Document 4

Management Strategies of Companies based on Zero-Emission Power Generation

December 8, 2017

Agency for Natural Resources and Energy

Contents

Review of statements from previous sessions

2nd Session - Friday, September 29th, 2017

Dr. Paul Stevens, Distinguished Fellow, The Royal Institute for International Affairs, UK

- The long-term demand for petroleum is overrated. The energy transition from hydrocarbon to electricity will accelerate. The reasons for the transition are climate change and technological innovation (cost reduction of renewable energy, EV).
- There is a high possibility that instability will increase in the Middle East based on the financial instability of the various Middle Eastern countries in the context of a decreasing global dependence on the region, in addition to the uncertainty caused by the Trump regime.

Mr. Adam Siminski, Chair for Energy and Geopolitics, Center for Strategic and International Studies, US

- Emerging nations drive primary energy consumption worldwide.
- Demand for coal will remain unchanged (possibility of decline), there will be rapid growth in renewable energy and natural gas. Gradual increase in nuclear energy.
- Japan's low energy self-sufficiency and dependence on thermal power are severe issues from a national security viewpoint. Diversifying energy sources to increase diversity is critical.
- The U.S. greatly reduced CO2 emissions without ratifying the Kyoto Protocol. Its withdrawal from the Paris Agreement is not a major problem.

Review of statements from previous sessions

3rd session - Monday, November 13rd, 2017

Mr. Michael Shellenberger (CEO of Environmental Progress, U.S.)

- Increasing density is the megatrend of energy choices (Wood -> Coal -> Oil -> Uranium)
- The social acceptability of nuclear power is critical. Social acceptability will increase through innovative technologies (accident resistant fuel, etc.).
- Unlike nuclear and hydro power, solar and wind power have weak correlation to CO2 emission intensity. (Introduction is not linked to CO2 reduction)
- Germany's dependence on coal continues, and achieving ▲40% by 2020 is likely to be difficult.

Jim Skea (Professor of Sustainable Energy, Imperial College London, UK)

- The UK realized a substantial reduction by shifting from coal-fired to gas, but achieving the reduction targets of the latter half of the 2020s (▲51% from 2023 - 2027) currently appears difficult. Innovation (hydrogen, CCS, etc.) is critical to achieve the goal.
- Rather than focusing on a single technology, it is important to promote "competition between technologies."
- The UK government is soliciting and supporting research program proposals for next-generation small modular reactors (SMRs) from the private sector as a national project.
- Germany is providing excessive support for renewable energy, and it must be made more effective.

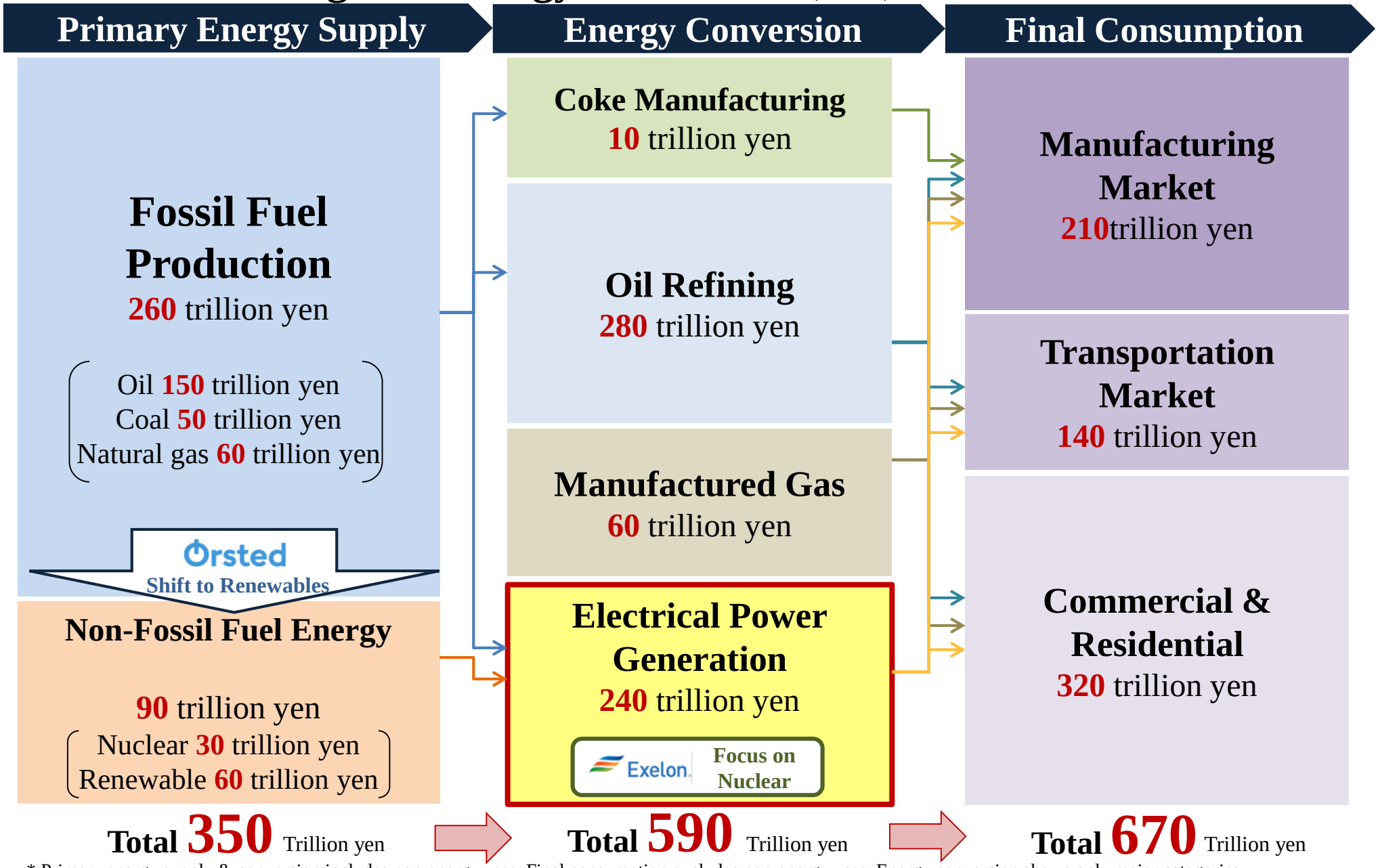
*** Dr. Claudia Kemfert (Head of Energy, Transportation, and Environment, German Institute for Economic Research, Germany**

(Only materials provided, not attending on the day)

- Investment in low-energy, renewable energy, and EV is necessary for a major reduction in CO2 emissions.
- It is possible to realize a 100% renewable energy system.
- Energy efficiency that crosses sectors is necessary, such as using excess electricity for hydrogen conversion.

Current status of major companies

Estimation of the global energy market size (2015)



* Primary energy supply & conversion includes non-energy uses. Final consumption excludes non-energy uses. Energy conversion shows only major categories.
* Market size represents approximate figures of energy balance multiplied by assumed unit price.
(ex. Electricity generation: 10 yen/kWh, Electricity for industry: 15 yen/kWh)

Source: IEA World Energy Balance etc.

Overview and power source composition of major enterprises

	Europe / North America					Japan	
	Engie (France)	EDF (France)	Enel (Italy)	Ørsted (Denmark)	Exelon (U.S.)	Tokyo Electric Power Co.	Kyushu Electric Power
Sales (Units: trillion yen)	9.4	10.1	10.2	1.5	3.6	6.1	1.8
	Overseas: 64% Pow. gen.: NA	Overseas:47% Pow. gen.: NA	Overseas:48% Pow. gen.:77%	Overseas:75% Pow. gen.:34%	Overseas:NA Pow. gen.:85%	Overseas:2% Pow. gen.:95%	Overseas: NA Pow. gen.:92%
Business area (Only in home country)	Generation Retail	Generation Transmission Distribution Retail	Generation Distribution Retail	Generation Distribution Retail	Generation Transmission Distribution Retail	Generation Transmission Distribution Retail	Generation Transmission Distribution Retail
Power generation mix							
Renew-able	19%	6%	31%	45%	3%	5%	10%
	Hydro:15%	Hydro:6%	Hydro:23%	Wind:45%	NA	Hydro:5%	Hydro:8%
Nuclear	6%	81%	14%	0%	89%	0%	14%
Thermal	75%	12%	55%	55%	8%	95%	76%
	Gas:58%	NA	Coal:30%	Coal:36%	NA	Gas:72%	Coal:42%

* Only sales of power

* Ratio of coal for Ørsted is estimated from the fossil fuel mix including heat

* Breakdown of thermal power for Japanese companies are estimated from "Electric Supply Plan 2016"

Source: SPEEDA, Annual report etc.

(Reference) Carbon Reduction Targets

CO_2 emission in 2015 (100 million tons)

	World	Developed countries	Emerging countries	Japan
Total	323	124	199	11.5
Electricity	127	45	82	5.0
Transport	77	41	36	2.0
Automobiles (Passenger vehicle, freight automobile,ect)	58	31	27	1.9
Others (Aircraft, ships, etc)	19	10	9	0.2
Industry	83	23	61	3.2
Steal and Iron (Not includes cokes production)	19	3	16	1.4
Petrochemicals (Includes petroleum products)	9	3	6	0.7
Heat (commercial & residential sectors)	35	14	21	1.3

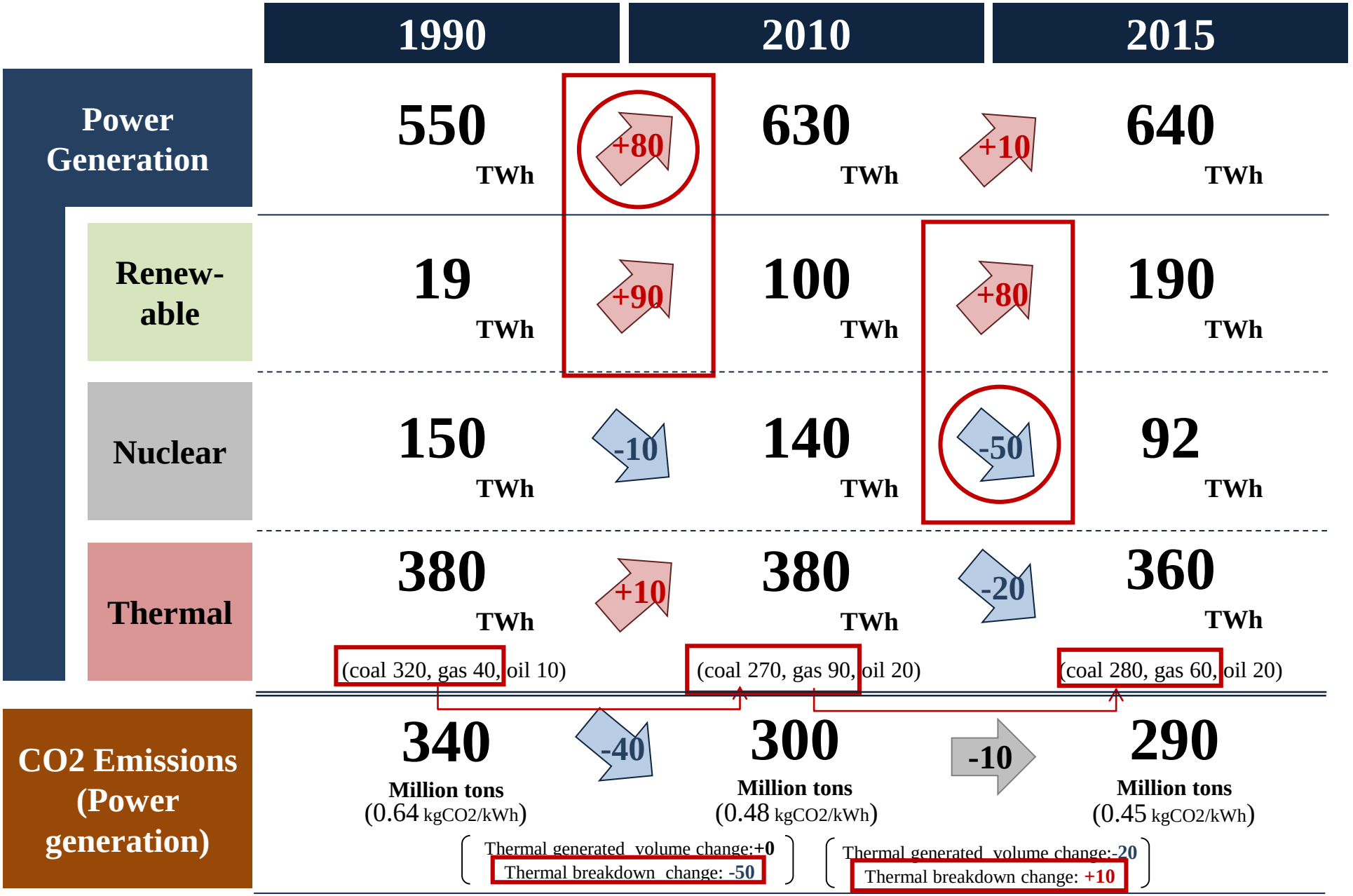
* Developed countries: OECD, Emerging countries: Non-OECD
* Definitions in IEA and METI data may be different.
* CO2 emissions from international marine/aviation bunkers are allocated to OECD and non-OECD

Source: IEA CO2 Emissions from Fuel Combustion, METI statistics

Transition of electricity market

(1990 -> 2010 -> 2015)

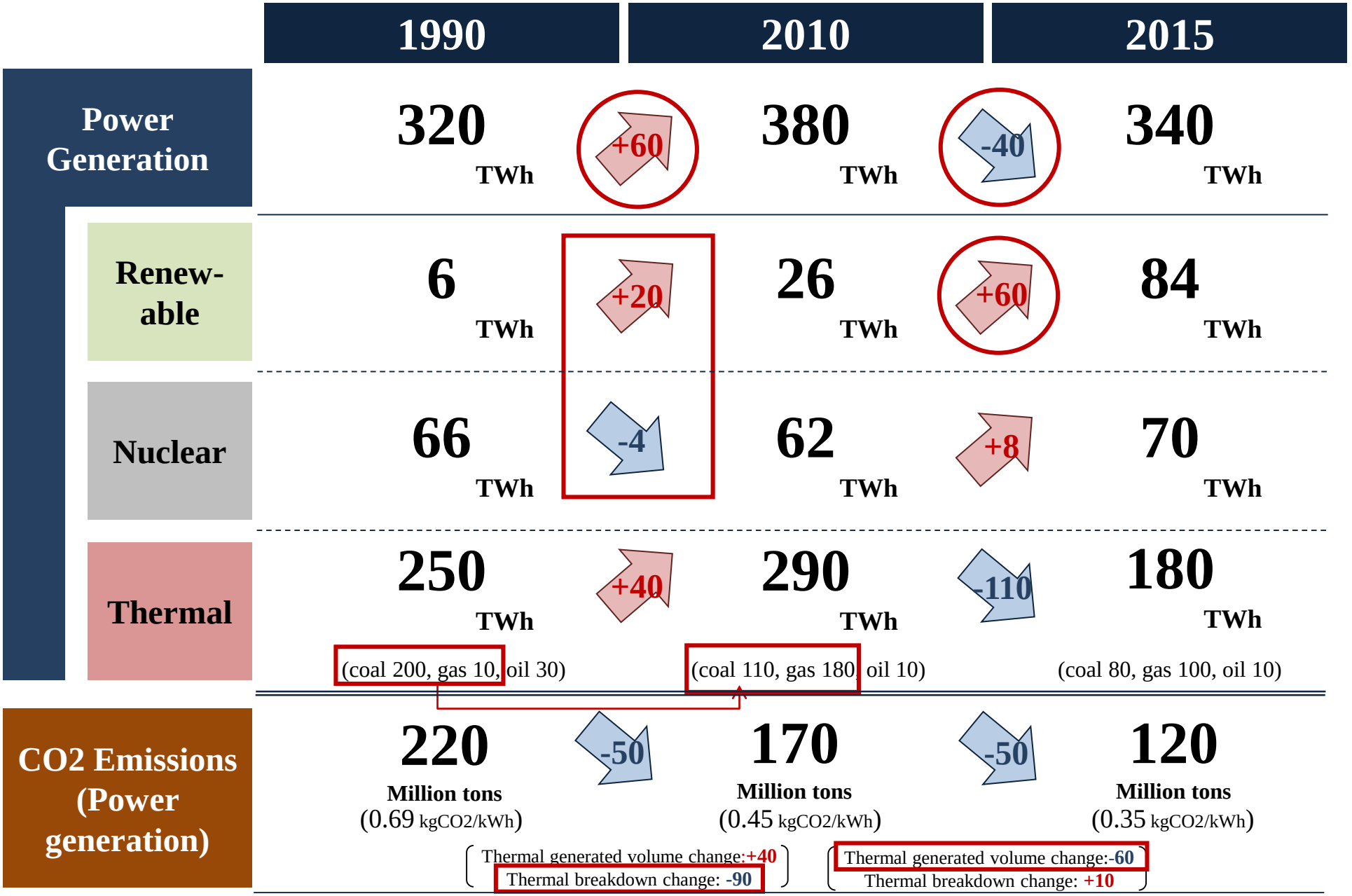
Transition of Germany's CO2 emissions from power generation



*Numbers are rounded. Totals may not match due to rounding errors.

Source: Produced from IEA Energy Balances, CO2 Emissions from Fuel Combustion

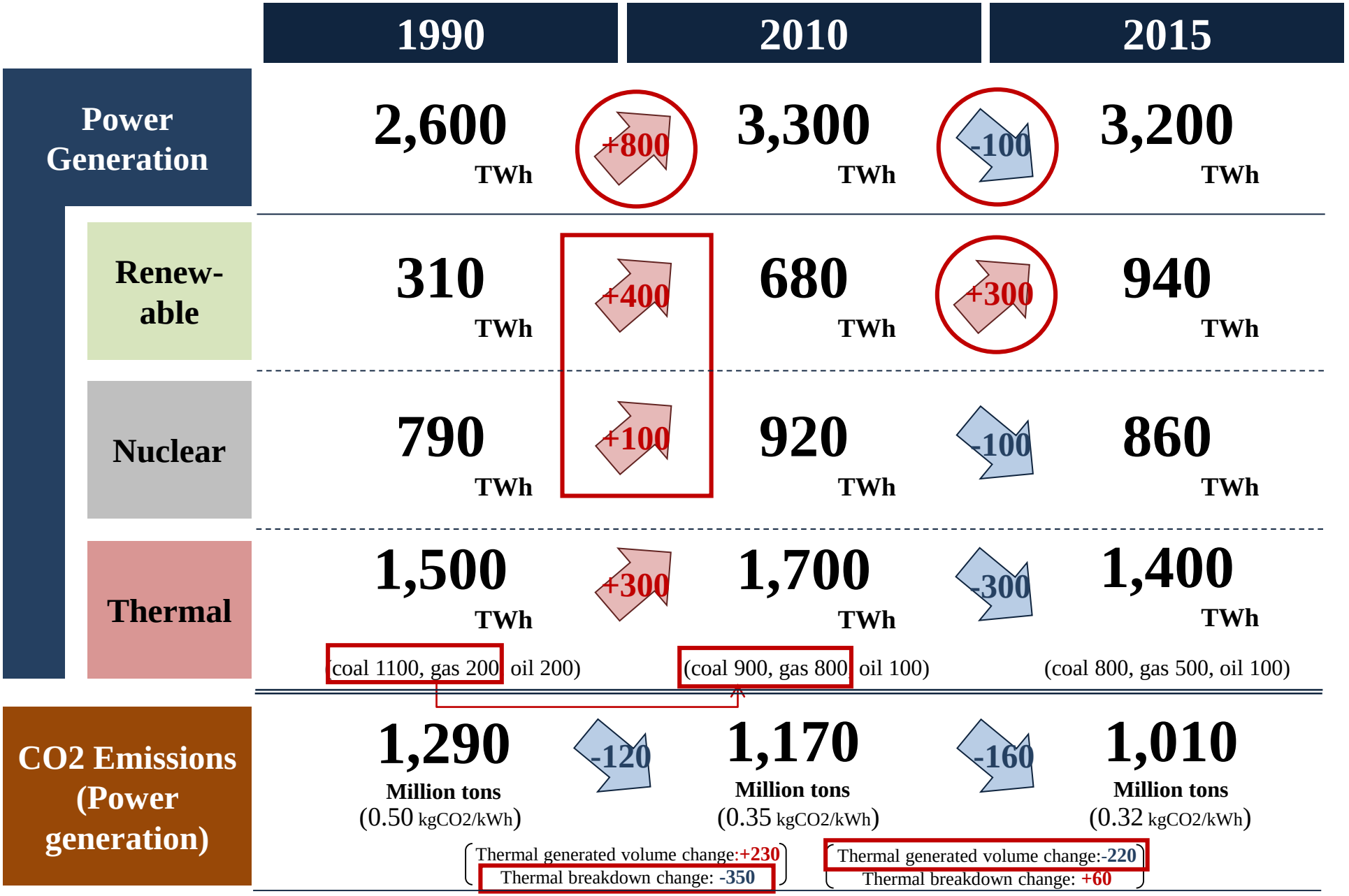
Transition of the UK's CO2 emissions from power generation



*Numbers are rounded. Totals may not match due to rounding errors.

Source: Produced from IEA Energy Balances, CO2 Emissions from Fuel Combustion

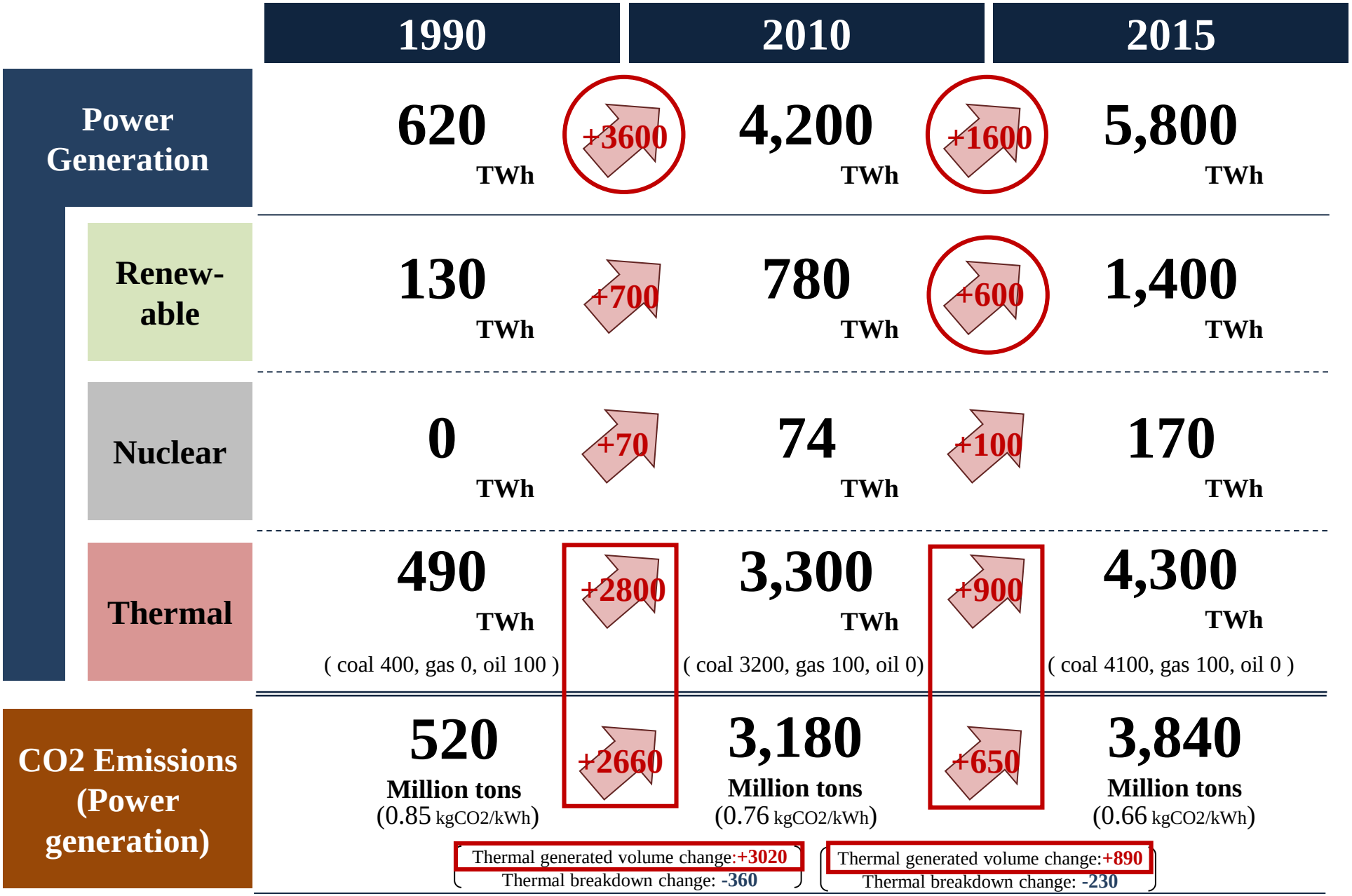
Transition of the EU's CO2 emissions from power generation



*Numbers are rounded. Totals may not match due to rounding errors.

Source: Produced from IEA Energy Balances, CO2 Emissions from Fuel Combustion

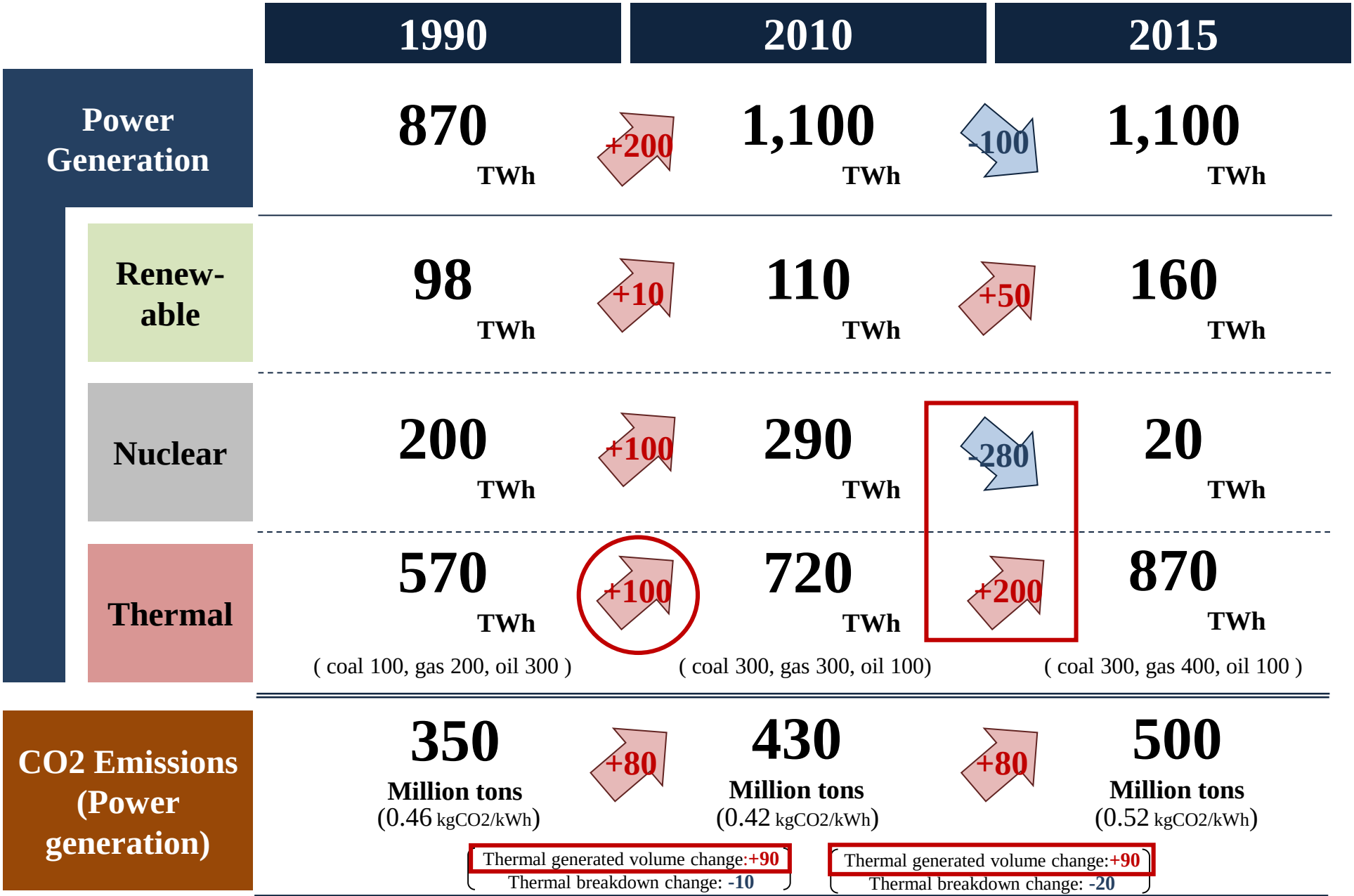
Transition of the China's CO2 emissions from power generation



*Numbers are rounded. Totals may not match due to rounding errors.

Source: Produced from IEA Energy Balances, CO2 Emissions from Fuel Combustion

Transition of the Japan's CO2 emissions from power generation



* Numbers are rounded. Totals may not match due to rounding errors.
* Definition of kgCO2/kWh in METI and IEA may be different.

Source: METI statistics, IEA Energy Balances etc.

CO2 emissions of EU and U.S.

(2015)

Emission coefficient and the electrical power generation mix of each country

CO2 Emission per kWh and Composition of Electricity Sources for Major EU Members and Japan (2015)

	Sweden	France	Denmark	Spain	EU Average※	Germany	Japan
	11gCO2/kWh	46gCO2/kWh	174gCO2/kWh	293gCO2/kWh	315gCO2/kWh	450gCO2/kWh	540gCO2/kWh
Stable Zero Emission	88%	88%	15%	33%	43%	25%	12%
	Stabel RE: 53% Nuclear：35%	Stable RE: 11% Nuclear：78%	Stable RE: 15% Nuclear：0%	Stable RE: 12% Niclear：21%	Stable RE: 16% Nuclear：27%	Stable RE: 11% Nuclear：14%	Stable RE: 11% Nuclear：1%
Variable Renewable Energy	10%	5%	51%	23%	13%	18%	4%
	PV：0% Wind：10%	PV：1% Wind：4%	PV：2% Wind：49%	PV：3% Wind：18%	PV：3% Wind：10%	PV：6% Wind：12%	PV：3% Wind：1%
Thermal Power	2%	7%	34%	44%	44%	56%	85%
	Coal：1% Gas：0% Oil：1%	Coal：2% Gas：4% Oil：1%	Coal：25% Gas：6% Oil：4%	Cola：19% Gas：19% Oil：7%	Coal：26% Gas：15% Oil：3%	Coal：44% Gas：10% Oil：2%	Coal：34% Gas：41% Oil：10%

※EU28

Source: IEA CO2 emissions from fuel combustion 2017, Comprehensive Energy Statistics

Emission coefficient and the electrical power generation mix of US states

CO2 Emission per kWh and Composition of Electricity Sources for Major US states (2015)

	Washington	New Hampshire	New York	California	Illinois	US average	Texas
	106gCO2/kWh	183gCO2/kWh	235gCO2/kWh	282gCO2/kWh	435gCO2/kWh	498gCO2/kWh	541gCO2/kWh
Stable Zero Emission	76%	62%	52%	26%	50%	27%	9%
	Stabel RE: 69% Nuclear：7%	Stable RE: 14% Nuclear：47%	Stable RE: 20% Nuclear：32%	Stable RE: 16% Niclear：9%	Stable RE: 0% Nuclear：50%	Stable RE: 8% Nuclear：19%	Stable RE: 1% Nuclear：9%
Variable Renewable Energy	6%	2%	3%	14%	6%	5%	10%
	PV：0% Wind：6%	PV：0% Wind：2%	PV：0% Wind：3%	PV：8% Wind：6%	PV：0% Wind：6%	PV：1% Wind：4%	PV：0% Wind：10%
Thermal Power	17%	36%	45%	60%	44%	67%	81%
	Coal：5% Gas：12% Oil：0%	Coal：5% Gas：30% Oil：1%	Coal：2% Gas：41% Oil：2%	Cola：1% Gas：59% Oil：0%	Coal：38% Gas：6% Oil：0%	Coal：34% Gas：32% Oil：1%	Coal：28% Gas：53% Oil：0%

Source: EIA Statistics

(Ref.) Comparison of the power business environment (U.S., EU, Japan)

(Reference) Comparison of the power business environments between Japan, Europe and the U.S.

		U.S.	Europe	Japan
Market overview	Market scale (Power Demand)	**3,800 TWh** TX:390 NY:150 CA:260 IL:140 (TWh)	**3,000 TWh** Germany:570 UK:330 France:470 Denmark:30 (TWh)	**1,000 TWh**
	Zero-emission Proportion	**33%** Nuclear: 19% Wind: 4% PV: 1% Hydro: 6%	**56%** Nuclear: 27% Wind: 9% PV: 3% Hydro: 11%	**17%** Nuclear: 2% Wind: 1% PV: 5% Hydro: 8%
Business environment	Retail Liberali-zation	**Varies by state** * Liberalization started in earnest from 2000 Entirely liberalized: 13 states *1 + Washington DC Partially liberalized: 6 states *2 * 1: New York, Illinois, Texas, etc. * 2: California, Nevada, etc.	**Entirely liberalized** 1996: First Energy Directive (Partial liberalization) 2003: Second Energy Directive (Complete liberalization)	**Entirely liberalized** 2000: Partial liberalization (Large scale factories, etc.) 2004: Partial liberalization (Medium scale factories, etc.) 2005: Partial liberalization (Small scale factories, etc.) 2016: Complete liberalization
	Generation/ Transmission Separation (System Operators)	**Varies by state** 1996: FERC Order 888: Recommended establishment of Independent System Operators (ISO) 1999: FERC Order 2000: Requested establishment of Regional Transmission Organizations (RTO)	**Legal separation *3 or Separation of property rights** 1996: Separation of accounting (First Energy Directive) 2003: Legal separation (Second Energy Directive) 2009: Legal separation or separation of property rights (Third Energy Directive)	**Vertical integration -> Legal separation** *** Planned for 2020** **(TEPCO conducted in advance)**
	Key zero emission related policies	**Varies by state** Implementation of tax measures, etc. by the federal government	**Varies by country** EU Goal: Raise renewable energy comprise 27% of final consumption by 2030	**FIT** **Sophisticated Methods of Energy Supply Structures Act, etc.**

*3 Two options exist: "1. Entrust power grid operation to an independent system operator," or "2. Secure the independence of the power system operation function through an independent power transmission operator"

(Reference) Electrical power business environment of the U.S.

		U.S.			
		Texas	California	New York	Illinois
Market overview	Market scale (Power Demand)	390 TWh	260 TWh	150 TWh	140 TWh
	Zero-emission Proportion	19% Nuclear: 9% Wind: 11% PV: 0.1% Hydro: 0.2%	40% Nuclear: 9% Wind: 6% PV: 8% Hydro: 7%	55% Nuclear: 32% Wind: 3% PV: 0.1% Hydro: 19%	56% Nuclear: 50% Wind: 6% PV: 0% Hydro: 0%
Business environment	Retail Liberali-zation	Entirely liberalized 1999: Act to restructure state power operators (Separation of generation, transmission/distribution, retail) 2002: Start of retail liberalization	Partially liberalized * Non-home use liberalized 1998: Start of complete liberalization 2001: Power crisis -> Halt to liberalization 2010: Restart of partial liberalization	Entirely liberalized 1998 - 2000: Start of liberalization at each power company	Entirely liberalized 2002: Start of complete liberalization 2005: End of upper price limit regulation
	Generation/ Transmission Separation (System Operators)	Independent System Operator (ISO) ERCOT Established 1996	Independent System Operator (ISO) CAISO Established 1998	Independent System Operator (ISO) NYISO Established 1999	Regional Transmission Operator (RTO) MISO Established 1996 Certified RTO 2001
	Key zero emission related policies	RPS (1999~) * RECs can be purchased	RPS (2002~) * RECs can be purchased ZEV regulation (2012~) * Constant rate of total car sales is required to be sales of ZEVs	Zero Emission Credits (2017~) * Utilities are required to procure REC and ZEC	RPS (2008~) * RECs can be purchased Zero Emission Credits (2017~) * Utilities are required to procure ZEC

※REC: Renewable Energy Credit ZEC:Zero Emission Credits ZEV: Zero Emission Vehicle

(Reference) Electrical power business environment of Europe