Renewable sources of energy

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What are RES?

- Renewable energy is energy derived from natural processes that is replenished at a higher rate than it is consumed.
- Solar, wind, geothermal, hydropower, bioenergy, ocean power.
- Traditional vs. „new“ renewables.
- Variable/non-dispatchable (wind, solar) vs. dispatchable (hydro, biomass/biogas) RES.
- Capacity factor – ratio of actual electrical energy output over a given period of time to the maximum possible electrical energy output over that period. Differs by region and instalation.

Conventional	Renewables
Can be stored indefinitely in arbitrary quantities (left in the ground)	Only few RES technologies readily allow mass storage (hydro dams, biomass). Other cannot be stored at all or only in small quantities
Require extraction	Freely available
Finite reserves	Constantly replenished
Not strongly exposed to meteorological factors	Subject to meteorological and climate conditions
Key parts of the supply chain localised (ports, pipelines, refineries, plants)	Large potential for decentralisation
Exploation requires large, dedicated infrastructure at site of extraction	Exploation done at micro level (small PV panels) up to large scale (large hydro)
Long-distance transport of primary resource common	Long-distance transport of primary resource impossible (with exception of biomass)

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Decarbonization of the global energy system

- Could RES be the pillar of the (global) energy system?
- What is the growth potential?

= are they ready to meet some substantial share of energy demand of society?

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Industry (technology) life cycle - government perspective

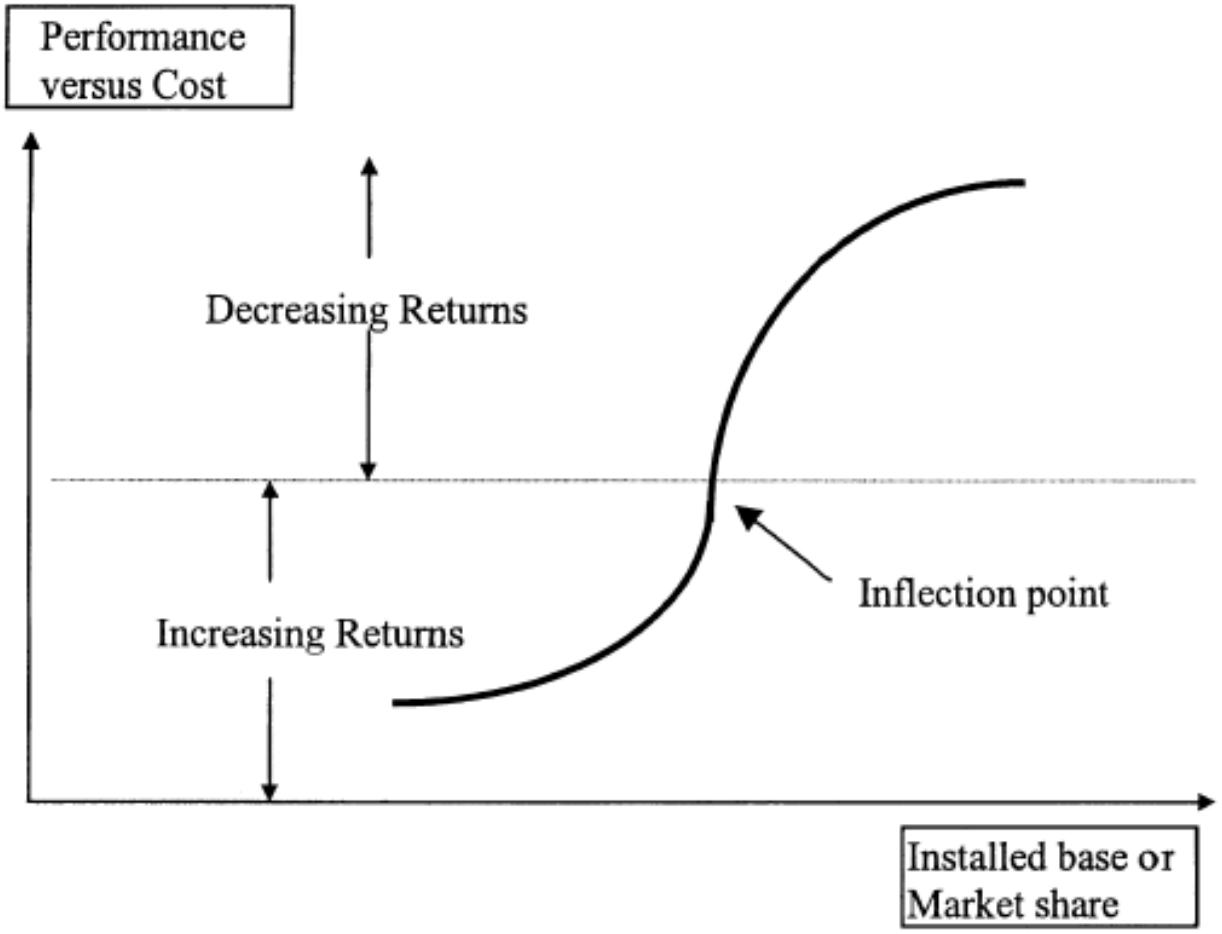
1) Inception phase – creating a climate allowing investment in early projects.

2) Take-off phase - managing support policy costs (efficient support structure), dealing with non-economic barriers, supporting an indigenous supply chain to develop.

3) Consolidation phase – integrating a mature technology to the system (RES can no longer be considered in isolation due to their impacts across the whole energy/power system that needs to acomodate them). Grid integration issues. Public acceptance. Integration in the financial dimension of the market.

4) Decline (?)

Deployment curve



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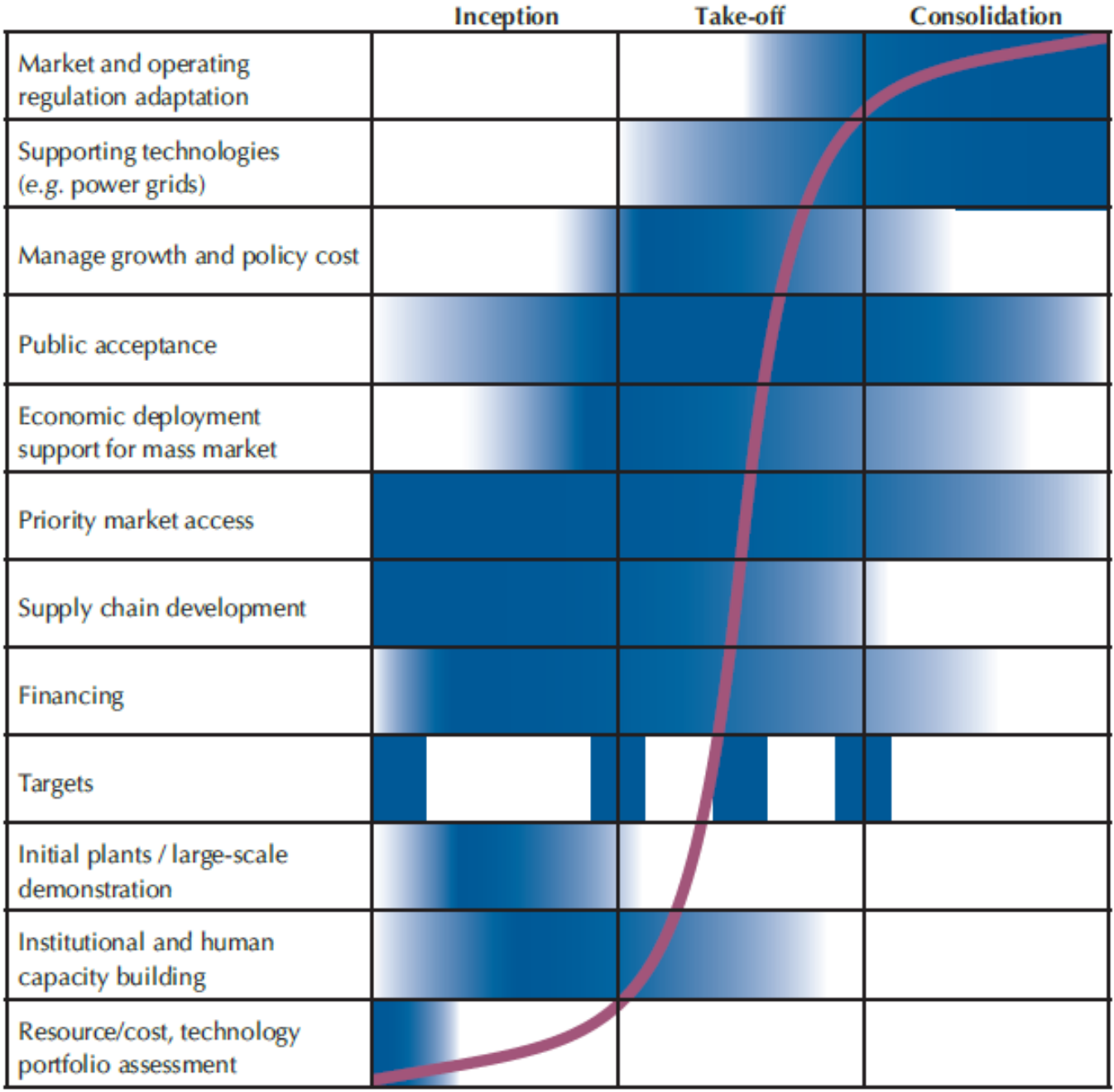
RES deployment curve



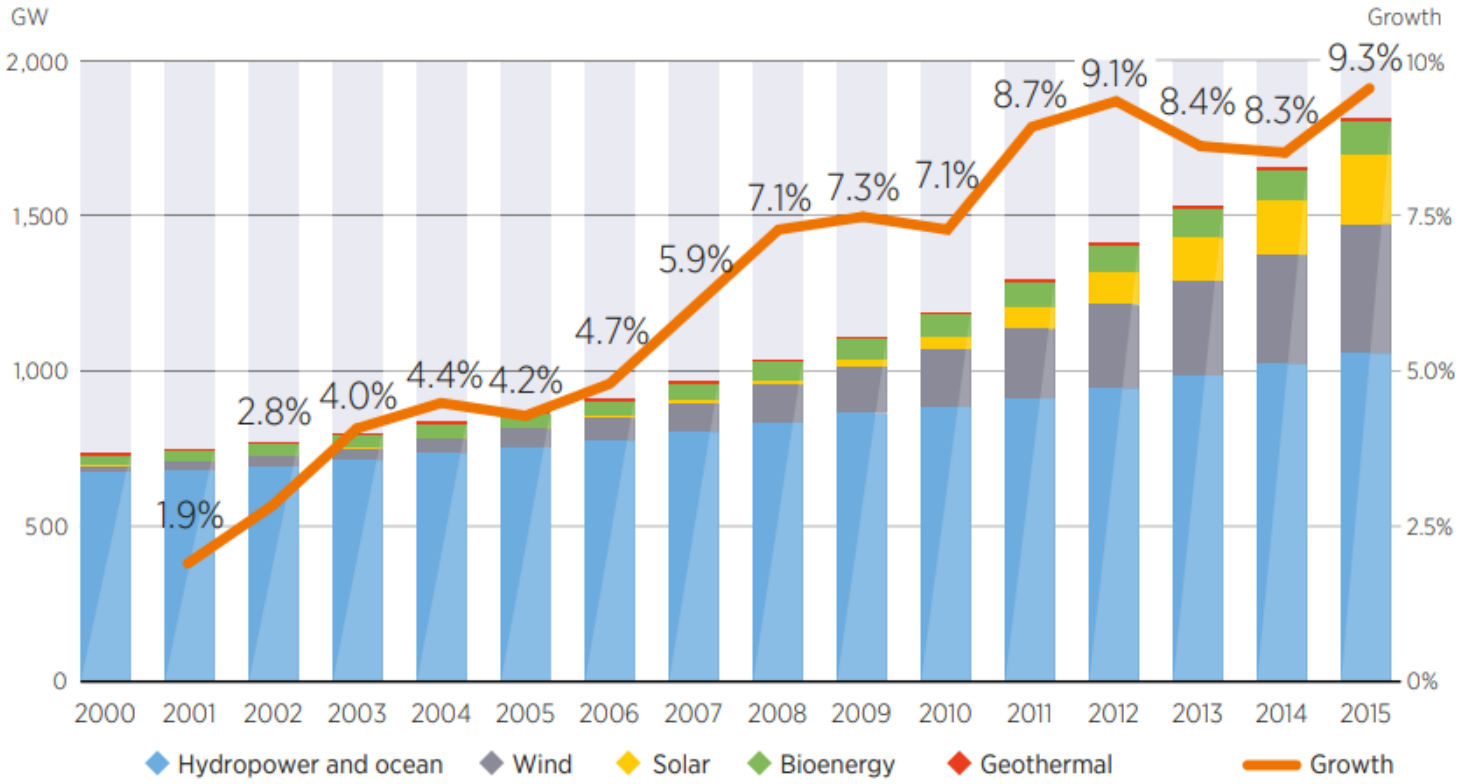
Inception phase

Drivers for deployment

- **Environmental (climate) concerns.**
- Energy security.
- Rural development.
- Employment.
- High-tech manufacturing.

Inception phase

- Targets combined with financial and regulatory support to create market for RES and decrease investment risks.



Renewable power capacity and annual growth rate, 2000-2015.

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Take-off

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Take off phase - barriers

Sector and barriers	Cost barriers	Regulatory barriers	Market entry barriers	Technical barriers
Electricity	Relatively high initial capital costs for some technologies; subsidies for fossil fuels and nuclear power; unfavorable power pricing rules	Non-existent or insufficient legal framework for independent producers; restrictions on siting, construction and transmission access; arduous permitting processes and utility interconnection requirements; inadequate market operation rules	Lack of access to credit; higher cost of capital due to lack of experience; perceived technology performance uncertainty and risk; lack of technical or commercial skill and information	Integrating high shares of variable renewable energy (VRE) into existing grids

Take off phase - barriers

Sector and barriers	Cost barriers	Regulatory barriers	Market entry barriers	Technical barriers
Heat	High initial capital costs compared to well-established conventional systems, such as gas boilers; subsidies for fossil fuels	Arduous permitting processes	Lack of access to credit and financial incentives; lack of local technical or commercial skills; insufficient public awareness of available technologies and the broad spectrum of application options	Integrating renewable heating and cooling systems into existing infrastructure; distributed nature of consumption; fragmentation of heating and cooling markets

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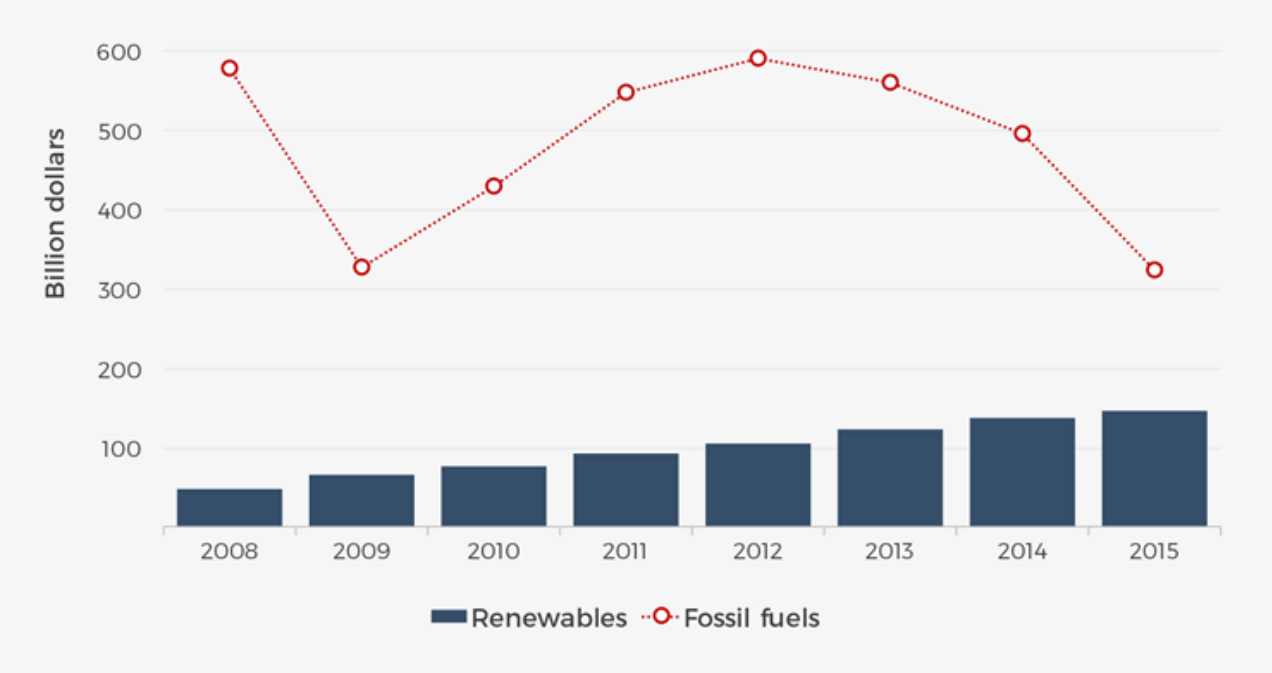
Sector and barriers	Cost barriers	Regulatory barriers	Market entry barriers	Technical barriers
Transport (biofuels)	Higher costs relative to conventional fuels, in some markets		Lack of government policy to set up charging infrastructure; cumbersome permitting process for setting up charging stations	Immaturity of third-generation technology
Transport (electricity)	High cost for renewable energy technologies in personal vehicle transport relative to existing technologies	Lack of government policy to set up charging infrastructure; cumbersome permitting process for setting up charging stations	Lack of energy infrastructure (e.g., electric vehicle (EV) charging stations)	Immaturity of technology; relatively short vehicle range

Economy of RES

Economic barriers - present when the cost of a technology is above the cost of competing alternatives. Mainly related to

- externalities of conventional technologies not internalized.
- subsidies for conventional technologies.
- level of technology maturity.

Global subsidies for fossil-fuel consumption and renewables



Coal largest source of subsidies (44%), then oil (41%), natural gas (10%), and elektricity output (4%).
China USD 1.4 trillion, U.S. USD 649 billion, Russia USD 551 billion, EU USD 289 billion, India USD 209 billion.

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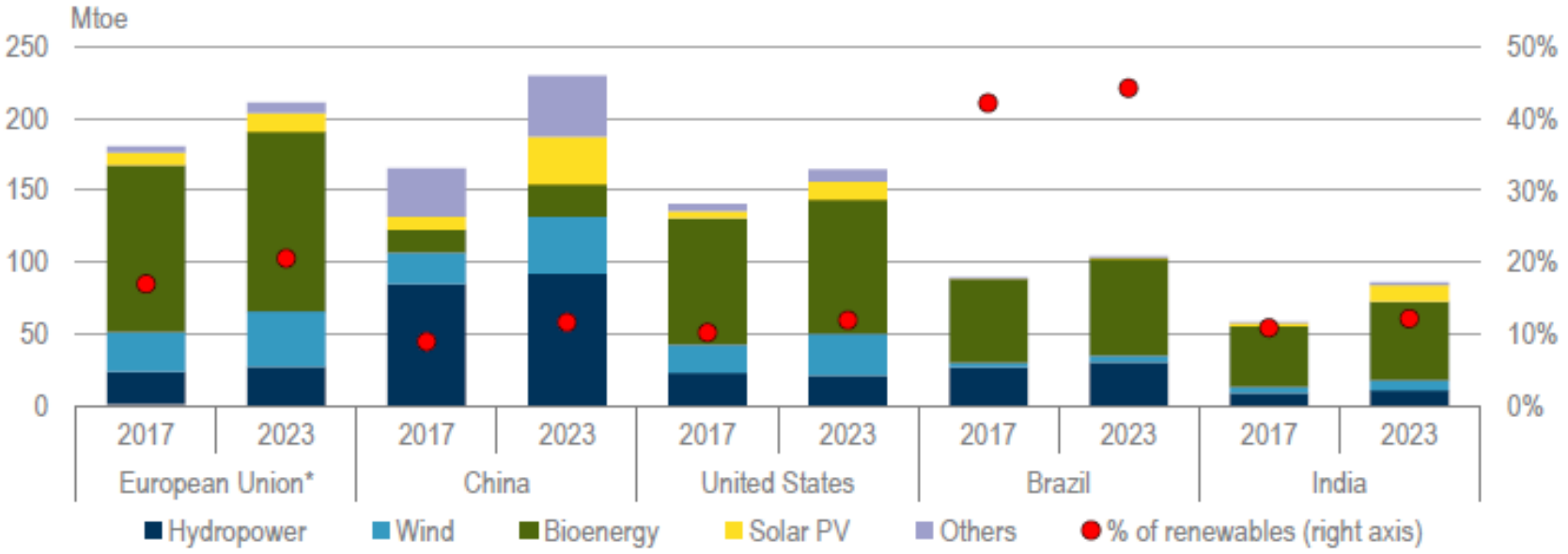
Current situation – RES consumption in major markets



- 23% of electricity.
- 5.5% of heat.
- 4% of transportation.

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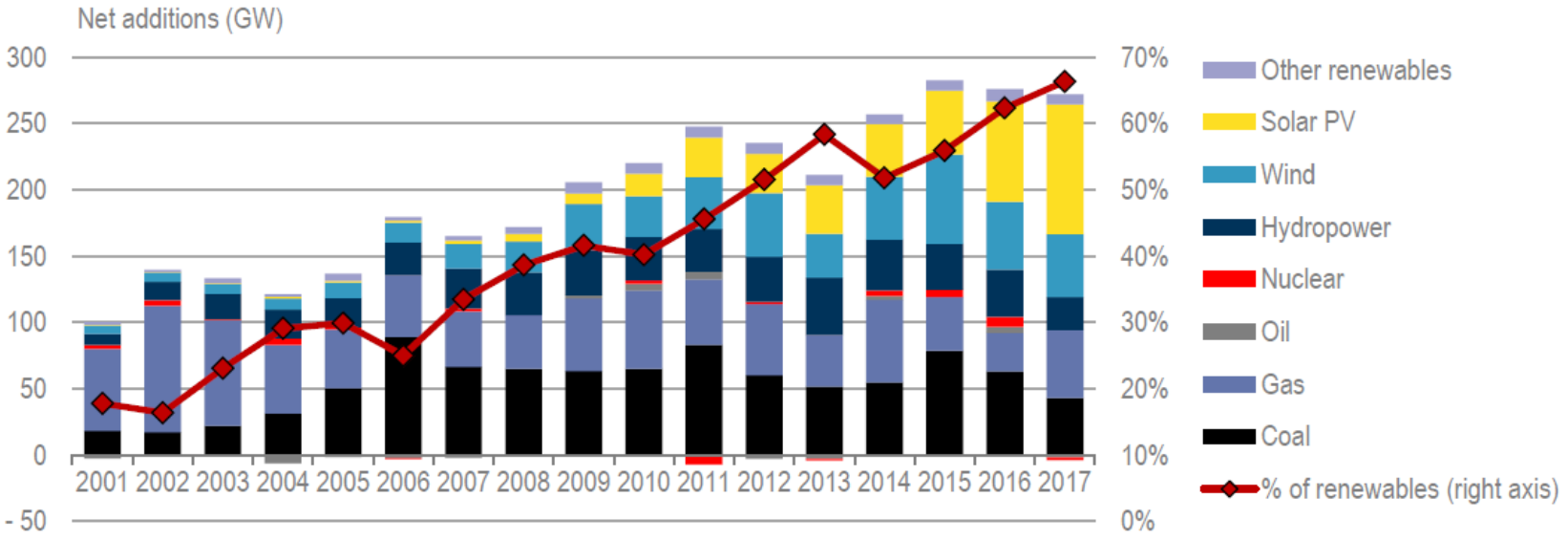
Current situation – electricity (data for 2017)

- RES accounted for more than 2/3 (75% in 2018) of global net electricity capacity growth.
- Solar expanded the most quickly at 97 GW of addictions (over half in China).
- China is responsible for 41% (438 GW) of global expansion.
- EU the second-largets growth market (124 GW operation in 2018-2023).
- Uncertain forecast in USA due to the changes in the federal tax code, trade policies etc.
- India is to double its capacity over 2018-2023 (PV, onshore wind)

Annual net electricity capacity additions by source



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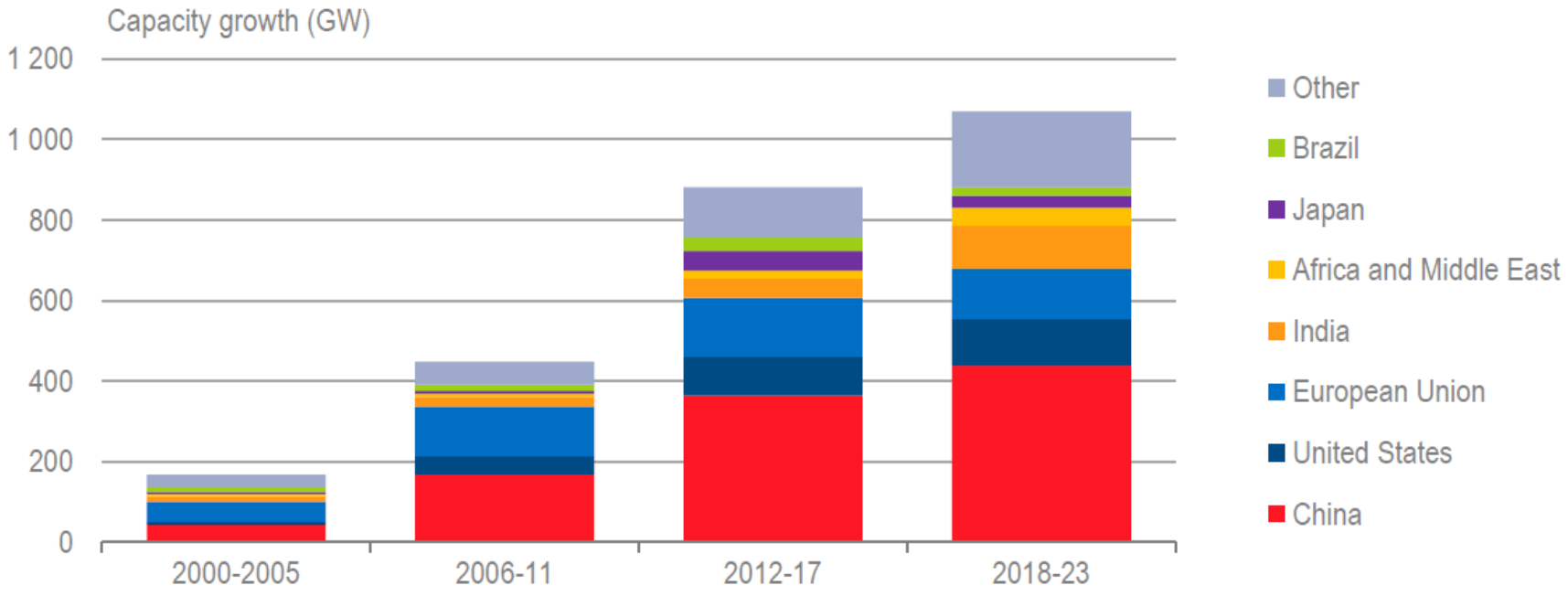
Renewable capacity growth by country/region



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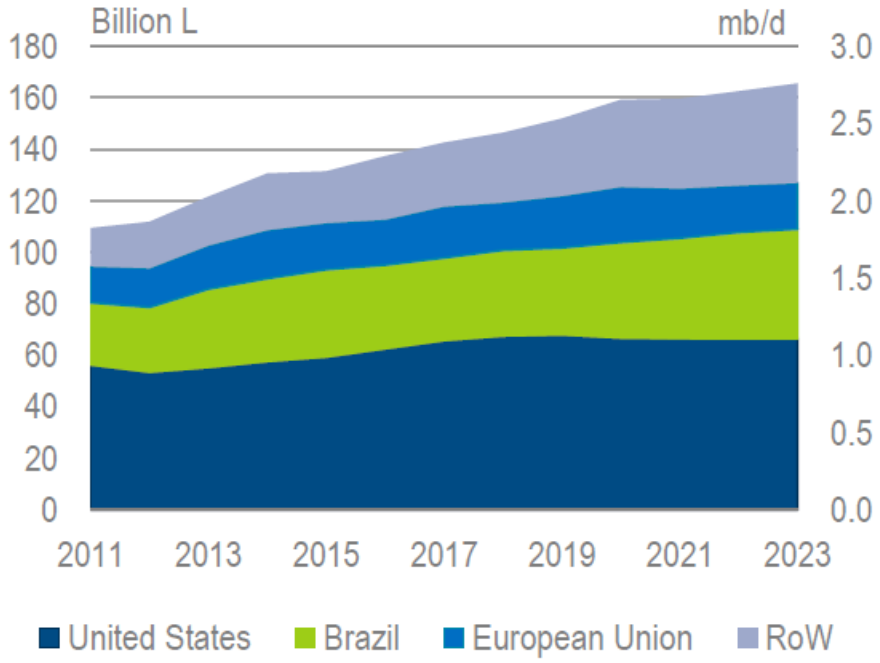
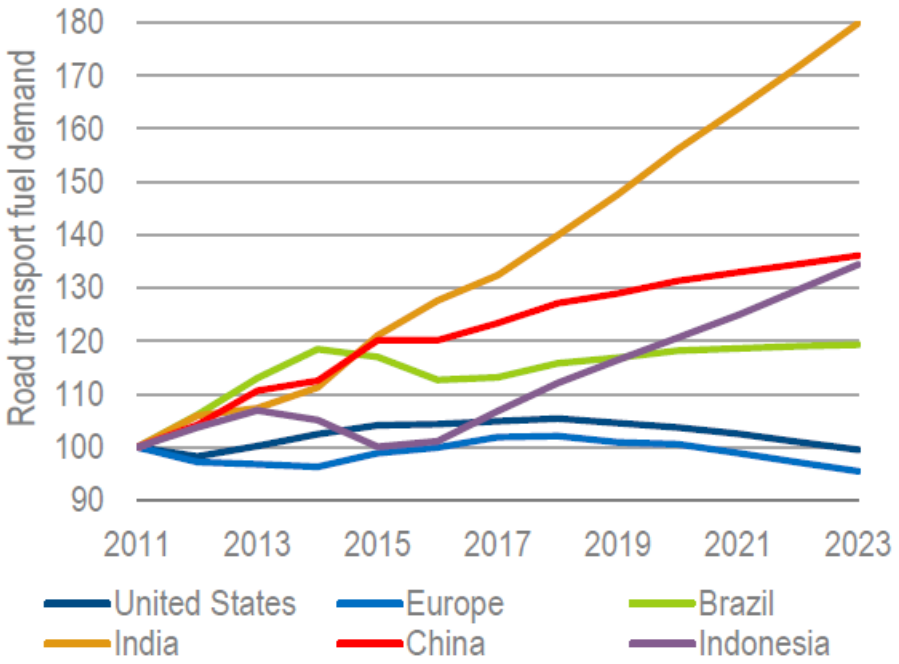
Current situation - transport

- RES met around 3.7% of transport fuel demands in 2018. 93% biofuels, elektricity the rest.
- Overal production of 154 billion litres.
- The Asia-Pacific region and China combined responsible for half of production growth (security of supply). Weakening support in the EU.
- Advanced biofuels (non-food crops, waste, residual feedstocks) expected to deliver 1.4 – 2.3 bn. litres in 2023.
- Biofuel demand in aviation sector is growing, production remains low.

Global conventinal biofuel production (L) and indexed road transport fuel demand (R)





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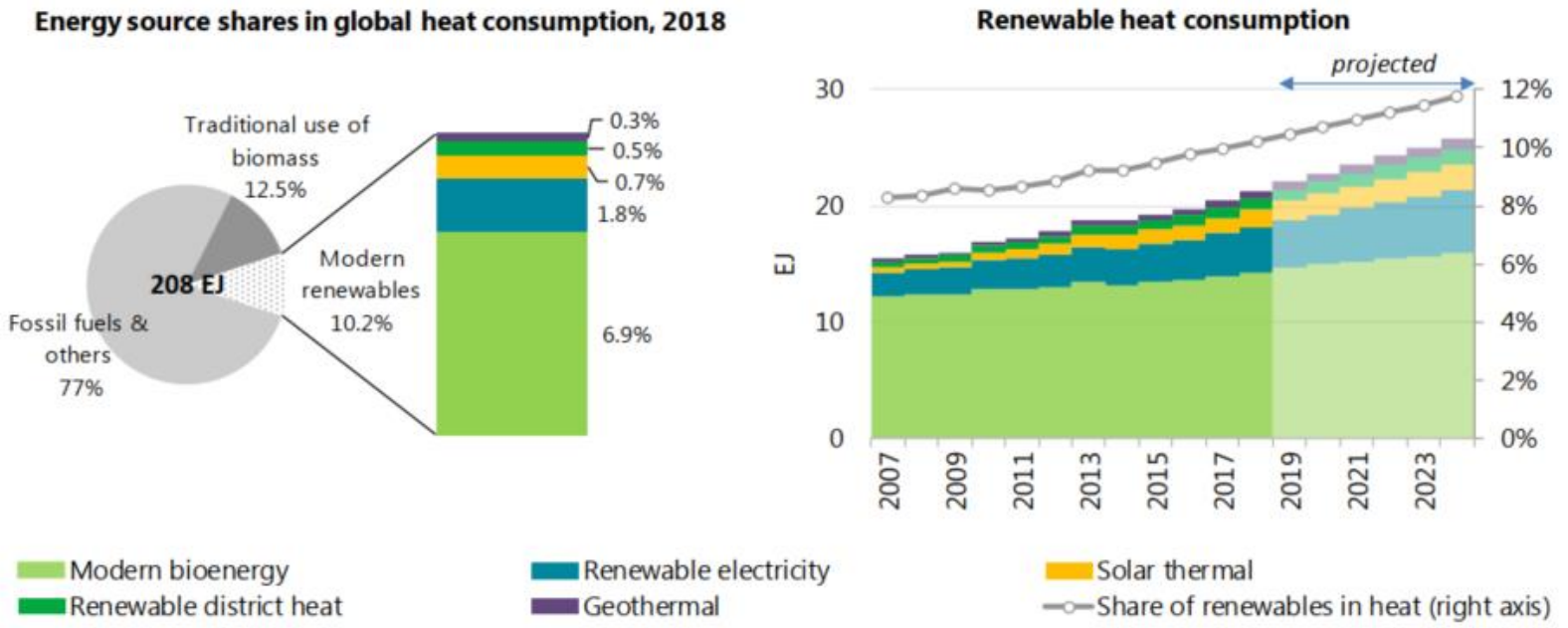
Current situation – heating /cooling

- Heat account for over half of total final energy consumption (heating houses, water, cooking, drying…) and 40% of CO_2 emissions. Modern RES only 10.2%, traditional 12.5%.
- About 50% of heat in industrial processes (iron, steal, cement, chemicals, aluminium, food, tobacco, pulp, paper…), another 46% in building for space and water heating, rest in agriculture (greenhouse heating).
- Projections fro 2019 – 2024 behind global climate change targets.
- RES electricity for heat is expected to have the 2nd largest absolute growth by 2023.

Heat consumption by source, and RES heat consumption outlook



Note: EJ = exajoules.

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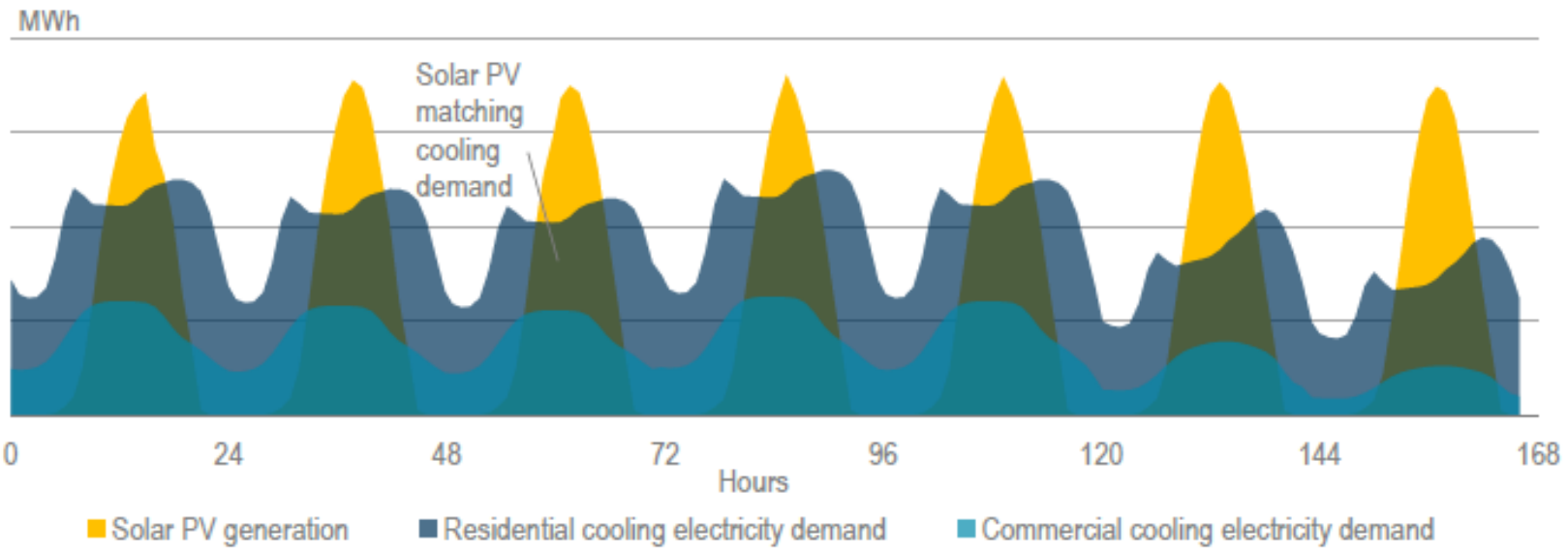
Illustrative daily profile of space cooling load and solar PV output

Cooling around 6% of energy consumption in building sector – vs. heat 80%. But increasing rapidly. Demand on the grid.



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Consolidation phase

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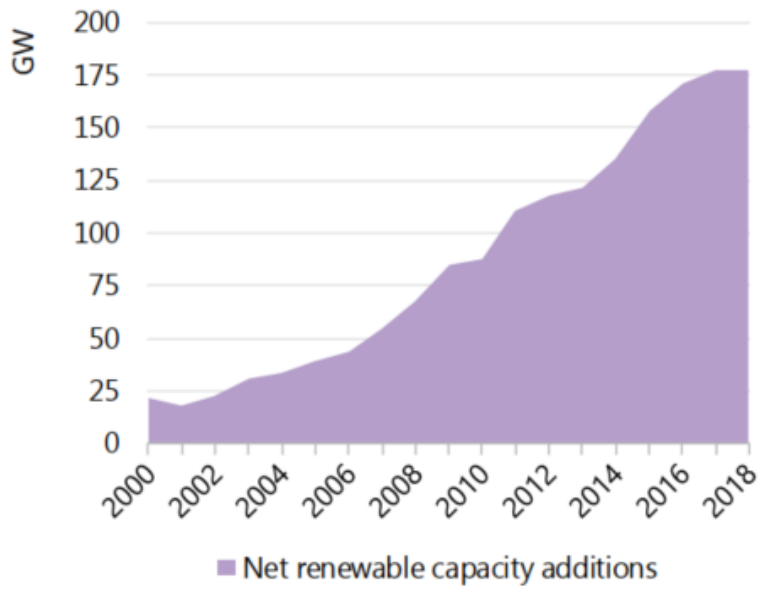
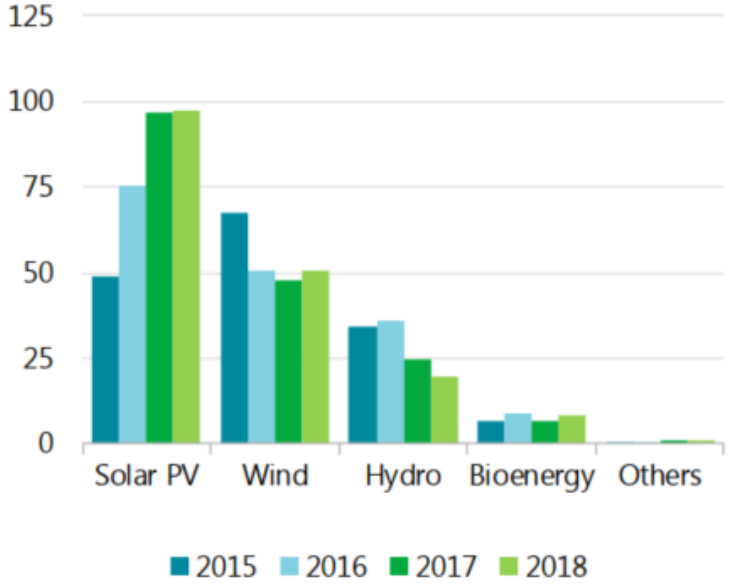
Annual net capacity additions in power sector by technology (GW)

Net renewable capacity additions in power sector stopped to increase year-on-year.





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Auctions

- About 2/3 of all new utility-scale renewable capacity over next 5 years will be competitively set. (China PV, EU PV and wind…).
- Focused primarily on solar PV and wind.

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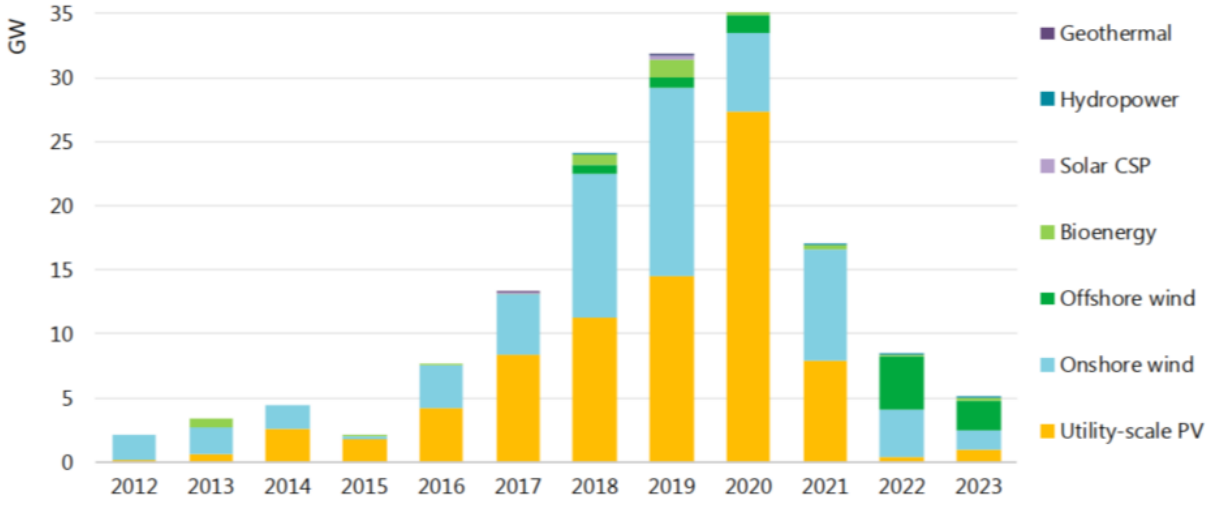
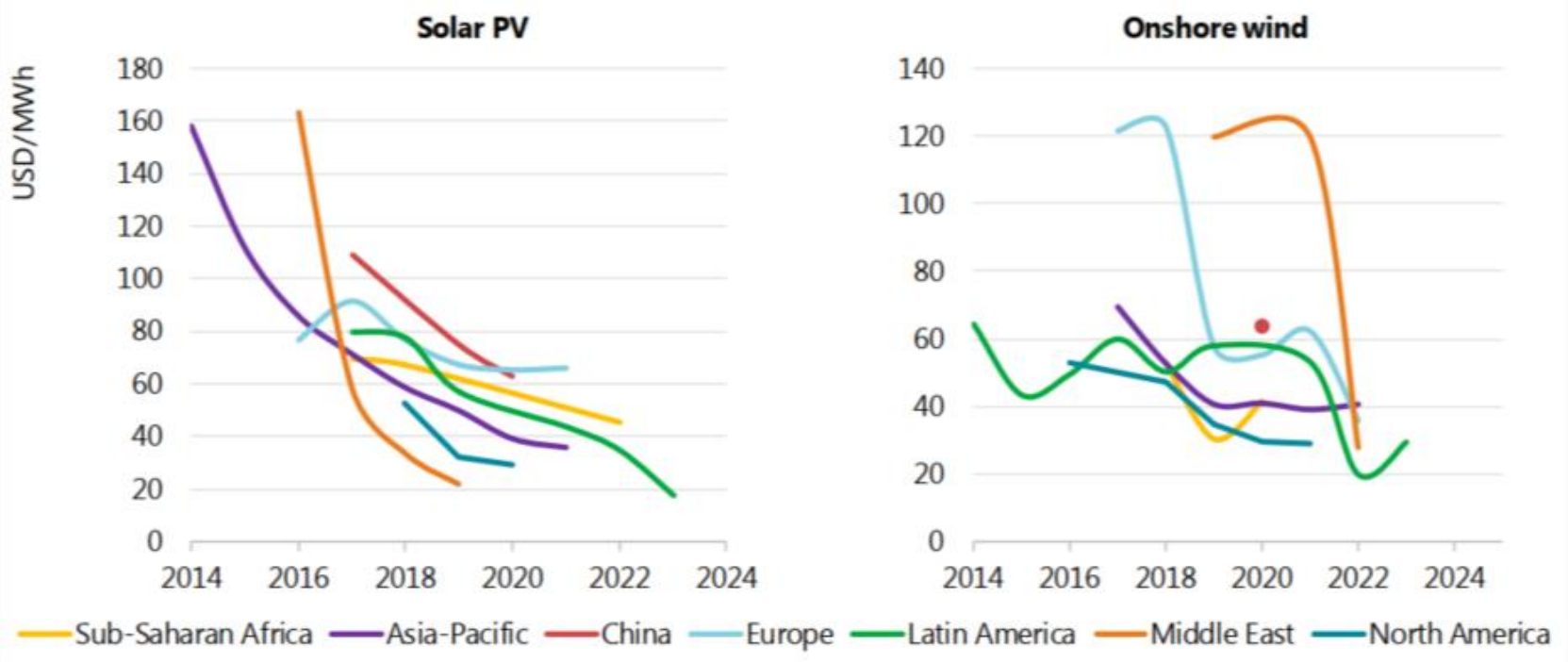
Chart : Awarded auction capacities by technology and expected comission date



Auctions

Awarded auction capacities by technology and expected comission date



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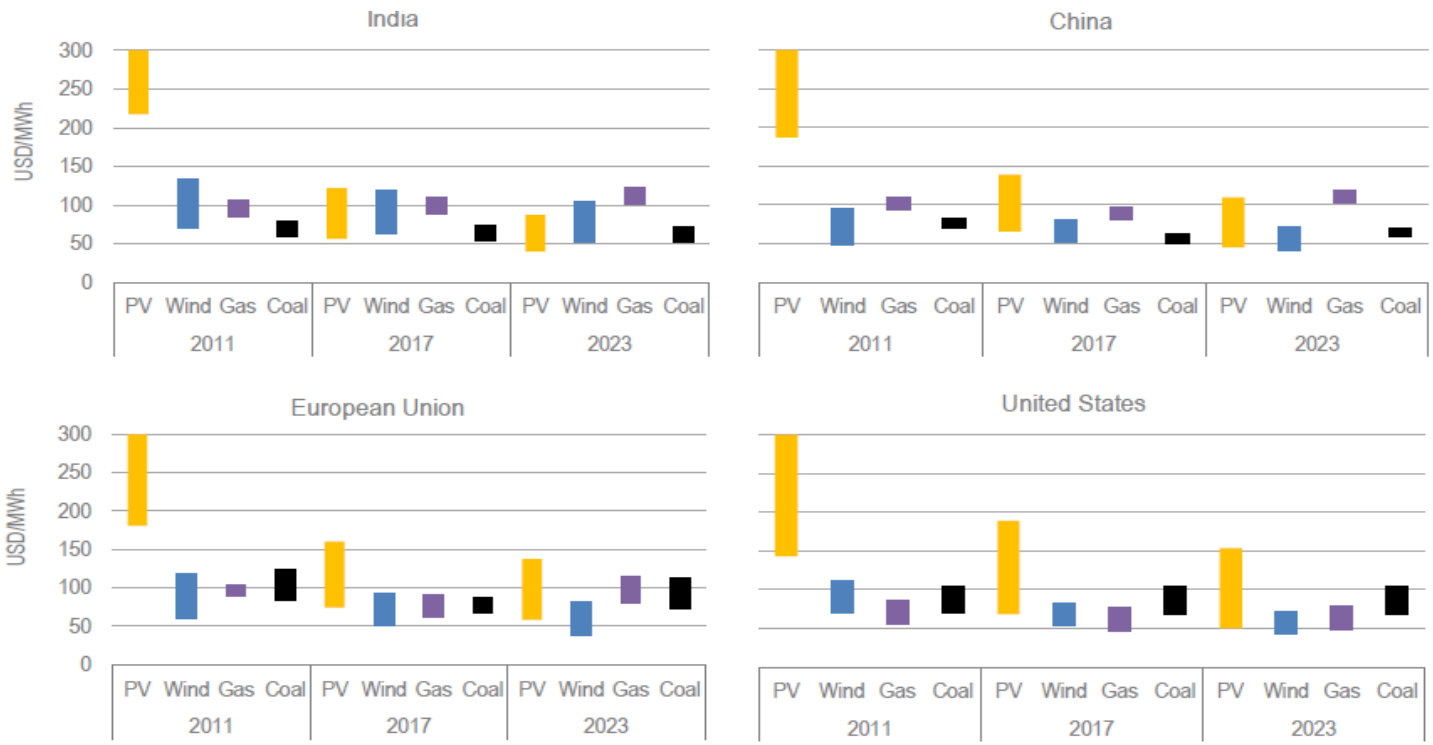
Competitiveness of RES

LCOE ranges for new utility-scale instalations by commissioning date



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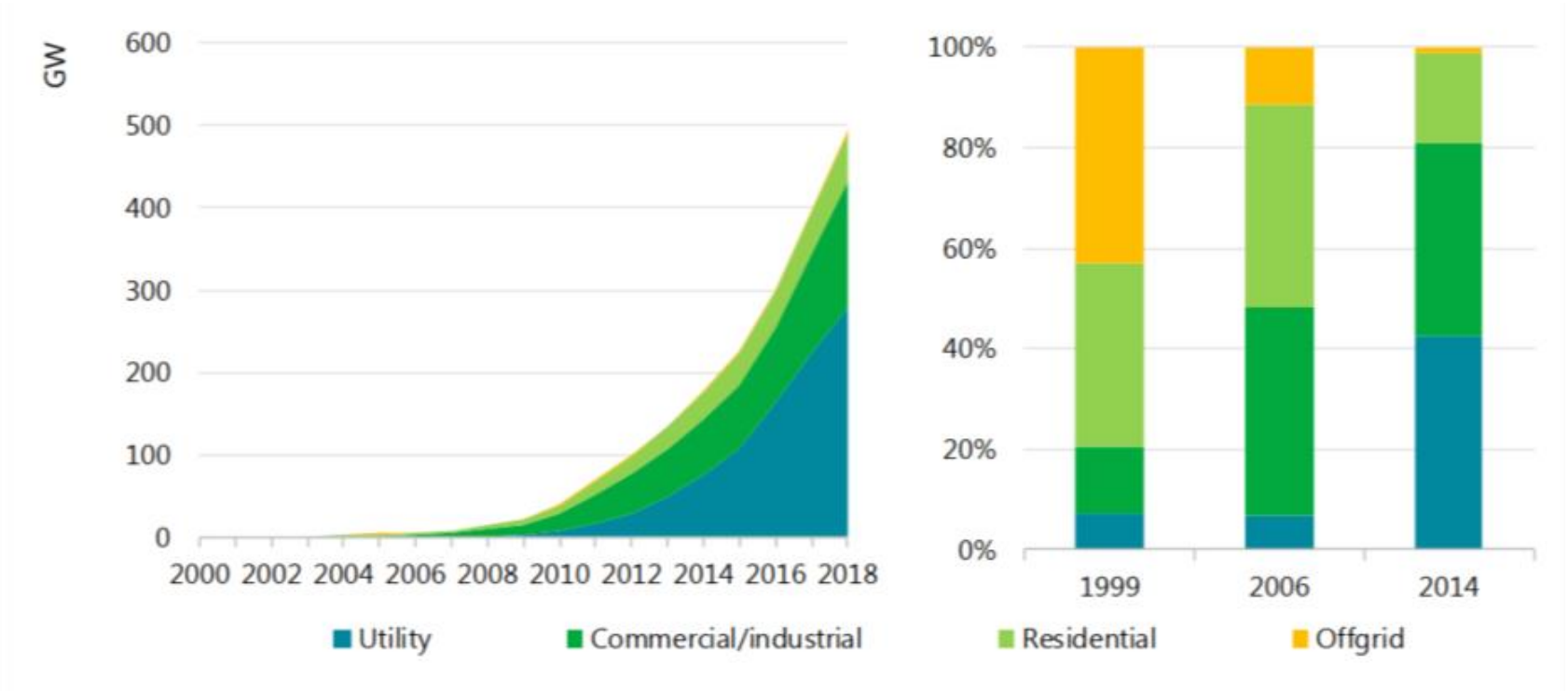
Solar PV perspectives

Cumulative solar PV capacity by application segment



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Solar PV perspectives

- Utility scale – 10MW and more.
- Commercial and industrial – savings, self-consumption of elektricity.
- Residential

Datong (China) – 250 acres, 100MW.

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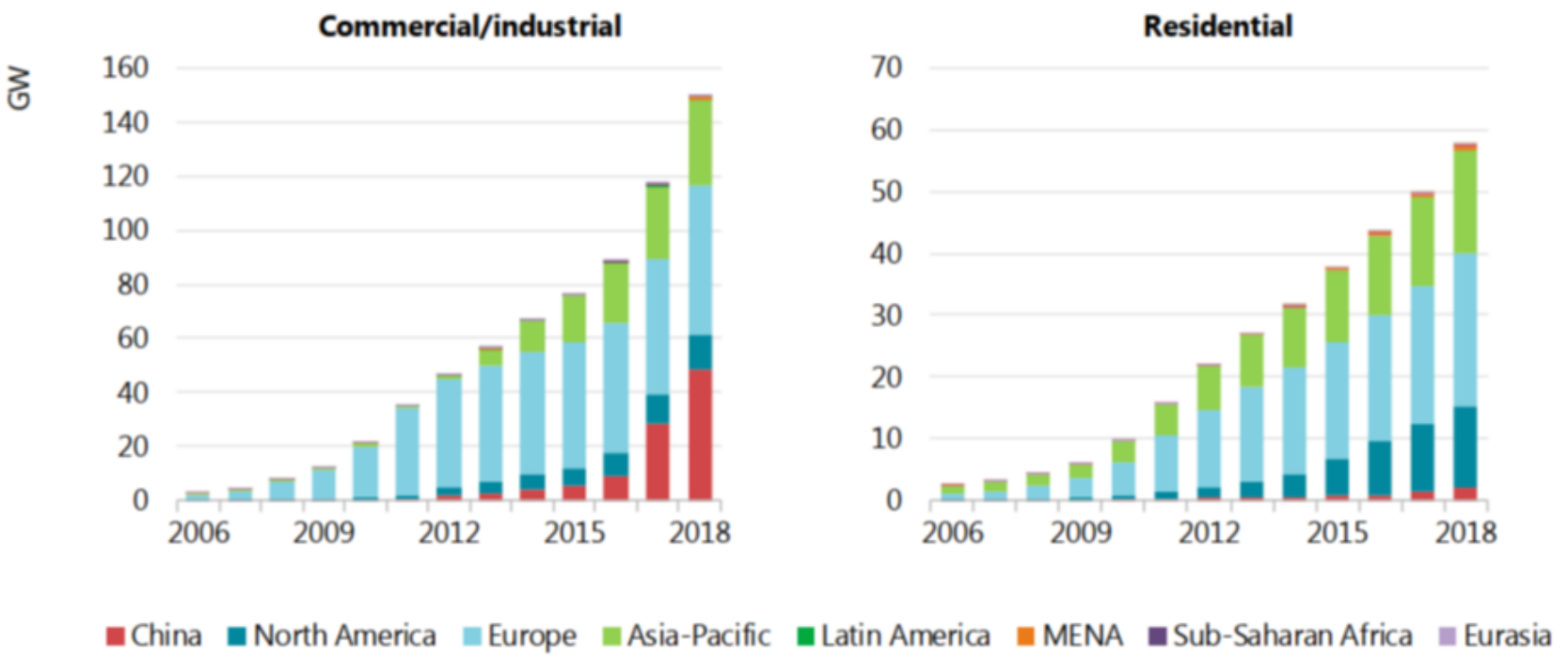
Solar PV perspectives

Commercial/industrial and residential capacity by country/region



- Environmental aspects
- Latecommers

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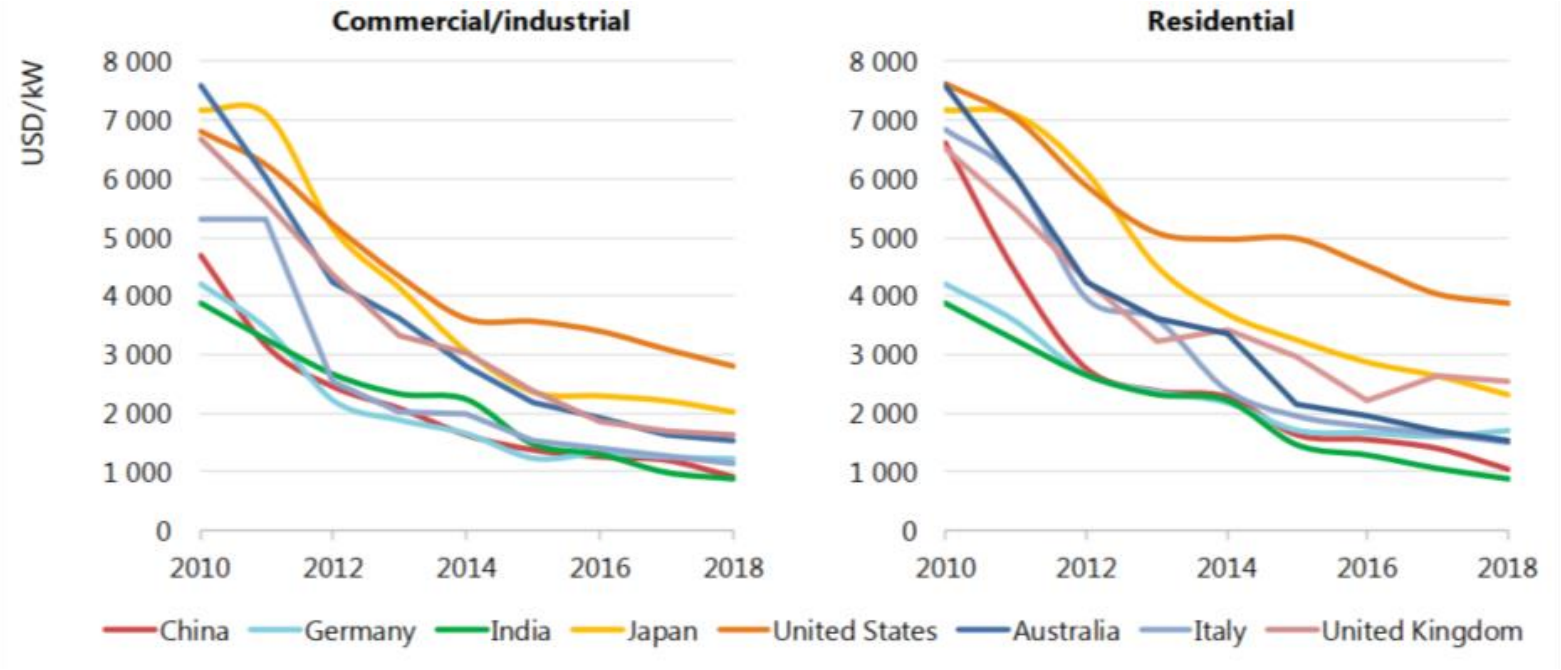
Solar PV perspectives

Investment costs



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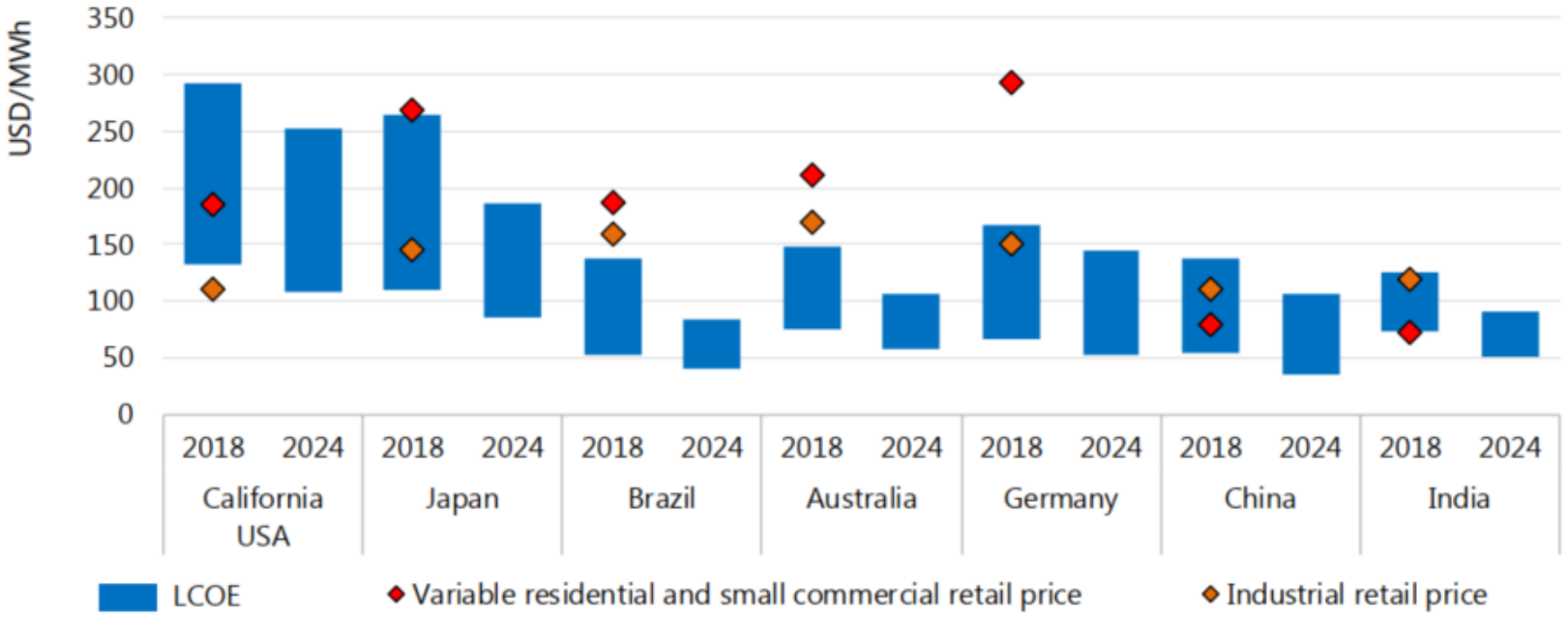
Solar PV perspectives

Residental electricity prices compared with average residental LCOE, 2017



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Integration of intermittent RES to the system

- Traditional systems built around base- and peak-load source. Both financially and technically.

- With VRE being pivotal part of the system flexibility is valued highly.

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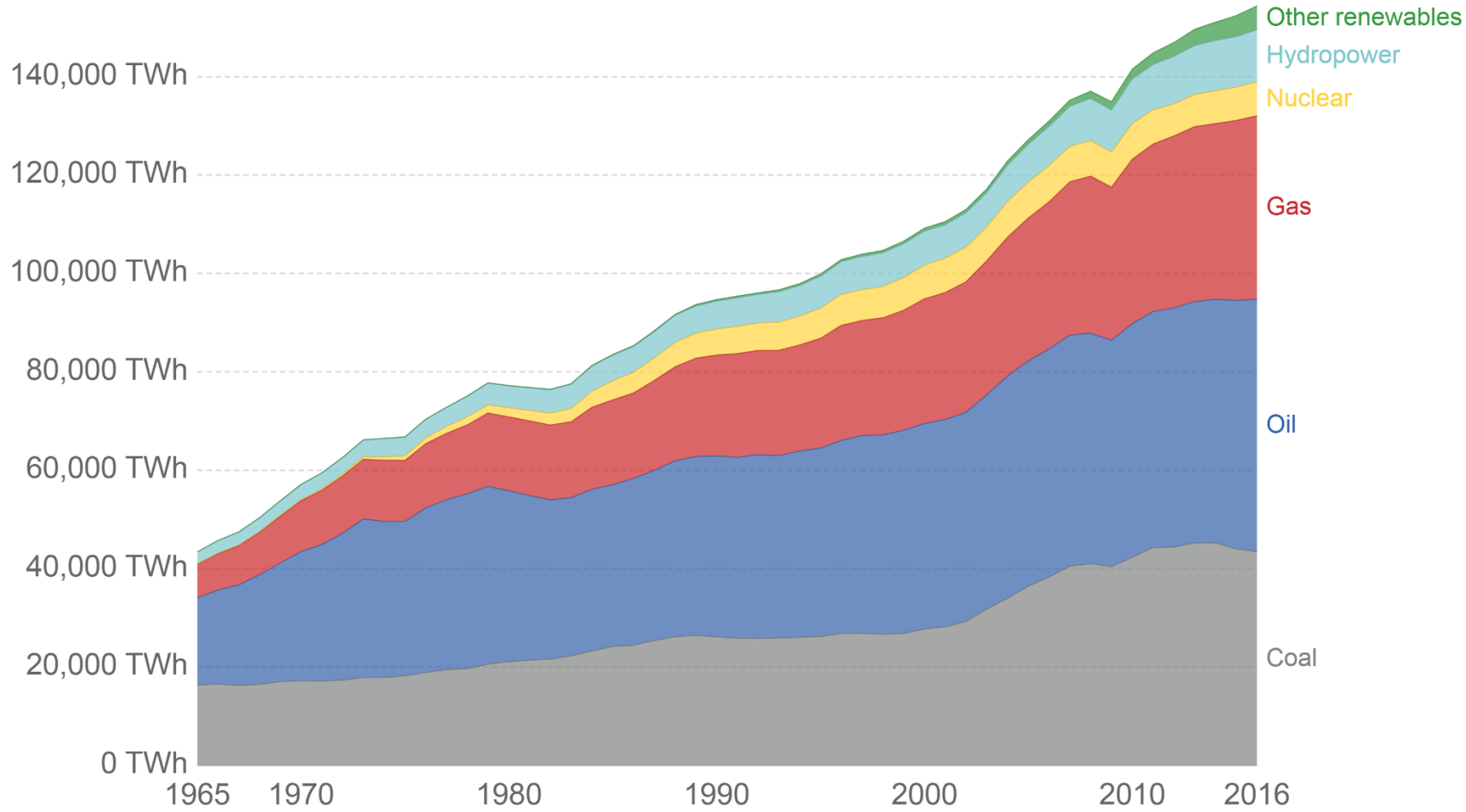
Primary energy consumption by source, World

Primary energy consumption by source across the world's regions, measured in terawatt-hours (TWh). Note that this data does not include energy sourced from traditional biomass, which may form a significant component of primary energy consumption in low to middle-income countries. 'Other renewables' includes renewable sources including wind, geothermal, solar, biomass and waste.



Source: BP Statistical Review 2016

RES and climate change

- Could RES be the pillar of the (global) energy system?
- What is the growth potential?

= are they ready to meet some substantial share of energy demand of society?

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Sources

- ODI (2017): Phase-out 2020: Monitoring Europe´s fossil fuel subsidies
- IRENA (2017): Rethinking Energy 2017
- IMF (2019): Global Fossil Fuel Subsidies Remain Large: An Update Based on Country-Level Estimates.

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Country	Ethanol	Biodiesel	Carbon intensity policy	Recent updates
United States	82 billion L of renewable fuels in 2018 and 136 billion L by 2022		LCFS in California and Oregon	-
Canada	5%	2%	LCFS in British Columbia; federal clean fuel standard in development	10% ethanol mandate in Ontario from 2020; clean fuel standard for liquid fuels in 2022
European Union	10%* renewable energy in transport by 2020 (T) with 7% cap for conventional biofuels		GHG intensity of fuels to fall 6% by 2020	Provisional agreement for 14%* renewable energy in transport in 2030
France	7.5%*	7.7%*	-	Conversion kits to allow cars to use E85 approved
Germany	-	-	Climate Protection Quota (CPQ) 6% reduction in 2020	Upstream fossil fuel emissions reductions eligible for CPQ target
Italy	7%* biofuels		-	-
Denmark	5.75%* biofuels		-	-
Finland	30%* biofuel supply obligation by 2030		-	-
Sweden	-		Emissions reduction obligation system introduced	-
United Kingdom	12.4% renewables share by 2032 in RTFO		-	RTFO target extended to 2032; cap on conventional biofuels of 4% in 2020, 2% in 2032
China	10%	-	-	10% ethanol mandate to extend nationwide in 2020
India	5%	-	-	Biofuels policy expands approved feedstocks for ethanol production
Indonesia	20%	2%	-	Mandated consumption extended to new sectors, including rail and mining
Malaysia	-	7%	-	-
Thailand	32% by 2036 (T)	Currently 7%, and 25% by 2036 (T)	-	-
Argentina	12%	10%	-	-
Brazil	27%	10%	RenovaBio signed into law, 10% GHG reduction by 2028 (T)	-

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