Energy and Climate Policy

Sumie Nakayama
J-POWER

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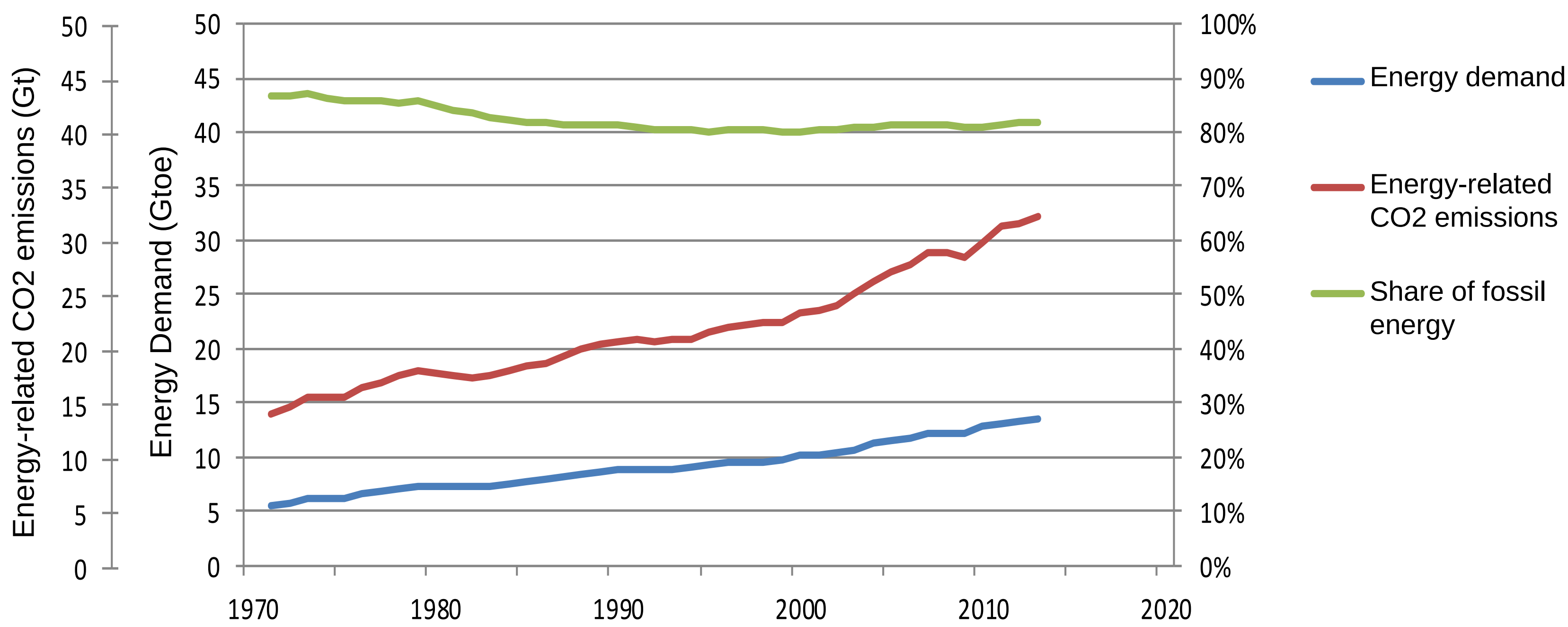
ENERGY TREND AND OUTLOOK (IEA WORLD ENERGY OUTLOOK)

Energy Trend: Demand, CO2 and Fossil

- Energy demand has been increasing for more than 45 years.
- Energy-related CO2 also has been increasing at higher rate.
- The share of fossil energy to total energy (in heat value) has remained over 80%.

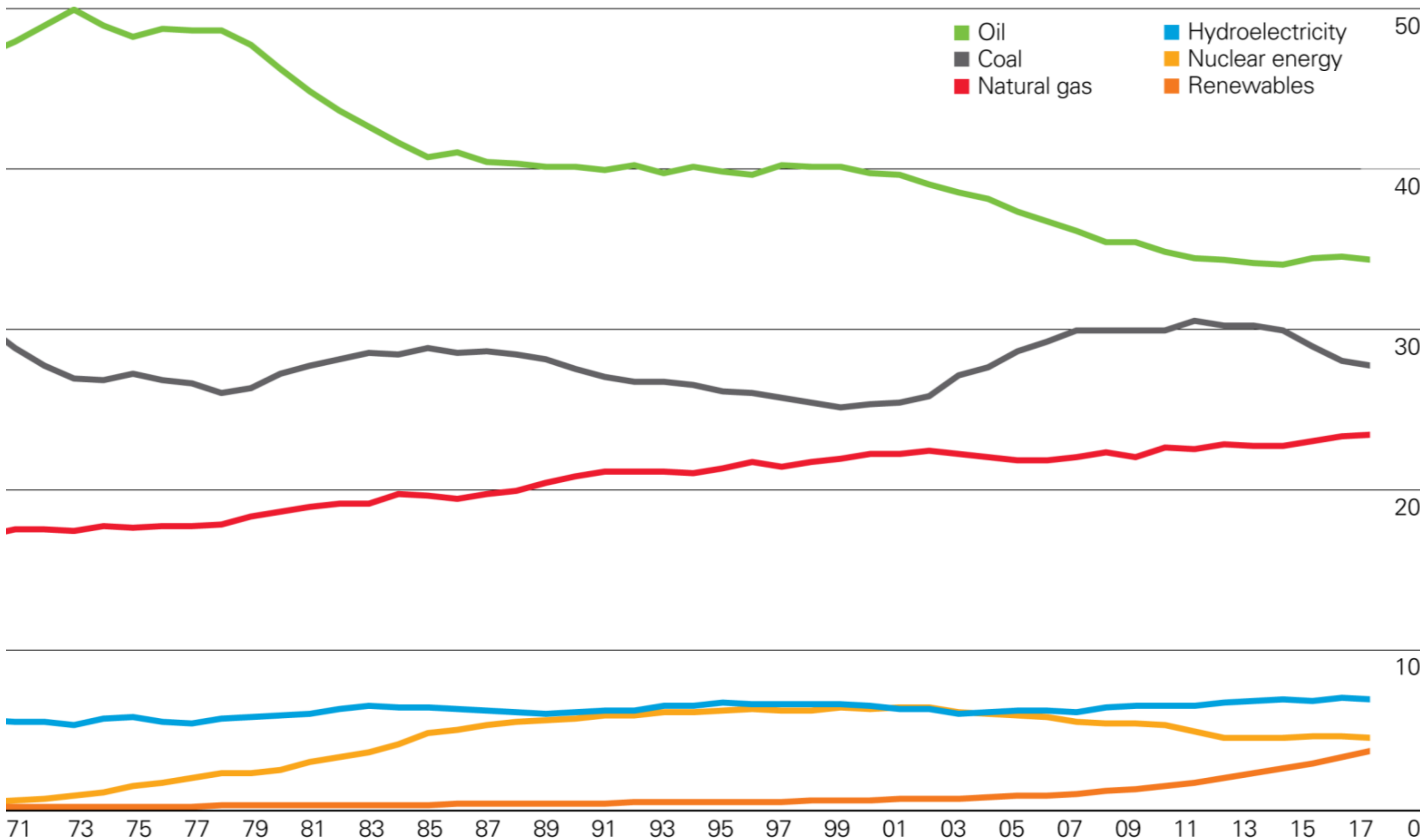


Change in energy demand, CO2 emissions and fossil share (1971-2015)

Source: IEA "CO2 emissions from fuel combustion 2015" CD-ROM data

Shares of global primary energy consumption

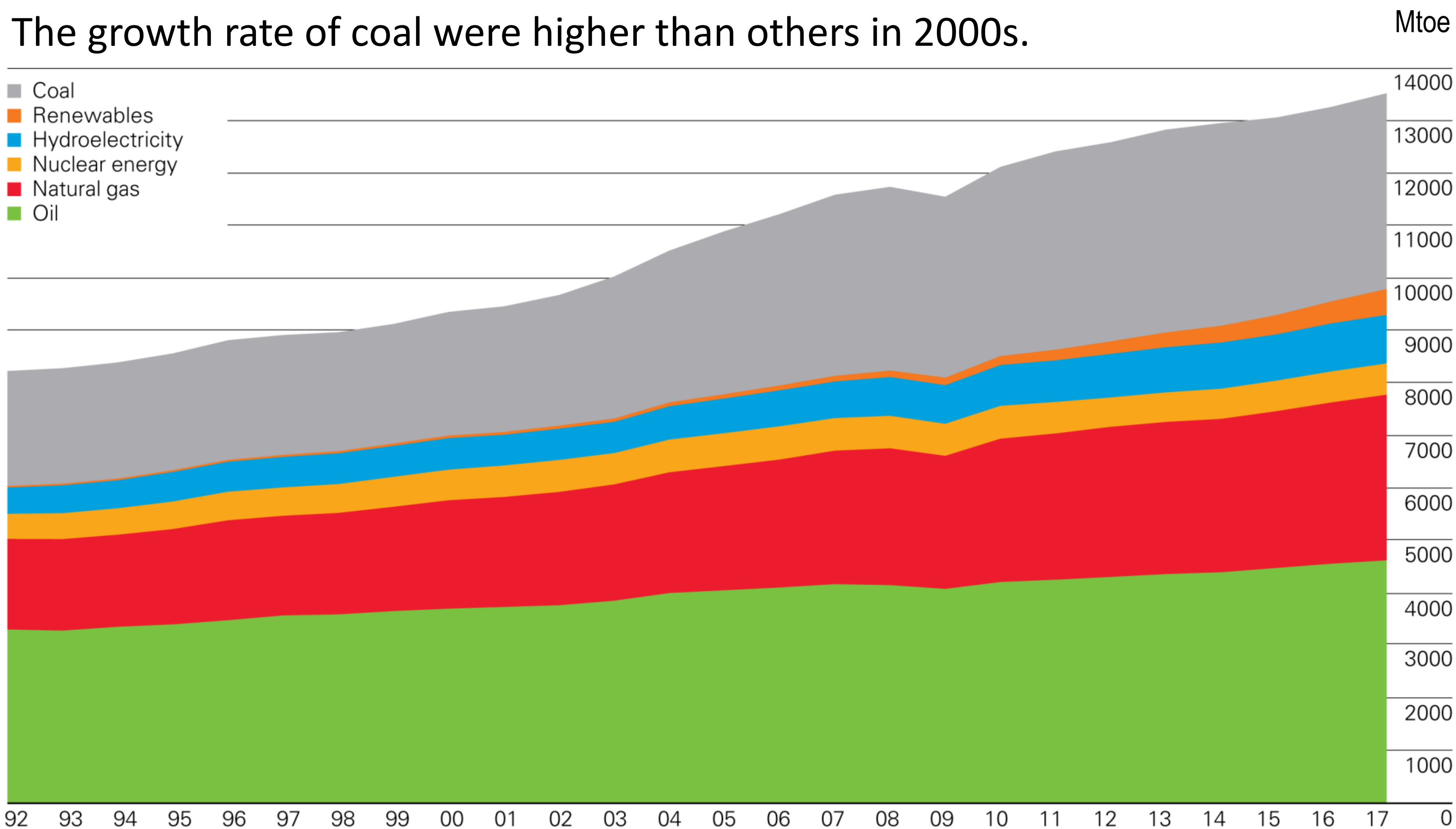
- Among fossil fuels, share of Oil is declining while share of gas is increasing and share of coal increased in 2000s followed by decrease.
- Share of renewables has been increasing since late 2000s.



Source: BP Statistical Review of World Energy 2018

Energy Trend : Primary energy by energy resource

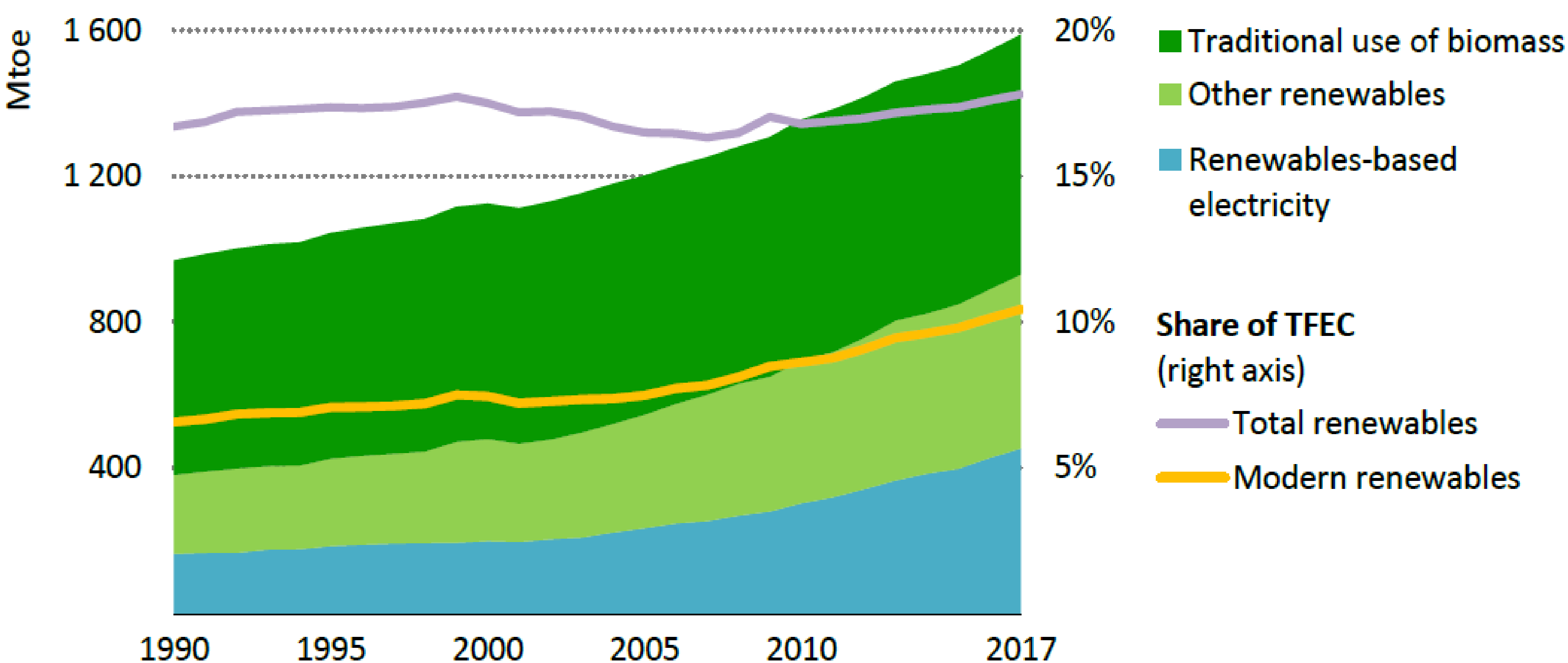
- Supply of all the energy resources have increased in the last 25 years.
- The growth rate of coal were higher than others in 2000s.



Source: BP Statistical Review of World Energy 2018

Renewable energy trend

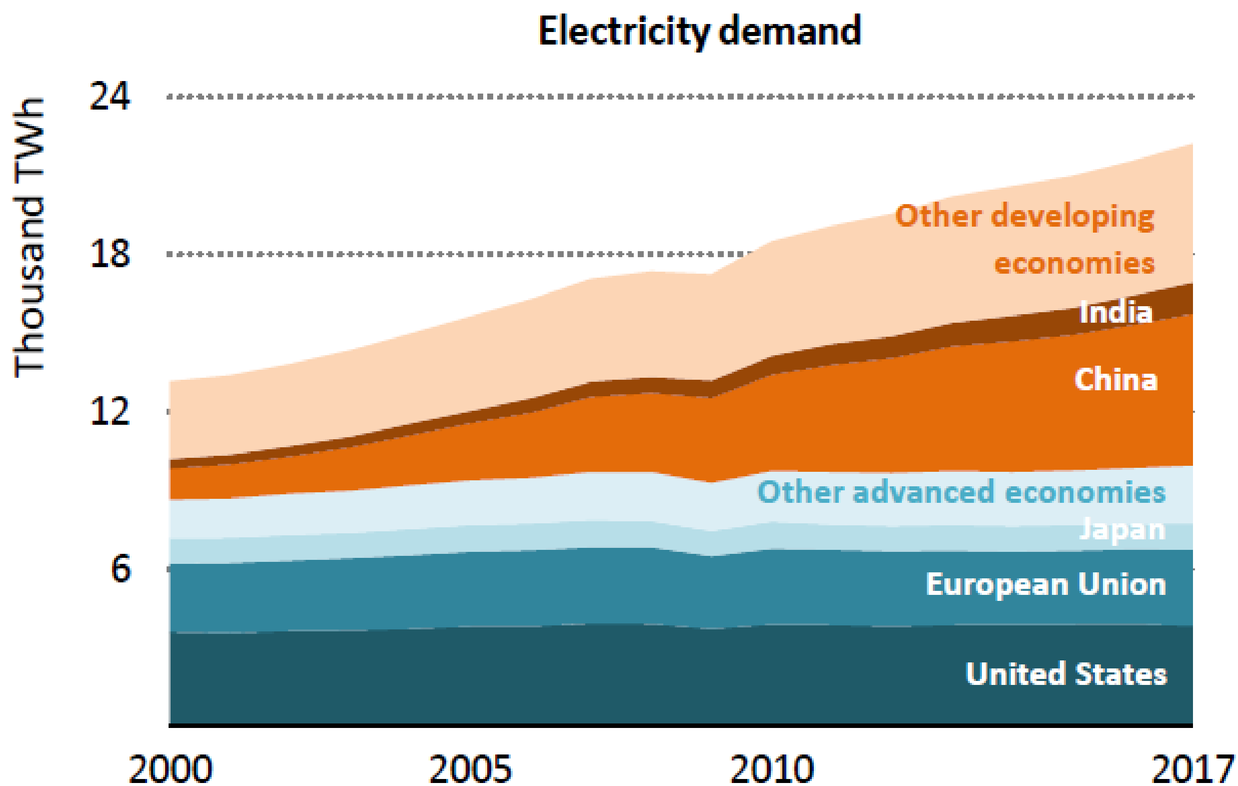
- The growth of renewable energy is faster than increase of energy consumption.
- Traditional biomass (firewood, animal waste) still remains the largest source of renewables.

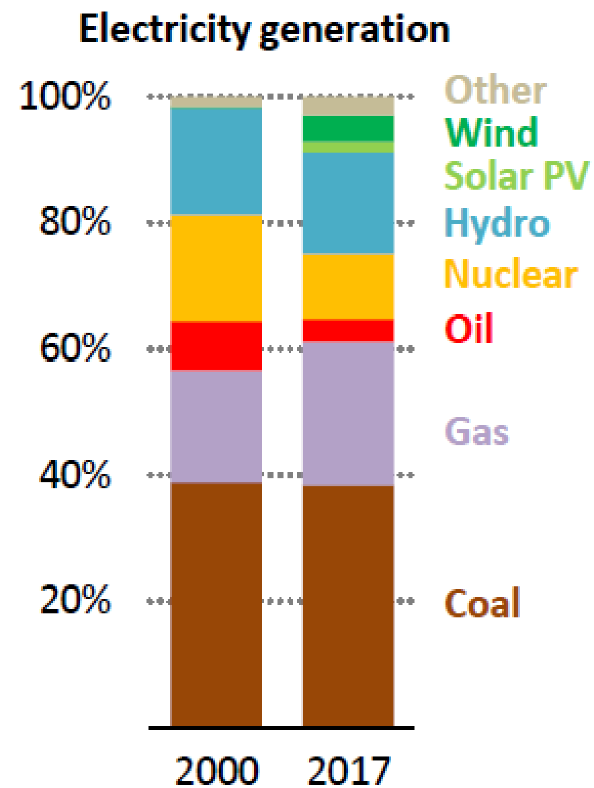


Source: IEA “Word Energy Outlook 2018”

Power generation trend

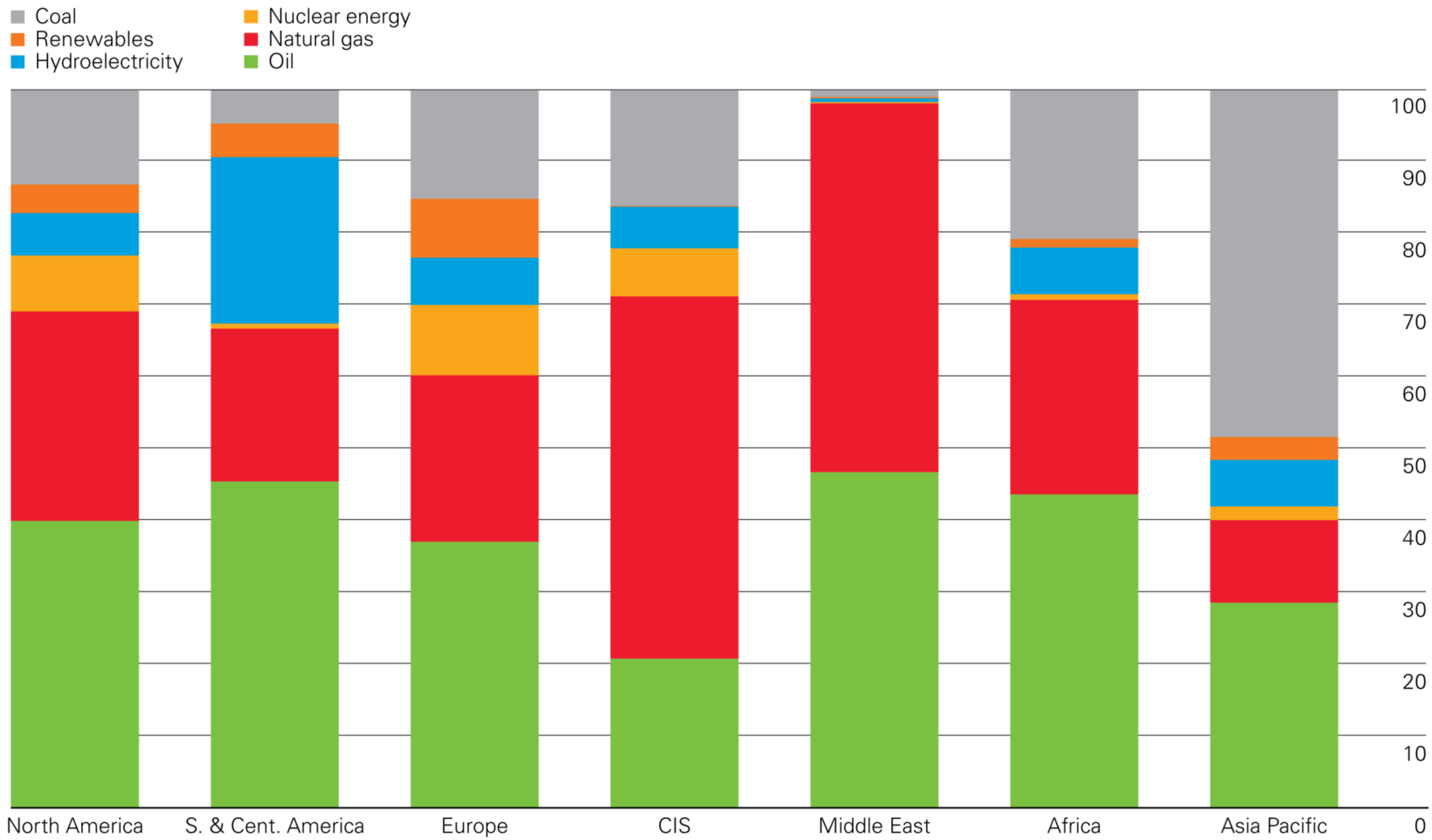
- Global electricity demand ha increased around 70% from 2000 to 2017.
- Power mix remains dominated by fossil fuel, especially coal even with growth in renewables.





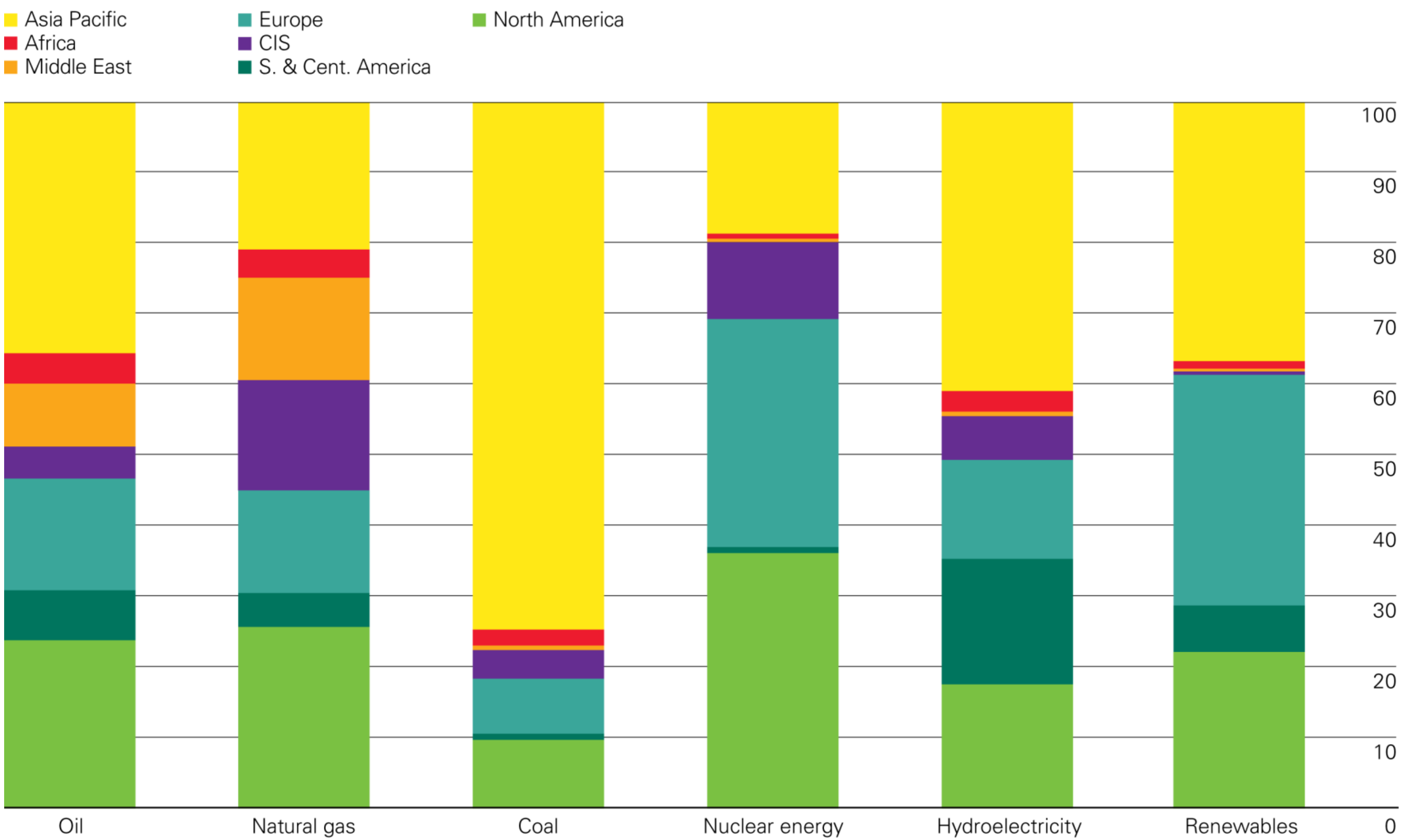
Source: IEA "Word Energy Outlook 2018"

Primary energy regional consumption by fuel 2017



Source: BP Statistical Review of World Energy 2018

Fuel consumption by region 2017



Source: BP Statistical Review of World Energy 2018

Power generation portfolio（2016）

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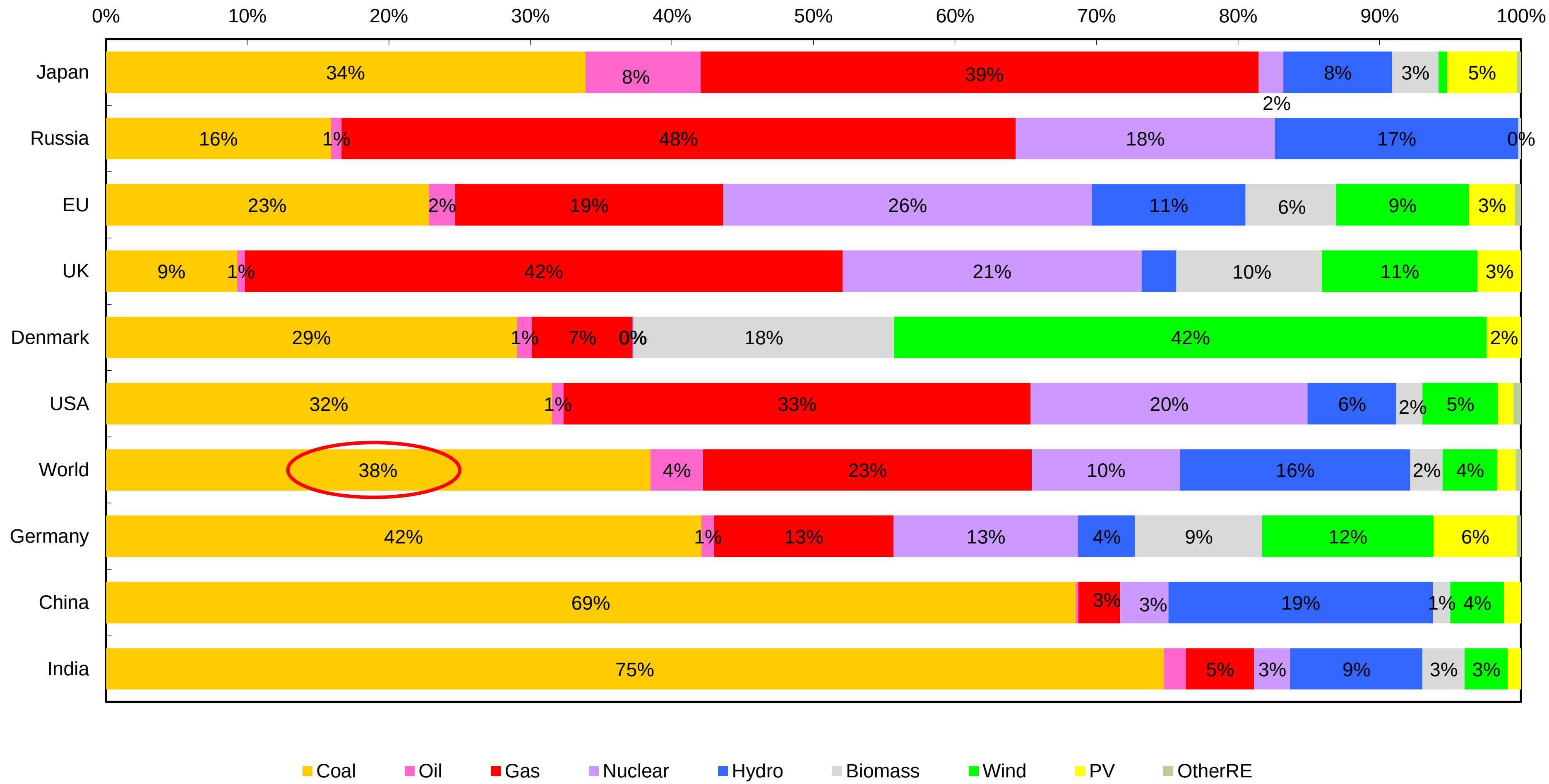
- ◆ Coal is supplying 38%, the largest share of world total power generation.
- ◆ Especially in China and India, coal share is approximately 70%.



Source: IEA "World Energy Outlook 2018", IEA "Electricity Information 2018"

Characteristics of Fossil Energy

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◻ Oil

Price is expensive and volatile. Reserve is limited and intensively located in Middle East.

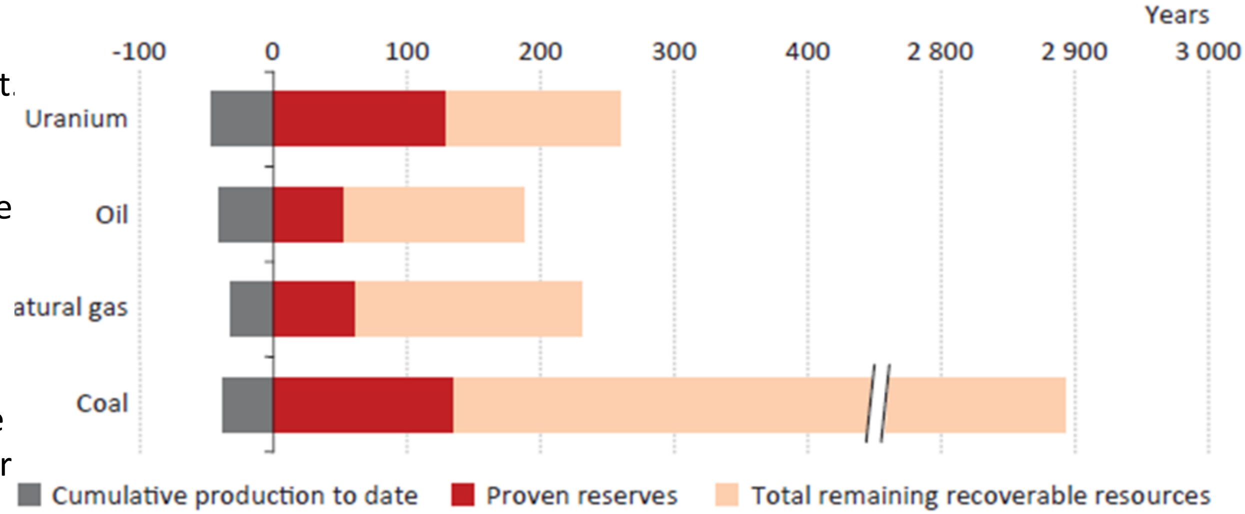
◻ Coal

Price is inexpensive and stable. Reserve is the largest and broadly distributed all over the world

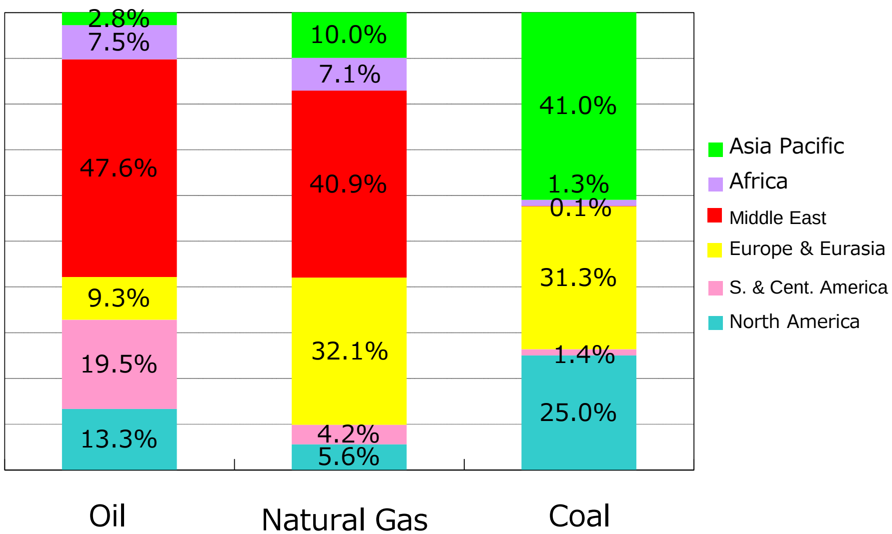
◻ Gas

Price is between oil and coal and less volatile than oil. Reserve distribution is more broader than oil.

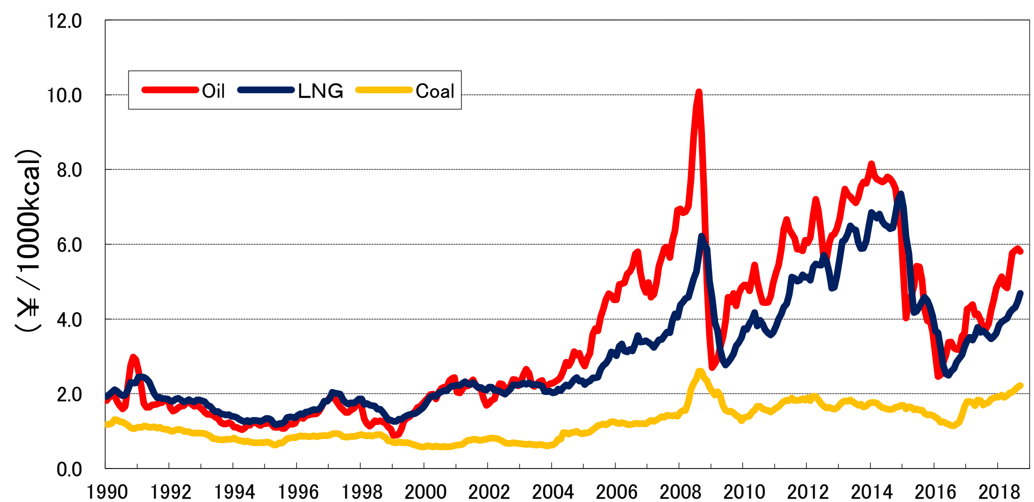
Lifetime of fossil fuels and uranium resources



Source: IEA WEO2014



Geographical distribution of fossil fuels



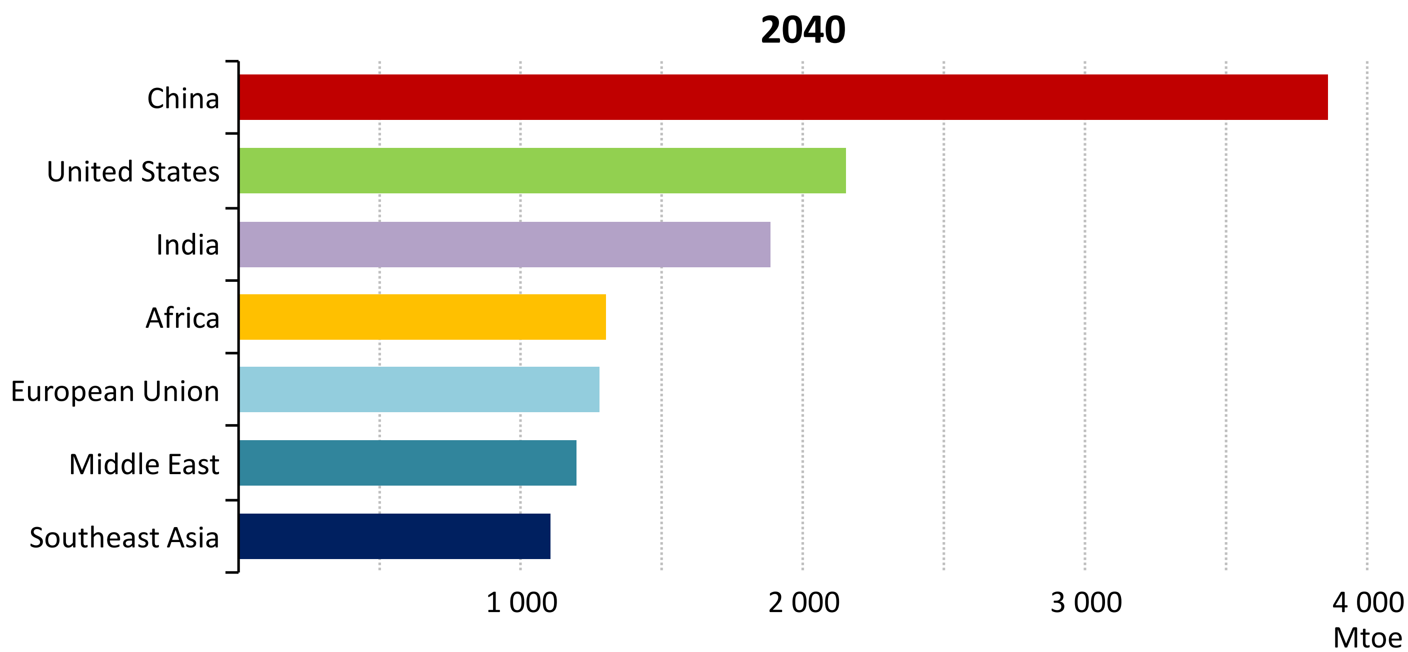
Historical market price of fossil fuels in Japan

Source: BP" Statistical Review of World Energy 2018"

Source: Trade Statistics of Japan

Energy Trend: Change in geography, record and outlook

Energy Demand

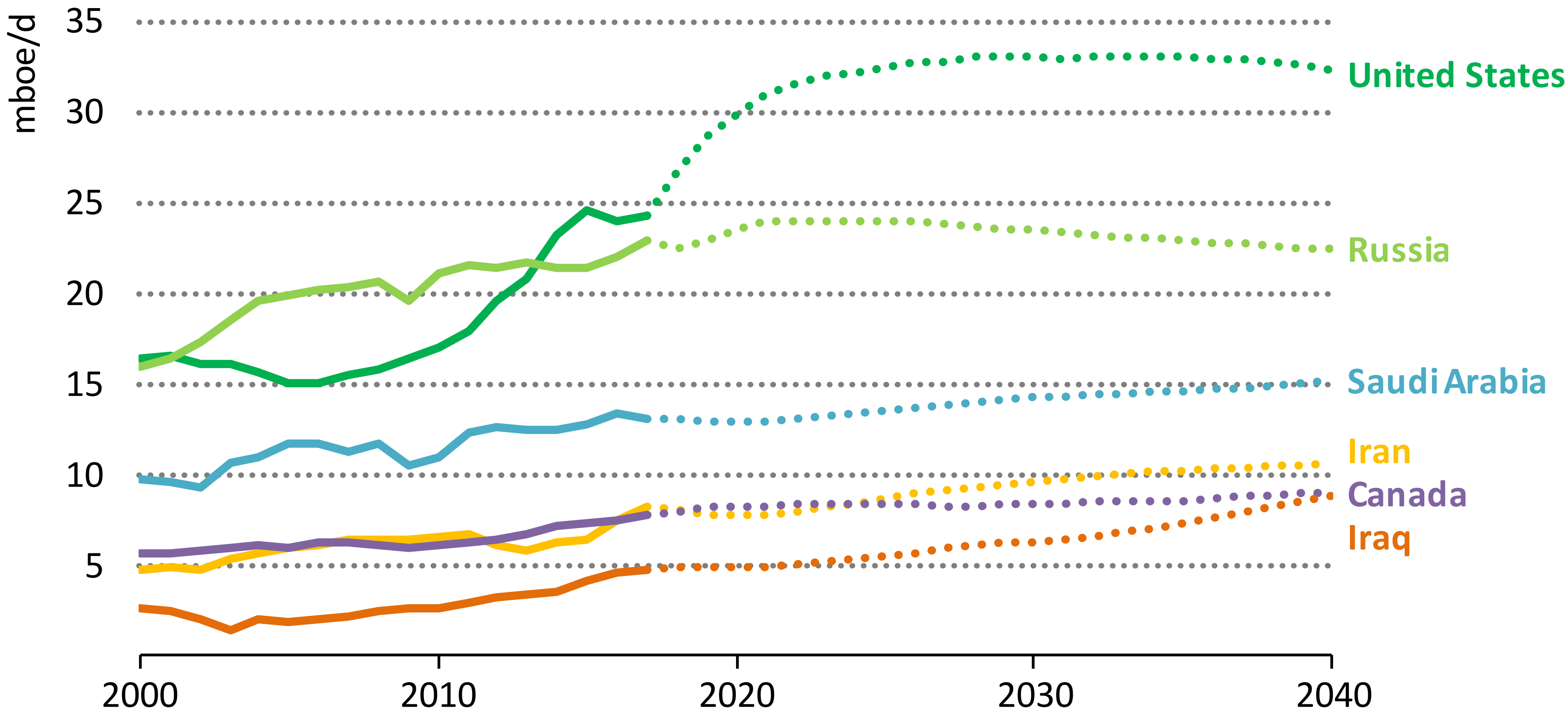


In 2000, more than 40% of global demand was in Europe & North America and some 20% in developing economies in Asia. By 2040, this situation is completely reversed.

Source: IEA "Word Energy Outlook 2018"

Oil and gas production outlook for selected countries

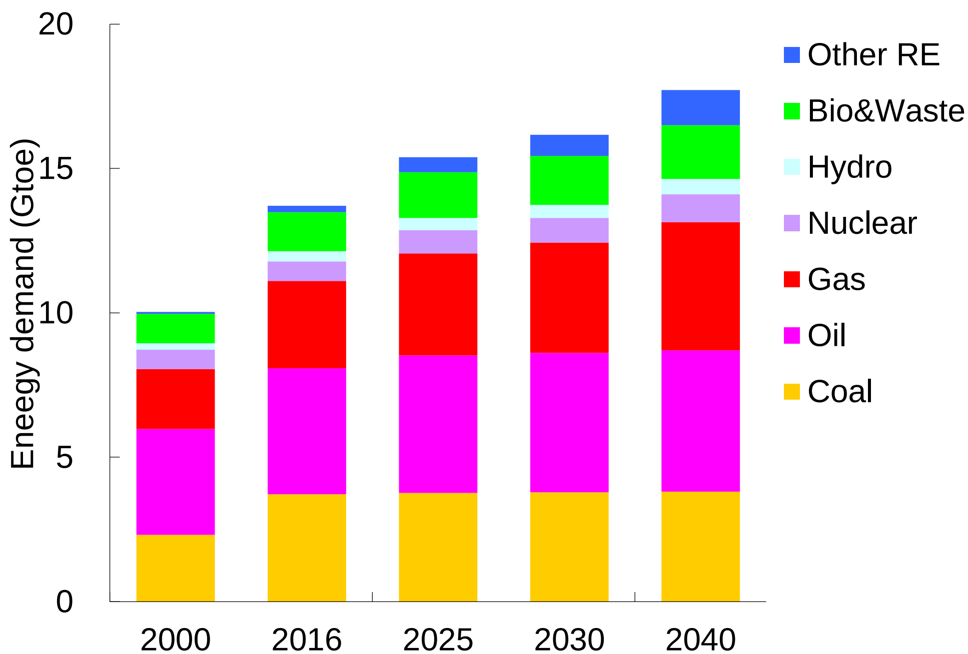
- The rise in US production of tight oil and shale gas since 2010 is the largest parallel increase in oil and gas output in history



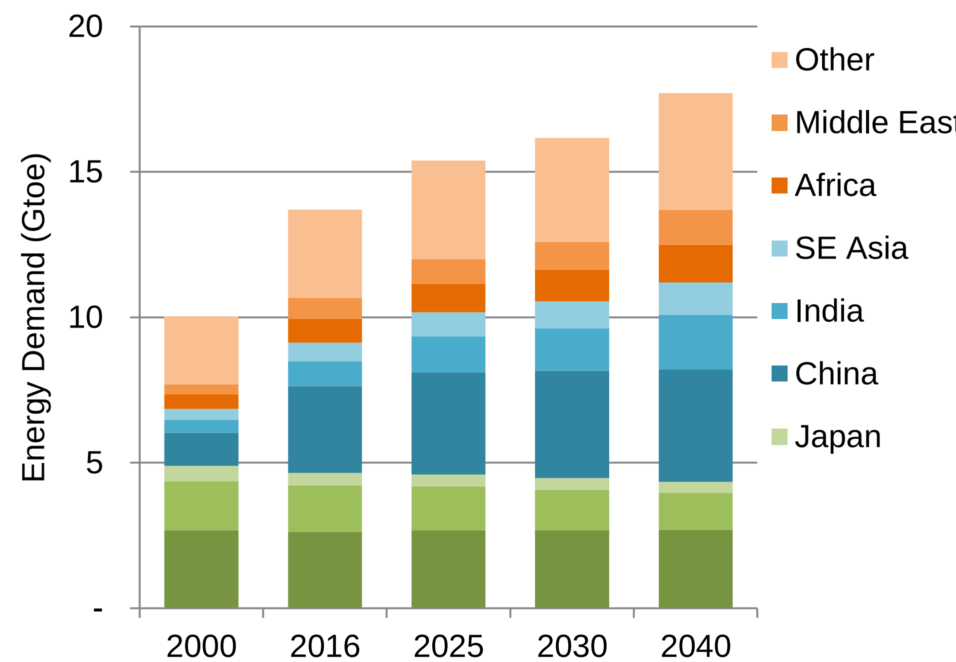
Source: IEA “Word Energy Outlook 2018”

Energy demand outlook

- Energy demand continues to grow through 2040.
- By energy resource, growth is seen in renewable energy.
- By region, growth is seen in developing countries, especially in Asia.



Primary energy supply by energy resource
（New Policy Scenario）



Primary energy supply by region
（New Policy Scenario）

Source: IEA World Energy Outlook 2018

Power generation outlook

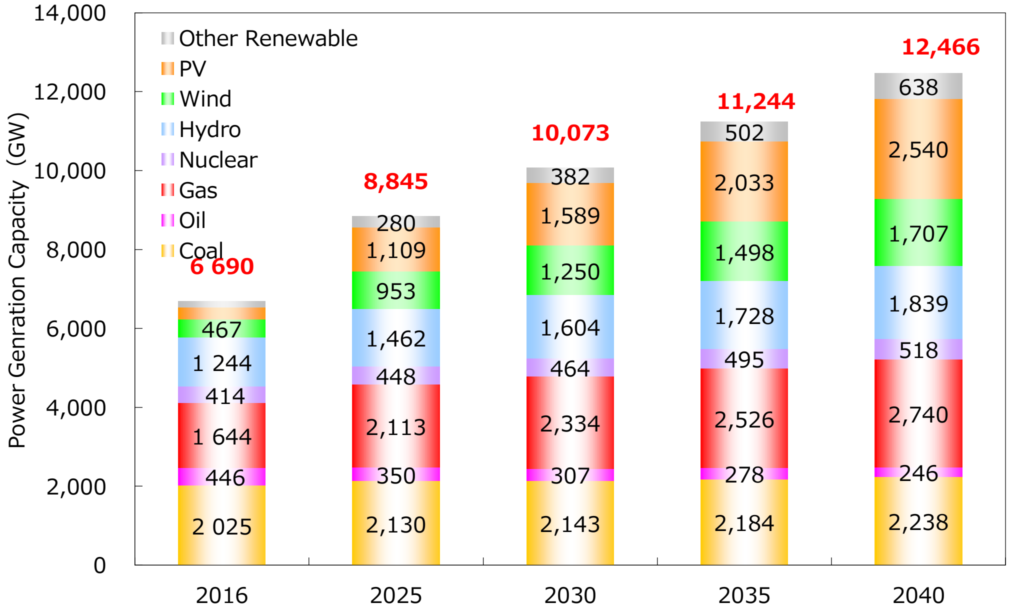
- Power Generation and Capacity will be increased toward 2040.

Power Generation Capacity will be increased by 1.9 times

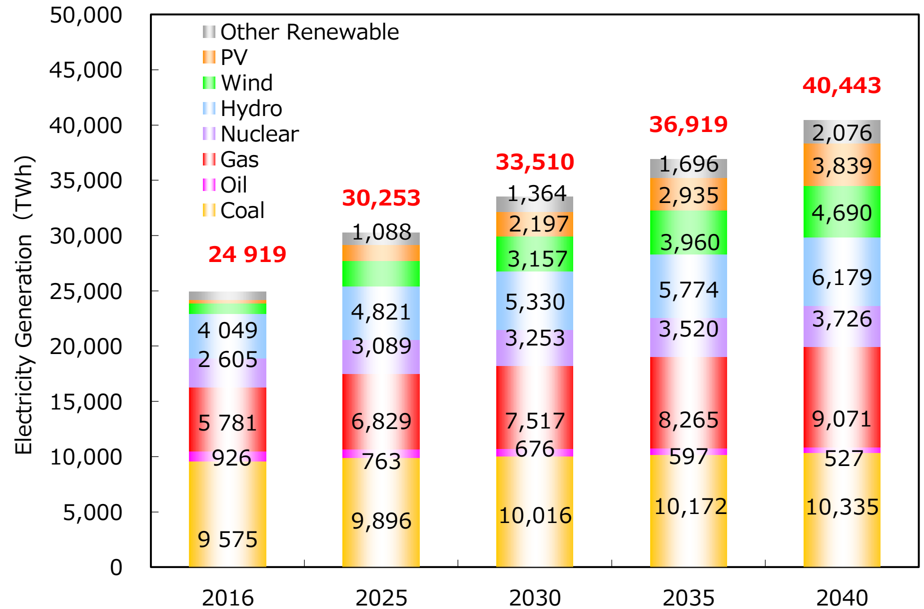
2016 6,690GW → 2040 12,466GW

Electricity Generation will be increased by 1.6 times

2016 24,575TWh → 2040 40,443TWh



Power Generation Capacity（New Policy Scenario）

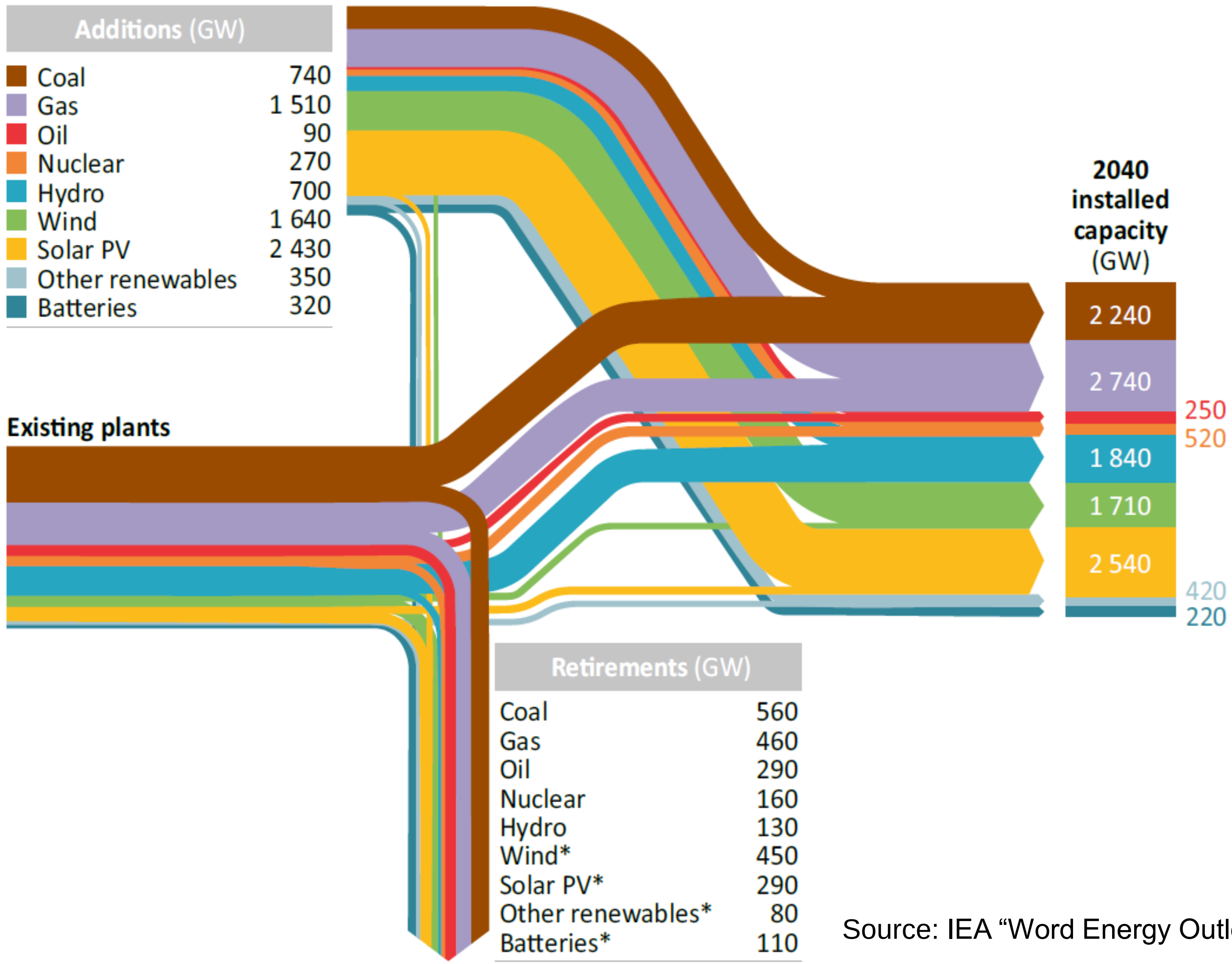


Generation Capacity（New Policy Scenario）

Source: IEA World Energy Outlook 2018

Power generation capacity outlook

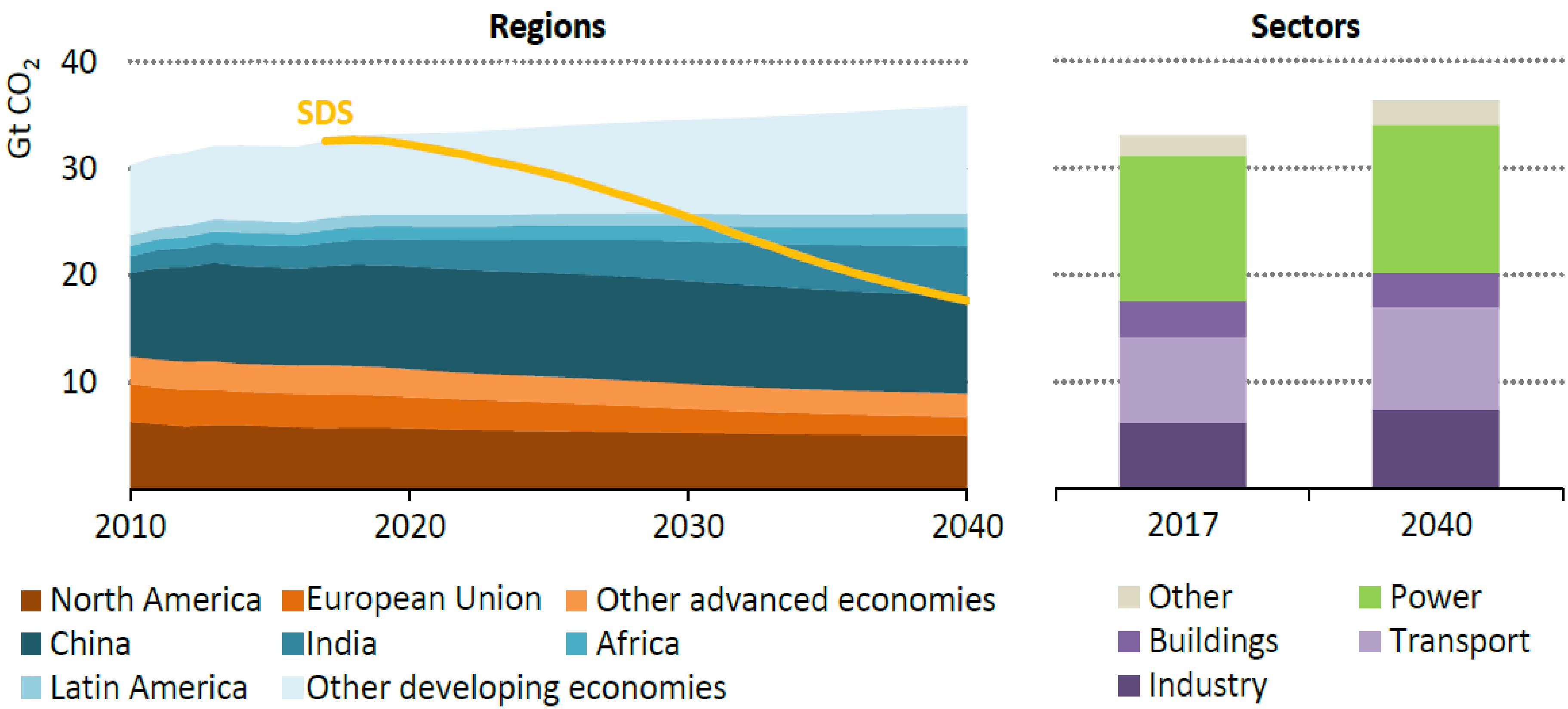
- Power generation capacity additions and retirements, 2018-2040.
- Wind and solar PV accounts for more than half of additions.



Source: IEA “Word Energy Outlook 2018”

Energy related CO2 outlook

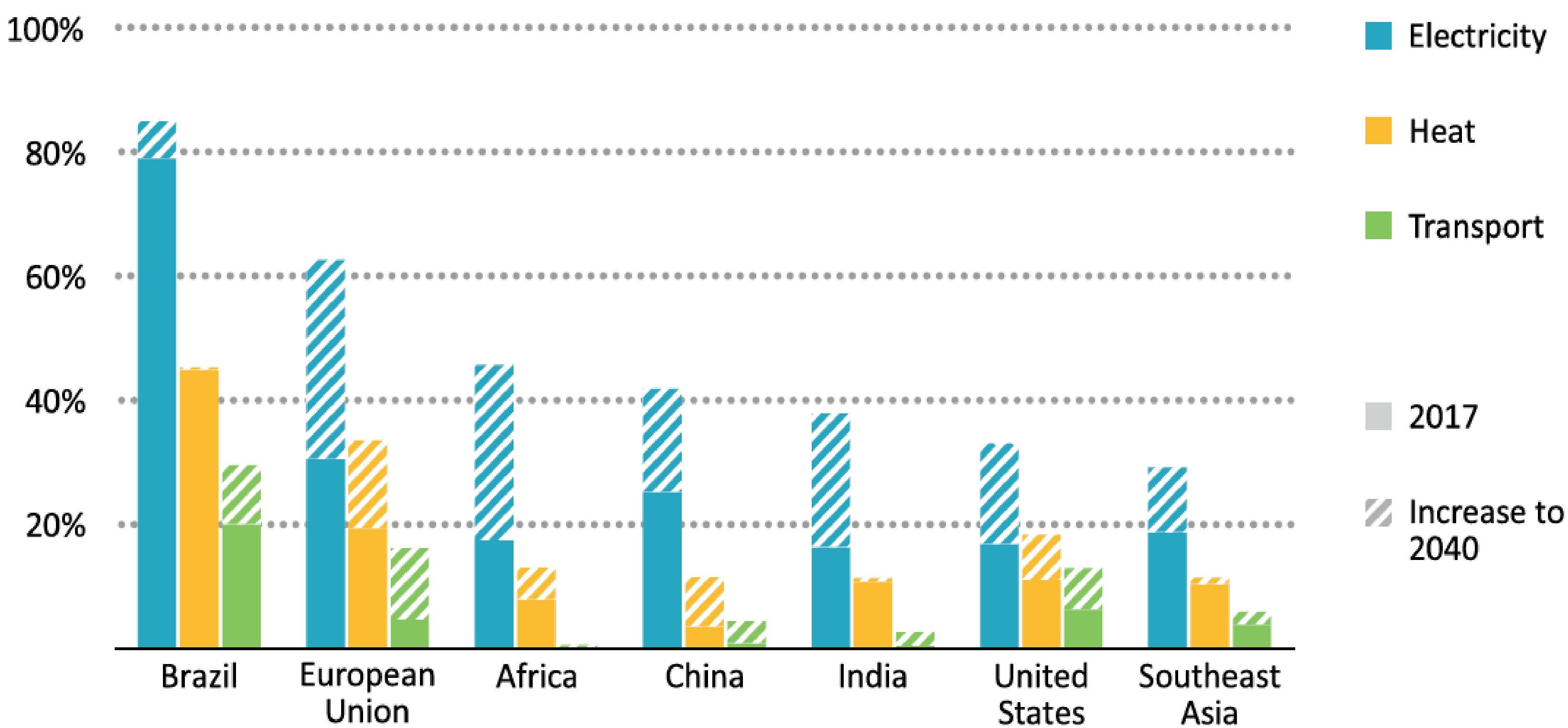
- Global CO2 emissions continue to rise through 2040.
- By regions, developing economies, by sector, transport and industry are driving the growth.



Source: IEA "Word Energy Outlook 2018"

Renewable energy outlook

- Renewable energy share will increase in all regions.
- Share in electricity sector grows remarkably.
- Growth in heat sector shows slower pace or stand still.
- Share in transport remains lower level in many regions.



Source: IEA “Word Energy Outlook 2018”

INTERNATIONAL CLIMATE POLICY (UNFCCC NEGOTIATION HISTORY, MAJOR COP DECISIONS AND PARIS AGREEMENT)

Major International Forum for Climate Change Policy

United Nation Framework Convention on Climate Change

- Objective (Article 2) : to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.
- 192 parties (countries and region (EU)) that ratified UNFCCC
- Decision is only made by consensus
- Annual conference of parties (COP) in Nov/Dec, and semi annual meetings of subsidiary bodies (SBI, SBSTA and temporally Ad-hoc meetings)
- Annual meeting under Kyoto Protocol and Paris Agreement are held in pallarel during COP

Other UN meetings

– United Nation Summit

G8 (G7), G20

COP Chronology

Year	Meeting	Venue	Major outcome
1992	UN summit	Rio de Janeiro	adoption of UN Framework Convention on Climate Change (UNFCCC)
1994			Effect of UNFCCC
1997	COP3	Kyoto	Adoption of Kyoto Protocol
2000	COP6	Bonn	US' withdrawal from Kyoto Protocol
2001	COP7	Marakech	Agreement on rules for Kyoto Protocol
2005	COP11	Montreal	Effect of Kyoto Protocol
2007	COP13	Bali	Agreement on "post 2012 framework by 2012"
2009	COP15	Copenhagen	Failure to agree on post 2012 framework
2010	COP16	Cancun	Agreement to continue long term vision and 2020 voluntary target
2011	COP17	Darbun	Agreement on "post 2020 framework with all parties' contribution by 2015"
2012	COP18	Doha	Agreement on work program for post 2020 framework
2014	COP20	Lima	Start of negotiation on post 2020 framework text
2015	**COP21**	**Paris**	**Adoption of Paris Agreement**
2016	COP22	Marakech	Effect of Paris Agreement
2018	COP24	Katowice	Agreement on major rules for Paris Agreement

Negotiation group in UNFCCC COP

Developing countries' groups

- Group of 77+China (G77+China) – a large alliance of 134 developing nations
- Least Developed Countries (LDCs) – a group of the world's poorest nations, which evolves as economies change
- Alliance of Small Island States (AOSIS) – a group of 44 small islands and low-lying coastal states
- Like-Minded Developing Countries (LMDCs) – a group of developing countries, representing 3.5bn people, with a strong focus on ensuring rich countries bear most responsibility for tackling climate change
- BASIC (Brazil, South Africa, India and China) – a coalition of four major emerging economies
- Bolivarian Alliance for the Americas (ALBA) – a Latin American and Caribbean alliance with socialist leanings

Regional developing countries' groups

- African Group – One of the UN's five regional negotiating groups, with 54 member states
- Arab Group – formally the League of Arab States, a regional organisation formed in 1945

Developed countries' group

- European Union (EU) – the 28 member states of the EU, with negotiations led by DG-Clima
- Umbrella Group (Australia, Belarus, Canada, Iceland, Israel, Japan, New Zealand, Kazakhstan, Norway, the Russian Federation, Ukraine and the United States)– a cross-continent group of countries

Source: Climate policy info hub

Photos from COP21

Paris Agreement in comparison with Kyoto Protocol

	Kyoto Protocol	Paris Agreement
What are to be done	Mitigation	Mitigation, Adaptation, Finance support, Review
Who are to mitigate	Developed countries	All parties
How to set mitigation target	Decided by COP (top-down)	Decided by each party (bottom-up)
What are mandated	Compliance of the target (penalty for no compliance)	Efforts to aim the target (compliance of the target is not mandate)
Emission coverage	26% (to global energy related CO2 between 2008-2012)	100%
Long term vision	No long term vision	Holding temperature increase well below 2 degree
Adaptation	—	Necessity for developing countries
Finance support	—	Mandate for developed countries to provide to developing countries
Transparency	—	All parties shall submit NDC and follow review process
Review	Kyoto Protocol shall be reviewed to decide new target for next commitment period	Each party shall submit new NDC in every 5 years

Overview of Paris Agreement

	Relevant text in Paris Agreement	Legal binding force
Long term target (Article 2)	This Agreement aims (…) to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by: (a) Holding the increase in the global average temperature to well below 2° C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5° C above pre-industrial levels	Not mandate
Pathway for the long term target (Article 3, Paragraph 1)	In order to achieve the long-term temperature goal set out in Article 2, (…) Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty.	Not mandate

Overview of Paris Agreement

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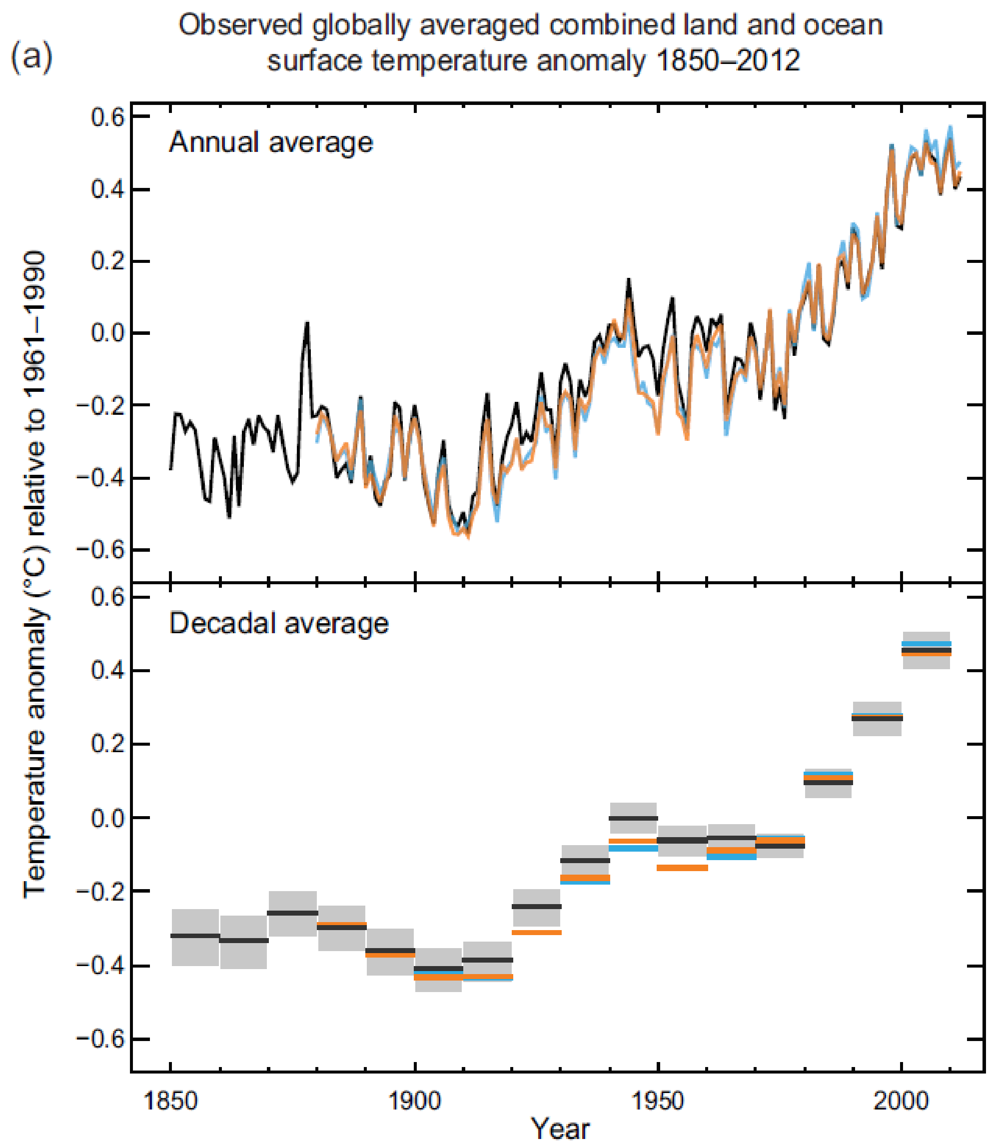
	Relevant text in Paris Agreement	Legal binding force
Short term target for all parties (Article 3, Paragraph 2)	Each Party shall prepare, communicate and maintain successive nationally determined contributions that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions.	Mandate: NDC preparation, communication, maintenance and pursuing domestic mitigation measures (achieving the objectives is not mandate)
Support to developing countries (Article 3, Paragraph 5)	Support shall be provided to developing country Parties for the implementation of this Article, in accordance with Articles 9, 10 and 11, recognizing that enhanced support for developing country Parties will allow for higher ambition in their actions.	Mandate
Mechanism to check progress of domestic measures (Article 13, Paragraph 7)	Each Party shall regularly provide the following information: (b) Information necessary to track progress made in implementing and achieving its nationally determined contribution under Article 4.	Mandate
Review process to check progress toward long term target (Article 14, Paragraph 1)	The Conference of the Parties serving as the meeting of the Parties to this Agreement shall periodically take stock of the implementation of this Agreement to assess the collective progress towards achieving the purpose of this Agreement and its long-term goals (referred to as the "global stocktake").	Mandate

CLIMATE CHANGE (IPCC AR5, SR1.5)

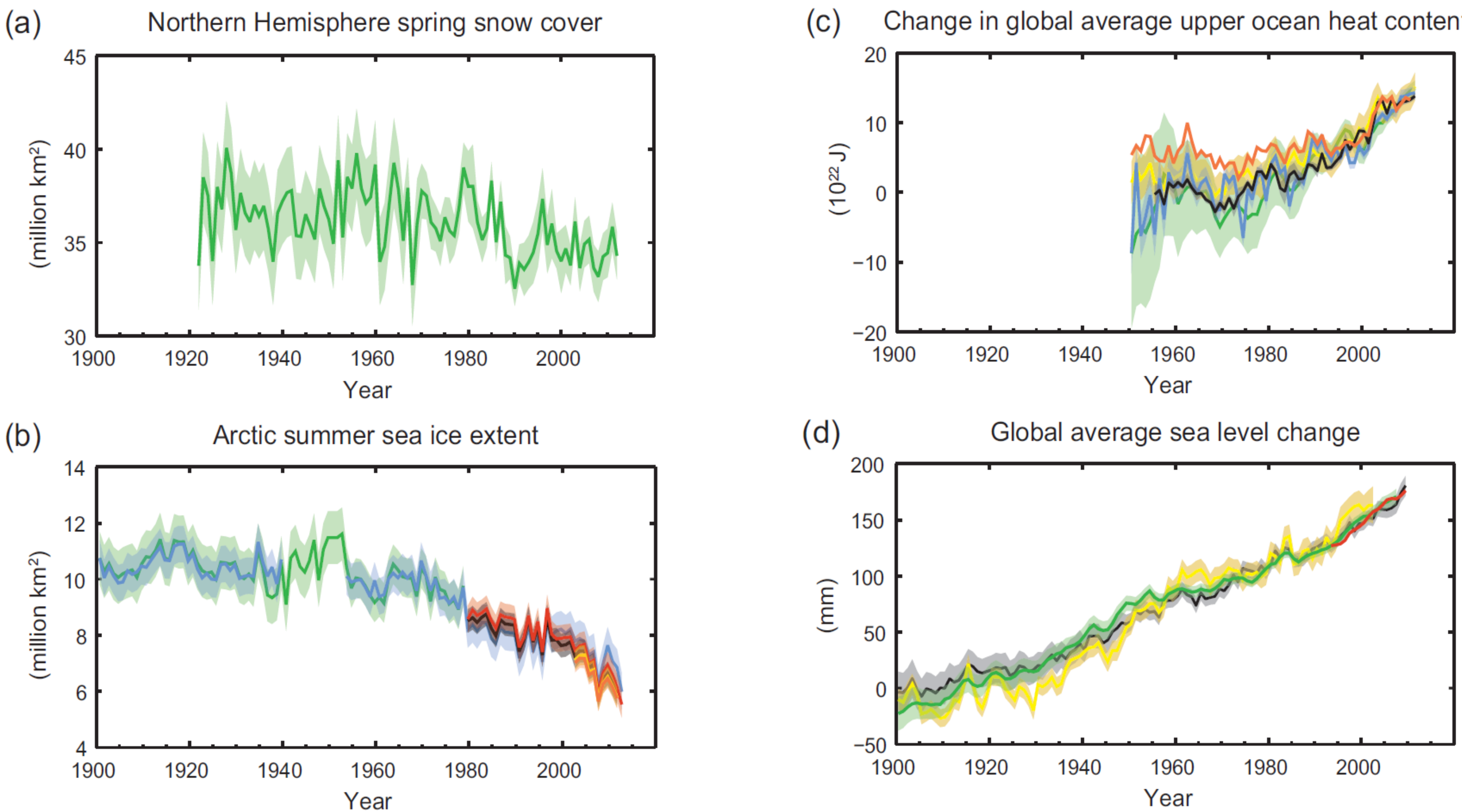
Scientific base for climate change

- The Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988.
- The objective of the IPCC is to provide governments at all levels with scientific information that they can use to develop climate policies.
- Since 1988, the IPCC has had delivered five Assessment Reports, the most comprehensive scientific reports about climate change.
- Three working groups are in charge of Assessment Report based on the latest academic findings;
  - Working Group I The Physical Science Basis
  - Working Group II Impacts, Adaptation and Vulnerability
  - Working Group III Mitigation of Climate Change
- Each Assessment Report (some thousands pages) and Synthesis Report (a couple of hundreds pages) are summarized into Summary for Policymakers (SPM, 20-30 pages) that were reviewed by government officials.

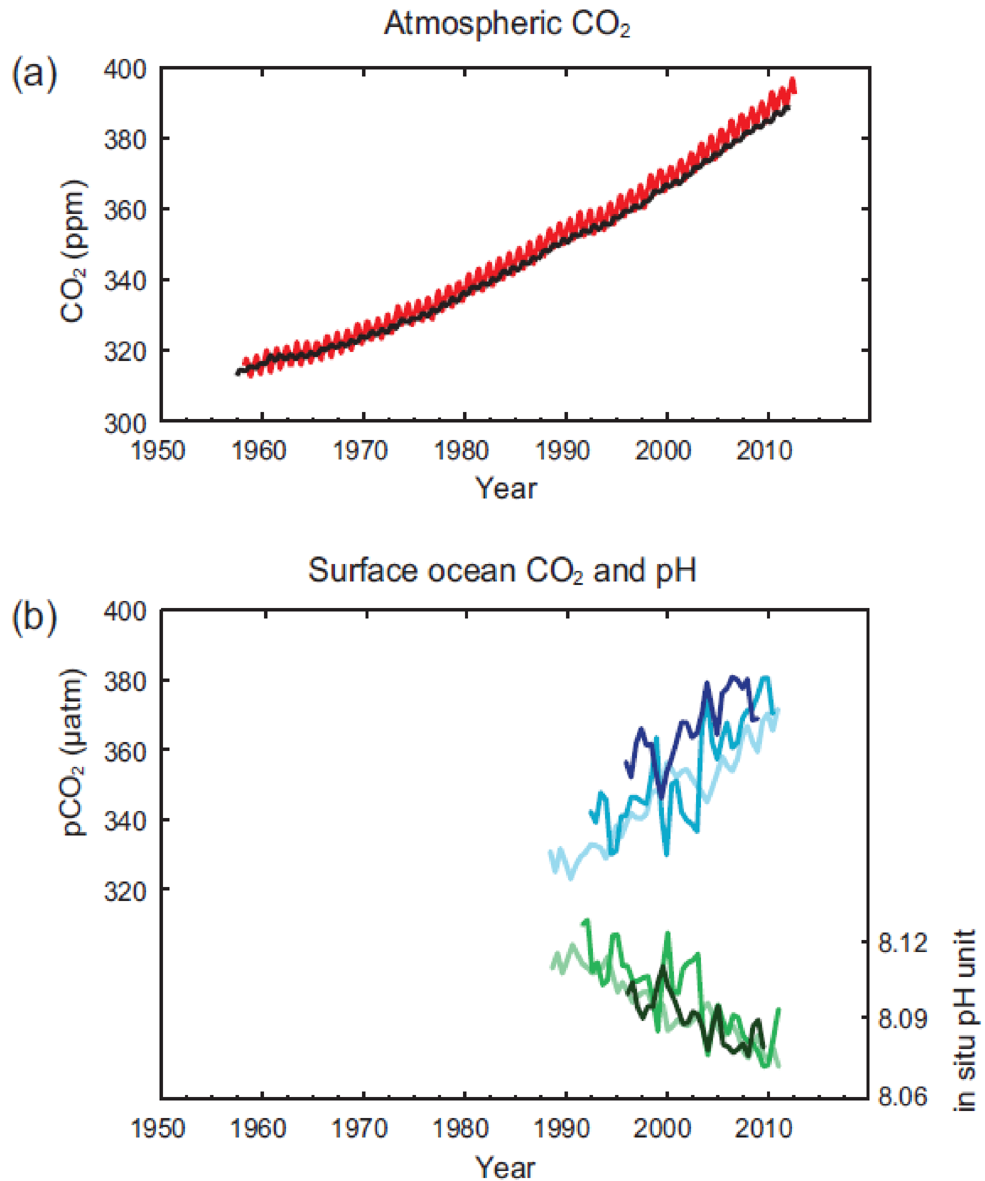
WG1 AR5 SPM: Figure SPM1



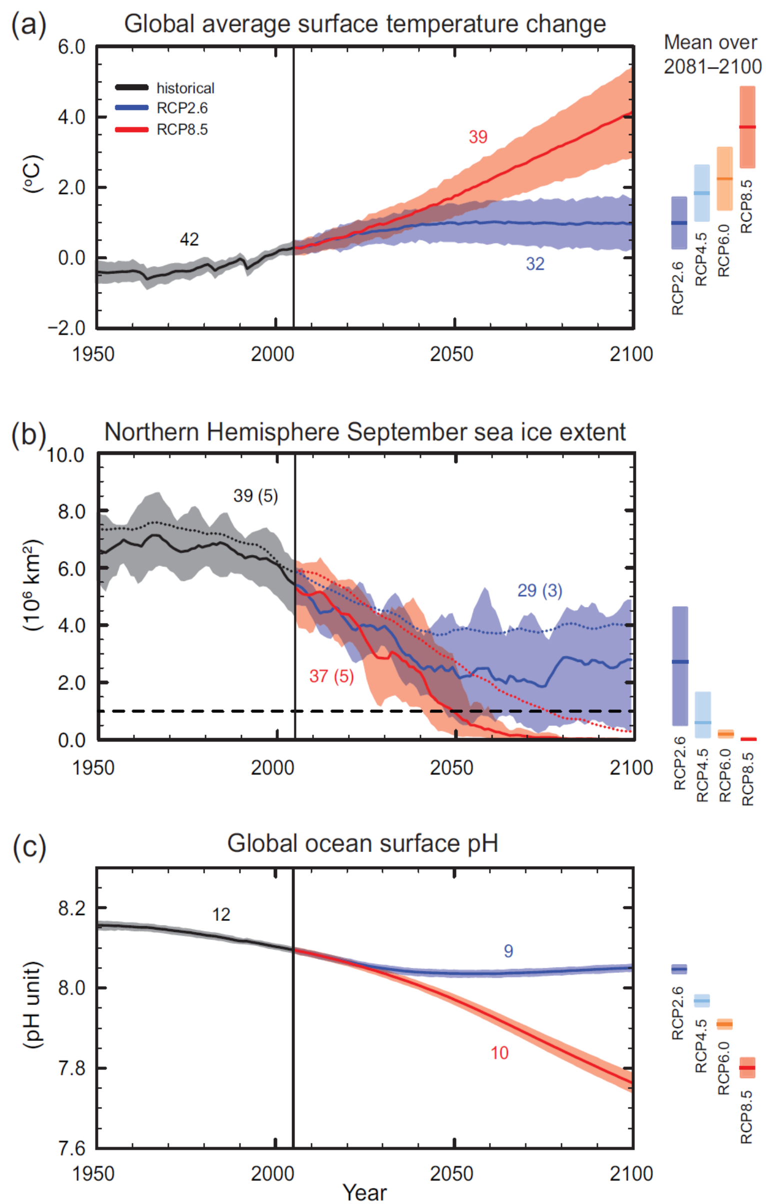
WG1 AR5 SPM: Figure SPM3



WG1 AR5 SPM: Figure SPM4

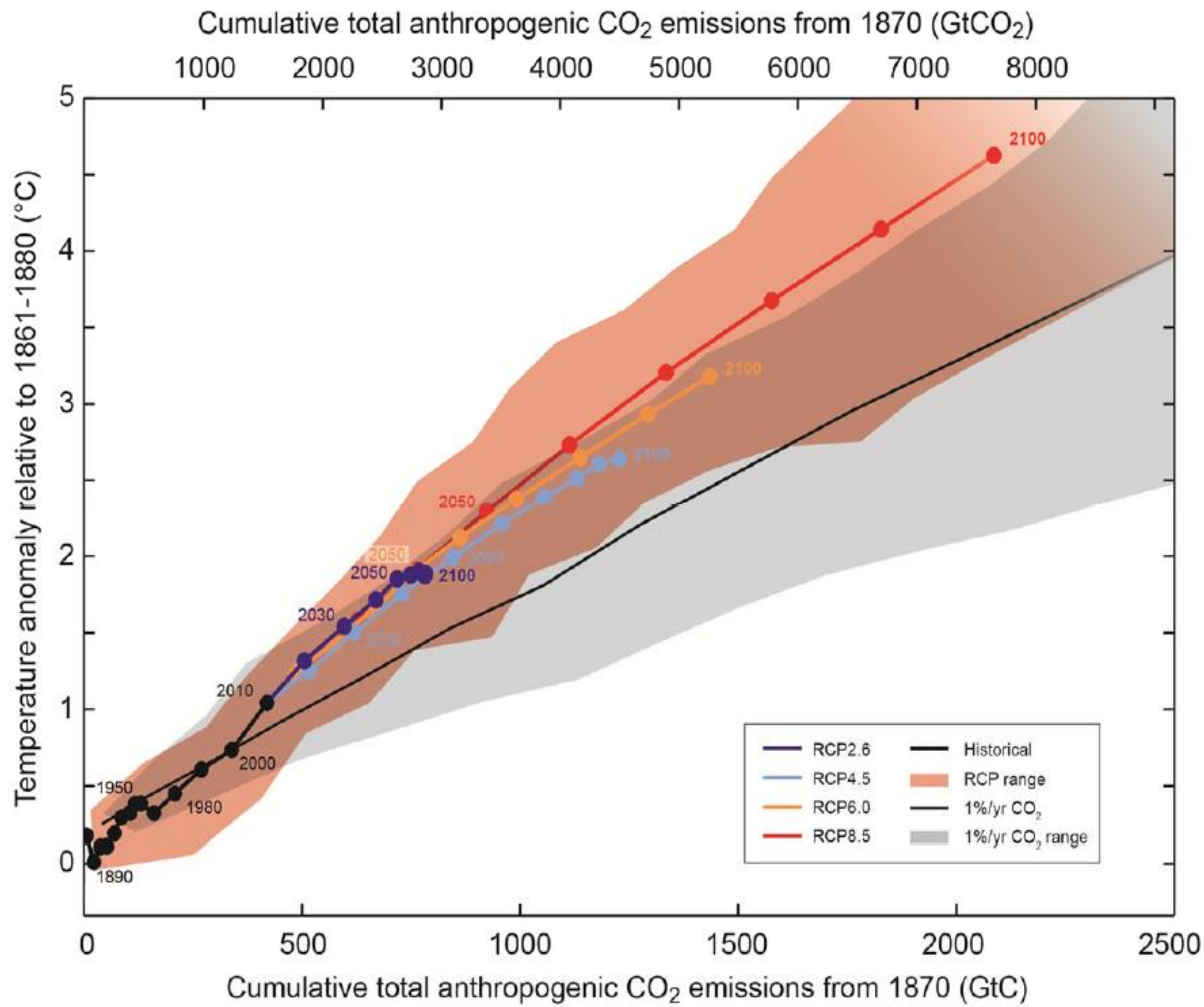


WG1 AR5 SPM: Figure SPM7

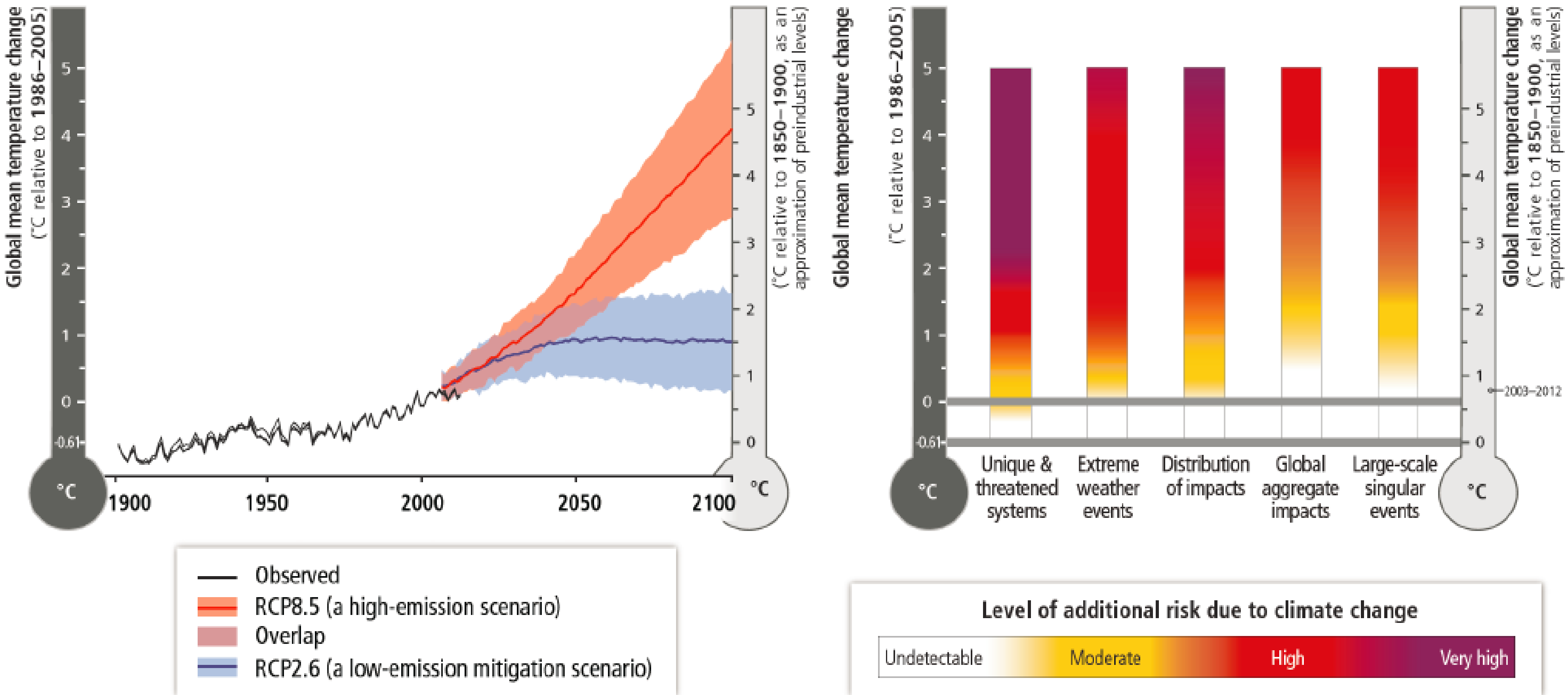


WG1 AR5 SPM: Figure SPM10

Figure SPM.10 [FIGURE SUBJECT TO FINAL COPYEDIT]



WG2 AR5 SPM: Assessment Box SPM.1 Figure 1.



WG2 AR5 SPM:

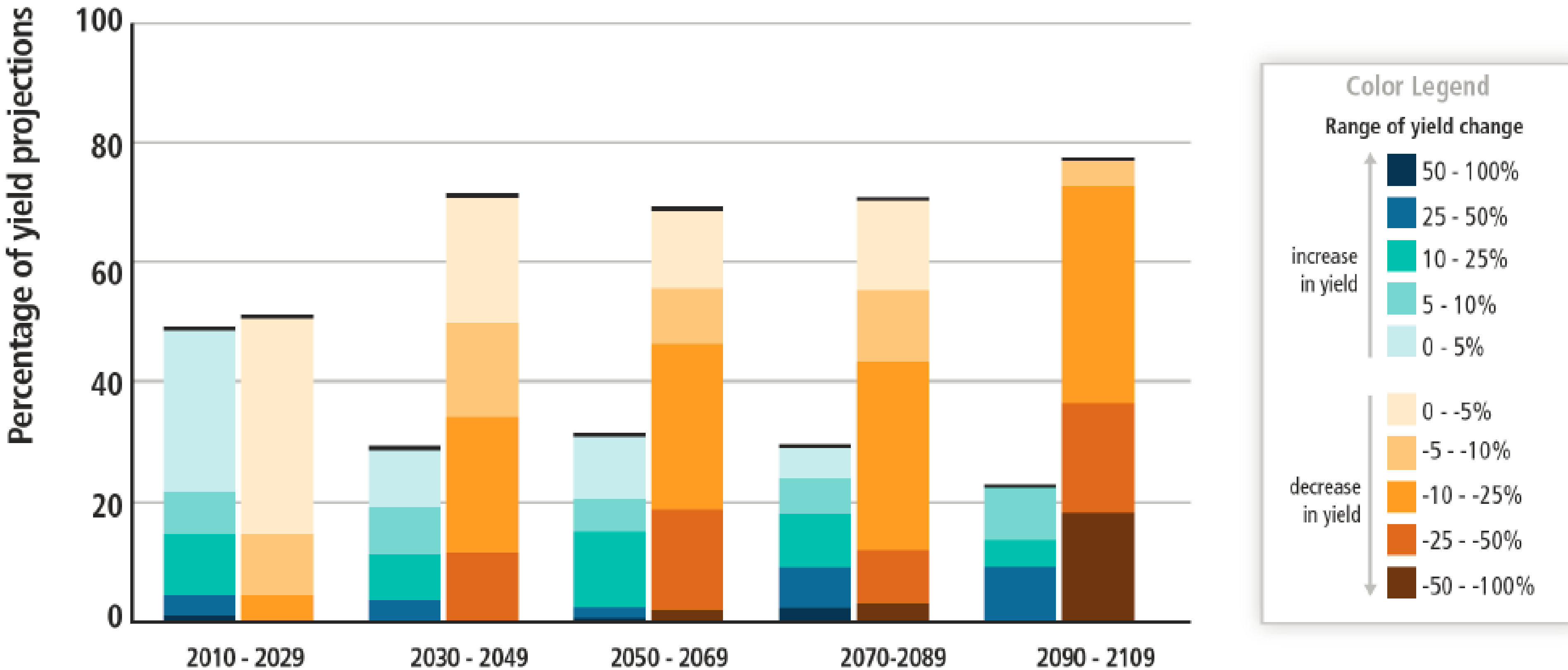


Figure SPM.7.

WG2 AR5 SPM: Figure SPM. 5

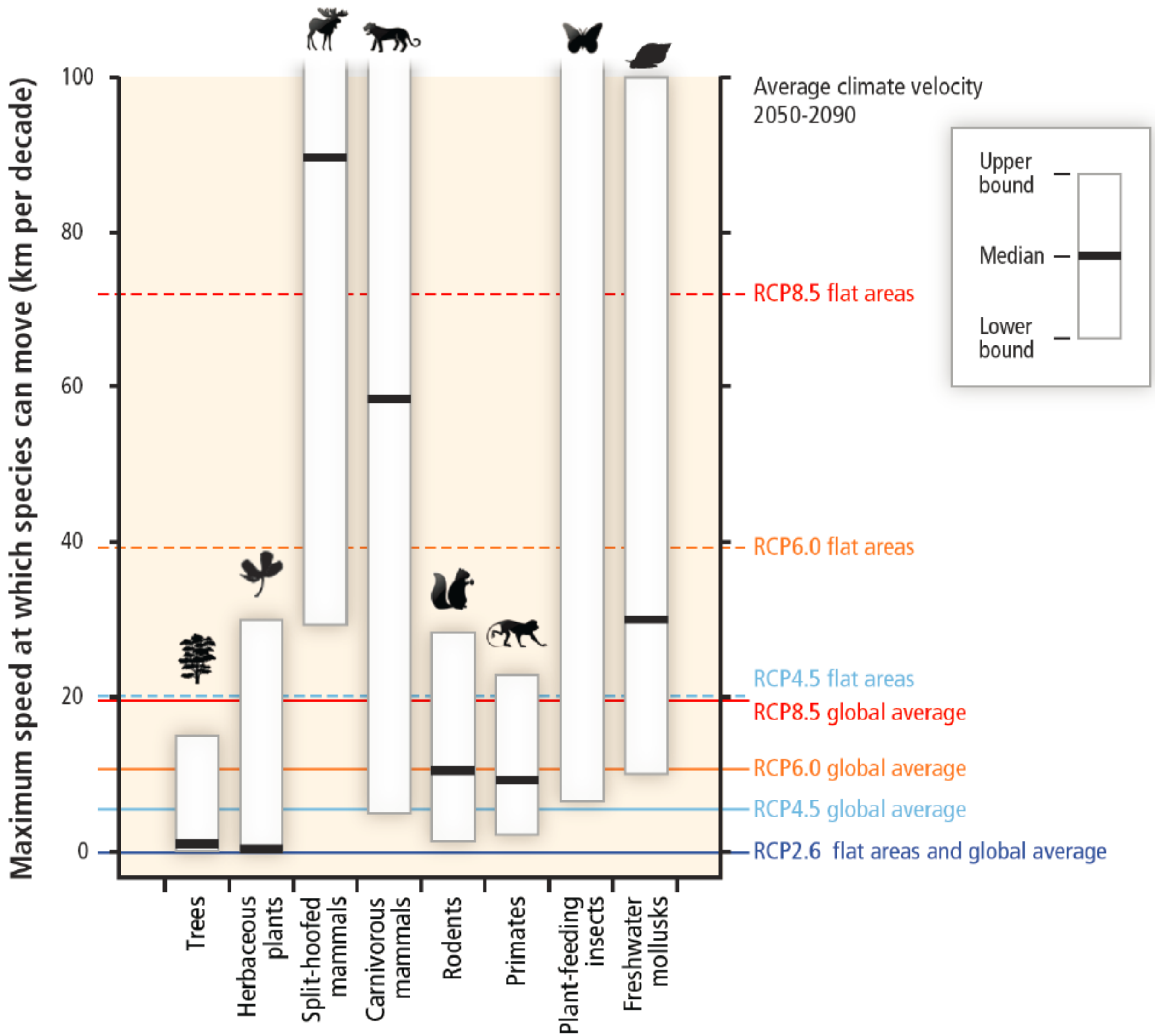
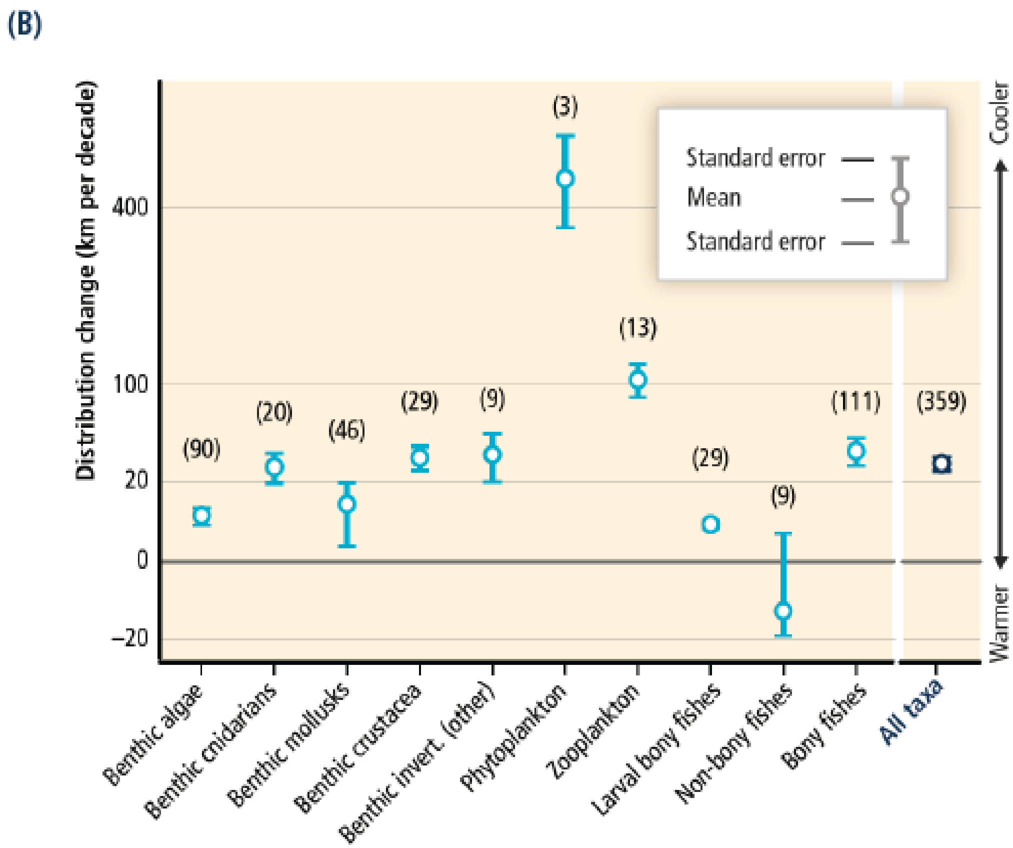


Figure SPM.5.

WG2 AR5 SPM: Figure SPM. 2



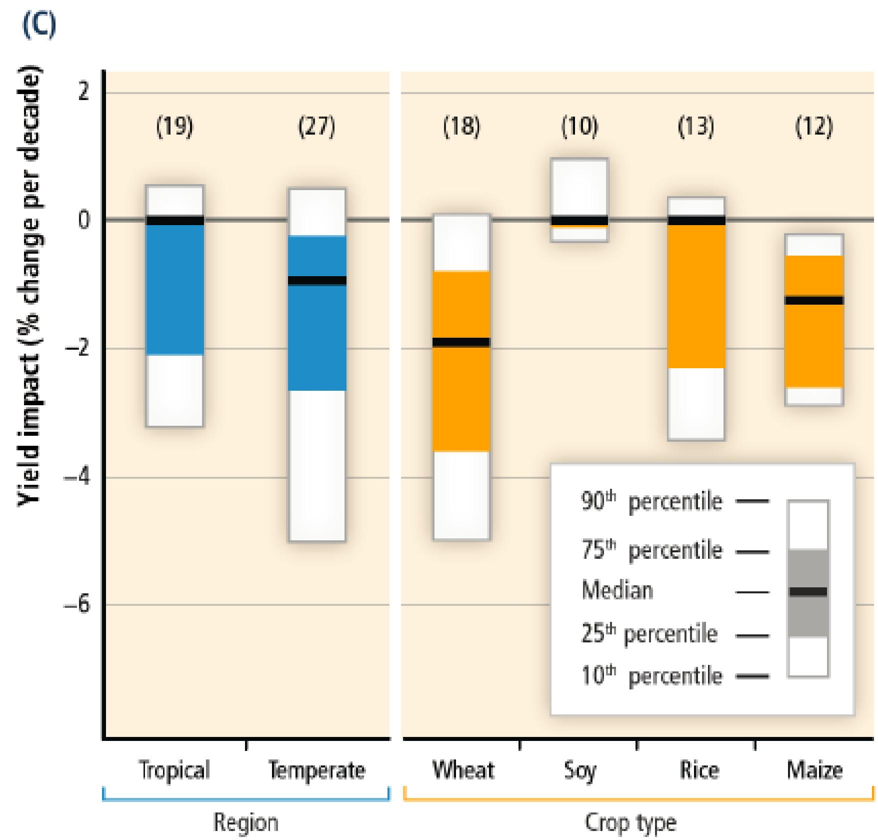


Figure SPM.2.

WG3 AR5 SPM: Figure SPM. 4

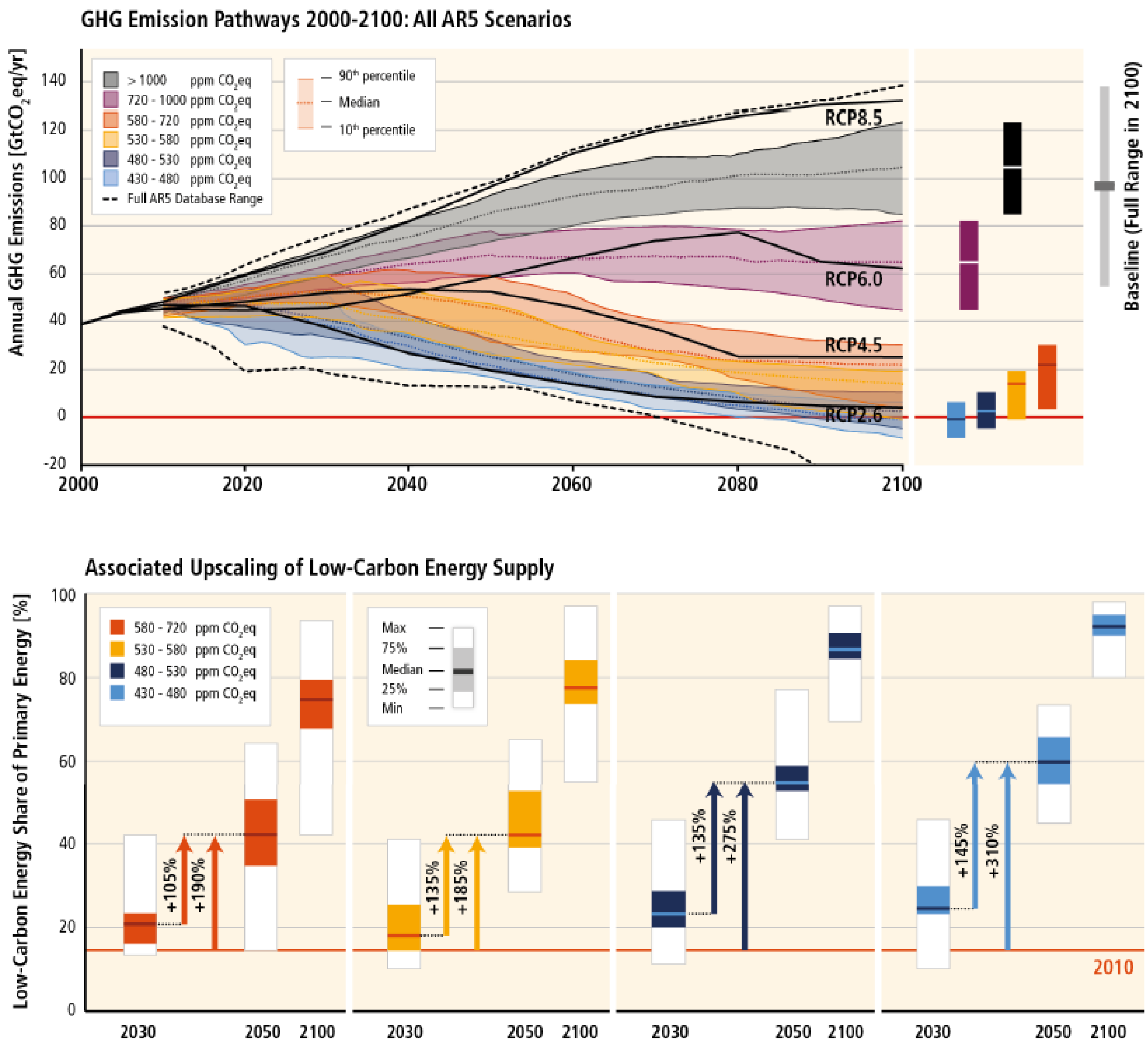
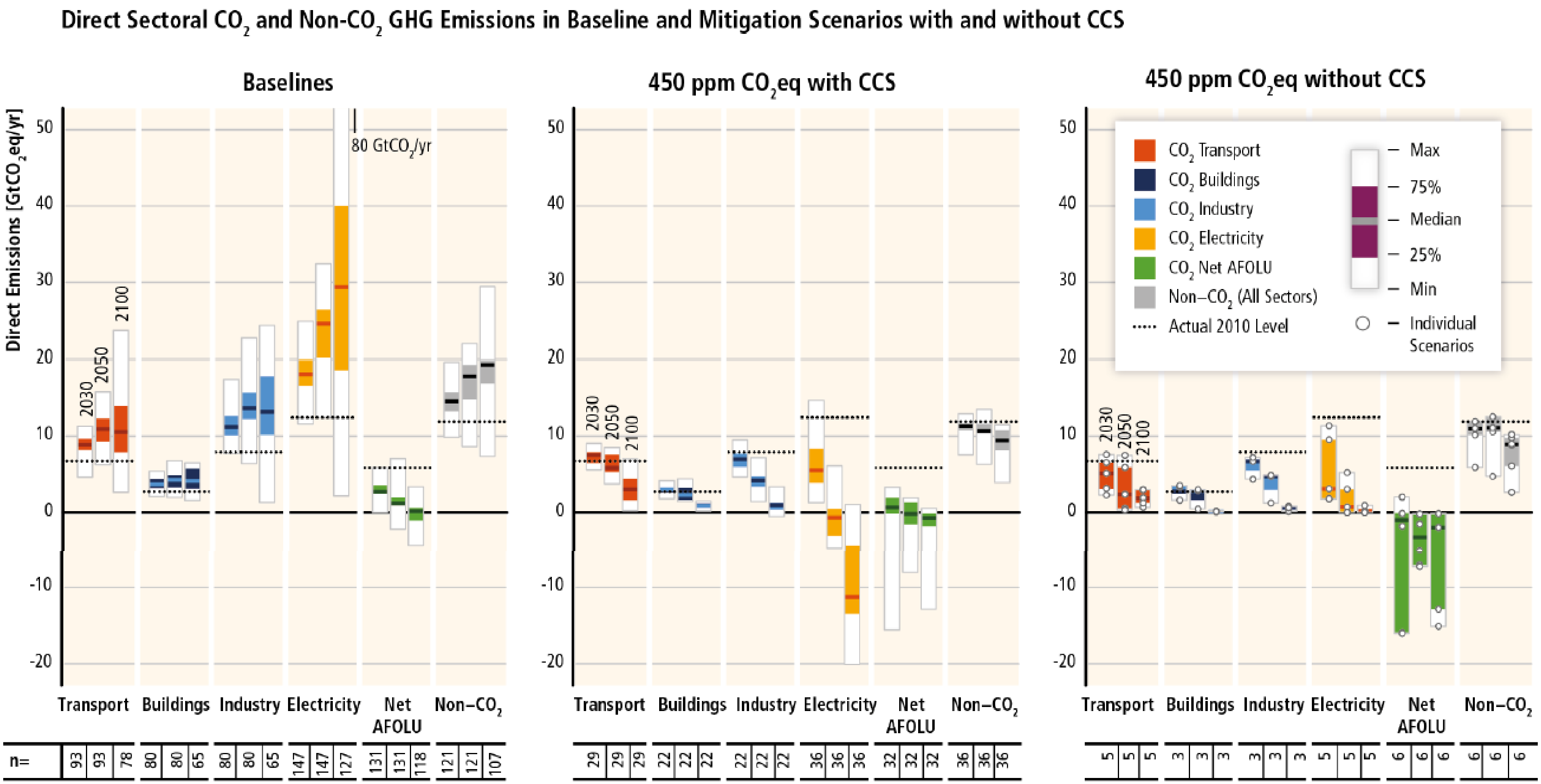
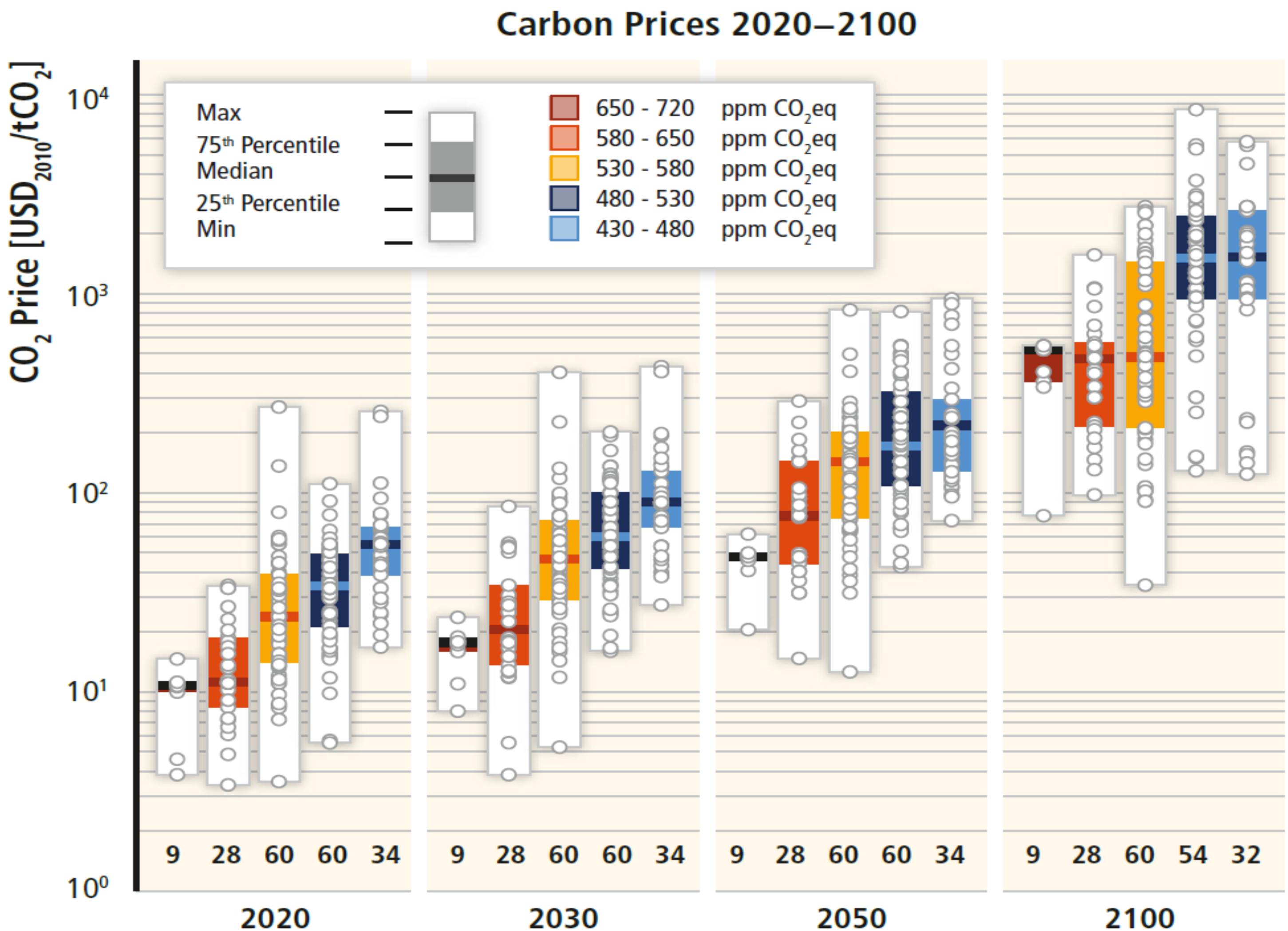


Figure SPM.4. Pathways of global GHG emissions ($GtCO_2eq/yr$) in baseline and mitigation scenarios

WG3 AR5 SPM: Figure SPM 7



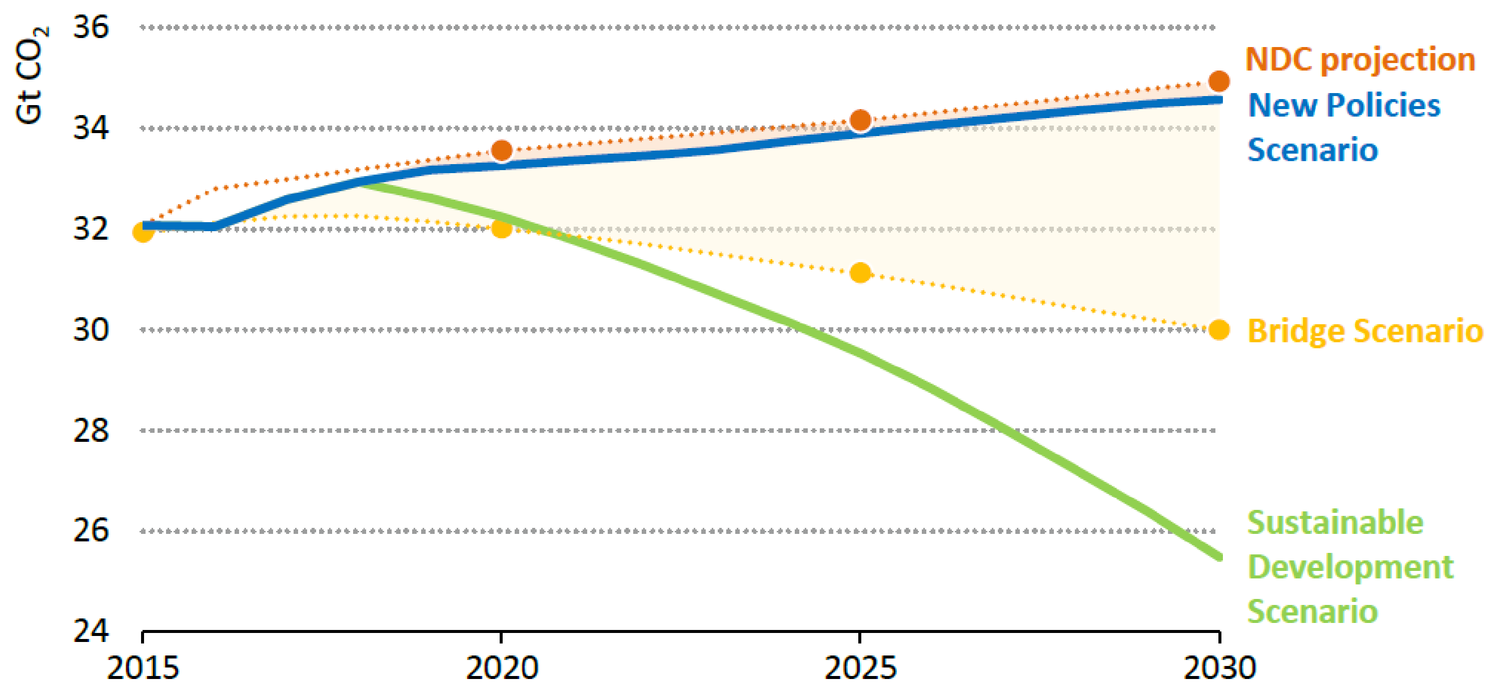
AR5 WG3 Technical Summary: Figure TS



GAP BETWEEN 2DEGREE SCENARIO AND REALITY(NDC)

Gap of CO2 emission between NDC and 2℃

Figure 2.11 ▷ CO_2 trajectories relative to aggregate emissions levels implied by NDCs, 2015-2030

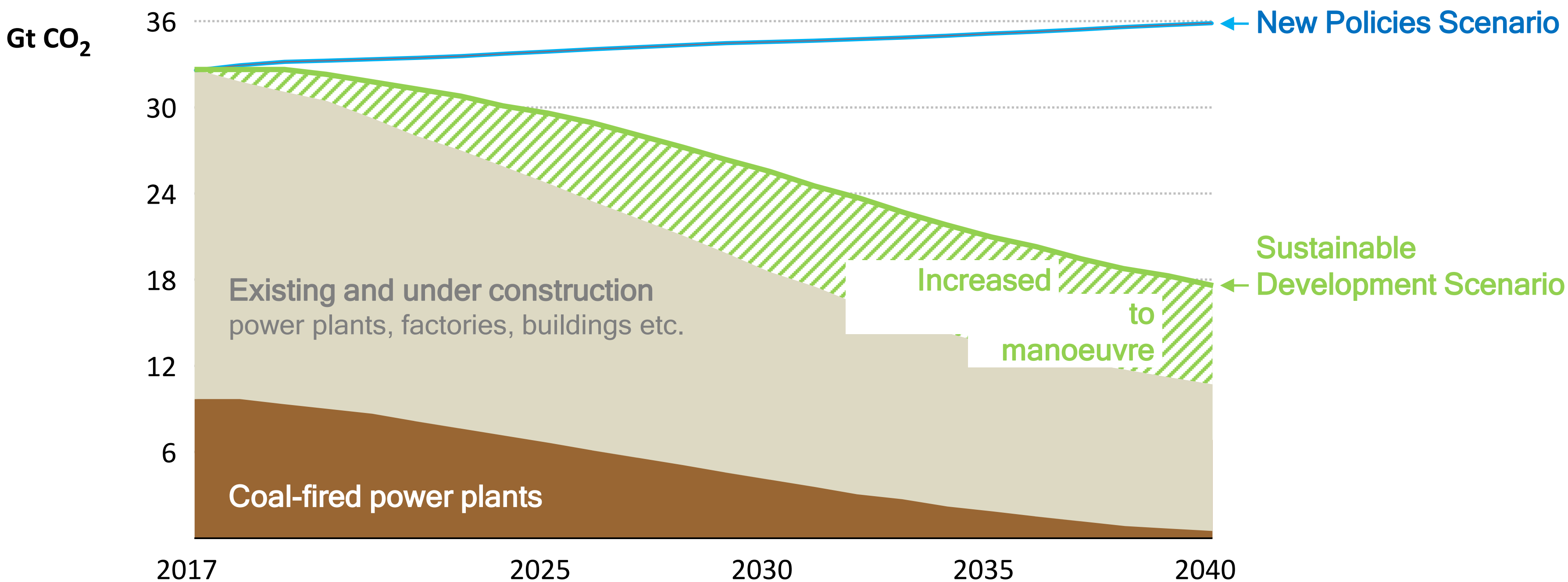


CO_2 emissions are currently higher than the level projected in the Bridge Scenario, and on a trend far from the trajectory of the Sustainable Development Scenario

Source: IEA "Word Energy Outlook 2018"

Global energy-related CO_2 emissions

- Half of coal plants are less than 15 years old.
- Policies are needed to support CCUS, efficient operations and technology innovation.



Source: IEA "Word Energy Outlook 2018"

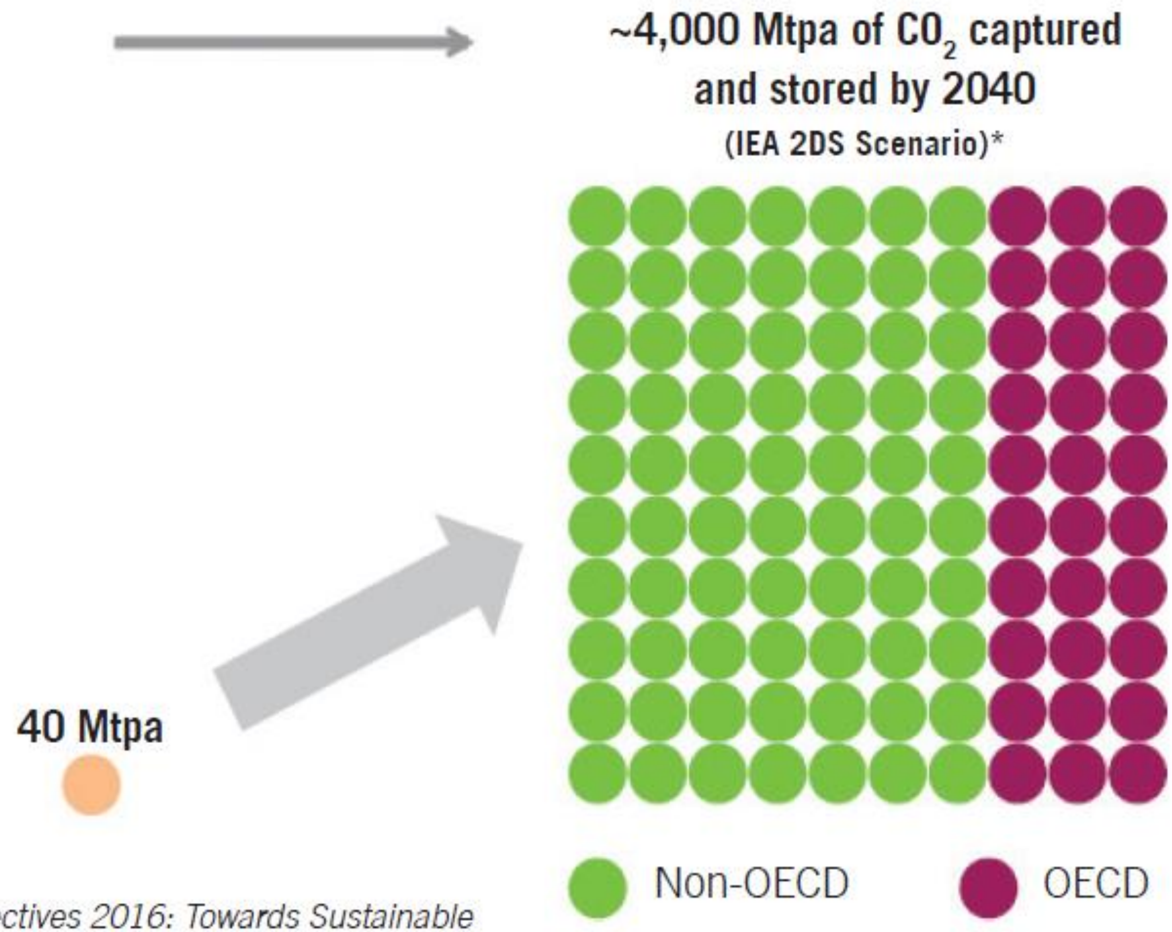
Progress in CCS

Figure 3 **A significant task for CCS deployment is required by 2040 under the IEA 2DS**

Global Status of CCS
November 2016

38 large-scale CCS projects – combined CO_2 capture capacity of approximately 70 Mtpa:

- 21 projects in operation or construction (**40.3 Mtpa**)
- 6 projects in advanced planning (8.4 Mtpa)
- 11 projects in earlier stages of planning (21.1 Mtpa)



*Source: IEA, *2016 Energy Technology Perspectives 2016: Towards Sustainable Urban Energy Systems.* Paris. OECD/IEA.

Source: GCCSI "Status report of CCS, 2016"

Progress in CCS

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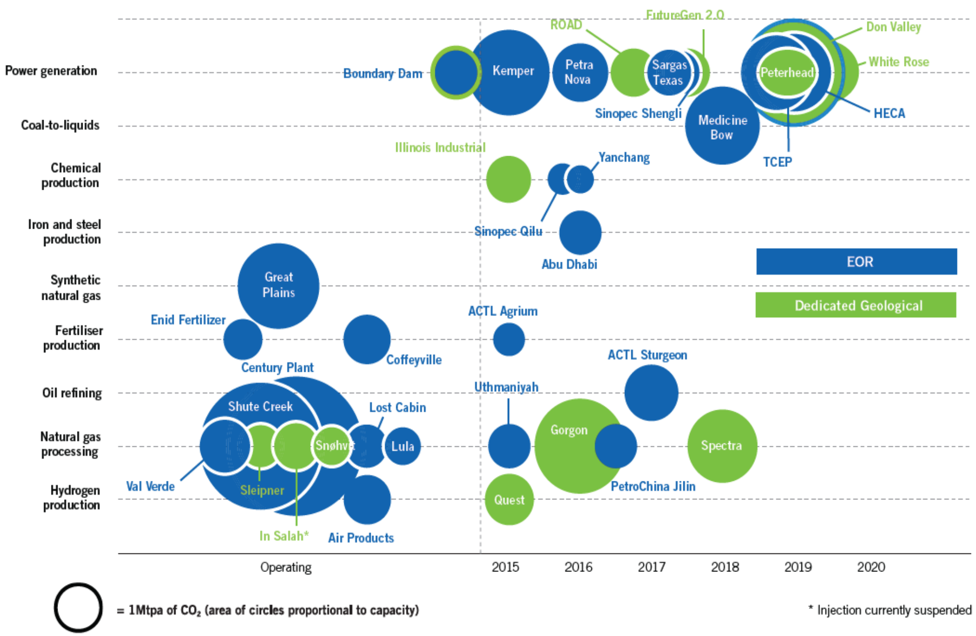
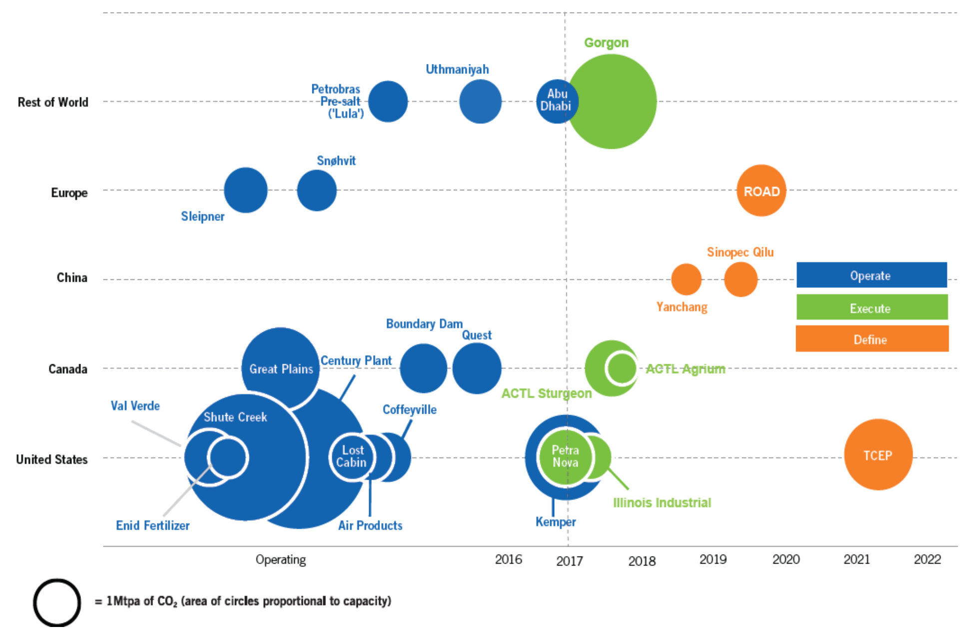
CCS project status in 2014

Figure 1.2 Actual and expected operation dates for large-scale CCS projects in the Operate, Execute and Define stages by industry and storage type, as shown in the *Global Status of CCS: 2014* report



CCS project status in 2016

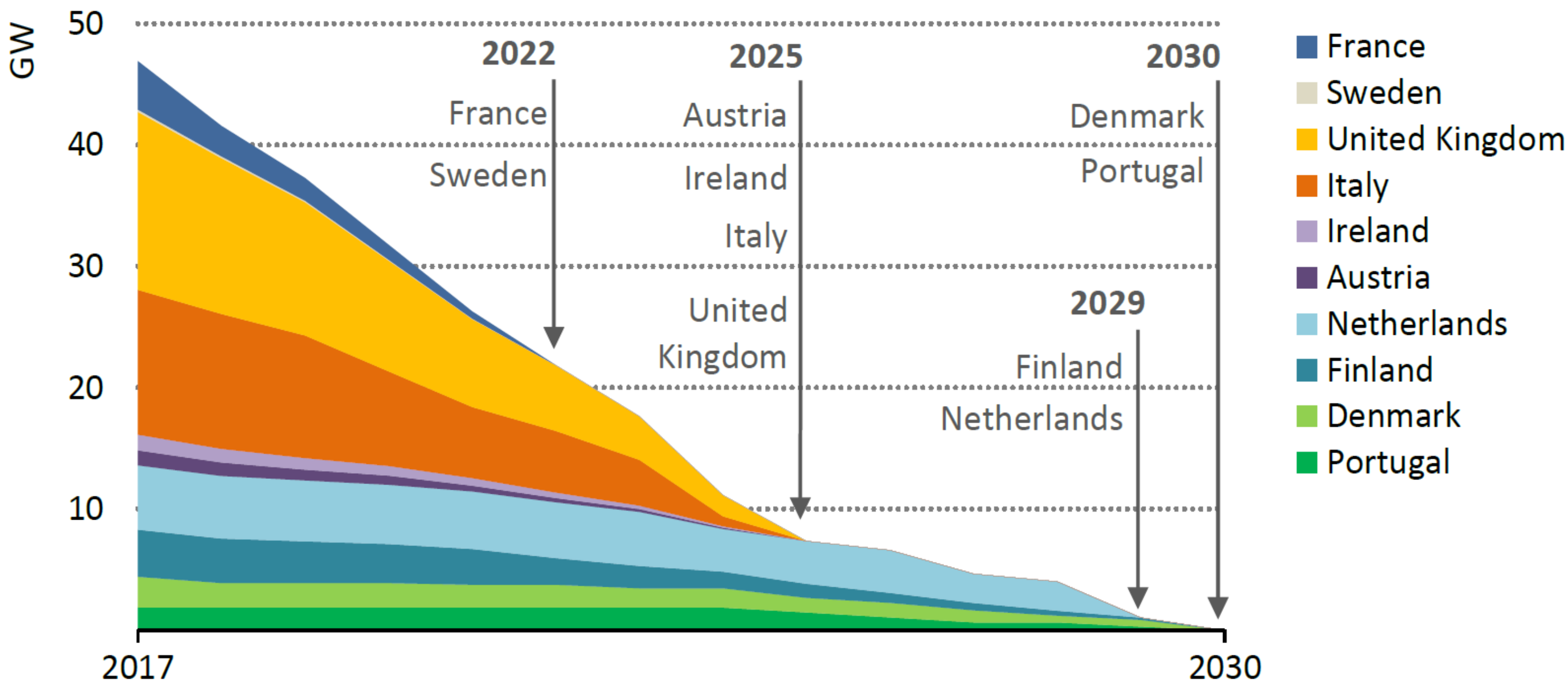
Figure 1.4 Actual and expected operation dates up to 2022 for large-scale CCS projects in the Operate, Execute and Define stages by region and project lifecycle stage, *Global Status of CCS: 2016* report



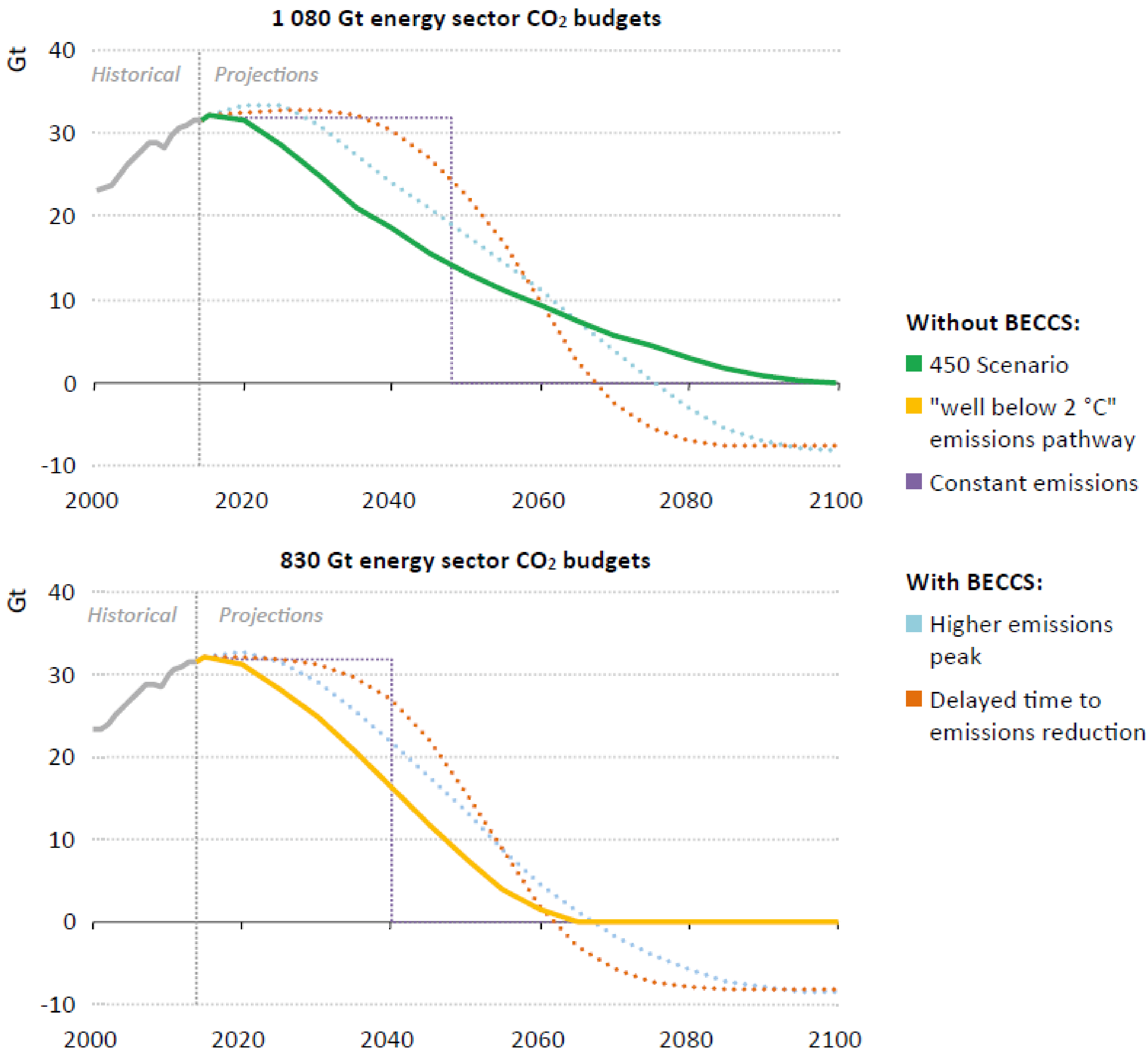
Source: GCCSI "Status report of CCS, 2016"

Plans to phase out coal in EU

- By 2030, 28% of the existing coal-fired power generation capacity will be retired in EU.
- To global existing coal-fired power generation capacity, it accounts for 2.2%.

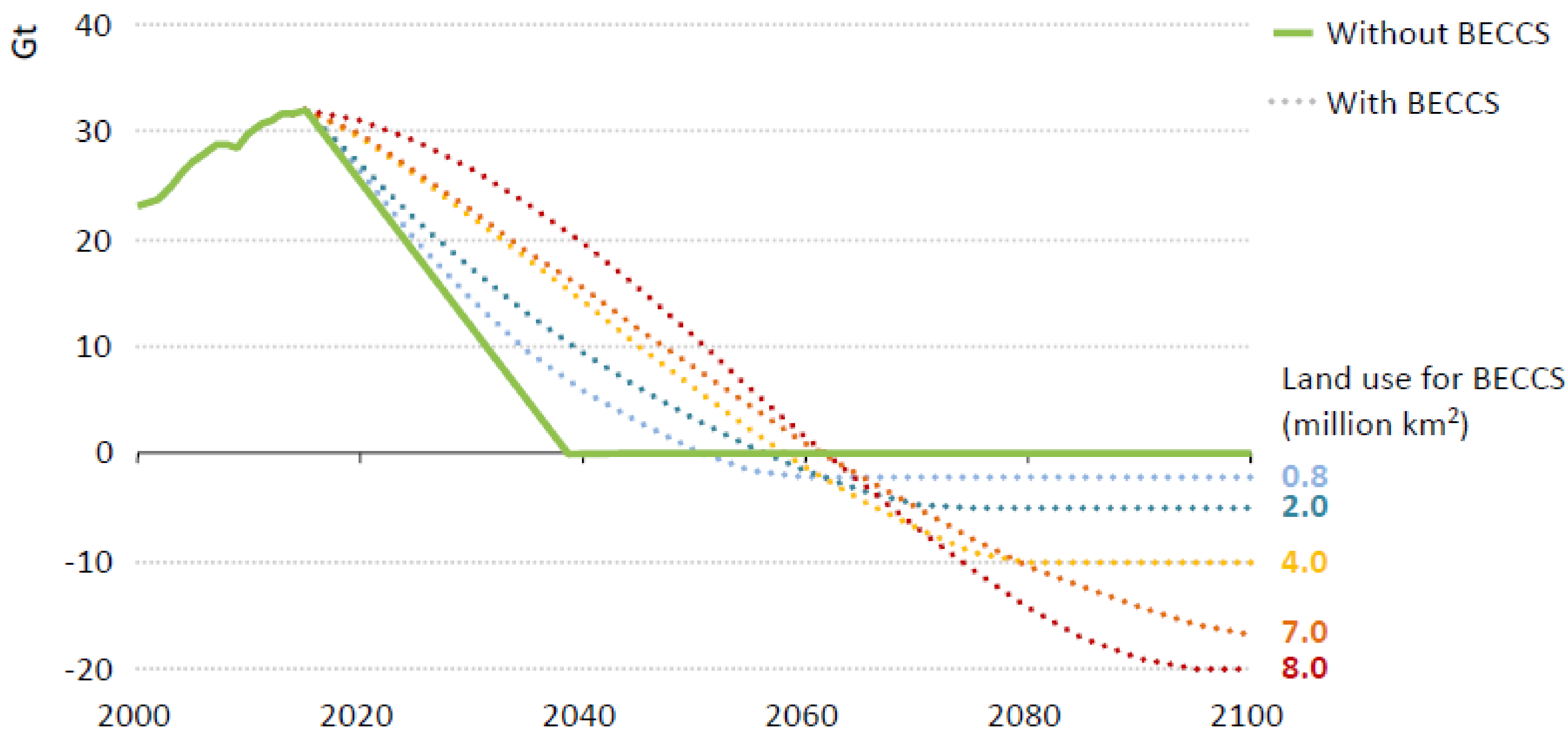


2℃ and “well below 2℃”



… and "1.5°C"

Figure 8.16 ▷ Energy sector CO_2 emission pathways consistent with a 1.5 °C temperature rise



POWER SECTOR LOW CARBONIZATION: VARIABLE RENEWABLE ENERGY AND FLEXIBILITY

Flexibility as the key feature of future-ready power systems

Variable renewable energy requires sufficient power system flexibility

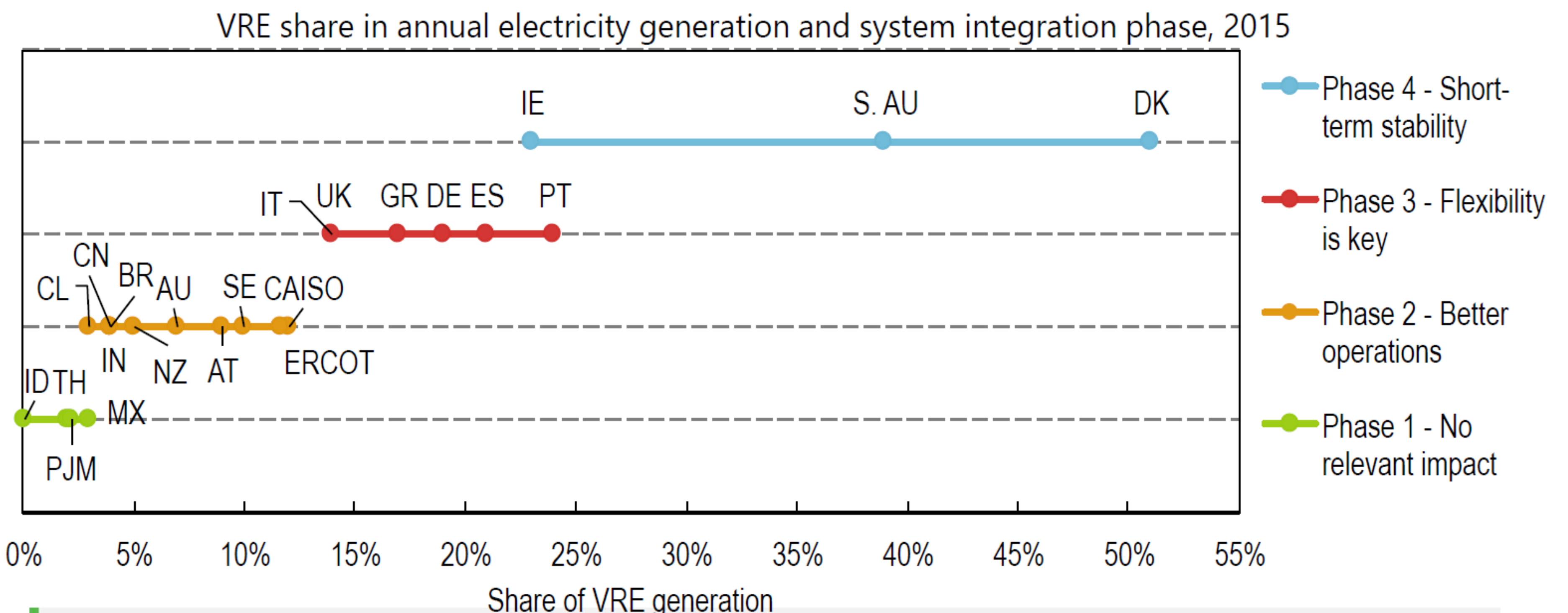
Flexibility requires both technologies and effective regulation/markets.

Global Attention to Power Plant Flexibility

- Advanced Power Plant Flexibility Campaign (APPF) was carried out as one of the activities of Clean Energy Ministerial from 2017 to 2018, coordinated by IEA.
- “Accommodating the growing shares of wind and solar power poses novel challenges for power systems”, “This raises the importance of power system flexibility”, “APPF seeks to build strong momentum and commitment from governments and industry to implement solutions that make power generation more flexible.”
- J-POWER participated in APPF as a private partner

VRE integration phase in selected countries

- IEA categorized VRE integration phase based on VRE penetration level and restrictions of respective power system.



Each VRE deployment phase can span a wide range of VRE share of generation; there is no single point at which a new phase is entered

AT = Austria; AU = Australia; BR = Brazil; CL = Chile; CN = China; DE = Germany; DK = Denmark; ES = Spain; GR = Greece; ID = Indonesia; IE = Ireland; IN = India; IT = Italy; MX = Mexico; NZ = New Zealand; PT = Portugal; S.AU = South Australia; SE = Sweden; UK = the United Kingdom; ZA = South Africa; TH = Thailand. PJM, CAISO and ERCOT are US energy markets in California and Texas, respectively.

8 © IEA 201

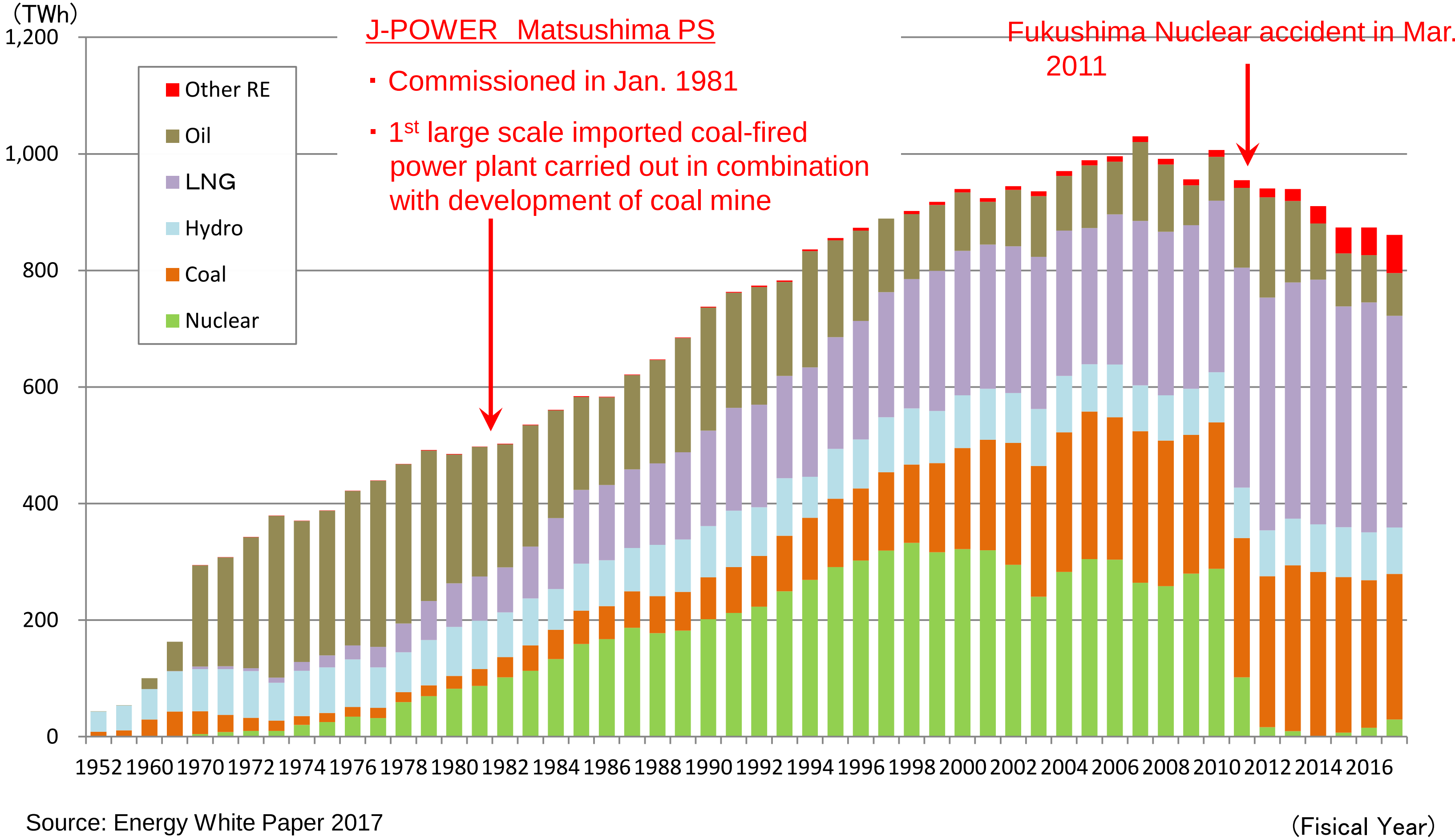
VRE integration phase and impact

	Attributes (incremental with progress through the phases)			
	Phase 1	**Phase 2**	**Phase 3**	**Phase 4**
Characterisation from a system perspective	VRE capacity is not relevant at the all-system level	VRE capacity becomes noticeable to the SO	Flexibility becomes relevant with greater swings in the supply/demand balance	Stability becomes relevant. VRE covers nearly 100% of demand at times
Impacts on the existing generator fleet	No noticeable difference between load and net load	No significant rise in uncertainty and variability of net load, but small changes to operating patterns	Greater variability of net load. Major differences in operating patterns;	No power plants are running around the clock; all plants adjust output to VRE output
Impacts on the grid	Local grid condition near points of connection, if any	Likely to affect local grid conditions; congestion is possible, driven by shifting power flows	Significant changes in power flow patterns across the grid; increased two-way flows between HV and LV grids	Requirement for grid-wide reinforcement, and improved ability of the grid to recover from disturbances
Challenges depend mainly on	Local conditions in the grid	Match between demand and VRE output	Availability of flexible resources	Strength of system to withstand disturbances

POWER SECTOR LOW CARBONIZATION: CASE STUDY IN JAPAN

Japan's Electricity Supply by Energy Resources

- After the oil crises in the 1970s, Japan's energy policy targeted achieving a well balanced energy portfolio and it was about to realize it in 2010.
- But nuclear generation has suddenly ceased after Fukushima nuclear accident in 2011.3.11. Single accident affects all nuclear plants.



[2010FY ⇒ 2017FY]

Other Renewables
1.1⇒7.6%

Oil & Petro
7.5⇒8.5%

LNG
29.3⇒42.2%

Hydro & Pumped Storage
8.5⇒9.3%

Coal
25.0⇒29.0%

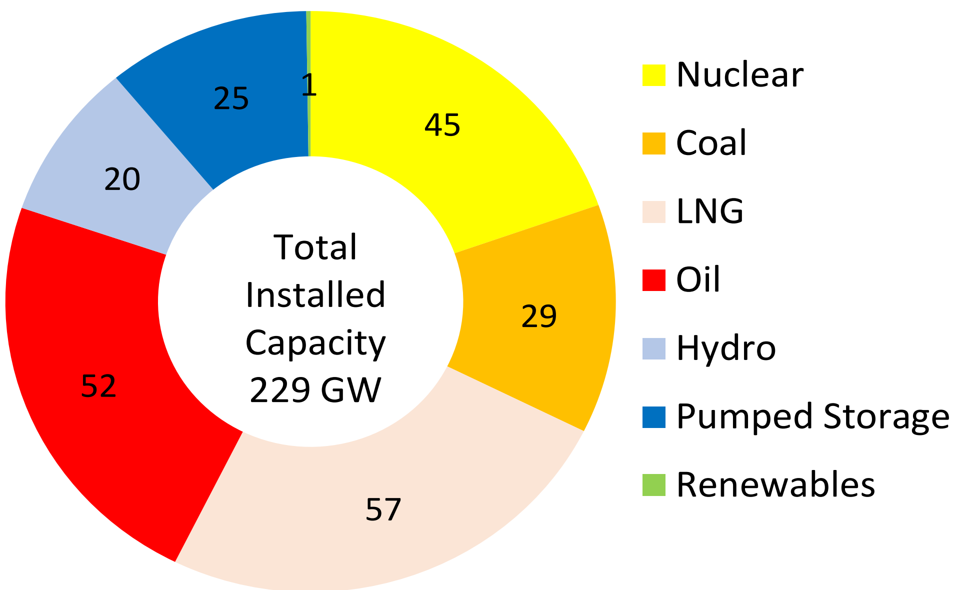
Nuclear
28.6⇒3.4%

Source: Energy White Paper 2017

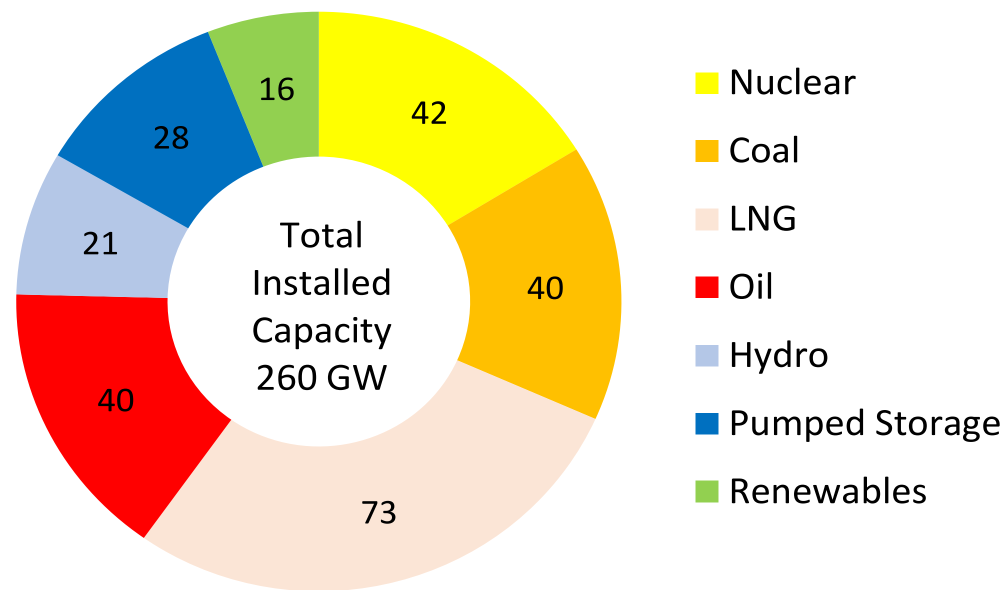
Japan’s Power Generation Capacity Portfolio

- From 2000 to 2015, installed capacity of RE has remarkably increased, though most of solar PV and wind farms are owned by new entrants and not presented in the pie charts.
- Existence of 28GW pumped storage hydro (PSH) is a unique aspect of Japan’s power generation capacity portfolio.

2000



2015

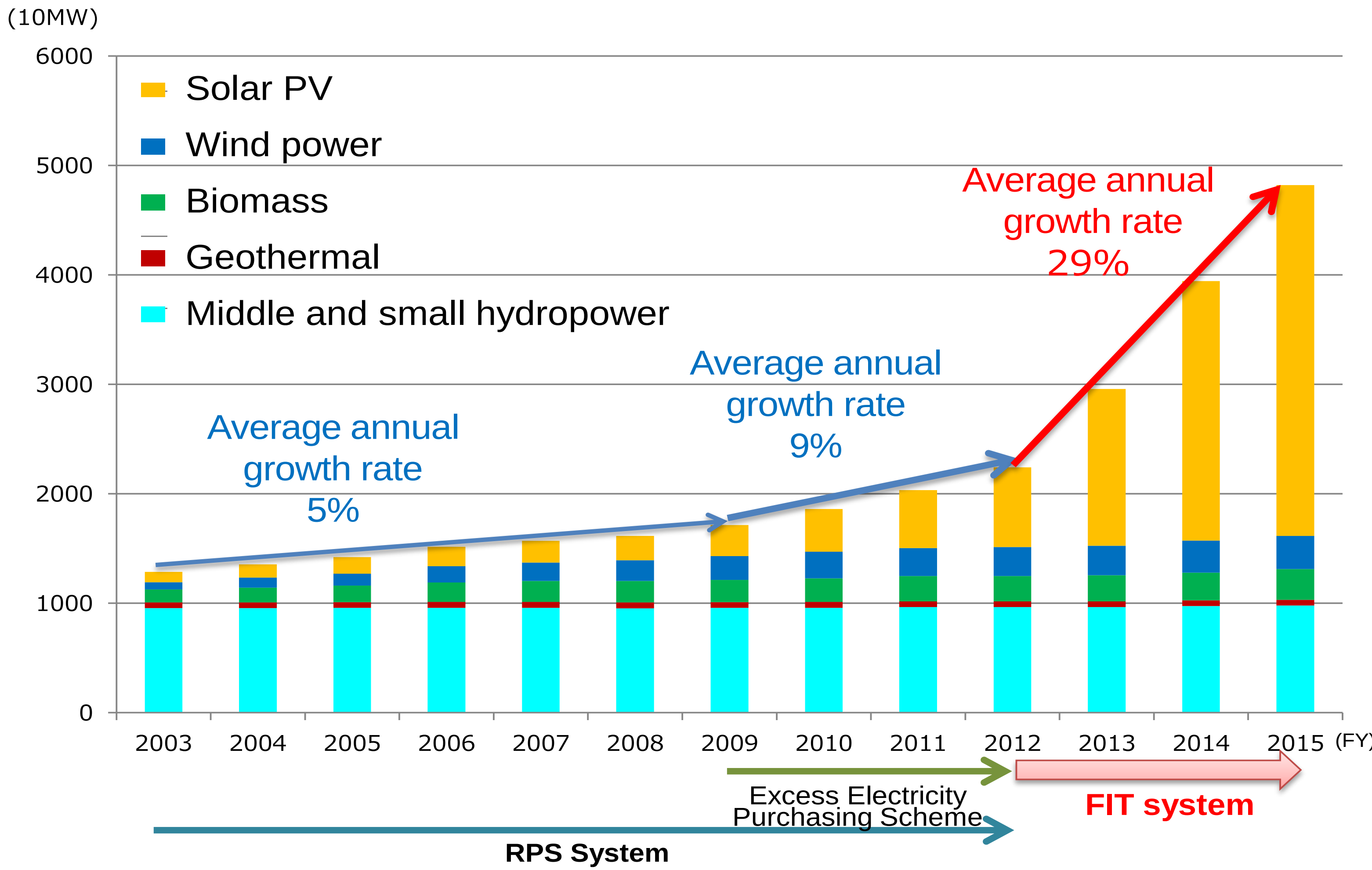


Power generation capacity by type in Japan (excluding new entrants)

Source: Energy White Paper 2017

Growth of Renewables

- RE promotion policy started with RPS in 2003 supplemented by Excess Electricity Purchasing Scheme in 2009. In 2012 they were replaced by Feed-in Tariff that triggered a surge of solar PV.

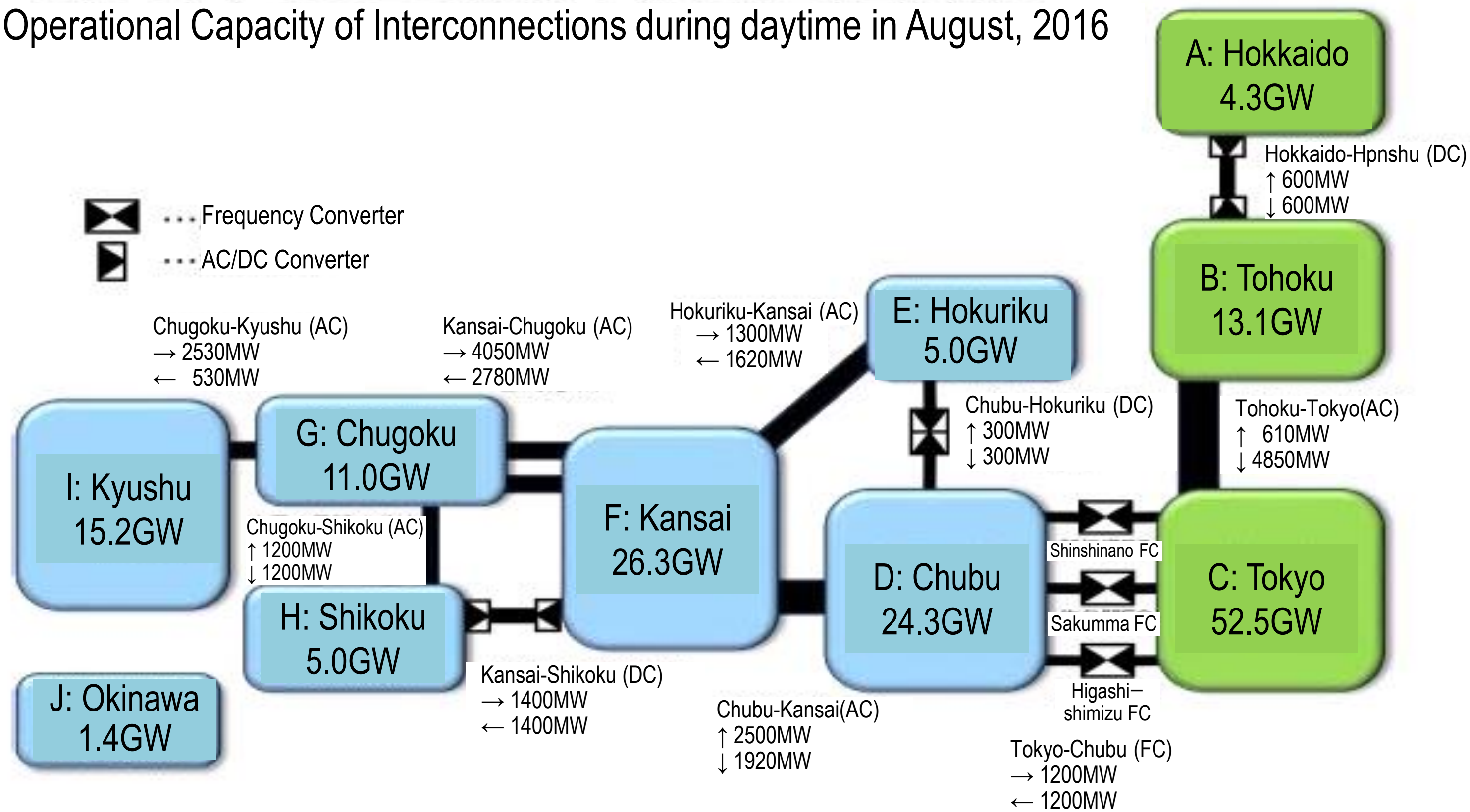


Source: presentation of Ministry of Economy, Trade and Industry

Power System in Japan

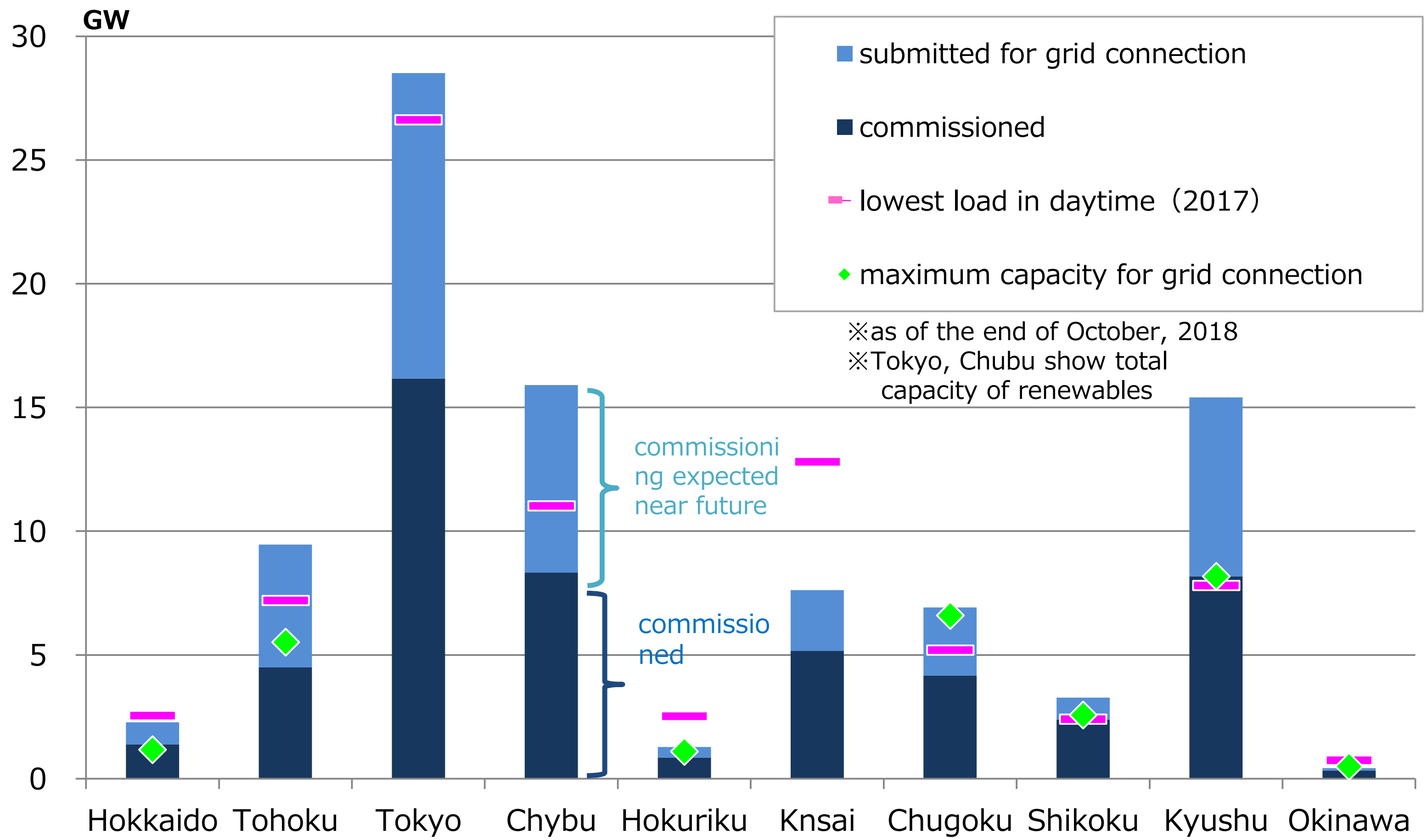
- Japan's power system consisting of 10 grids is divided between East (50Hz) and West (60Hz) in frequency.
- 9 grids going through four main islands are connected with interconnections and FCs like "fishbone", which is totally different from the meshed network in the US or Europe.
- Interconnections between grids vary in number, capacity and type(AC/DC).

Operational Capacity of Interconnections during daytime in August, 2016



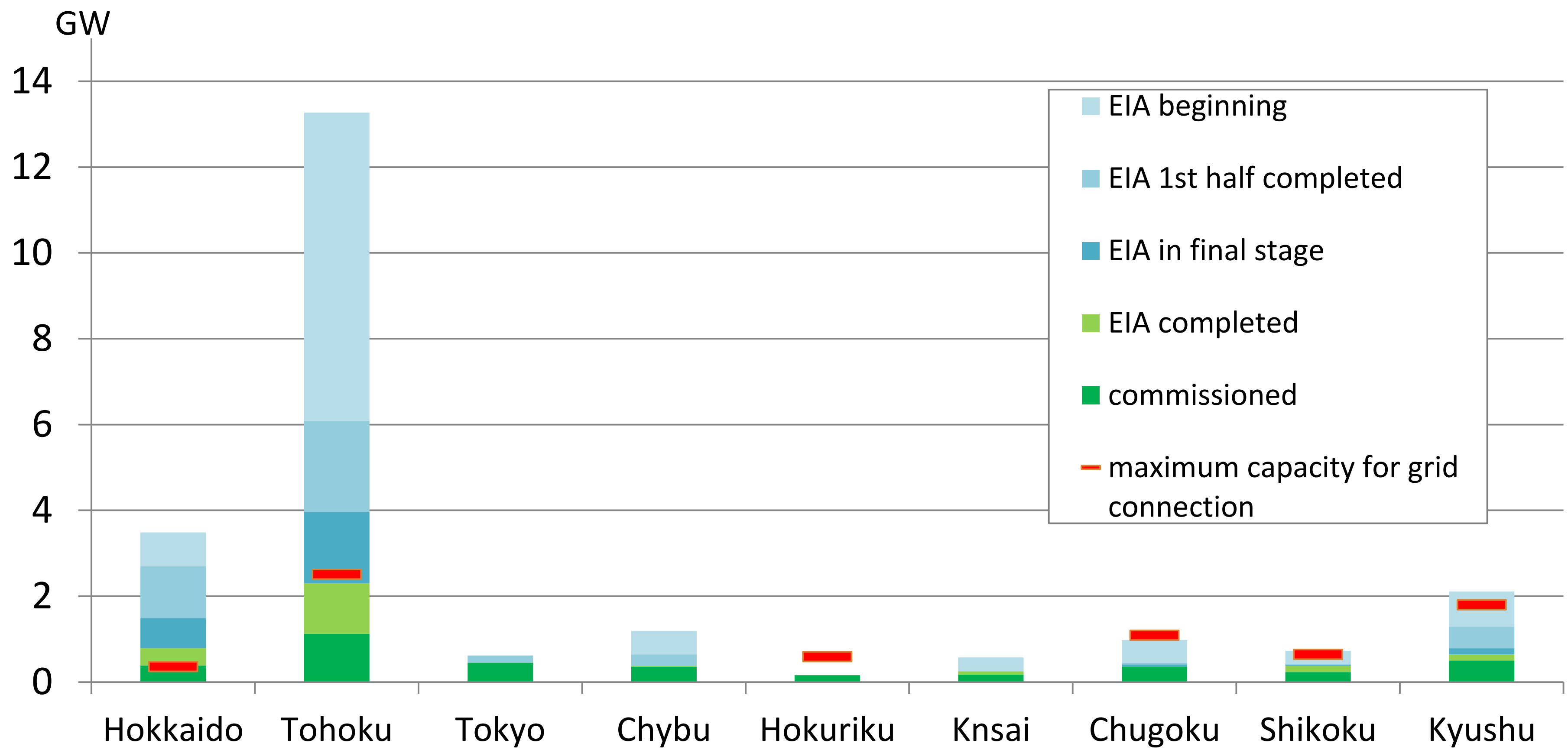
Solar PV penetration under FIT by grid

- In Kyushu, the commissioned solar PV is over the maximum capacity for grid connection.
- In Tohoku, the sum of commissioned and EIA completed is about to exceed the maximum capacity for grid connection.



Wind penetration under FIT by grid

- In Hokkaido, commissioned wind is over the maximum capacity for grid connection.
- In Tohoku, the sum of commissioned and EIA completed is about to exceed the maximum capacity for grid connection.



Model Description

- The analysis used a production cost model customized for Japan's power system.
- Objective function: Minimizing generation cost (fuel cost plus start-up cost) of the total power system of interconnected 9 power grids and one isolated grid for 8760 hours.

$$\min\left(\sum_{ig=1}^{Ngrid}\sum_{i=idx_{ig}}^{idx_{ig}+NG_{ig}-1}(F(P_i))\right)=\min\left(\sum_{ig=1}^{Ngrid}\sum_{i=idx_{ig}}^{idx_{ig}+NG_{ig}-1}(b_i\cdot P_i+c_i\cdot U_i+startup\cdot ST_i)\right)$$

- As a nature of production cost simulation, it does not take fixed cost (capital cost nor depreciation) into account.
- Limiting conditions
  - Balance between demand and supply
  - Balance between variability and available flexibility (LFC* capacity)
  - Upper and lower limit of hourly output in each power generation unit
  - Capacity of interconnection for energy interchange

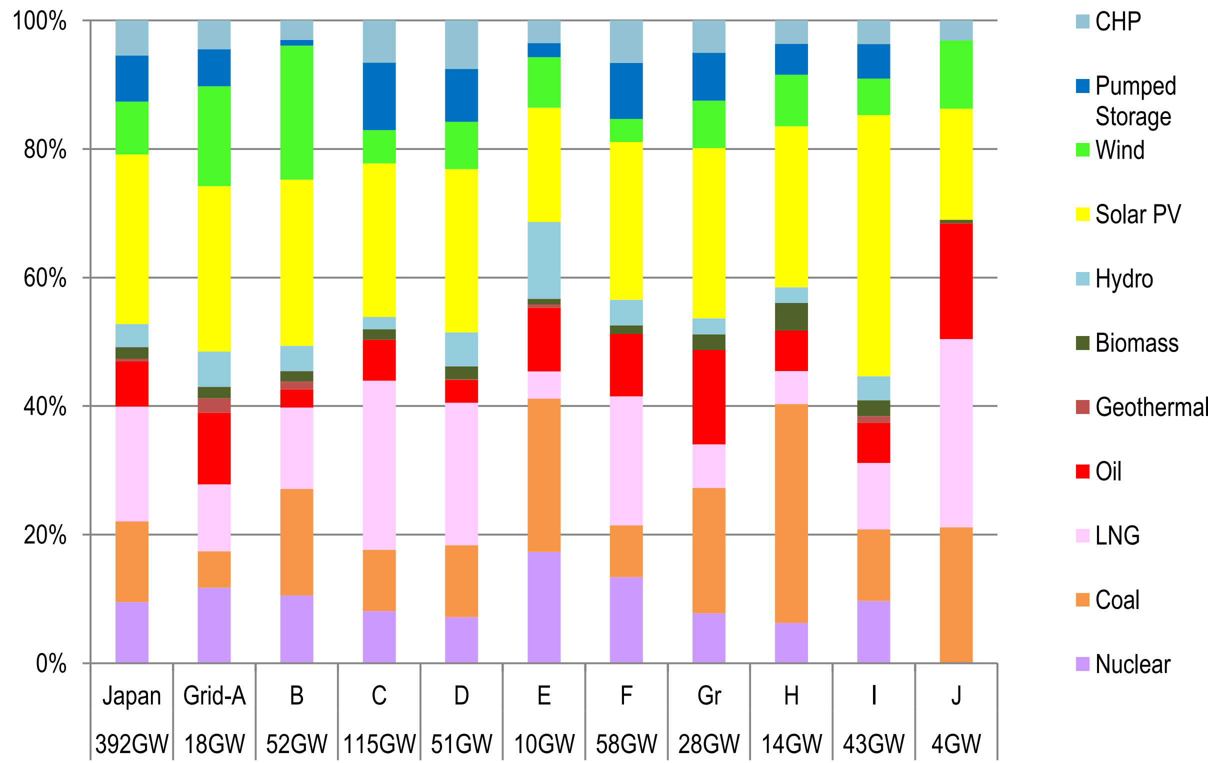
* LFC (Load Frequency Control) balancing capacity able to regulate variability in a few to 15 minutes .

Calculation Condition

- The total capacity of solar PV (103GW) and wind (32GW) in 2030 assumed to represent "massive VRE deployment "
- Solar PV and wind distribution by grid assumed to reflect the current unevenness
- Other type of power generation capacity in 2030 assumed in line with Long Term Energy Demand and Supply Outlook 2015

VRE capacity by grid

GRID	PV(GW)	Wind(GW)
A: Hokkaido	4.5	2.7
B: Tohoku	13.5	10.9
C: Tokyo	27.4	5.9
D: Chubu	12.9	3.7
E: Hokuriku	1.8	0.8
F: Kansai	14.2	2.1
G: Chugoku	7.5	2.1
H: Shikoku	3.6	1.1
I: Kyushu	17.3	2.4
J: Okinawa	0.6	0.4
Total	103.4	32.2



Power generation capacity by type by grid

Cases for Flexibility Evaluation

- The impact by availability of source of flexibility to VRE utilization and operation cost were analyzed.
  - Coal-fired power plants' LFC capacity
  - Pumped storage hydro
- Priority dispatch for VRE, a known measure to support VRE, was also analyzed for comparison

Analyzed case and available source of flexibility

Case	Available Source of Flexibility		
	Energy Transmission by Interconnections	LFC service from Coal-fired PP	Pumped Storage Hydro
Current situation in Japan	✔	*Not fully*	✔
Base Case (Base)	✔	✔	✔
without Interconnection (E0)	No	✔	✔
without Coal LFC (C0)	✔	No	✔
without PSH (P0)	✔	✔	No
without flexibilities above (F0)	No	No	No

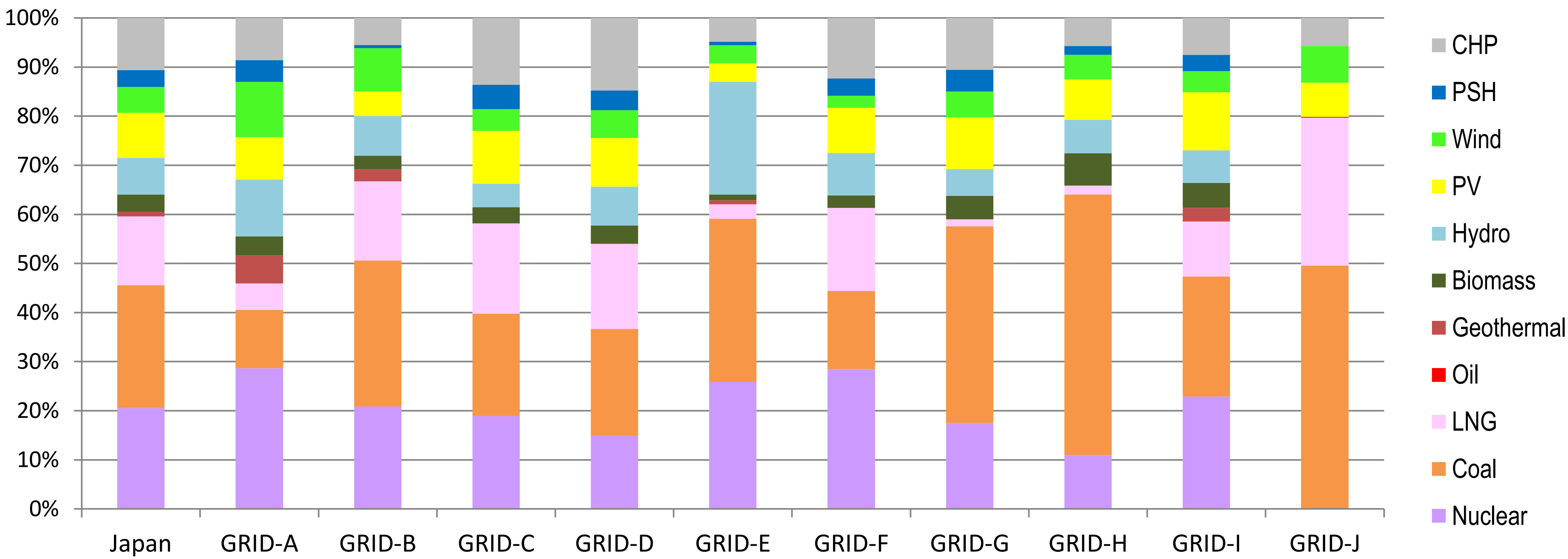
Result of Analysis: Power Generation Mix

- The power generation mix in Base Case by energy type shows;

  Nuclear: Coal: Gas: Oil: Renewables = 21%: 23%:27%:1%:28%

*Gas includes CHP, and Renewables includes PSH as in line with Long Term Energy Demand and Supply Outlook 2015

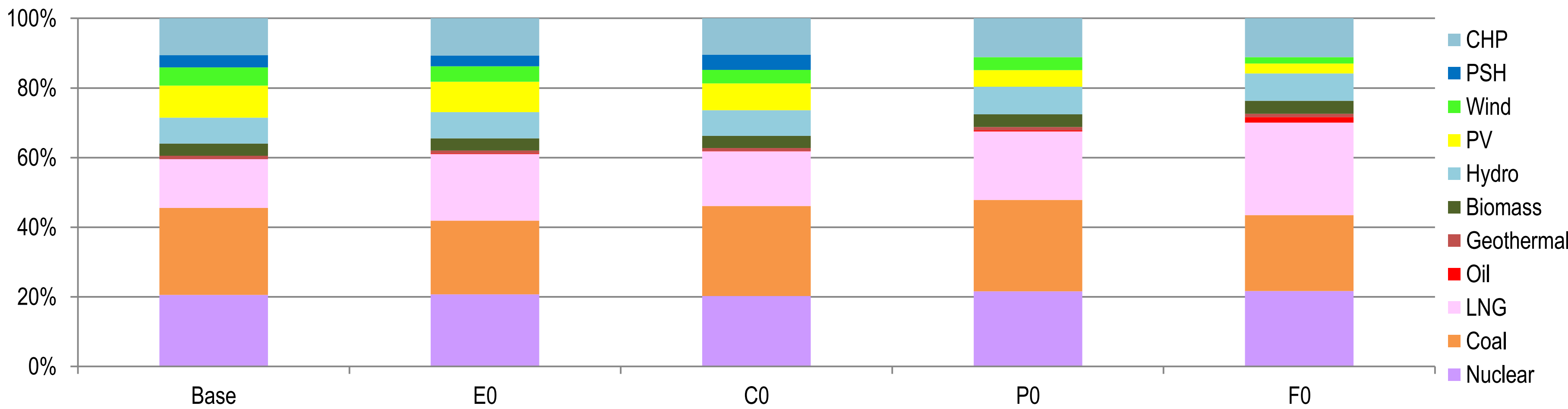
- The power generation mix varies by grid, mainly due to capacity portfolio in each grid but also due to conditions in neighboring grids.



Power generation mix in Japan total and by grid in Base Case

Result of Analysis: Power Generation Mix

- The power generation mix varies by case.
- When Coal LFC or PSH is not available, LNG power generation increase.
- When flexibility is not available, the share of VRE is reduced significantly from 14% in Base to 5%.

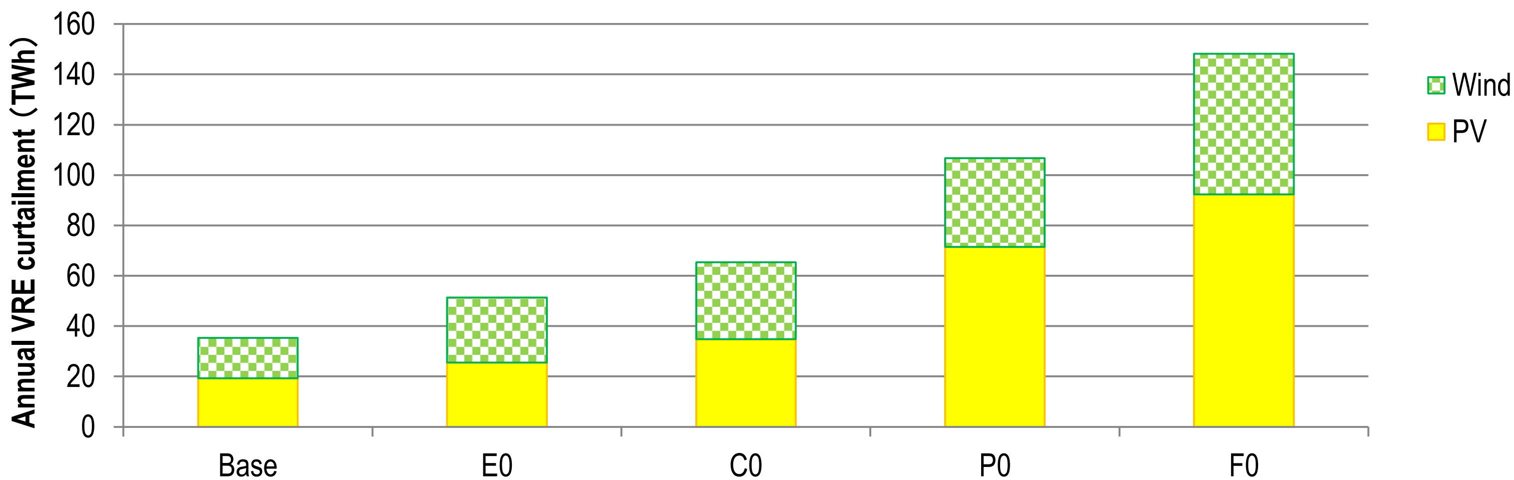


	Base	E0	C0	P0	F0
VRE	14%	13%	12%	9%	5%
Renewables	30%	28%	28%	21%	17%
Fossil	50%	51%	52%	57%	61%

Power generation mix and share of selected indicators by case and by grid

Result of Analysis: VRE Curtailment

- Each source of flexibility affects VRE curtailment, for both of Wind and Solar PV.
- The impact vary, interconnection < coal LFC < pumped storage hydro.
- Unavailability of PSH largely increases curtailment solar PV because PSH works to storage to accumulate PV’s surplus power generation in daytime as well as providing flexibility.
- Without all the flexibility, 75% of VRE power is curtailed.

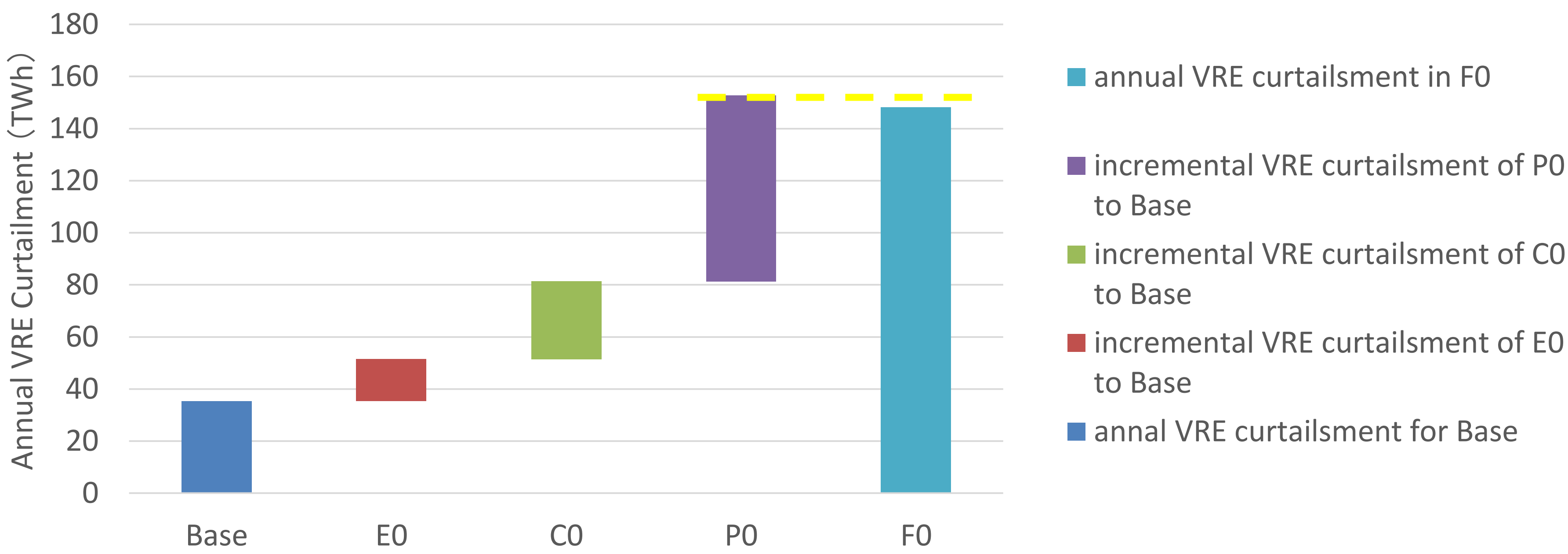


	Base	E0	C0	P0	F0
Curtailment ratio: Wind	21%	34%	41%	47%	74%
Curtailment ratio: Solar PV	16%	21%	28%	58%	75%

VRE curtailment (upper figure) and VRE share in total power generation (lower table) by case

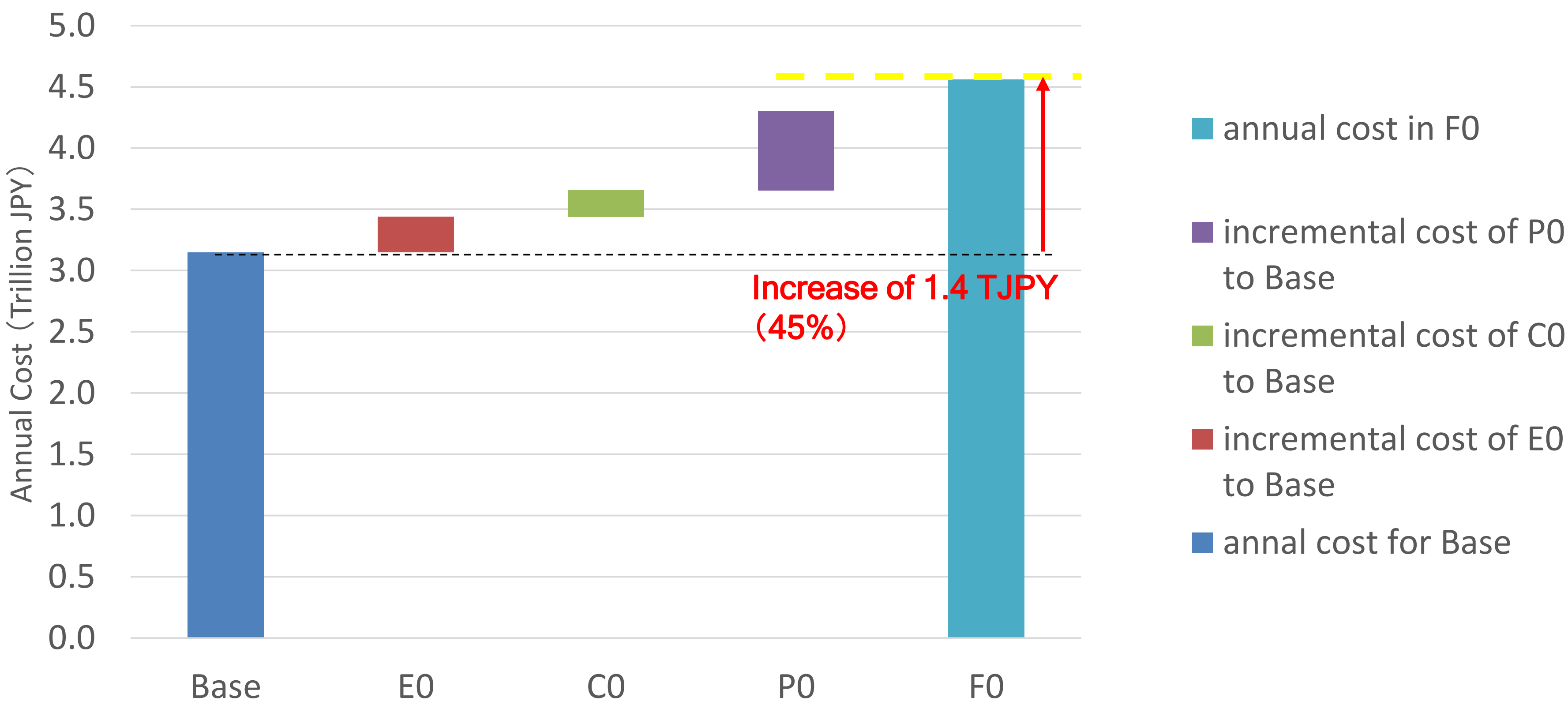
Flexibility and VRE curtailment

- The sum of VRE curtailment for base and total incremental VRE curtailment by each unavailable flexibility almost equals the VRE curtailment for F0, no-flexibility available case.
- It means the impact of each flexibility is independent, so no offset in the total impact.



Flexibility and cost

- The sum of annual cost for base and total incremental annual cost by each unavailable flexibility almost equals the annual cost for F0, no-flexibility available case.
- It means the impact of unavailability of multiple flexibility has negative synergetic affect.



Useful source of Information

Energy

- IEA: Executive summary of WEO, many free publication
- DOE/EIA: “International Energy Outlook”, energy statistic and outlook for USA and the world.
- IEEJ (The Institute of Energy Economics, Japan 日本エネルギー経済研究所) “IEEJ Energy Outlook”, energy statistic and outlook for Asia and the world.
- Eurostat: economic (including energy) statistic in EU

Climate Change

- UNFCCC
- IPCC
- UNEP

J-POWER

J-POWER

電源開発

http://www.jpower.co.jp/english