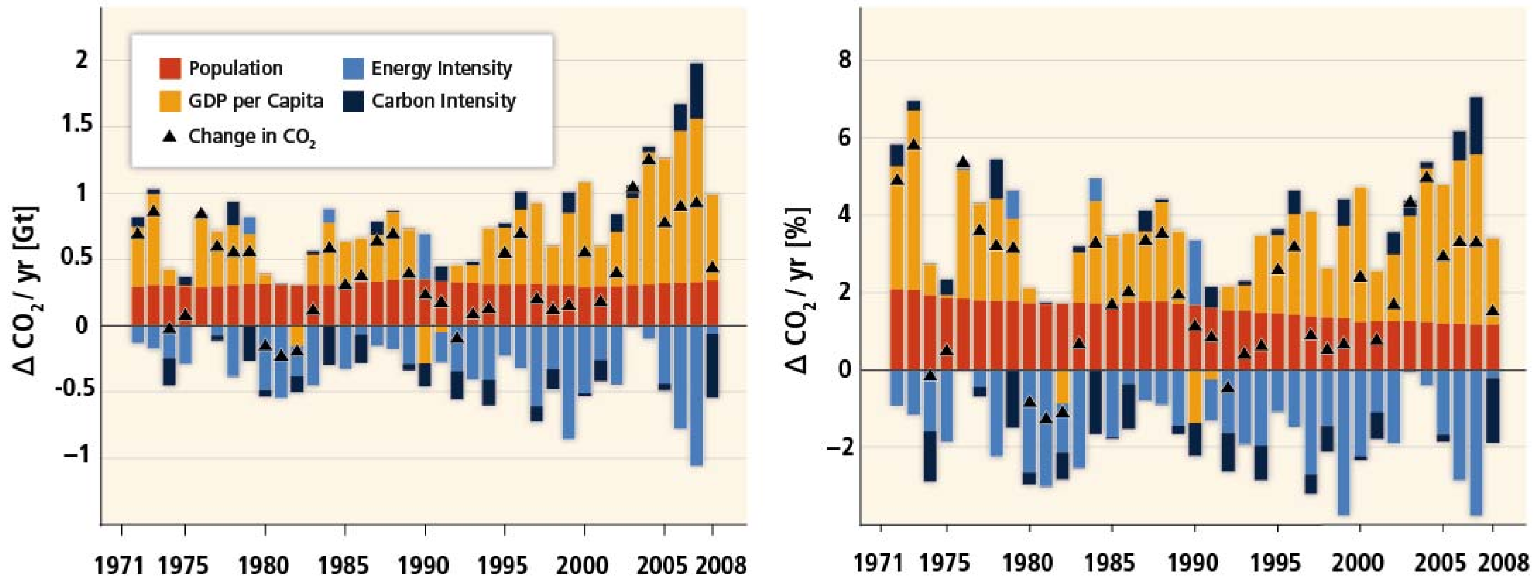
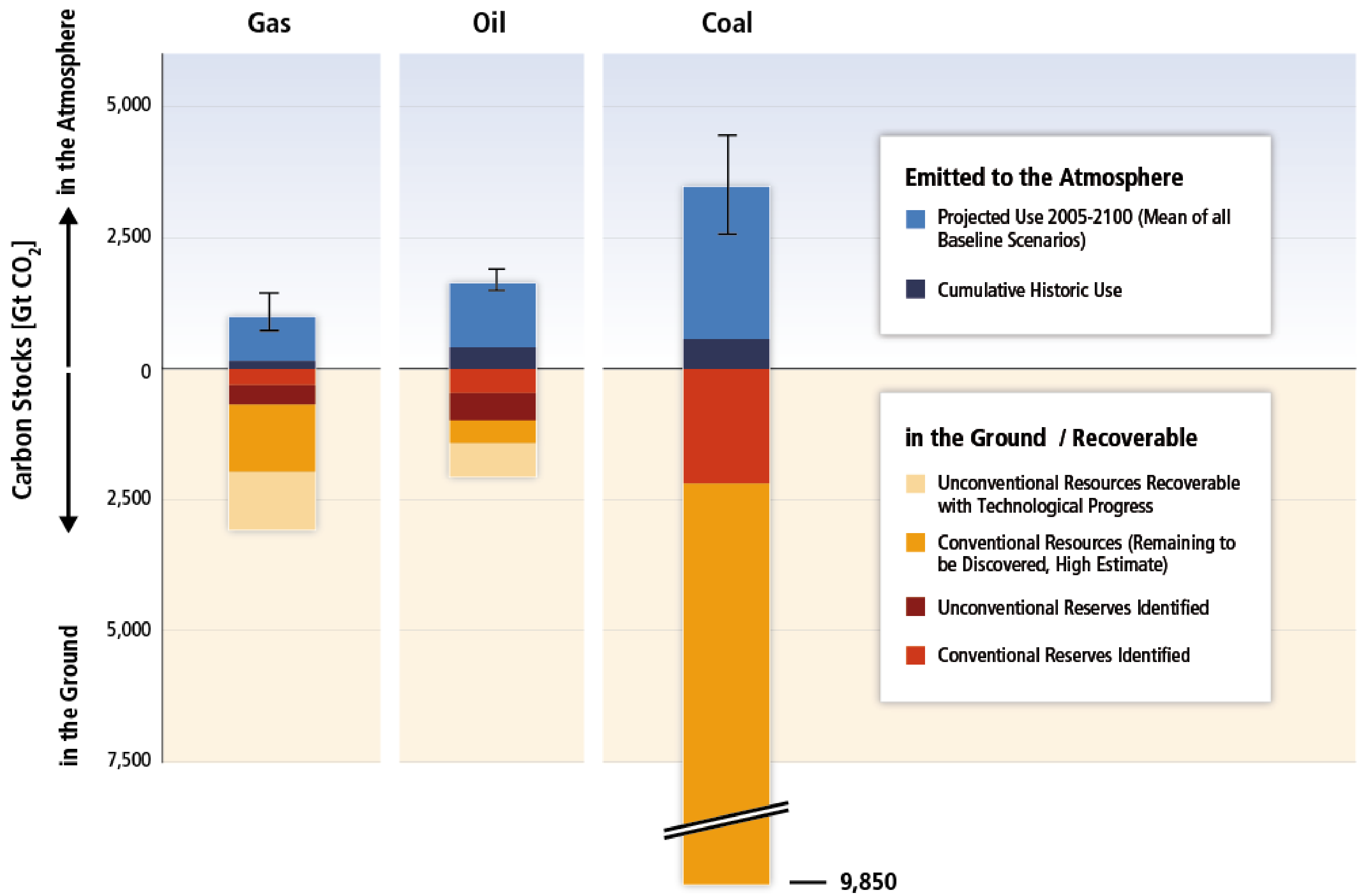
Annual change in global energy-related CO_2 emissions



Replacing fossil fuels with RE technologies lowers carbon intensity, while improved energy efficiency can lower emissions.

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



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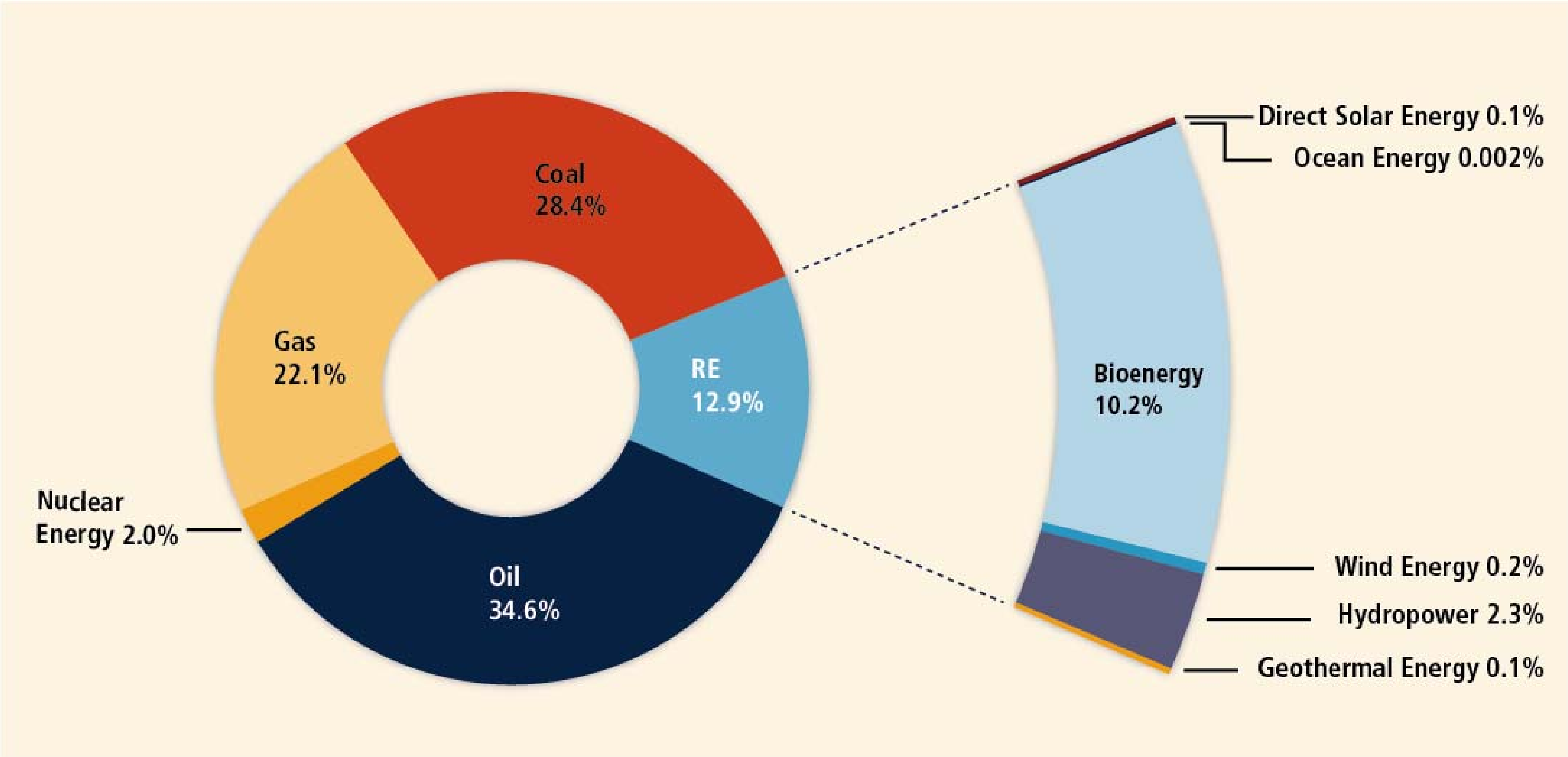
The current global energy system is fossil fuel dominated.



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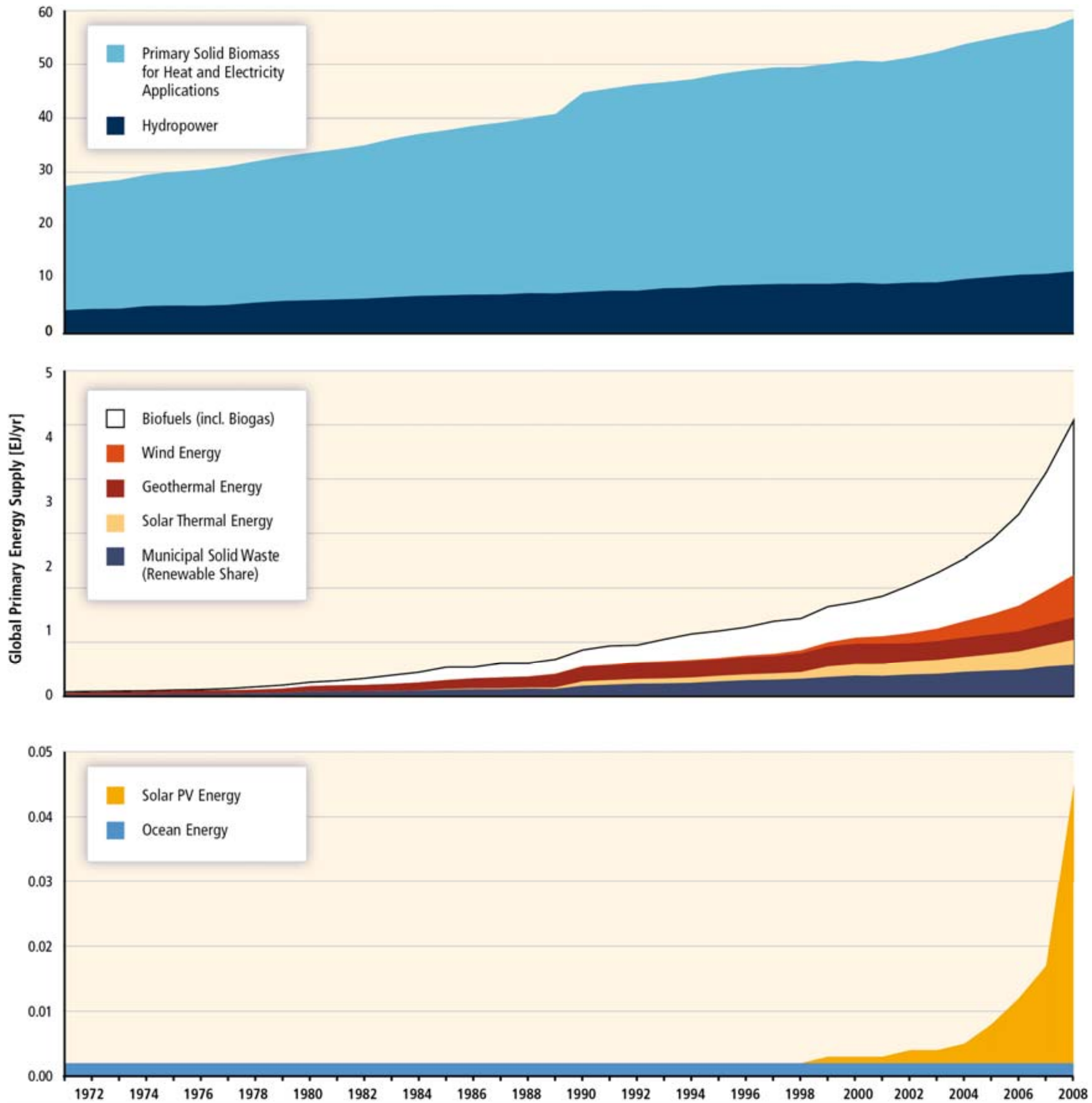
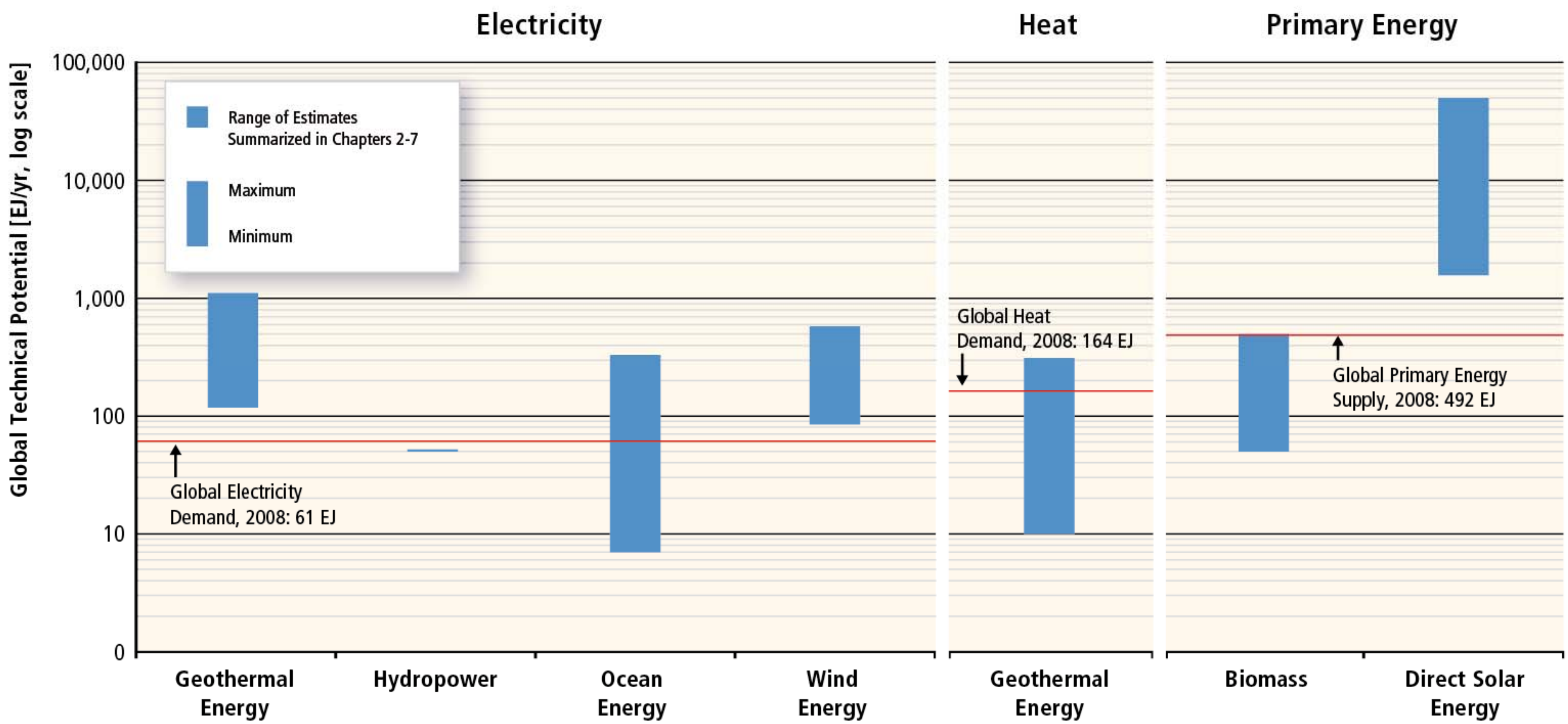
RE growth has been increasing rapidly in recent years.



150 GW of new RE power plant capacity was built in 2008-2009.

This equals 50% of all power plants built during that period.

The potential of renewable energy technologies to supply energy services exceeds current demands.



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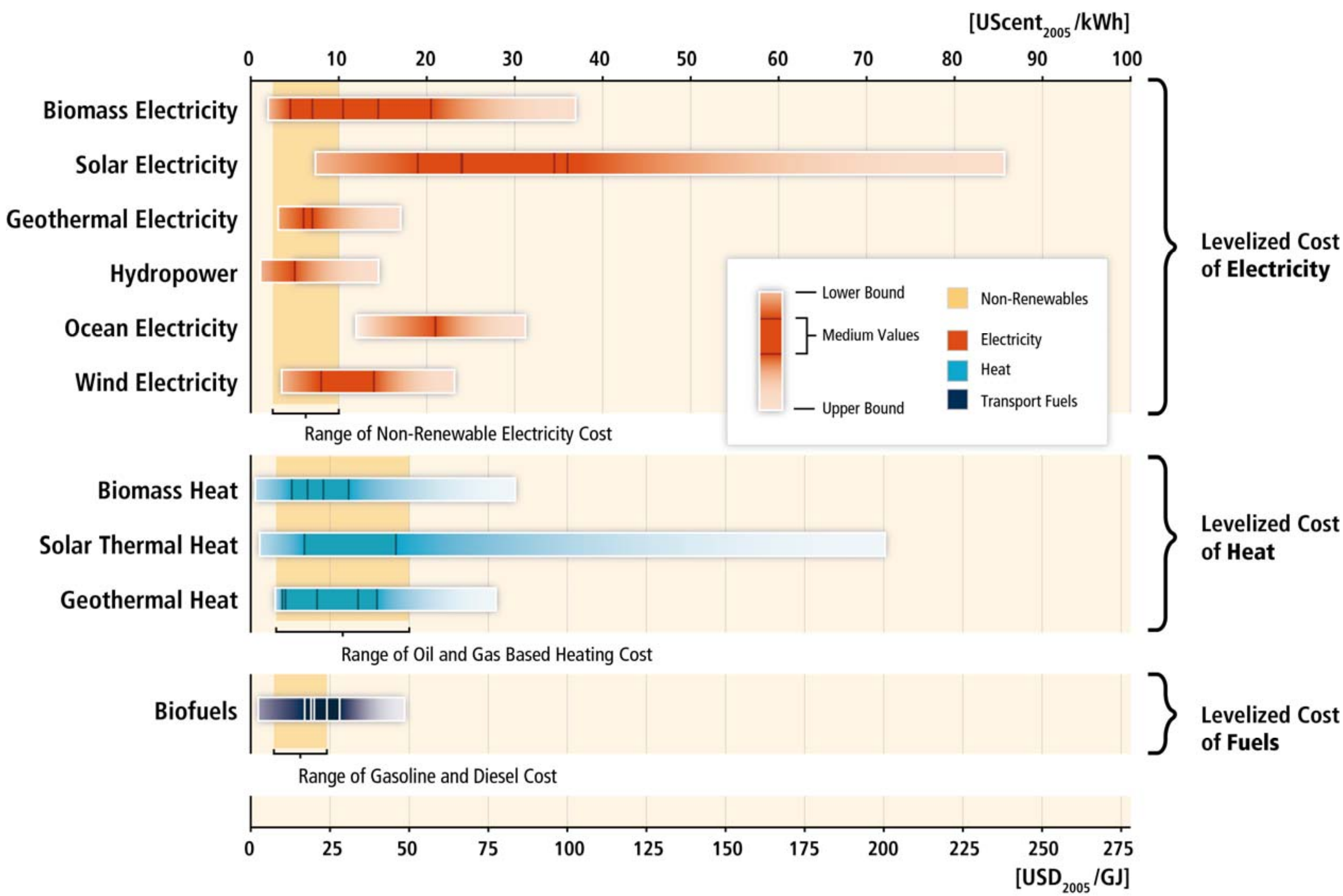
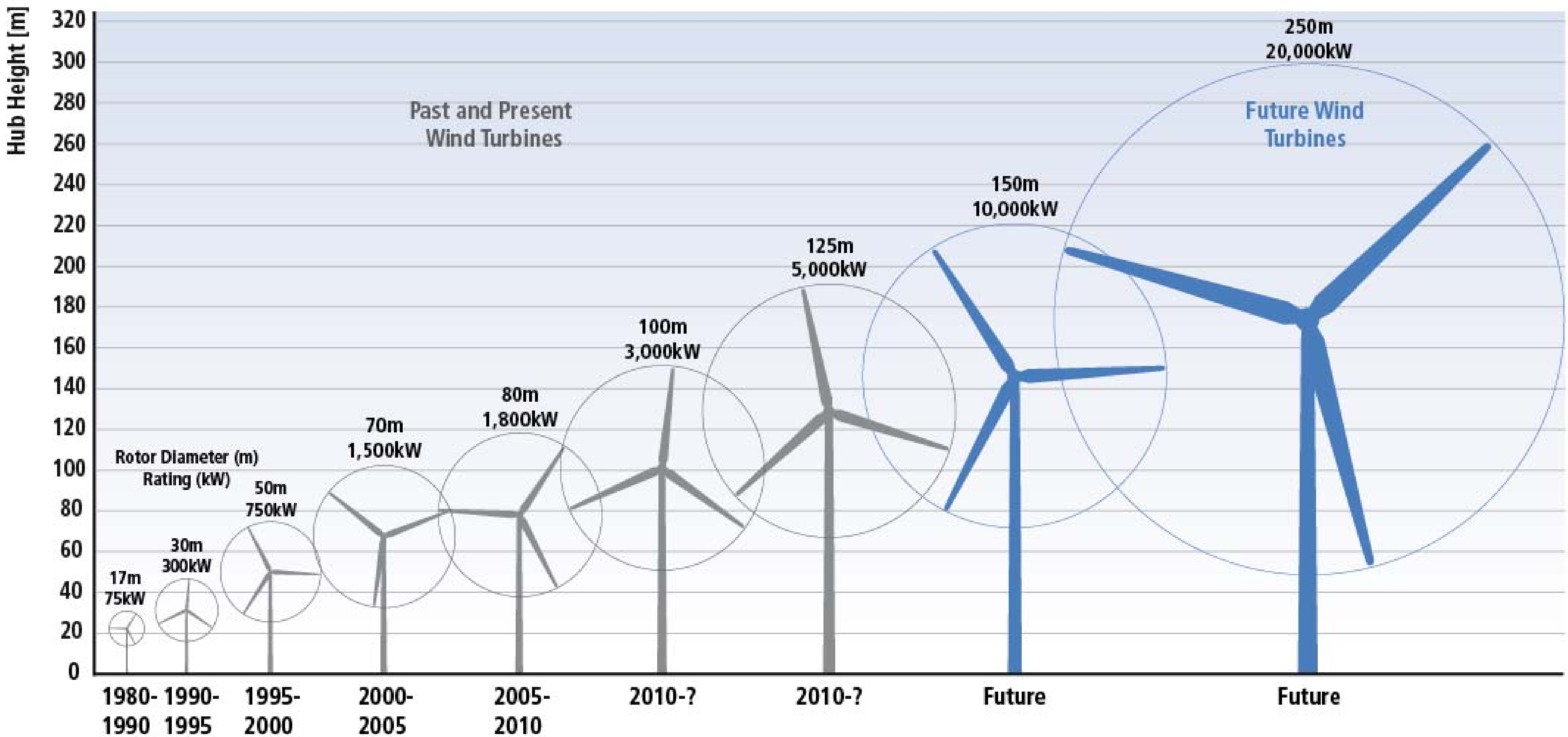
RE costs are still higher than existing energy prices but in various settings RE is already competitive.



Technical Advancements: For instance growth in size of typical commercial wind turbines.



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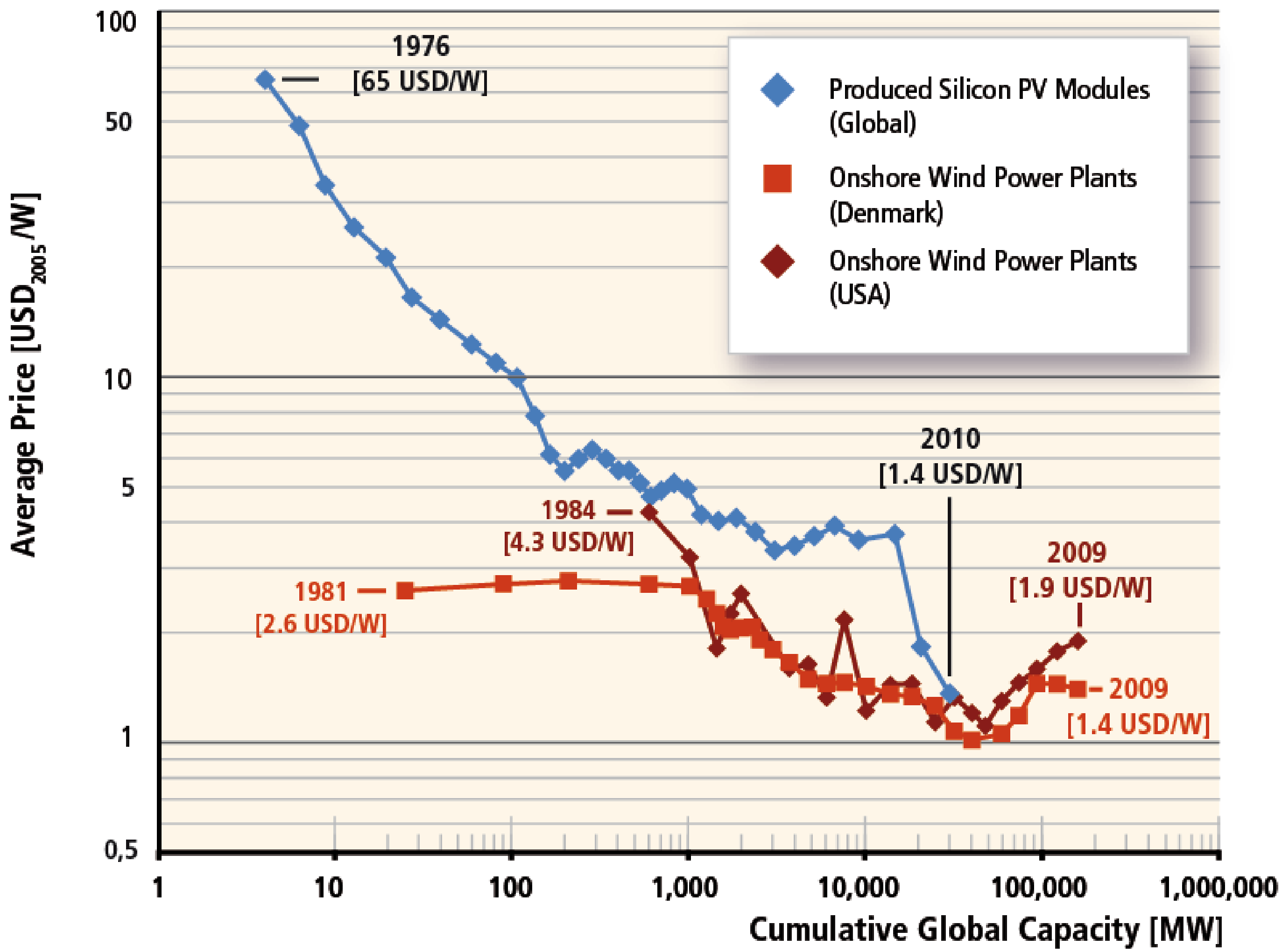
RE costs have declined in the past and further declines can be expected in the future.



Integration characteristics for a selection of RE technologies

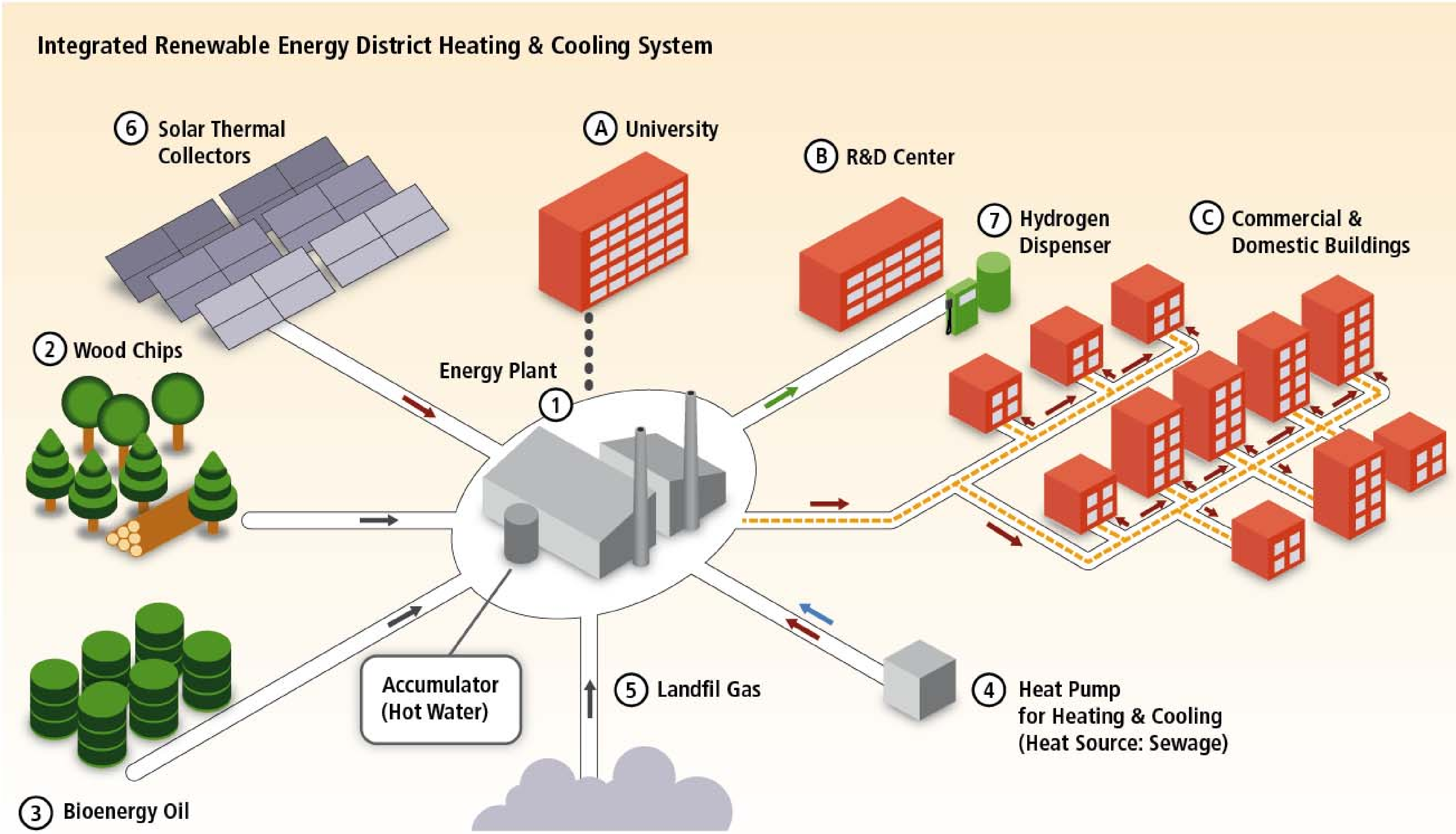
		Plant size range	Variability: Characteristic time scales for power system operation	Dispatchability	Geographical diversity potential	Predictability	Capacity factor range	Capacity credit range	Active power, frequency control	Voltage, reactive power control
		(MW)	Time scale		Quality ranking		%	%	Quality ranking	
Bioenergy		0.1 - 100	Seasons (depending on biomass availability)	+++	+	++	50 - 90	Similar to conventional thermal and CHP	++	++
Direct solar energy	PV	0.004 – 100 modular	Minutes - years	+	++	+	12 –27	25-75%	+	+
	CSP with thermal storage *	50 - 250	Hours – years	++	+ **	++	35-42	90%	++	++
Geothermal energy		2 - 100	Years	+++	N/A	++	60 – 90	Similar to conventional thermal	++	++
Hydro power	Run of river	0.1 - 1500	Hours – years	++	+	++	20 – 95	0 – 90	++	++
	Reservoir	1 – 20000	Days – years	+++	+	++	30 - 60	Similar to conventional thermal	++	++
Ocean Energy	Tidal range	0.1- 300	Hours – days	+	+	++	22.5 - 28.5	<10%	++	++
	Tidal current	1-200	Hours – days	+	+	++	19-60	10-20	+	++
	Wave	1- 200	Minutes - years	+	++	+	22-31	16	+	+
Wind energy		5– 300	Minutes - years	+	++	+	20 – 40 on-shore, 30-45 off-shore	5-40	+	++

Capacity credit is an indicator for the reliability of a generation type to be available during peak demand hours.

		[...]	Capacity credit range
		[...]	%
Bioenergy		[...]	Similar to conventional thermal and CHP
Direct solar energy	PV	[...]	25-75%
	CSP with thermal storage *	[...]	90%
Geothermal energy		[...]	Similar to conventional thermal
Hydro power	Run of river	[...]	0 – 90
	Reservoir	[...]	Similar to conventional thermal
Ocean Energy	Tidal range	[...]	<10%
	Tidal current	[...]	10-20
	Wave	[...]	16
Wind energy		[...]	5-40

If a type of generation has low capacity credit,
then the available output tends to be low during high demand periods.

An integrated RE-based energy plant in Lillestrøm, Norway, supplying commercial and domestic buildings



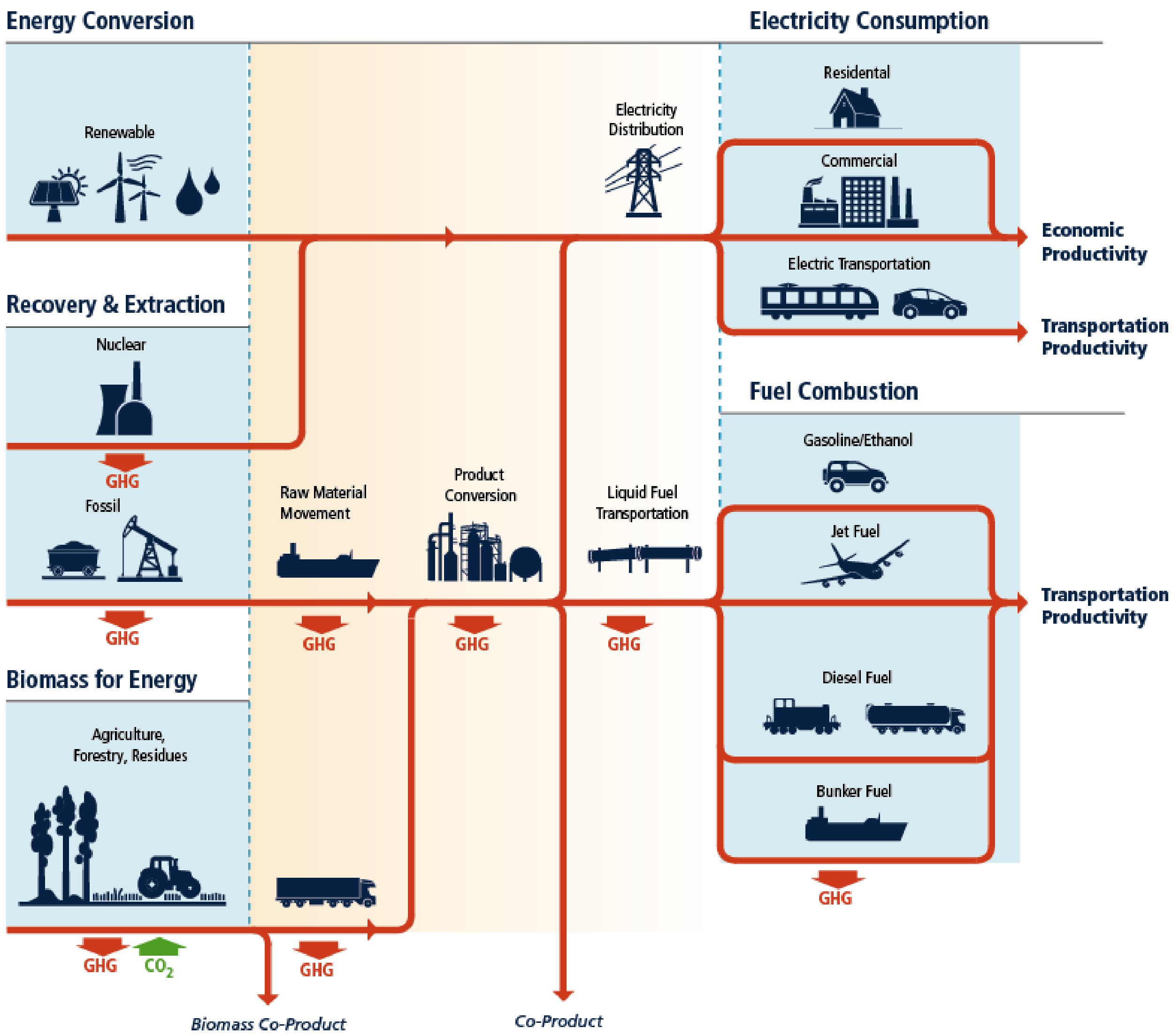
Few, if any, fundamental technical limits exist to the integration of a majority share of RE, but advancements in several areas are needed.

- Transmission and distribution infrastructure
- Energy storage technologies
- Demand side management
- Improved forecasting of resource availability

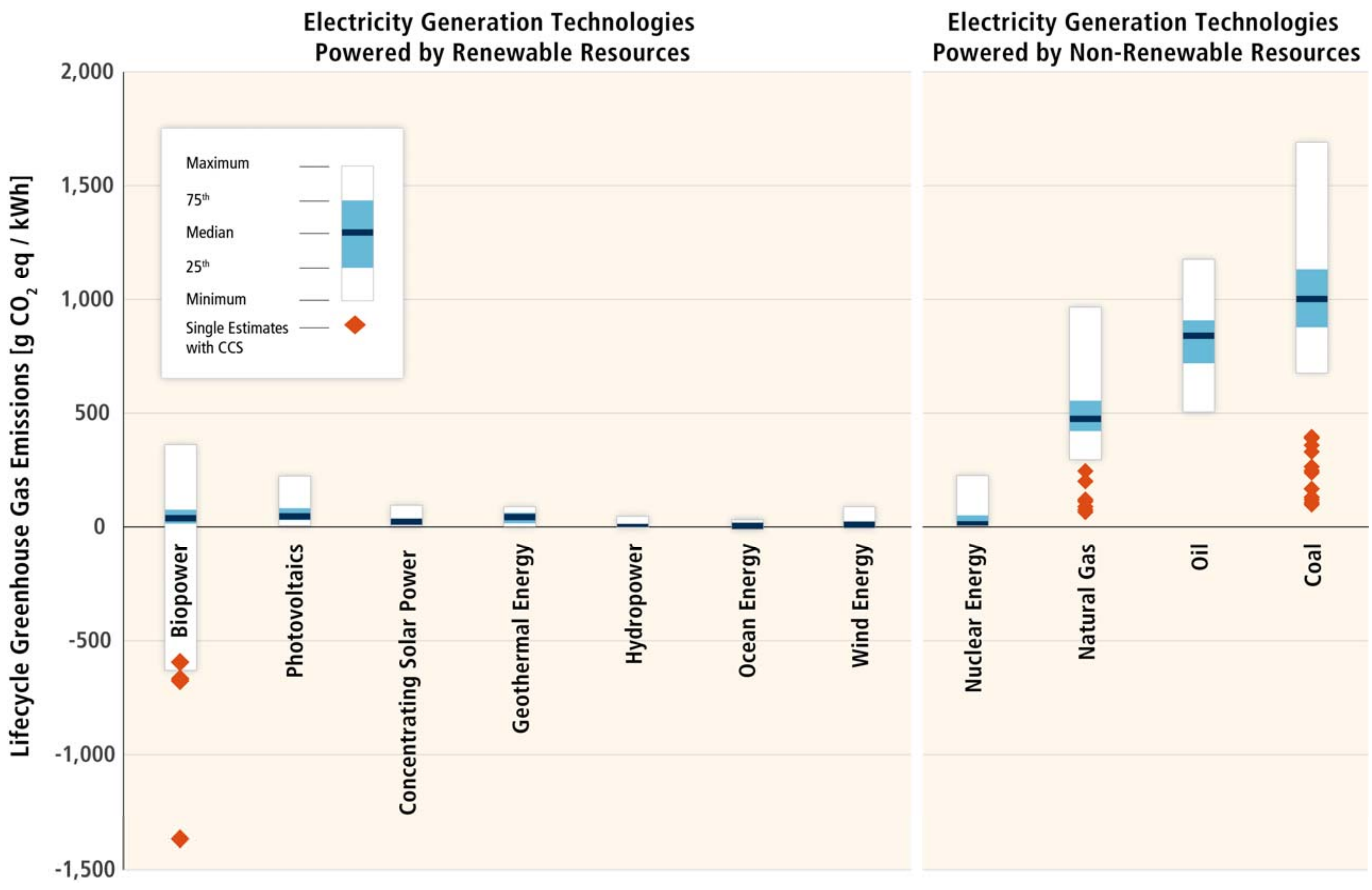
RE can contribute to sustainable development.

- RE can accelerate access to energy, particularly for the 1.4 billion people without access to electricity and the additional 1.3 billion people using traditional biomass.
- RE deployment can reduce vulnerability to supply disruptions and market volatility.
- Low risk of severe accidents
- Environmental and health benefits

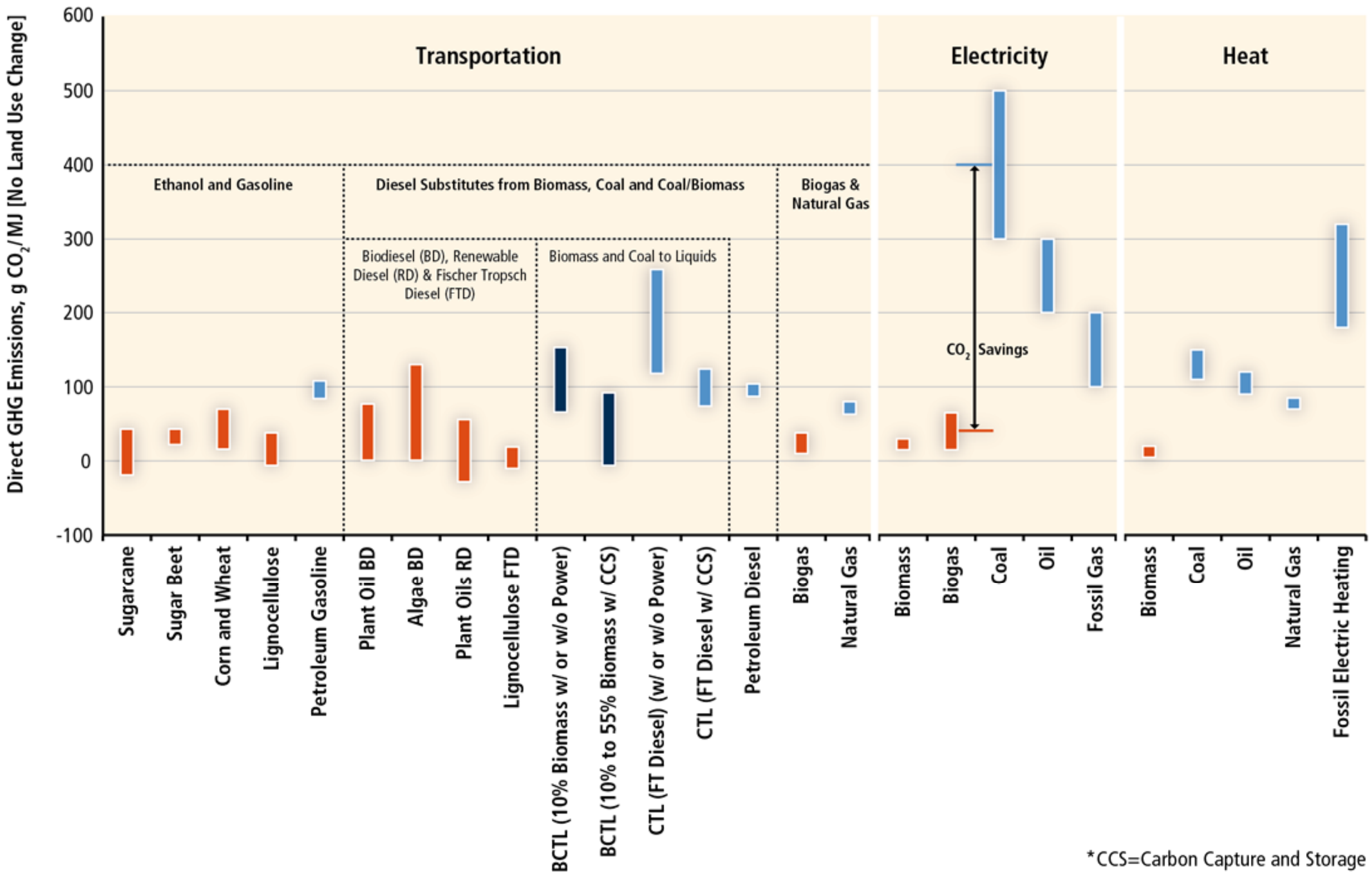
A systemic approach is needed for a comparison of “cradle to grave” emissions.



Lifecycle GHG emissions of RE technologies are, in general, considerably lower than those of fossil fuel options.



GHG emissions from modern bioenergy chains compared to fossil fuel energy systems, excluding land-use change effects.



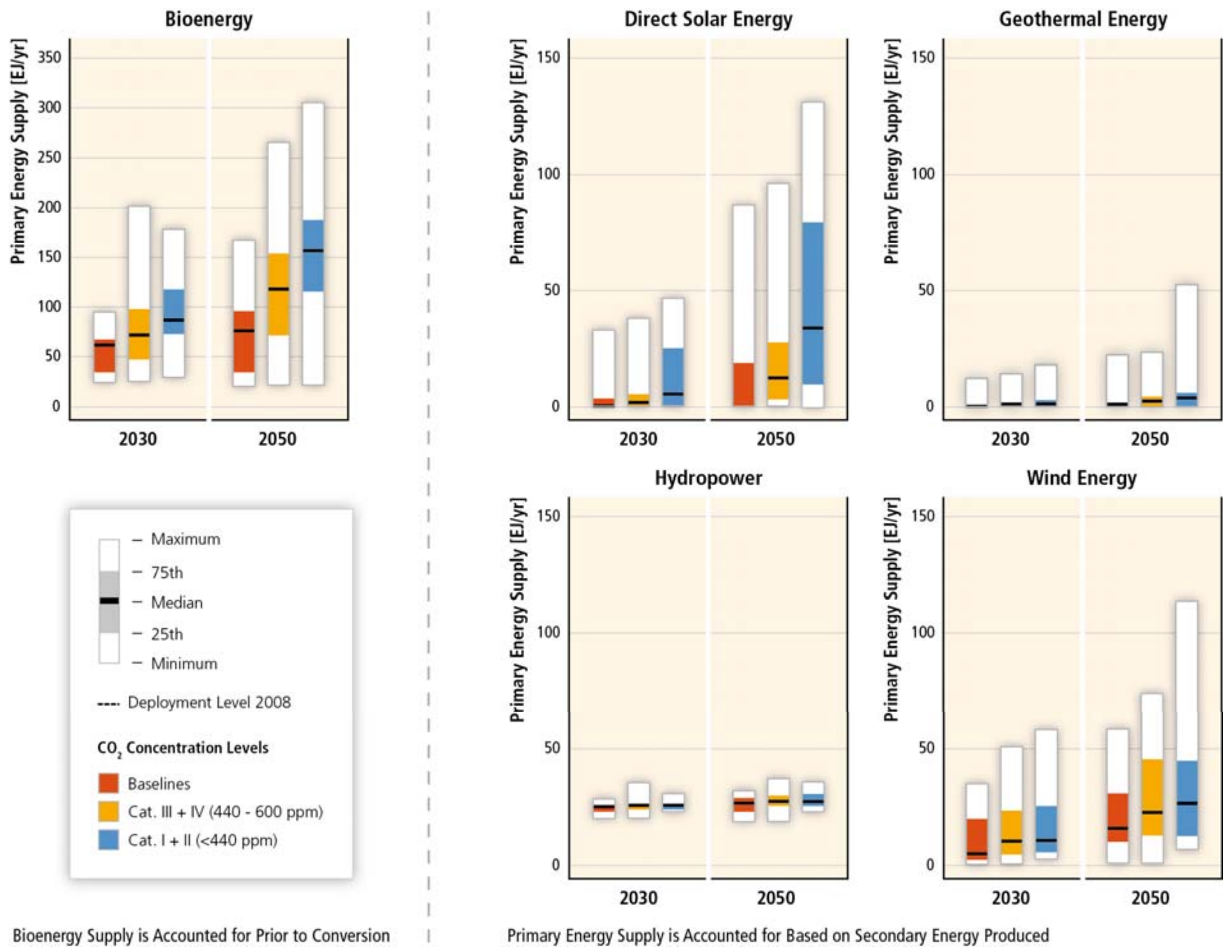
*CCS=Carbon Capture and Storage

Land-use change and bioenergy

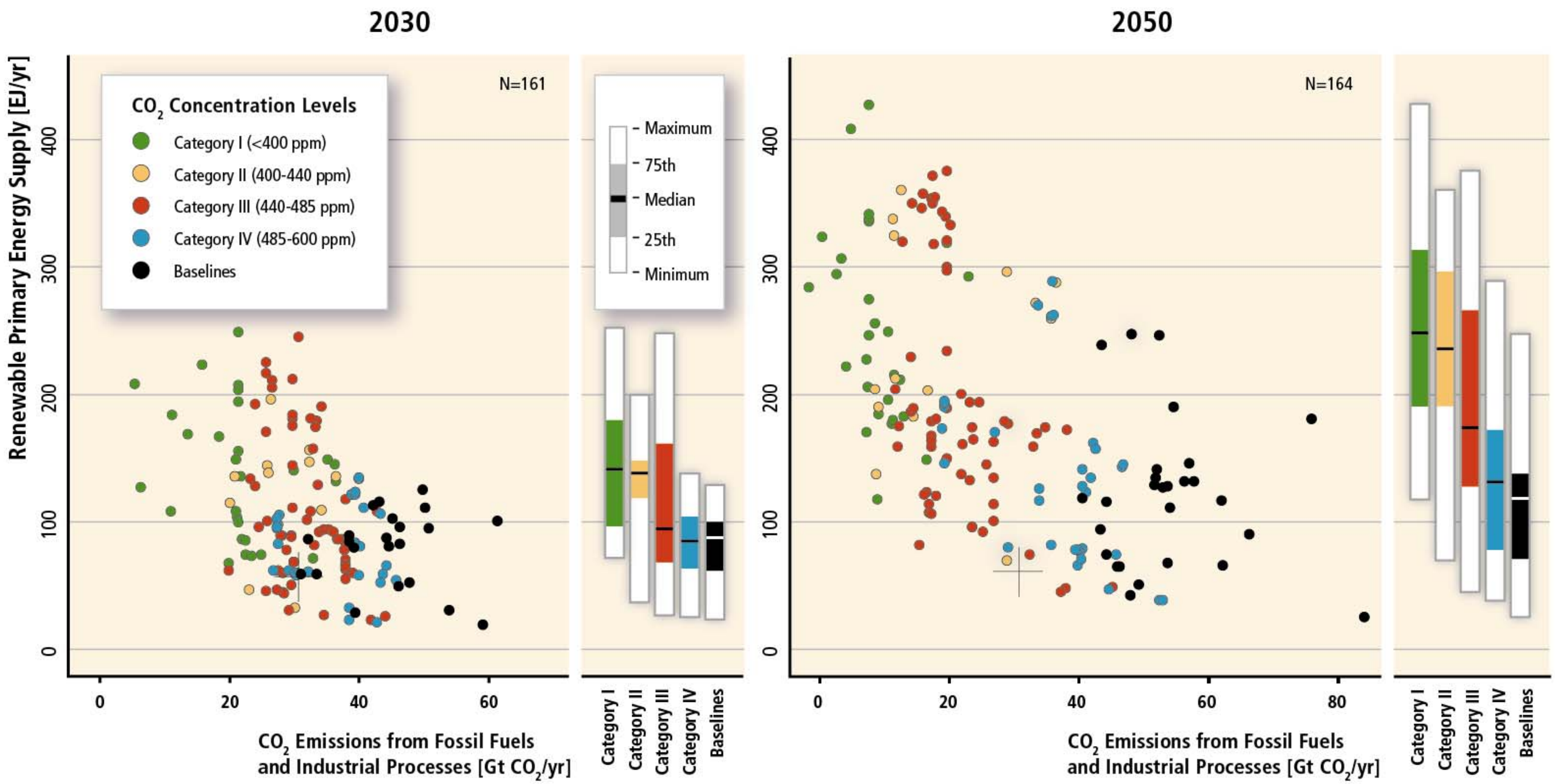
- The positive greenhouse gas balance of biofuels can be affected by direct and indirect land-use changes.

- Proper governance of land-use, zoning, and choice of biomass production systems are key challenges for policy makers.

RE deployment increases in scenarios with lower greenhouse gas concentration stabilization levels.



Global RE primary energy supply from 164 long-term scenarios versus fossil and industrial CO_2 emissions.



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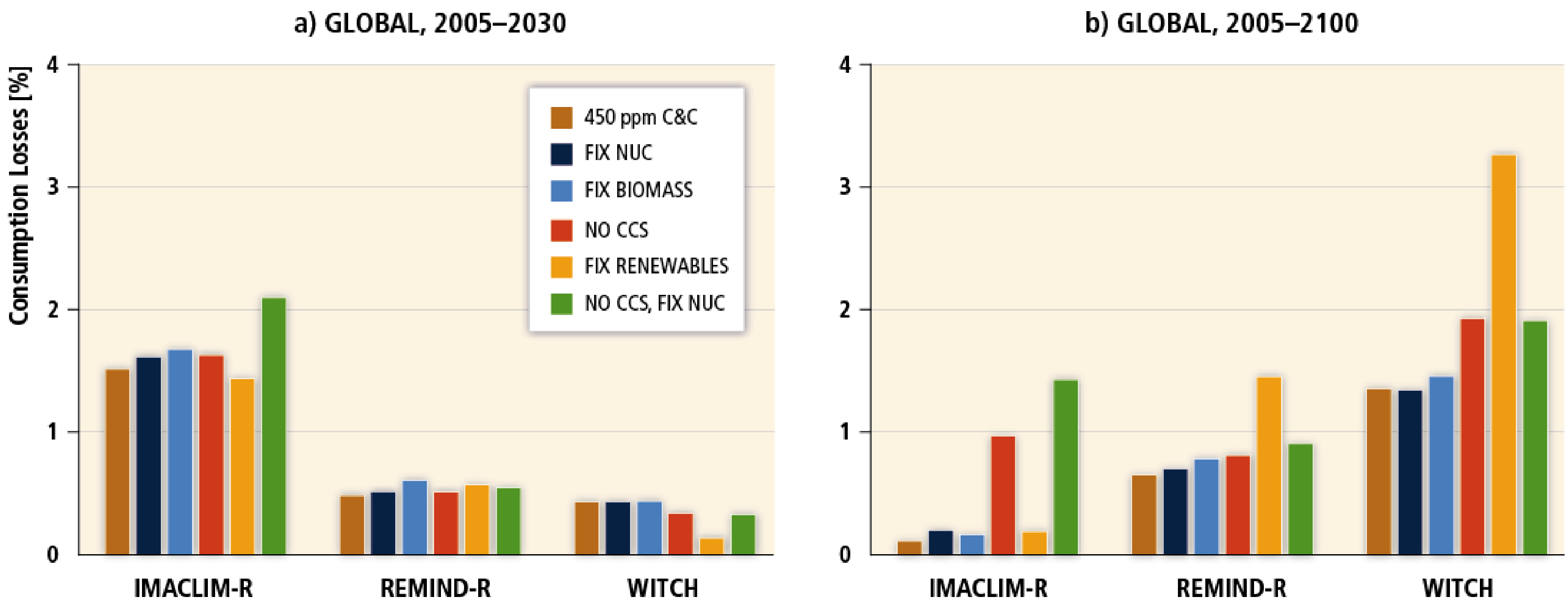
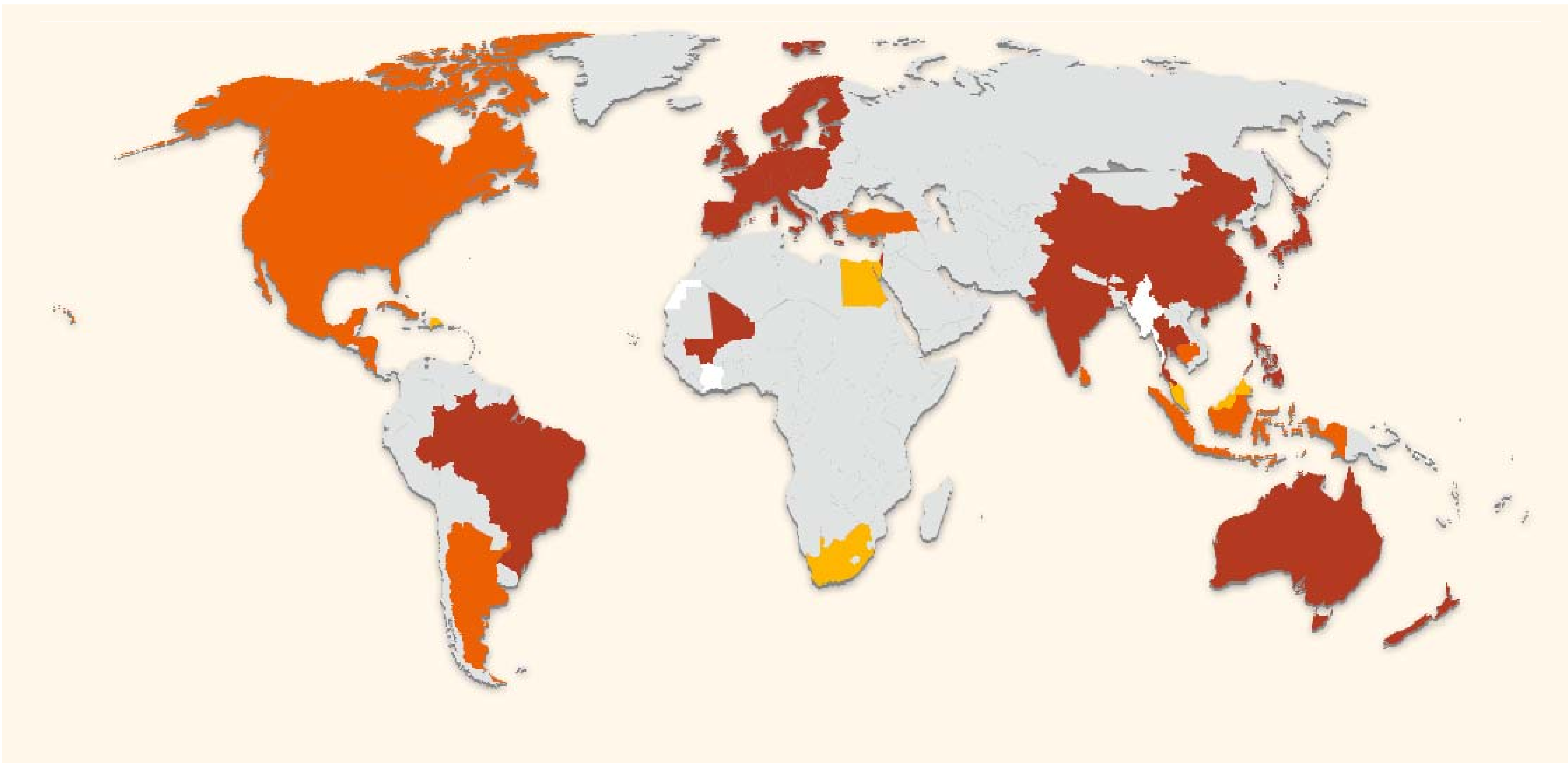
Mitigation Costs



RE and Climate Change Mitigation Policies
2004



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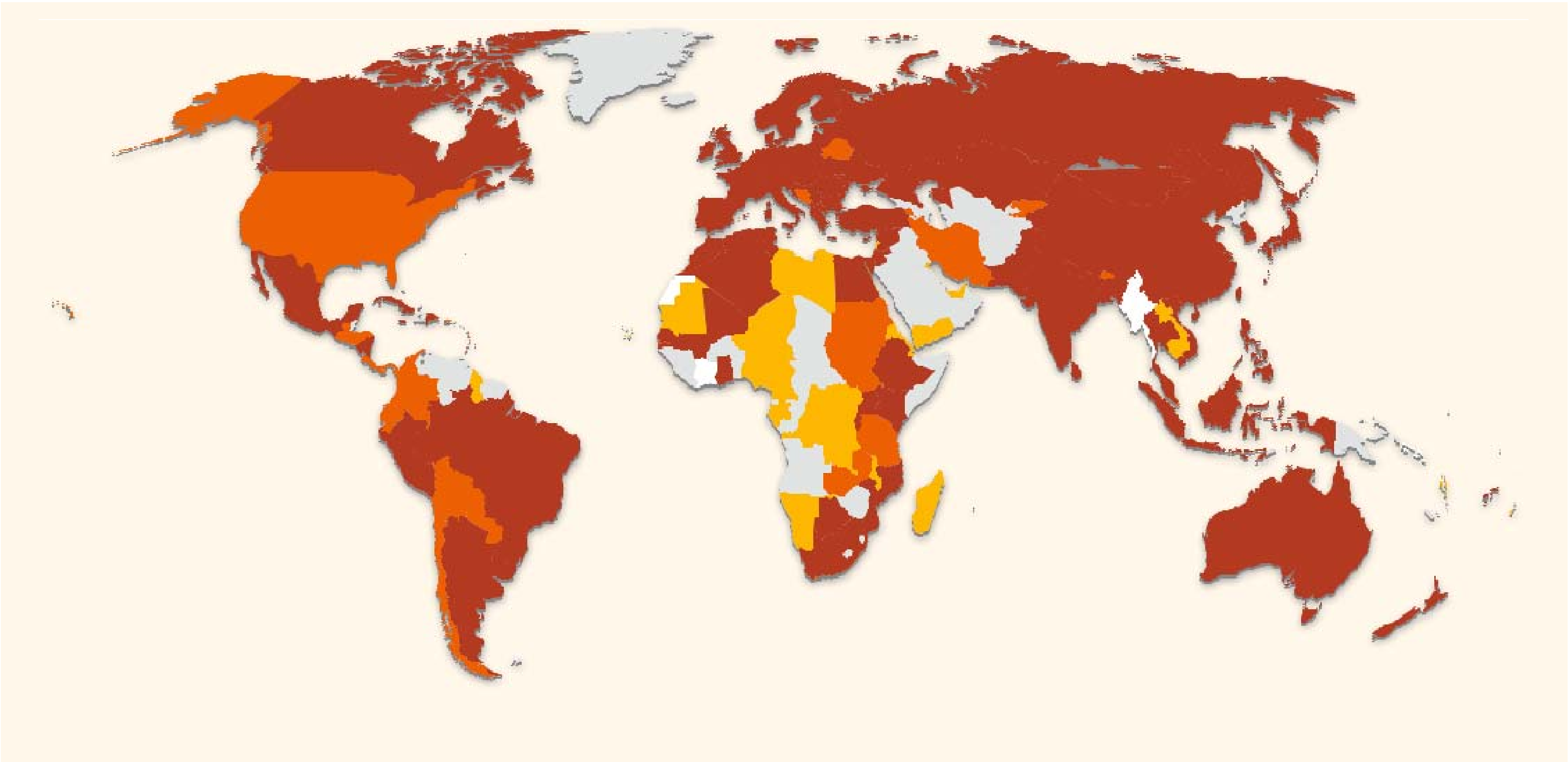
RE and Climate Change Mitigation Policies 2011



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Conclusion (I)

- Close to 80 percent of the world‘s energy supply could be met by renewables by mid-century if backed by ambitious climate policies combined with the right enabling public policies.
- High deployment rates are consistent with increasing energy access for the world‘s poor population, improved security for energy supply and human well-being.

Conclusion (II): This pathway is not without risks

- Renewables need further technological progress which leads to decreasing costs.
- The costs of integration into an existing energy system are not quantified yet.
- High deployment rates of bioenergy have opportunities but also risks, like direct and indirect land-use change.
- Climate and renewable energy policies could contradict each other.

Conclusion (III): Dealing with unknown unknowns

- The existing scientific knowledge is significant and can already facilitate the decision-making process.
- The report has identified the most important known unknowns (e.g. future cost and timing).
- However, the unknown unknowns require the flexibility to learn from experience and to adapt to inconvenient and convenient experiences.