Comparison of Recent Trends in Sustainable Energy Development in Japan, U.K., Germany and France

Japan - U.S. Workshop on Sustainable Energy Future

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Trends & Movements in Japan

1-1. Past Stream; Vision & Strategy for Research

▼Council for Science and Technology Policy （CSTP）／3rd Science and Technology Basic Plan 【from 2006 to 2010】

- Environment ; One of “four priority fields to be promoted”
- Energy ; One of “four fields to be promoted”

▼Cabinet／Cool Earth 50 （in May of 2007）

- Setting a target of “cutting greenhouse gas emissions by half, until 2050”

1-2. Past Stream; Vision & Strategy for Research

▼Ministry of Economy, Trade and Industry （METI）／Cool Earth Energy Innovative Technology Plan （in March of 2008）

- Selection of 21 categories for technology innovation, that should be given higher priority

▼Power Generation／Transmission

1）High-Efficiency Natural Gas Fired Power Generation

2）High-Efficiency Coal Fired Power Generation

3）Carbon Dioxide Capture and Storage

4）Innovative Photovoltaic Power Generation

5）Advanced Nuclear Power Generation

6）High-Efficiency Superconducting Power Transmission

1-3. Past Stream; Vision & Strategy for Research

▼**Transportation**

7)Intelligent Transport System

8)Fuel Cell Vehicle

9)Plug-in Hybrid Vehicle／Electric Vehicle

10)Production of Transport Biofuel

▼**Industry**

11)Innovative Iron and Steel Making Process

12)Innovative Material, Production and Processing Technology

1-4. Past Stream; Vision & Strategy for Research

▼**Commercial／Residential**

13)High-Efficiency House and Building

14)Next-Generation High-Efficiency Lighting

15)Ultra High-Efficiency Heat Pump

16)Stationary Fuel Cell

17)High-Efficiency Information Device and System

18)HEMS／BEMS／Local-Level EMS

▼**Cross-Cutting**

19)High-Performance Power Storage

20)Power Electronics

21)Hydrogen Production, Transport and Storage

1-5. Past Stream; Vision & Strategy for Research

▼CSTP／Low Carbon Technology Plan （in May of 2008）

- R&D Road Map for the target of “cutting greenhouse gas emissions by half, until 2050”
- Key technologies with a significant reduction effect, as of necessary countermeasures “at the time range of around by 2030”

▼Energy Supply Side

・Advanced Use of Light-Water Reactors

・High-Efficiency Fired Power Generation （Coal and Natural Gas）

1-6. Past Stream; Vision & Strategy for Research

▼Energy Demand Side

- Hybrid Vehicle
- Plug-In Hybrid Vehicle
- Electric Vehicle
- Fuel Cell Vehicle
- High-Efficiency Heat Pump
- High-Efficiency Home Electronics and Information Devices

1-7. Past Stream; Vision & Strategy for Research

- **Key technologies with a significant reduction effect, as of necessary countermeasures “at the time range of after 2030”**

▼**Energy Supply Side**

- **Nuclear Power Generation （Next Generation Light-Water Reactors and Fast Breeder Reactor and Its Fuel Cycle Technology）**
- **Third Generation Photovoltaic Cells**
- **Hydrogen Production Technology**

▼**Energy Demand Side**

- **Hydrogen Reduction Iron and Steel Making Process**

2-1. Past Stream; Recent Movements for Energy

▼**Ministry of Economy, Trade and Industry（METI）／Basic Energy Plan（in June of 2010）**

▼**Council for Science and Technology Policy（CSTP）／4th Science and Technology Basic Plan【from 2011 to 2015】**

- **Green Innovation （Innovation for Energy & Environment）**
- **Life Innovation （Innovation for Life Sciences）**

2-2. Past Stream; Recent Movements for Energy

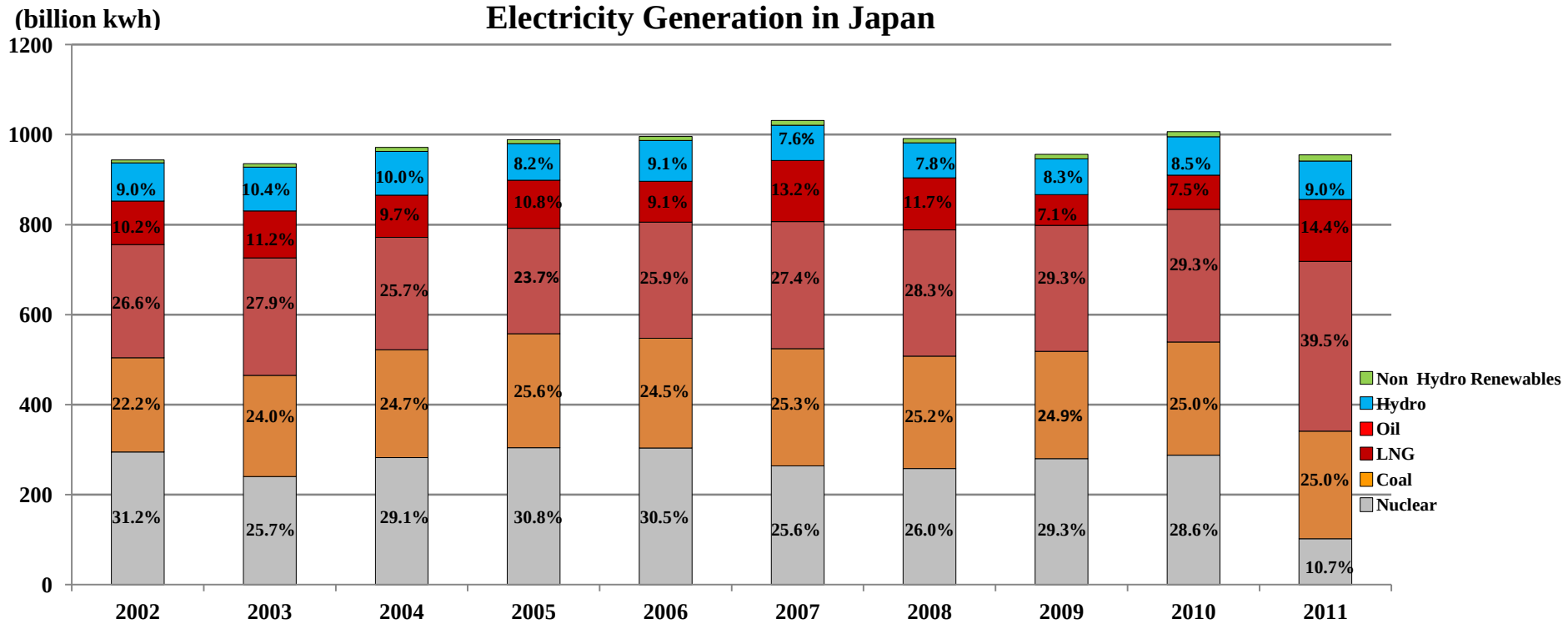
- **Cabinet Secretariat, National Policy Unit, Energy and Environment Council／Innovative Strategy for Energy and Environment （around Summer of 2012）**

- **Ministry of Economy, Trade and Industry （METI）, Agency for Natural Resources and Energy, Advisory Committee for Natural Resources and Energy／Basic Energy Plan to be revised （around Summer of 2012）**

Current Situations in Japan

3. Changes after Great East Japan Earthquake／ Increase of Fossil Energy Consumption

- **Federation of Electric Power Companies of Japan announced on June 13, increase of fossil energy ratio at electricity generation from 61.8% of 2010 to 78.9% of 2011.**
- **Ratio of LNG is increased from 29.3% of 2010 to 39.5% of 2011, and oil is increased from 7.5% of 2010 to 14.4% of 2011, respectively.**



(Source) Federation of Electric Power Companies of Japan, Related-Information on the Website, et. al

4. Changes after Great East Japan Earthquake／Feed in Tariff for Renewables

- **Ministry of Economy, Trade and Industry announced on June 18, "Feed in Tariff for Renewable in Japan" will be enacted on July 1 of 2012.**
- **Activities of electricity utilities can be enhanced, for solar, wind, geothermal, small hydro and biomass.**

Energy Source		Solar		Wind		Geothermal		Small Hydro			Biomass
		10kw≦	＜10kw	20kw≦	＜20kw	15000kw≦	＜15000kw	1000kw≦～＜30000kw	200kw≦～＜1000kw	＜200kw	7 categories
Cost	Construction (thousand yen / kw)	325	466	300	1250	790	1230	850	800	1000	310～3920
	Operation (thousand yen / kw･year)	10	4.7	6.0	-	33	48	9.5	69	75	22～184
Feed in Tariff	Price (yen / kwh)	42.00	42.00	23.10	57.75	27.30	42.00	25.20	30.45	35.70	13.65～42.00
	Duration (years)	20	10	20		15		20			20

(Source) Ministry of Economy, Trade and Industry, Related-Information on the Website, et. al

5. Changes after Great East Japan Earthquake／Revision of Basic Energy Plan

- **Fundamental Issues Subcommittee, under Advisory Committee for Natural Resources and Energy, announced on June 19, a draft for New Basic Energy Plan.**
- **The draft indicates “1 reference case and 4 options” for future energy mix in 2030, where ratio of renewables, nuclear, fossil and cogeneration is designed.**

A Draft for New Energy Basic Plan / Electricity Generation

		energy source (%)						electricity generation (10^{12} kWh)	CO_2 emission in comparison with 1990 (%)
		renewables	nuclear	coal	LNG	oil	cogeneration		
2010 / actual		11	26	24	27	9	3	1.1	+25
2030 / current plan		20	45	11	12	4	8	1.2	-27
2030 / revised plan	ref. 1	25	35	16	3	4	15	1.0	-33
	case 1	25～30	20～25	21	8	4	15		-15
	case 2	30	15	23	11	4	15		-8
	case 3	35	0	24	17	6	15		+5

(Source) Ministry of Economy, Trade and Industry, Related-Information on the Website, et. al

Energy Vision in Each Country

6. Announcement of Future Energy Vision

- **In recent years, future energy vision has been considered seriously, in Japan, Germany, France, U.K. and U.S..**

	Announcement of Energy Vision			Outline & Key Point
	Date	Organization	Title	
Japan	October, 2010	Ministry of Economy, Trade and Industry	Basic Energy Plan	・It was planned, ratio of nuclear is increased, ratio of renewable is increased and ratio of fossil is decreased. ・After Great East Japan Earthquake, the Basic Energy Plan has been revised toward sustainable energy future for Japan.
Germany	September, 2010	Federal Ministry of Economics and Technology, Federal Ministry for Environment, Nature Conservation and Nuclear Safety	Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply	・It was planned, nuclear take an important role as bridging technology from current energy system to future energy system. ・After Great East Japan Earthquake, it has been decided, nuclear is not used after 2022.
France	February, 2012	French Ministry of Economy, Finance and Industry	Energy 2050	・4 options were indicated about nuclear, expanding lifespan of existing reactor, transfer to third and/or fourth generation reactor, gradual reduction of nuclear and no nuclear.
U.K.	July, 2010	Department of Energy and Climate Change	2050 Pathways Analysis	・6 pathways were illustrated, including the case where no nuclear plant is built. ・In U.K., Infrastructure Planning Commission accepted Hinkley Point nuclear power station application for examination in November of 2011, where EDF Energy proposed construction.
U.S.	March, 2011	Executive Office of the President	Blueprint for a Secure Energy Future	・It was planned, 80% of total electricity is generated from clean energy source by 2035, including solar, wind, biomass, hydro, nuclear, efficient natural gas and clean coal. ・Nuclear Regulatory Commission approved combined construction and operating license in February of 2012, for 2 new nuclear reactors at Plant Vogtle.

7-1. Energy Vision in Germany／Targeted Goals

- In “Energy Concept for Environmentally Sound, Reliable and Affordable Energy Supply”, announced in September of 2010, Germany set their goals as follows.

▼Greenhouse gas emissions are reduced by 40% until 2020, by 55% until 2030, by 70% until 2040 and 80 to 95% until 2050, in comparison with 1990.

▼Primary energy consumption is decreased by 20% until 2020 and by 50% until 2050, in comparison with 2008.

▼Electricity consumption is decreased by 10% until 2020 and by 25% until 2050, in comparison with 2008.

▼At energy consumption, ratio of renewables is planned, 18% until 2020, 30% until 2030, 45% until 2040 and 60% until 2050.

▼At electricity consumption, ratio of renewables is planned, 35% until 2020, 50% until 2030, 65% until 2040 and 80% until 2050.

7-2. Energy Vision in Germany／Targeted Goals

- **With regard to buildings, heat demand is reduced by 20% until 2020, and primary energy demand is reduced by 80% until 2050, in comparison with 2008.**

- **With regard to mobility, energy consumption is reduced by 10% until 2020 and by 40% until 2050, in comparison with 2005. And, it is planned, 1 million electric vehicles on the road until 2020 and 6 million until 2030.**

- **Offshore wind capacity is expanded to 25GW until 2030.**

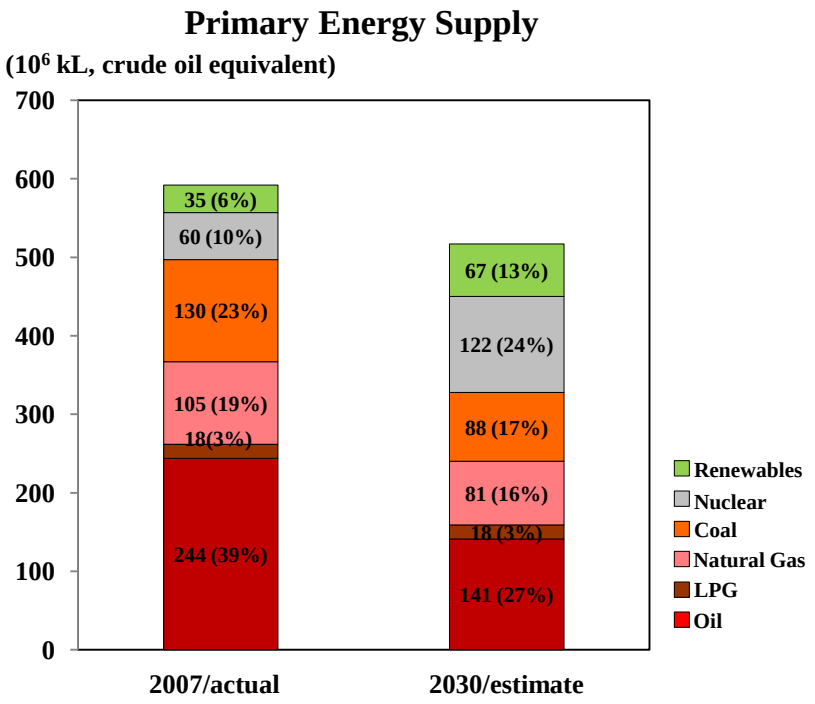
- **2 pilot plants for CCS is constructed until 2020.**

8. Energy Vision in Germany／key Issues

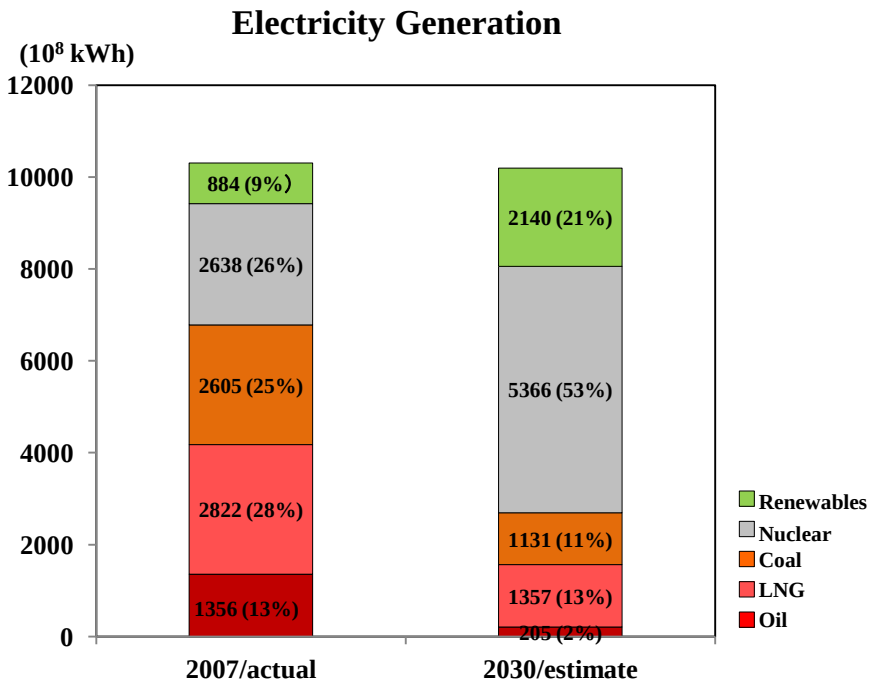
- **It is considered, energy mix for electricity generation in 2050 is 80% of renewables and 20% of fossil (such as gas fired or gas turbine).**
- **It was planned, nuclear works as a bridging technology from current energy system to future one. Afterward, it was decided, nuclear is not used after 2022.**
- **It is considered, coal fired should be used as an bridging technology in near-term, and fundamentally, wind should take role of bridging technology instead of nuclear.**
- **At expansion of wind, offshore has higher potentiality. In case of offshore, electricity generation is done in North and consumption in South.**
- **It is considered, electricity transmission at long distance with higher efficiency should be key, and advancement of grid and storage systems is examined, such as DC transmission & AC distribution.**

9. Energy Vision in Japan／Former Basic Plan

- **It was targeted, ratio of zero-emission energy sources for electricity generation is increased to 70% in 2030 (50% in 2020), consisting of renewables and nuclear.**
- **Corresponding to the target, it was planned, ratio of renewables at electricity generation is increased to 21% in 2030, and nuclear is increased to 53%.**
- **Based on these, it was estimated, CO_2 reduction should be approximately 30% in 2030, in comparison with 1990.**



(Source) Ministry of Economy, Trade and Industry, Related-Information on the Website, et. al



(Source) Ministry of Economy, Trade and Industry, Related-Information on the Website, et. al

10-1. Energy Vision in Japan／Revision of Basic Plan

- **At the draft for future energy mix of “primary energy supply”, ratio of renewables in 2030 varies from 17% to 22%, and nuclear varies from 0% to 16%.**
- **Based on these, it is estimated, CO_2 emission in 2030 varies from -28% to -16%, in comparison with 1990.**

A Draft for New Energy Basic Plan / Primary Energy Supply

		energy source (%)						primary energy supply (10^8 kL, crude oil quivalent)	CO_2 emission in comparison with 1990 (%)
		renewables	nuclear	coal	natural gas	LPG	oil		
2010 / actual		7	11	23	19	3	37	5.7	+6
2030 / current plan		13	24	17	16	3	28	5.1	-31
2030 / revised plan	ref. 1	17	16	19	13	3	31	4.7	-28
	case 1	17～19	10～12	21～22	15～16	3	31		-23
	case 2	19	7	22	17	3	32		-20
	case 3	22	0	23	21	3	32		-16

(Source) Ministry of Economy, Trade and Industry, Related-Information on the Website, et. al

10-2. Energy Vision in Japan／Revision of Basic Plan

- **At the draft for future energy mix of “electricity generation”, ratio of renewables in 2030 varies from 25% to 35%, and nuclear varies from 0% to 35%.**
- **Based on these, it is estimated, CO_2 emission in 2030 varies from -33% to +5%, in comparison with 1990.**

A Draft for New Energy Basic Plan / Electricity Generation

		energy source (%)						electricity generation (10^{12} kWh)	CO_2 emission in comparison with 1990 (%)
		renewables	nuclear	coal	LNG	oil	cogeneration		
2010 / actual		11	26	24	27	9	3	1.1	+25
2030 / current plan		20	45	11	12	4	8	1.2	-27
2030 / revised plan	ref. 1	25	35	16	3	4	15	1.0	-33
	case 1	25～30	20～25	21	8	4	15		-15
	case 2	30	15	23	11	4	15		-8
	case 3	35	0	24	17	6	15		+5

(Source) Ministry of Economy, Trade and Industry, Related-Information on the Website, et. al

10-3. Energy Vision in Japan／Revision of Basic Plan

- **At the draft for future energy mix of “renewable for electricity generation”, ratio of wind in 2030 varies from 3% to 12%, and geothermal varies from 3% to 4%.**
- **On the other hand, ratio of solar, biomass and hydro do not vary, and their ratio in 2030 is 6%, 3% and 11 %, respectively.**

A Draft for New Energy Basic Plan / Renewable for Electricity Generation

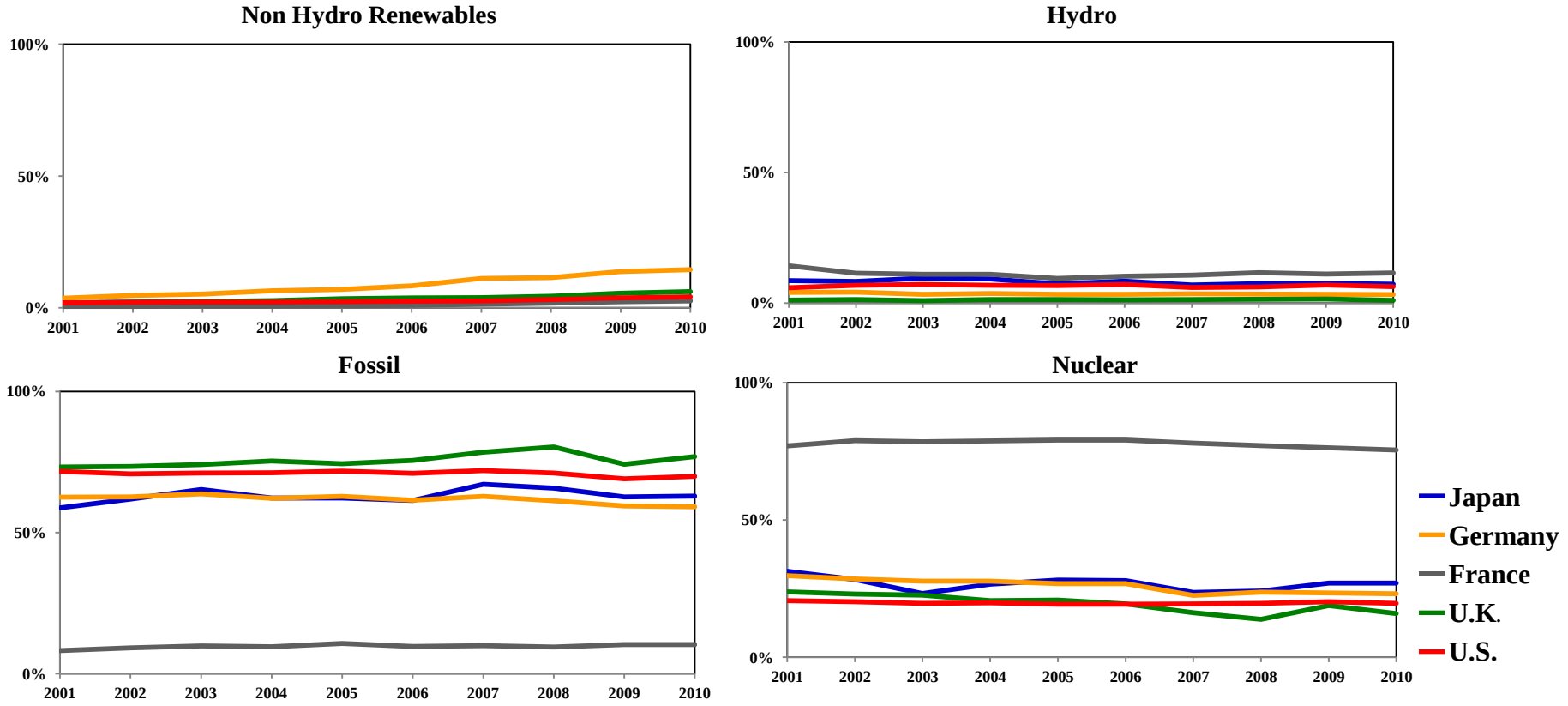
		Renewables (%)					
		solar	wind	geothermal	biomass & waste	hydro	total
2010 / actual		0.3	0.4	0.2	1	8	11
2030 / current plan		5	2	1	3	10	20
2030/ revised plan	ref. 1	6	3	3	3	11	25
	case 1	6	3～7	3	3	11	25～30
	case 2	6	7	3	3	11	30
	case 3	6	12	4	3	11	35

(Source) Ministry of Economy, Trade and Industry, Related-Information on the Website, et. al

Researches for Sustainable Energy

11. Electricity Generation in Each Country

- **Japan, Germany, U.K. and U.S. have similar energy sources for electricity generation, where fossil is the primary source and nuclear is the secondary.**
- **In comparison with these countries, France has much higher ratio of nuclear, and lower ratio of fossil for electricity generation.**
- **In Germany, ratio of non hydro renewables has been up to 10% at electricity generation.**



(Source) U.S. Energy Information Administration, Related-Information on the Website, et. al

12. Renewables in Germany／Electricity Generation

- **In Germany, ratio of renewables at electricity generation has reached to 20% in 2011.**
- **Among these, ratio of wind is 7.6%, biomass is 6.1%, hydro is 3.2% and Solar is 3.1%, respectively.**

	Electricity Generation by Renewables (GWh)						Ratio at Electricity Consumption (%)
	Hydro	Wind	Biomass et. al.	Solar	Geothermal	Total	
1990	15,580	71	1,434	1	0	17,086	3.1
1991	15,402	100	1,471	2	0	16,974	3.1
1992	18,091	275	1,558	3	0	19,927	3.7
1993	18,526	600	1,636	6	0	20,768	3.9
1994	19,501	909	1,875	8	0	22,293	4.2
1995	20,747	1,500	2,013	11	0	24,271	4.5
1996	18,340	2,032	2,102	16	0	22,490	4.1
1997	18,453	2,966	2,277	26	0	23,722	4.3
1998	18,452	4,489	3,260	32	0	26,233	4.7
1999	20,686	5,528	3,589	42	0	29,845	5.4
2000	24,867	7,550	4,737	64	0	37,218	6.4
2001	23,241	10,509	5,207	76	0	39,033	6.7
2002	23,662	15,786	6,038	162	0	45,648	7.8
2003	17,722	18,713	8,247	313	0	44,995	7.5
2004	19,910	25,509	10,077	556	0.2	56,052	9.2
2005	19,576	27,229	14,025	1,282	0.2	62,112	10.1
2006	20,042	30,710	18,685	2,220	0.4	71,657	11.6
2007	21,169	39,713	24,281	3,075	0.4	88,238	14.3
2008	20,446	40,574	27,531	4,420	17.6	92,989	15.1
2009	19,036	38,639	30,341	6,583	18.8	94,618	16.4
2010	20,956	37,793	33,866	11,683	27.7	104,326	17.1
2011	19,500	46,500	36,920	19,000	18.8	121,939	20.0

(Source) Federal Ministry for Environment, Nature Conservation and Nuclear Safety, Development of renewable energy sources in Germany 2011 (March 2012)

13. Renewables in Germany／Job Creation

- **In Germany, ratio of renewables (including hydro) at electricity generation was increased from 6.7% of 2001 to 17.1% of 2010.**
- **Number of jobs for renewables have reached to 367400 persons in 2010, 122000 at biomass, 120900 at solar, 96100 at wind, 13300 at geothermal and 7600 at hydro, respectively.**

	Number of Jobs at Each Year			
	2004	2007	2009	2010
Biomass	56,800	119,500	128,000	122,000
Solar	25,100	49,200	80,600	120,900
Wind	63,900	85,700	102,100	96,100
Geothermal	1,800	10,300	14,500	13,300
Hydro	9,500	8,100	7,800	7,600
Other Renewables	3,400	4,500	6,500	7,500
Total	160,500	277,300	339,500	367,400

(Source) Federal Ministry for Environment, Nature Conservation and Nuclear Safety, Development of renewable energy sources in Germany 2010 (December 2011)

14-1. Characteristic Action in Germany／6th Energy Research Programme

- Corresponding to “Energy Concept for Environmentally Sound, Reliable and Affordable Energy Supply”, 6th Energy Research Programme of the Federal Government was announced in November of 2011.

- The 6th Programme is a joint program of 4 ministries (Federal Ministry of Economics and Technology, Federal Ministry of Environment, Nature Conservation and Nuclear Safety, Federal Ministry of Food, Agriculture and Consumer Protection and Federal Ministry of Education and Research), and 3.46 billion Euros are prepared for energy research funding from 2011 to 2014.

- Under the programme, joint funding initiatives have been developed in selected fileds of strategic importance for future energy supply in Germany.

▼Energy Storage

▼Electricity Grids

▼Solar Buildings – Energy Efficient Cities

14-2. Characteristic Action in Germany／Energy Storage Initiative

- **Federal Ministry of Economics and Technology, Federal Ministry of Environment, Nature Conservation and Nuclear Safety and Federal Ministry of Education and Research jointly launched “Funding Initiative Energy Storage Systems” in 2011.**

- **The budget is 200 million Euros, and main subjects are as follows.**

▼**Electrical storage**
- **Air pressure storage**
- **RedoxFlow batteries**
- **Optimisation of Li-batteries (life time, cycle stability, costs, own consumption)**
- **Interconnection of heat pumps**
- **Underground storage (pump storage)**

▼**Material storage**
- **Hydrogen through flexible electrolysis**
- **Geological hydrogen storage**
- **Methane production**

▼**Thermal storage**
- **New isolation materials for heat storage**
- **Phase-changing materials, sorption storage, demand-orientated storage**
- **Thermal storage for concentrating solar power**

15. Characteristic Action in Japan／Budgetary Condition in 2012

▼Ministry of Economy, Trade and Industry （METI）

- **Advanced Technology Development and Deployment Support for Renewable Energy and Energy Efficiency; 262.7 billion yen**
  - ▼Technology Development for Renewable Energy; 44.1 billion yen
  - ▼Innovative Technology Development for Energy Efficiency; 42.5 billion yen

▼Ministry of Education, Culture, Sports, Science and Technology （MEXT）

- **Promotion of Green Innovation; 31.1 billion yen**
  - ▼Advanced Energy Research and Development for Tohoku Renovation; 2.0 billion yen
  - ▼Advanced Low Carbon Technology Research and Development; 4.8 billion yen
  - ▼Creation of Innovative Material Technology for Low Carbon Society; 5.7 billion yen
    - ・COE for the Element Strategy Initiative; 2.3 billion yen

16-1. Characteristic Action in Japan／Materials for Resource Issues

Freedom from Resource Limitation

Rare metals are included in many core parts supporting the advanced product

In

Transparent electrodes for flat-screen TVs

Dy

Rare earth magnets for various motors

W

Cemented carbide tools

Pt

Exhaust gas catalyst

Ce

Precision polishing of glass for LCDs

Tb/Eu

Fluoresc-ent materials

Nanotechnology is applied to **develop substitute materials** to **reduce the unit consumption** of **rare metals** substantially. METI launched the Strategy for Ensuring Stable Supplies of Rare Metals in 2007.

Rare metal substitute materials development projects

[2007-2011fy]	Indium (In) for transparent electrodes	: 50% reduction
	Dysprosium (Dy) for rare earth magnets	: 30% reduction
	Tungsten (W) for cemented carbide tools	: 30% reduction
[2009-2013fy]	Platinum (Pt) for exhaust gas catalysts	: 50% reduction
	Cerium (Ce) for precision polishing	: 30% reduction
	Terbium (Tb), Europium (Eu) for fluorescent materials	: 80% reduction

\0.82B @2012 (METI)

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(Source) Kazunobu Tanaka, Principal Fellow, Center for Research and Development Starategy, Japan Science and Technology Agency, "Japan's R&D Strategy of Nanotechnology", INC8 (May 2012)

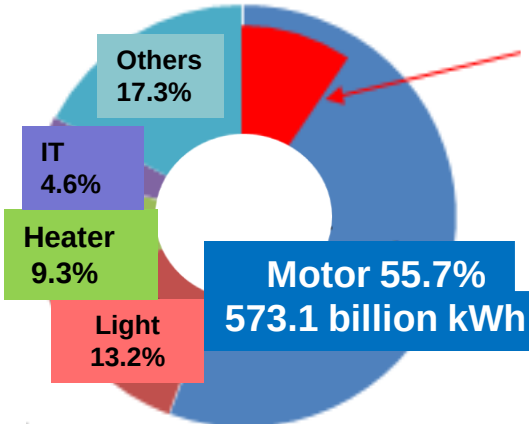
16-2. Characteristic Action in Japan／METI Project for Replacing Rare Metals

Project for developing magnetic materials for the high-efficiency motor of automobile in the next generation

\2B@2012 (METI)

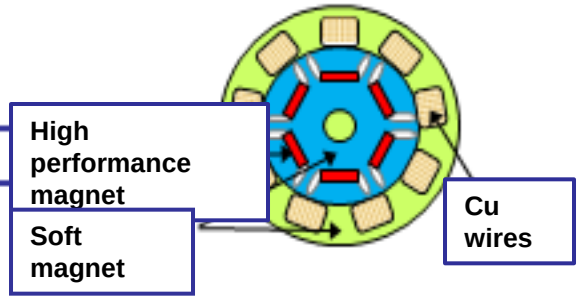
Aim of the project

- Development of **Fe-N based powders** with high coercivity
- Development of **nanocomposite magnet** for the remarkable improvement of magnetic properties
- Development of **Dy-free magnet**
- Development of **innovative process** to make novel low-loss soft magnets



Total electricity consumption in Japan 999.5 billion kWh (2005)

Sum of electrical loss caused by moto (114.6 billion kWh) reaches 11% of to electricity consumption in Japan.



Structure of high efficiency motor

Automobile in the next generation

Electronics, Industrial equipment

(Source) Kazunobu Tanaka, Principal Fellow, Center for Research and Development Starategy, Japan Science and Technology Agency, "Japan's R&D Strategy of Nanotechnology", INC8 (May 2012)

16-3. Characteristic Action in Japan／COE for the Element Strategy Initiative of MEXT

Intensify collaboration among research communities & multidisciplinary fusion of academic fields

Produce new approach of research and development

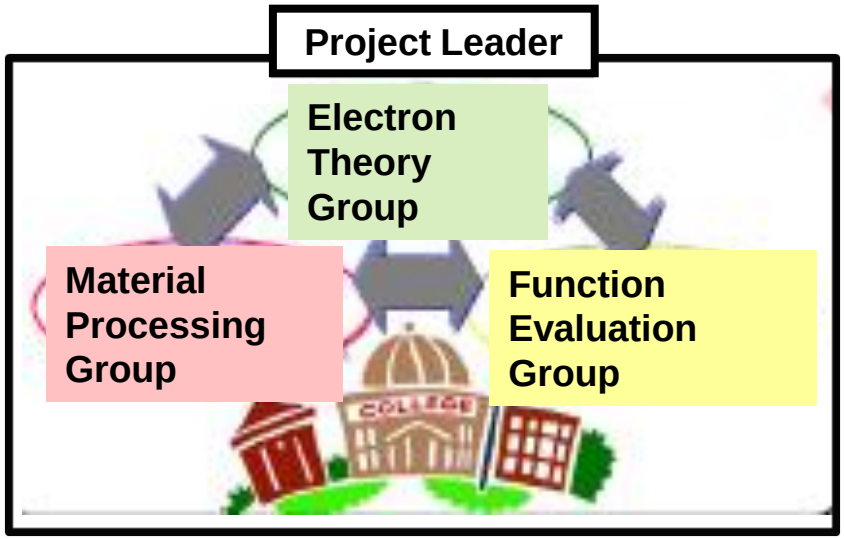
Generate innovative technologies to realize the replacement of rare elements

Go one step ahead globally in R&D for designing high functional materials

Aim of the project

- **Promotion of collaboration between material processing and quantum electronics as COE**
- **Promotion of collaboration among young researchers in different research fields in the COE**
- **Promotion of the utilization of advanced equipments**

\2.25B@2012 (MEXT)



Target Fields

- **Magnetic Materials**: Development of rare element free magnet through theoretical examination on the origin of magnetic property
- **Catalyst・Materials for battery**: Development of rare element free battery and catalyst through theoretical examination on the surface chemical reaction of solids
- **Electronic materials**: Development of electronic devices with ubiquitous elements through theoretical design of electronic state
- **Engineering materials**: Development of engineering materials which reduce rare element usage drastically through theoretical examination on atomic bonding and defects in lattice

(Source) Kazunobu Tanaka, Principal Fellow, Center for Research and Development Starategy, Japan Science and Technology Agency, "Japan's R&D Strategy of Nanotechnology", INC8 (May 2012)