Document 7

Provisional Translation

Next-generation technologies and innovation for decarbonization

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Agency for Natural Resources and Energy
Ministry of Economy, Trade and Industry

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*Reference slides are available in Japanese version

Review of statements from previous sessions

2nd Session - Friday, September 29th, 2017

<u>Dr. Paul Stevens (Distinguished Fellow, The Royal Institute for International Affairs, UK)</u>

- 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.

<u>Mr. Adam Siminski (Chair for Energy and Geopolitics, Center for Strategic and International Studies, US)</u>

- 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 CO_2 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.

Prof. 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.

Review of statements from previous sessions

4th session – Friday, December 8th, 2017

Mr. Christopher D. Gould (Senior Vice President, Exelon Corporation)
Mr. Ralph L. Hunter, Jr. (Managing Director and Chief Operating Officer, Exelon Nuclear Partners)

- High capacity factor knowhow for nuclear reactors (at least 90%) drives competitiveness.
- Growth funded by corporate value enhancement from raising capacity factor of nuclear reactors at acquired companies.
- Electricity is no longer a simple commodity as reliability, resilience, environmental capabilities, and other aspects provide value; market design that fairly assesses these values is important.
- Small Modular Reactor (SMR) might offer benefits in cost and safety.

Mr. Matthias Bausenwein (General Manager for Asia Pacific, Ørsted, Denmark)
Ms. Yichun Xu (Head of Market Development Asia Pacific, Ørsted, Denmark)

- Global leader in offshore wind power; integrated handling of development, construction, ownership, and operation.
- Increasing business focus by allocating proceeds from selling non-core businesses (hydropower, gas-fired thermal power, and onshore wind power) to the strategic business (offshore wind power) .
- Cost savings points for offshore wind power are economies of scale from larger wind turbines, equipment and system standardization in multiple projects, and global procurement from multiple companies.
- Requires commitment by the government to market cultivation over the medium term and clear rules for general sea areas; deployment of clusters in suitable areas fosters a supply chain for the area and contributes to further cost savings.

Review of statements from previous sessions

5th session – Wednesday, January 31st, 2018

Mr. Guy Outen (Executive Vice President, Royal Dutch Shell, the Netherlands)

- The future is uncertain. Assuming several scenarios is more appropriate than trying to predict the future. Energy transformation and digitalization are mega trends.
- We will make investments in different fields (such as gas, biofuel, renewable energy, hydrogen, and CCS) to adapt to a wide range of scenarios.
- While continuing the conventional upstream fossil business, we will change our business portfolio (by giving higher priority to shale oil business as a growing business and investing certain amounts in the new energy field as an emerging businesses).
- As a preparation for the worldwide implementation of carbon pricing, we use a shadow carbon price (40 U.S. dollars/t CO2) in internal decision of the investment.

Ms. Marianne Laigneau (Senior Executive Vice President at EDF, France)

- Pursuing both nuclear and renewables is important for a better balance among stable supply, low carbon, and competitiveness.
- As future electric power systems, we are pursuing smart grids and utilization of EVs.
- Germany has increased renewables but continues to rely on coal, with the amount of CO2 emissions remaining unchanged. This situation is against the decarbonization trend.

Mr. Didier Holleaux (Executive Vice-President at ENGIE, France)

- Based on the global trend (decarbonization, dicentralization, and digitization), we are, for example, re-shaping our portfolio and making investments in emerging technologies.
- Natural gas is important as an alternative to coal and oil and as a backup of renewable energies. As a zero-emission gas, we expect the markets for hydrogen and biomass-derived gases will expand.
- Electrification should follow decarbonization in electric power. In Germany, the order is the other way around.

Images of innovation toward 2050

Images of innovation toward 2050

Requirements toward 2050

- Energy Security: Pursuit of all technologies and options
- Paris Agreement: Significant reduction of GHG emissions
- Adapting to digitization: Toward Society 5.0

Demand-side innovation

1. Transport: Consumption reduced through automatization and design optimization
   Electrification (EVs, FCVs, etc.)
2. Industry: Efficiency improved through robotization, AI, etc.
   Electrification, use of hydrogen, and increased use of non-fossil materials
3. Buildings: Increased efficiency through IoT and popularized ZEBs and ZEHs
   Electrification and methanation

Supply-side innovation

1. Electricity: Increased efficiency through data utilization
   Innovation in the technology of zero emission power
2. Hydrogen: Zero emission sources of supply, cost reduction, and establishing supply chains

Innovation to be globally extended to reduce CO_2 emissions at a global level

1. Leading the world in innovation ⇒ Enhanced international competitiveness
2. Establishing a system that can compete with conglomerates in China, US, and Europe etc.

CO_2 Emissions by sector and corresponding mitigation technologies

Sector	Main factors	Present	Future
Transport (210 Mt)	Vehicle Body/System	Internal-combustion engine, manual driving Metal car body	Electrification, automated driving Multi materials
	Fuel	Fossil fuel	Electricity/Hydrogen Biofuel
Industry (310 Mt)	Process	Development in smart technologies	CCUS/Hydrogen reduction Further development of smart technologies
	Product	Fossil energy materials	Non-fossil energy materials
Buildings (120 Mt)	Heat source	Oil, gas, and electricity	Electricity, hydrogen, etc.
	Device	High-efficiency devices	Devices supporting the IoT M2M control
Power generation (510 Mt)	Thermal	Oil, coal, and natural gas	CCUS and hydrogen power generation etc.
	Nuclear	Generation III+ reactor	Next-generation reactor
	Renewable energy	Challenges of installation (Costs for installation flexibility, grid systems, etc.)	Power storage x Innovation in grid system

Innovation

Hydrogen (Supply Chain and Methanation)

＊ The figures inside ( ) are the amounts of CO2 emissions in FY 2015.

Source: Agency for Natural Resources and Energy

(Reference) Review of the Innovation toward 2050

- ✓ The government's support for promoting innovation is important (Mr. Sieminski and Dr. Stevens)
- ✓ Diversity should be ensured in both of demand and supply. (Mr. Sieminski).
- ✓ We should not target a specific technology. Competition among technologies is important. (Prof. Skea).

	Demand side	Supply side
Statements from previous sessions	✓ **EVs** can be effectively used **as a flexible source of power system.** (Dr. Stevens) ✓ **Digitalization** creates new services for consumers. (EDF) ✓ Consumer needs promotes **decentralization**. (ENGIE) ✓ In urban areas, energy saving advances **based on the use of data**. (ENGIE)	✓ It is also important to **develop new types of storage batteries** that are not only based on liquid lithium. (Mr. Sieminski) ✓ The **development of nuclear technology** increases social acceptability. (Mr. Shellenberger) ✓ It is important to use **integrated approaches** including conversion of surplus power into hydrogen (Dr. Kemfert). ✓ **Hydrogen** is potentially an important energy carrier. (Shell)
NESTI 2050 **National Energy & Environment Strategy for Technological Innovation towards 2050**	<Energy system integration technology> ✓ Demand response ✓ Utilization of AI, big data, and IoT <Core technologies that consist systems> ✓ Innovative sensor ✓ Multi-purpose superconductor <Energy saving> ✓ Innovative production process ✓ Ultralight and heat-resistant structure material	<Energy storage> ✓ Next-generation storage battery ✓ Production, storage, and use of hydrogen, etc. <Energy creation> ✓ Next-generation solar power generation ✓ Next-generation geothermal power generation <Fixing and effective utilization of CO_2> ✓ CCUS
Long-term strategies of major countries	✓ **Electrification** in the transport, buildings, and industrial sectors (U.S.A., Canada, France, U.K., and Germany) ✓ Popularization and promotion of **EVs** (France and U.K.) ✓ Utilization of **hydrogen** in transport and industrial processes (U.S.A., Canada, U.K., and Germany) ✓ **CCUS** in heavy industries (Canada, France, and Germany)	✓ **Battery storage and grid system stabilization** that promote installation of renewables (U.S.A. and U.K.) ✓ Investment in and development of **next-generation nuclear power plant** (U.S.A. and U.K.) ✓ Utilization of **thermal power generation with CCS** (Canada and France)

(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**	**5.1**
Transport	77	41	36	2.1
Automobiles (Passenger vehicle, freight automobile,ect)	58	31	27	1.9
Others (Aircraft, ships, etc)	19	10	9	0.2
Industry	83	23	61	3.1
Steal and Iron (Not includes cokes production)	19	3	16	1.3
Petrochemicals (Includes petroleum products)	9	3	6	0.7
Heat (commercial & residential sectors)	35	14	21	1.2

* 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

(Reference) Investments by major companies in research and development

		Transport		Industry		Residential/Commercial	
		Volkswagen (Germany)	**Toyota** (Japan)	**GE** (U.S.A.)	**Hitachi** (Japan)	**Google*** (U.S.A.) *Alphabet	**Panasonic** (Japan)
Company overview	Sales amount	28.1 trillion yen	28.4 trillion yen	14.2 trillion yen	10.0 trillion yen	9.0 trillion yen	7.6 trillion yen
	Overseas Ratio	80%	70%	55%	48%	54%	52%
Research and development	Investment amount	1.6 trillion yen	1.1 trillion yen	0.6 trillion yen	0.3 trillion yen	1.5 trillion yen	0.4 trillion yen
	Examples of development fields	Jan. 2018 Expansion in the IT segment and enhancement of development of digital products	Jan. 2018 Automotive battery recycling business	Oct. 2017 Development of IoT applications	Dec. 2017 Development of self-competition learning AI	2017.12 Setup of an AI development base in China	Jun. 2017 Development of AI giving advice according to interests of individuals

Source: SPEEDA, Corporate annual reports etc.

(Reference) Investments by major companies in research and development

		Power		Oil		Gas	
		EDF (France)	TEPCO (Japan)	Shell (Netherlands)	INPEX (Japan)	Engie (France)	Tokyo Gas (Japan)
Company overview	Sales amount	10.1 trillion yen	6.1 trillion yen	25 trillion yen	0.9 trillion yen	9.4 trillion yen	1.9 trillion yen
	Overseas Ratio	47%	2%	64% * The countries outside Europe are regarded as overseas countries.	89%	64%	NA
Research and development	Investment amount	0.09 trillion yen	0.02 trillion yen	0.13 trillion yen	0.001 trillion yen	0.03 trillion yen	0.01 trillion yen
	Examples of development fields	Sep. 2013 Setup of a smart grid research lab.	Mar. 2017 Drone-based automated inspection of power facilities	Oct. 2017 Buyout of an EV recharging service company	Jul. 2017 Survey of the largest gas field in the SE-Asia started	May 2017 Order for a large electricity storage system	May 2017 Development of technology for increasing the efficiency of fuel cells

Source: SPEEDA, Corporate annual reports etc.