September 5, 2011

Nuclear Power Plant Accident and Japanese Energy and Climate Policy

No Energy Policy Review without reviewing climate policy

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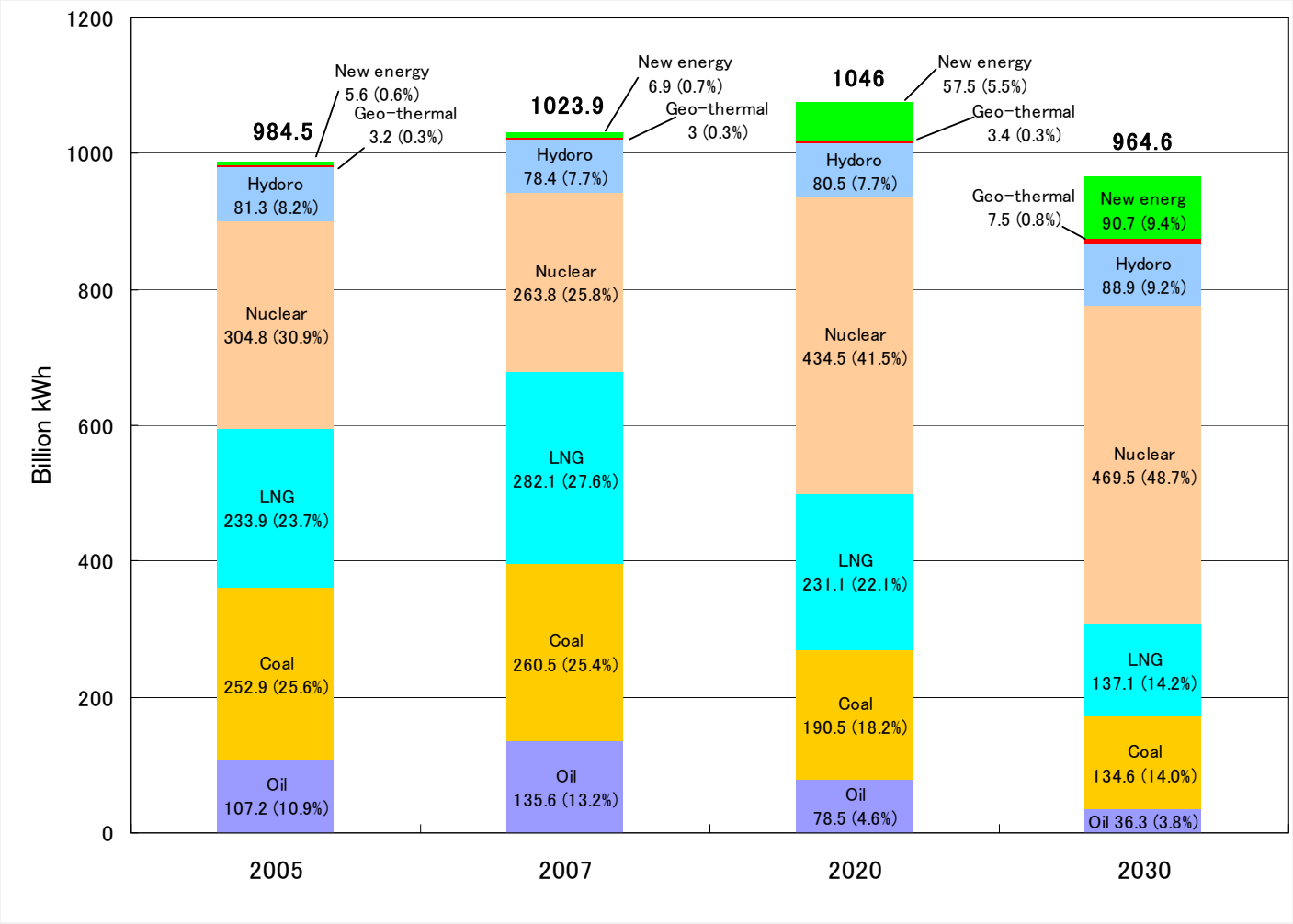
Japan's mid- and long-term Energy Plan

2010 (before nuclear accident)



Power Generation by fuels and technologies

Mid- and long-term plan of power generations

Generation Capacity

(1000kW)

		2020 (plan)		2030 (plan)	
Hydro		49,250	18%	50,770	17%
	General	21,700	8%	23,020	8%
	Pumping up	27,550	10%	27,750	9%
Thermal		137,610	49%	120,900	41%
	Coal	37,880	14%	30,030	10%
	LNG	57,670	21%	48,810	17%
	Oil	42,060	15%	42,060	14%
Nuclear		60,150	21%	63,150	21%
Geothermal		530	0%	1,200	0%
New Energy		33,000	12%	59,750	20%
Total		280,540	100%	295,770	100%

Power Generation

(Billion kWh)

		2020 (plan)		2030 (plan)	
Hydro		80.5	8%	88.9	9%
	General	78.1	7%	83.4	9%
	Pumping up	2.4	0%	5.4	1%
Thermal		470.1	45%	308	32%
	Coal	190.5	18%	134.6	14%
	LNG	231.1	22%	137.1	14%
	Oil	48.5	5%	36.3	4%
Nuclear		434.5	42%	469.5	49%
Geothermal		3.4	0%	7.5	1%
New Energy		57.5	5%	90.7	9%
Total		1,046	100%	964.6	100%

Mid- and long-term plan in 2010

		1990		2005	
Hydro		36,320	21%	45,740	19%
	General	19,310	11%	20,610	9%
	Pumping up	17,010	10%	25,130	10%
Thermal		104,090	60%	143,030	59%
	Coal	12,230	7%	37,670	16%
	LNG	38,390	22%	58,740	24%
	Oil	53,470	31%	46,620	19%
Nuclear		31,480	18%	49,580	21%
Geothermal		240	0%	520	0%
New Energy				2,500	1%
Total		172,130	100%	241,370	100%

		1990		2005	
Hydro		88.1	12%	81.3	8%
	General	78.8	11%	71.4	7%
	Pumping up	9.3	1%	9.9	1%
Thermal		446.6	61%	594	60%
	Coal	71.9	10%	252.9	26%
	LNG	163.9	22%	233.9	24%
	Oil	210.8	29%	107.2	11%
Nuclear		201.4	27%	304.8	31%
Geothermal		1.5	0%	3.2	0%
New Energy				5.6	1%
Others				-4.4	0%
Total		737.6	100%	984.5	100%

Actual Figures

Nuclear Accident and the Kyoto Protocol Target

- Existing Nuclear Facilities (As of September 5, 2011)

  Among total 54 reactors

In operation	11 reactors
Suspension due to regular inspection	28
Suspension due to trouble or government request	11
Operation terminated	4

- Scenario 1 (until the end of 2012)

  Suspension of only Fukushima-Dai-ichi and Hamaoka reactors (8.2 GW)
  Additional CO2 emissions: 60Mt (annual average of 12Mt, +1% of 1990 GHG）
- Scenario 2 (until the end of 2012)

  No operation after regular inspection
  Additional CO2 emissions: 470Mt (annual average 98Mt, +7.4% of 1990 GHG）

List of Nuclear Reactors as of December 2010

Generators	Reactors		1000kW	Operation started	2020*	2030*	Damaged reactors	In operation as of Sept.1
HEPCO	Tomari	No.1	579	1989.6		●		
〃		No.2	579	1991.4				
〃		No.3	912	2009.12				○
Tohoku	Onagawa	No.1	524	1984.6		●	✓	
〃		No.2	825	1995.7			✓	
〃		No.3	825	2002.1			✓	
〃	Higashidori	No.1	1,100	2005.12			✓	
TEPCO	Fukushima	No.1	460	1971.3	●		✓	
〃	Daiichi	No.2	784	1974.7	●		✓	
〃		No.3	784	1976.3	●		✓	
〃		No.4	784	1978.10	●		✓	
〃		No.5	784	1978.4	●		✓	
〃		No.6	1,100	1979.10	●		✓	
〃	Fukushima	No.1	1,100	1982.4		●	✓	
〃	Daini	No.2	1,100	1984.2		●	✓	
〃		No.3	1,100	1985.6		●	✓	
〃		No.4	1,100	1987.8		●	✓	
〃	Kashiwazaki	No.1	1,100	1985.9		●		
〃	Kariwa	No.2	1,100	1990.9		●		
〃		No.3	1,100	1993.8				
〃		No.4	1,100	1994.8				
〃		No.5	1,100	1990.4		●		○
〃		No.6	1,356	1996.11				○
〃		No.7	1,356	1997.7				
Chubu	Hamaoka	No.3	1,100	1987.8		●		
〃		No.4	1,137	1993.9				
〃		No.5	1,267	2005.1				
Hokuriku	Shiga	No.1	540	1993.7				
〃		No.2	1,206	2006.3				
KEPCO	Mihama	No.1	340	1970.11	●			
〃		No.2	500	1972.7	●			○
〃		No.3	826	1976.12	●			
〃	Takahama	No.1	826	1974.11	●			
〃		No.2	826	1975.11	●			○
〃		No.3	870	1985.1		●		○
〃		No.4	870	1985.6		●		
〃	Ooi	No.1	1,175	1979.3	●			
〃		No.2	1,175	1979.12	●			○
〃		No.3	1,180	1991.12				
〃		No.4	1,180	1993.2				
Chugoku	Shimane	No.1	460	1974.3	●			
〃		No.2	820	1989.2		●		○
Shikoku	Ikata	No.1	566	1977.9	●			
〃		No.2	566	1982.3		●		○
〃		No.3	890	1994.12				
Kyushu	Genkai	No.1	559	1975.10	●			○
〃		No.2	559	1981.3		●		
〃		No.3	1,180	1994.3				
〃		No.4	1,180	1997.7				○
〃	Sendai	No.1	890	1984.7		●		
〃		No.2	890	1985.11		●		
JAPC	Tokai Daini		1,100	1978.11	●		✓	
〃	Tsuruga	No.1	357	1970.3	●			
〃		No.2	1,160	1987.2		●		
	Total	54	48,847					12

Source：Handbook of Energy & Economic Statistics in Japan 2011 P.204

*2020 and 2030 shows the reactors that become over 40 years of operation

⇦ Current Nuclear Reactors

⇩ Planned Towards 2020 & 2030

Planned construction of nuclear reactors in 2010

Generators	Reactors	10000kW	Under construction rector at the time of EQ	In operation before 2020	In operation before 2030
Tohoku	Namie・Odaka	82.5			○
	Higashidori No. 2	138.5			○
TEPCO	Fukushima— No. 7	138		○	○
	Fukushima— No. 8	138		○	○
	Higashidori No. 1	138.5		○	○
	Higashidori No. 2	138.5			○
Chubu	Hamaoka No.6	140			○
Chugoku	Shimane No. 3	137.3	○	○	○
	Kaminoseki No. 1	137.3		○	○
	Kaminoseki No. 2	137.3			○
Kyushu	Sendai No. 3	159		○	○
J-POWER	Ooma	138.3	○	○	○
JAPC	Tsuruga No. 3	153.8		○	○
	Tsuruga No.4	153.8		○	○

How to do on the Kyoto Target (1)

- Article 2

  Stabilization at the level not dangerous

  Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to **enable economic development to proceed in a sustainable manner**

- IPCC AR4 WG3 Ch.1

  -- the balancing of the risks of climate change (risks of gradual change and of extreme events, risk of irreversible change of the climate, including risks for food security, ecosystems and sustainable development) against the risk of response measures that may threaten economic sustainability.

→ Sustainable Economic Growth

How to do on the Kyoto Target (2)

- The Kyoto Protocol and penalty provisions
- Canada's declaration of non-compliance April 2007
  no penalty, will withdraw if forced
- What Japan should do?
  Force Majeure
  Sustainable development is the purpose
  Long-term global reduction is necessary
  What if nuclear accident occur in Europe or the United States
  Can Japan join international treaty without force majeure provisions
  In 2007 earthquake, TEPCE purchased credit
- On the condition that major sector's energy efficiency should be the best in the world

Effects on the Mid-term Target

- 25% reduction target (base year 1990)
  ambitious target, fair and effective framework, all major economies participate
- Why 25%　consistent with what the science calls ---
- Japan's Mid-term Target
  Aso (former prime minister): 15% reduction relative to 2005)corresponding to 8% reduction from 1990.　June 2009
  Hatoyana (former prime minister): 25% reduction from 1990 corresponding to 30% reduction from 2005, September 2009
- 9 new nuclear power plants (13GW) in both cases
- Load factor more than 80%

What does 25% mean to Japan?

- No one knows

  no discussions on to what extent Japan will reduce domestically

- Comparison with EU and the United States

Marginal abatement cost and per capita GDP

	Japan	USA	EU
Marginal abatement Cost	＄476	＄60	＄48～＄135
Cast/GDP	1.13%	0.29%	0.08～0.26%

Effects on CO2 emissions

in 2020

- **Case 1**: 6 reactors at Fukushima dai-ichi decommissioned, 2 new reactors (-14.88GW)
- **Case 2**: In addition to case 1 above, all existing reactors more than 41 years old will be shut down (12 reactors with capacity of 8.71GW will be shut down) (-23.57GW)
- **Case 3**: All the 15 damaged reactors cannot restart operation by 2020 and no new reactor construction (-26.4GW)

Additional CO2 emissions in 2020 due to replacement of fossil fuel

	Reduction of Generating Capacity (relative to the original plan) 1000kW			Additional CO2 emissions Mt (Load factor 80%)			Additional CO2 emissions Mt (base year 1990, GHG 1260Mt)	
Case	**Existing Facilities**	**Planned Facilities**	**Total**	**Existing Facilities**	**Planned Facilities**	**Total**		
Case 1	4700	10180	14880	20	43	63		**+5%**
Case 2	13390	10180	23570	56	43	99		**+8%**
Case 3	1346	1294	26400	57	54	111		**+9%**

Collapse of 25% target

1. Conditions not met
2. Even if it is satisfied, still impossible
3. In addition, nuclear accident

Effects of replacing 1GW nuclear reactors with other technologies

	A	B	C	D	E	F	G	H
	overnight cost (¥1,000/kW)	generating capacity (1000kW)	Load factor (%)	electricity generation (B.kW/h)	initial investment (Billion Yen)	generation cost (Yen/kWh) E/D*1/10	CO2 reduction (1000t)	needed capacity to replace 1 GW of nuclear plant (GW)
Solar	520	1000	12	1.05	520	49.5	630	6.67
Wind (on shore)	190	1000	20	1.75	190	10.8	1050	4.00
Wind (off Shore)	289	1000	30	2.63	2,890	11.0	1580	2.67
Mini-Hydro	1,600	1000	80	7.01	1,600	22.8	4210	1.00
Geo-thermal	660	1000	70	6.13	660	10.8	3680	1.14
Nuclear	279	1000	80	7.01	279	6.2	4210	1.00
LNG	164	1000	80	7.01	164	10.3	-	1.00
Coal	272	1000	80	7.01	272	7.4	-	1.00
Oil	269	1000	80	7.01	269	16.0	-	1.00

Replacement Scenario (Physical feasibility)

	Reduction of generating capacities (GW)	Replacement by Solar (GW)	Replacement by Wind (GW)
Case 1	14.88	99 (127)	59.52 (64.52)
Case 2	23.57	160 (188)	94.28 (99.28)
Case 3	26.40	180 (208)	105.60 (110.60)

Figures in brackets are the total figures included in original mid-term target; Solar 28GW and Wind 0.5GW

According to Japan Photovoltaic Energy Association, maximum capacity in 2030 will be 100GW.
If 10M houses installed PVs, total will be 35-40GW (in 2009, only 0.15M houses had it)
On shore wind potential: 6.4GW (METI), and 280GW (MOE)

Alternative Scenario (economic aspect)

- Cost of nuclear generations

  overnight cost increasing, subsidies to local communities, rules strengthened

  Yen 8 (overnight cost increase) and Yen 1.8 (subsidies) kWh

- Cost of solar generations

  Recent tendency (not decreasing drastically) ref. next slide

  PV portion is 65%, to what extent cost will be down by innovation

  Assume same capacity increase every year, average purchasing price is

  Yen 36 until 2020, the scheme continues for 10 years

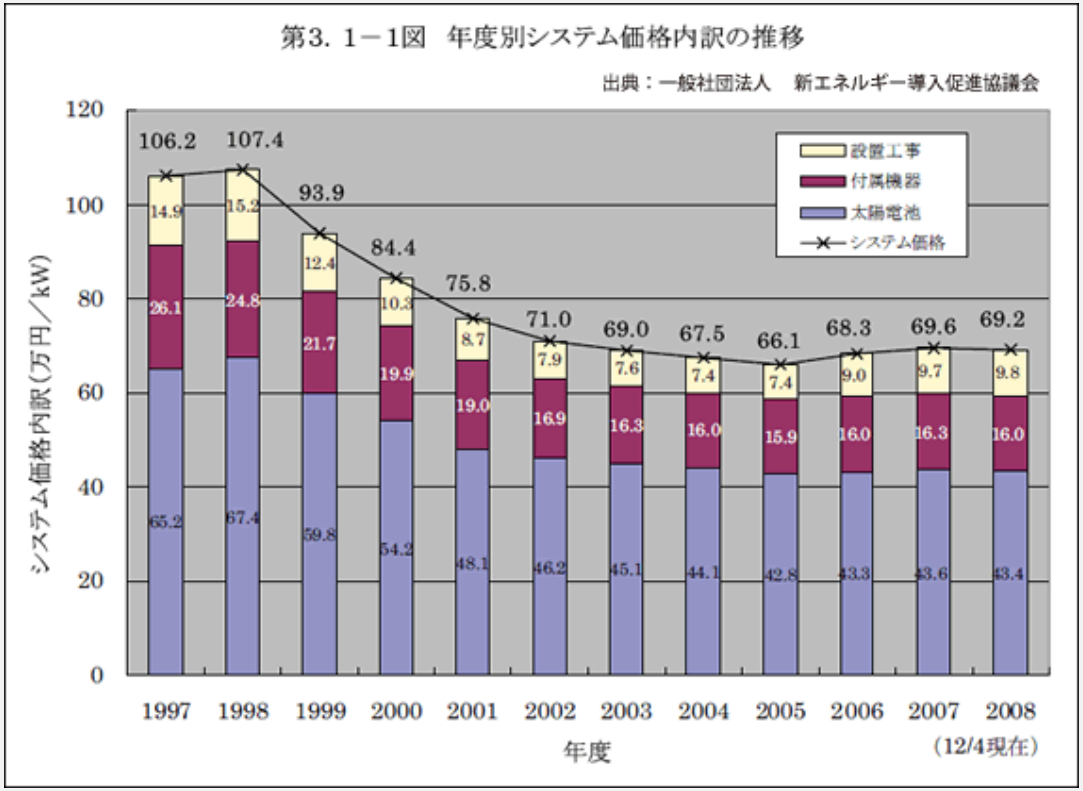
  Wind

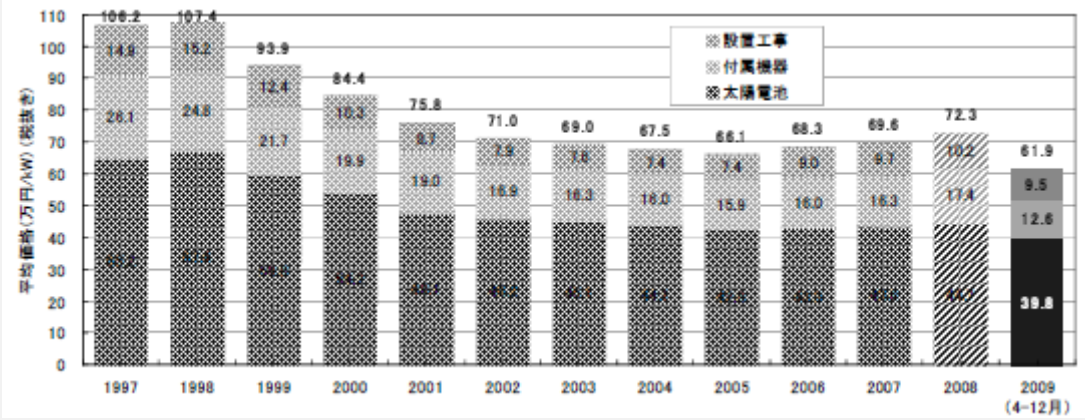
  Minimum requirement of FIT for 15 years at Yen 20 (METI projection)

- Grid stabilization cost (for solar 28GW case)

  $18 Billion - $208 Billion

Change of PV system price





PV: 65%
Others: 35%

Source: METI

Economic potential of wind power

	Resources (GW)	Potentials (GW)	Potentials by each scenario (GW)			
			Scenario 1-1	Scenario 1-2	Scenario 1-3	Scenario 2
Wind (on shore)	1322.33	282.94	24.37	101.30	137.64	673.74
Wind (off shore)		1572.62	0	0.17	3.00	141.08
Total	1322.33	1855.56	24.37	101.47	140.64	414.82

Source: Ministry of Environment, 2011

Scenarios 1-1: FIT Yen 15/kWh, purchasing period 15 years

Scenarios 1-2: FIT Yen 20/kWh, purchasing period 15 years

Scenarios 1-3: FIT Yen 20/kWh, purchasing period 20 years

Scenarios 2: FIT Tariff and purchasing period remain unchanged even if cost will be drastically reduced due to innovation

Cost of alternative technologies (trillion yen)

		Case 1	Case 2	Case 3
Solar	No subsidy	35	53	59
	With subsidy	33	50	56
	difference	2	3	3
Wind	No subsidy	23	34	37
	With subsidy	20	29	32
	difference	3	5	5

Grid stabilization costs are for solar 6 and for wind 4 trillion Yen.
Cost of replacement will be reduced by either technology innovation or further strengthening of nuclear regulations
Sensitivity Analysis: Yen 1 change will be 1 trillion in case 1 and 2 trillion Yen in case 3

No possibility for renewables to replace 100% of nuclear shortage

- To increase renewables to the extent we can

  ref. cases in Spain and Germany

- Best mix among fossil fuel, renewables, and nuclear

	Advantages	Disadvantages
Fossil Fuel	Low cost (excl. oil), usability	Energy security (Oil & Gas), climate protection, Depletion of resources and long-term price increase, loss of national wealth
Nuclear	Good for climate protection and energy security, Low cost (should be re-examined), Not affected by fossil fuel price fluctuations	Catastrophic loss, pubic acceptance
Renewable (Solar, Wind)	Good for climate protection and energy security, Decentralized generation, Not affected by fossil fuel price fluctuations	High cast (esp. solar), need subsidies, area limitation, Noise (wind), additional cost of grid stabilization

Review of Mid-term Target

- Full replacement by renewables are impossible, CO2 emissions increases (review of 25% inevitable)
- Due to nuclear accident, drastic review of long-term energy policy is inevitable, so does climate policy
- At this moment, Japan should declare the freeze of mid-term target for the moment (lost the opportunity at Deauville Summit in May 2011)
- Then review both energy and climate policy

No climate policy without reviewing energy policy

If energy policy is reviewed, so does climate policy

How to do with Japanese Mid-term Target?

- Withdraw 25% reduction as conditions not met
- 15% reduction relative to 2005 (8% reduction relative to 1990) is globally consistent as conditions are not met
- Take nuclear accident into account, the above corresponds to

  Case 1: -10% relative to 2005 (-3% from 1990)

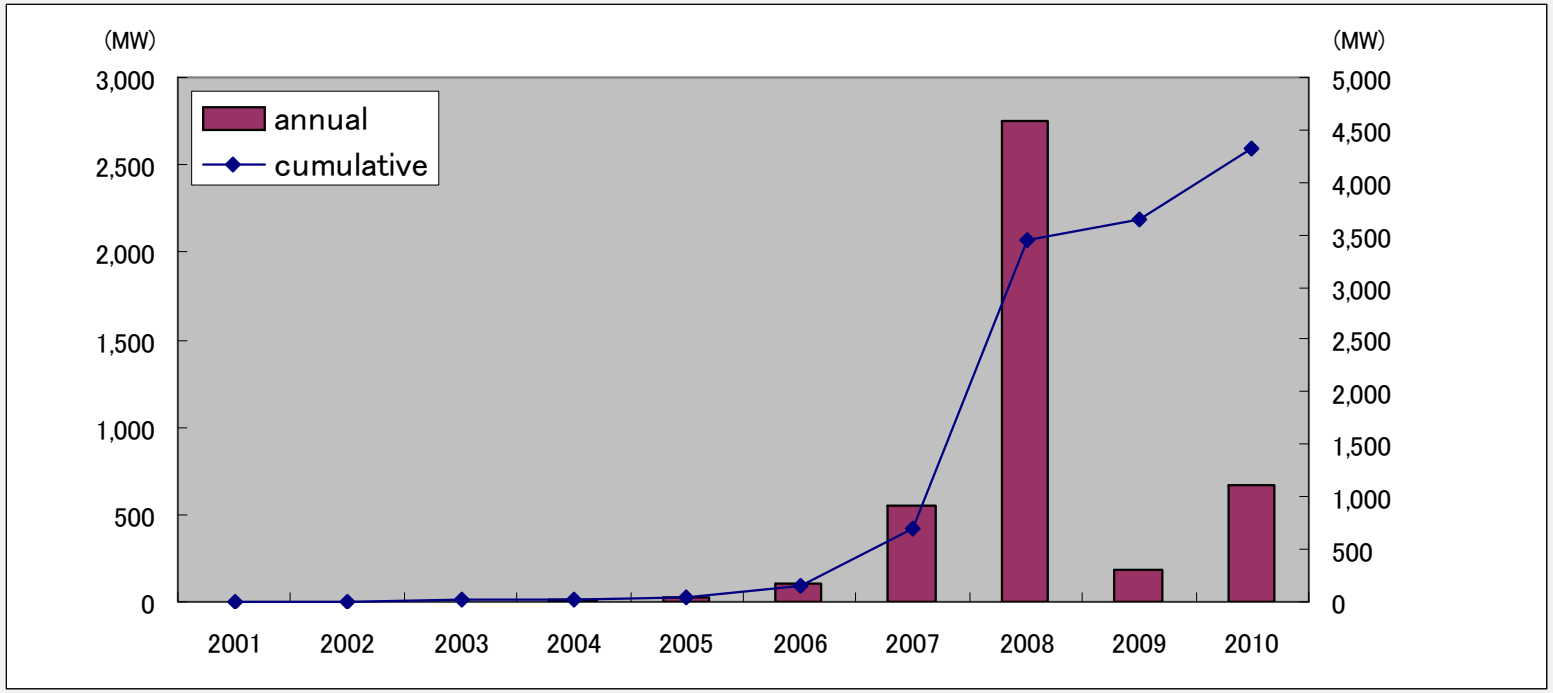
  Case 2: -8% relative to 2005 (same as 1990)）

  Case 3: -7% relative to 2005 (+1% from 1990)

  Even in this case, MAC is around $150.
- Mid-term target should be decided in view of the above as well as situation of nuclear and renewables
- Also set unilateral target additionally

Renewables, Spanish case

Solar power generating capacities, annual and cumulative (MW)



Source: compiled based on CNE（2010）Información Estadística sobre las Ventas de Energía del Régimen Especial

2004: RD436/2004, Promotion of renewable energies
2007: RD 661/2007, Introduction of FIT
2008: RD1578/2008, Decrease of tariffs and cap for capacity led to the collapse of bubble
2010 (Nov.): RD1565/2010, Constraint of mega-solar generations (reduction of tariffs)
2010 (Dec.): RDL14/2010, change of conditions retroactively to existing facilities
2011 (Jan.): Setting up of Euro 22 billion Electricity Deficit Amortisation Fund

Renewables, Germany's case (1)

Net present cost of promotinf PV.

	Annual increase Mio, kWh	Nominal specific net cost		Cumulated net cost	
		1st year € Cents/kWh	20th year € Cents/kWh	Nominal Bn €	Real Bn €2007
2000	64	47.99	42.49	0.581	0.559
2001	52	47.94	42.15	0.469	0.442
2002	72	45.36	39.33	0.609	0.563
2003	125	42.9	36.63	0.989	0.897
2004	244	47.74	41.21	2.152	1.913
2005	725	50.23	44.85	6.919	6.027
2006	938	47.3	41.78	8.385	7.164
2007	1280	44.5	38.86	10.705	8.969
2008	1310	41.82	36.05	10.282	8.409
2009	3073	37.85	31.96	21.515	17.345
2010	3073	30.08	24.07	16.701	13.224
Total	10956			79.307	65.512

Renewables, German experience (2)

- we encourage the government to consider more market-based renewables promotion policies, such as a renewables obligation scheme, in the next phase of renewables promotion.
- A static feed-in tariff is not able to incorporate dynamic changes in market conditions
- RECOMMENDATIONS

The government of Germany should consider policies other than very high feed-in tariffs to promote solar photovoltaics.

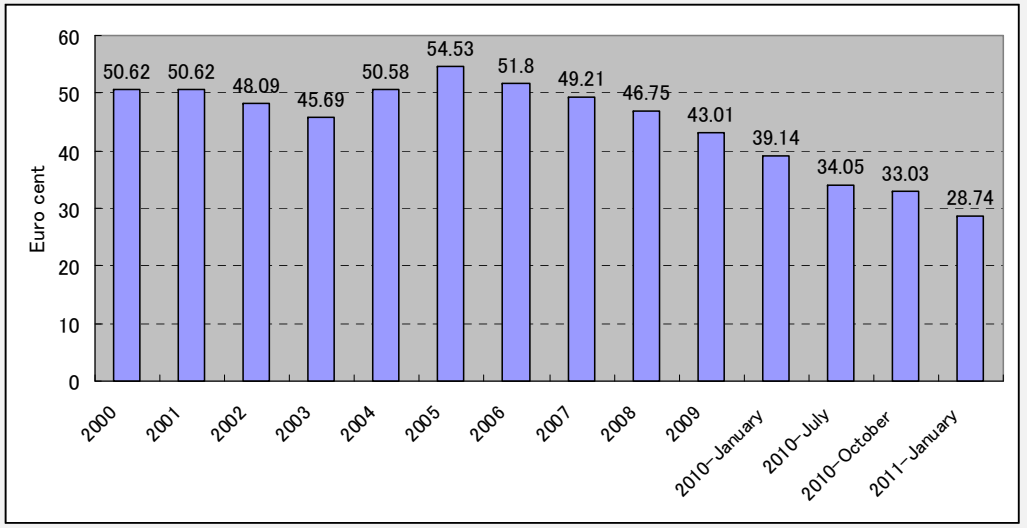
IEA, Energy Policies of IEA Countries; Germany 2007 Review

Renewables, Germany (3)

- FIT. Change of Tariff for roof-top PV generation

unit: Euro cent

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010			2011
										January	July	October	January
50.62	50.62	48.09	45.69	50.58	54.53	51.8	49.21	46.75	43.01	39.14	34.05	33.03	28.74



Source: Frondel et al. (2010) and Izumi Kaizuka (2011)

World Nuclear Generations

- IEA Blue Map Scenario, ETP 2008

  2 degree target (halving emissions in 2050)

  Nuclear generation; 368GW→570GW（BAU in 2050）

  ACT/Blue Map Scenario: 1250GW (annual 30GW increase)

  Hi-Nuclear scenario: 2000GW (annual increase of 50GW)

  Under Blue Map Scenario, ratio of nuclear power generation is estimated as 20-35%

- Effects to German, Swiss and Italian situations
- May or may not affects 2 degree target

About the cost of accident

- Ordinary case

  Damages x annual probability = annual damages

  2 serious accidents in 12700 reactor years by 2008
- Similarity of nuclear accident to abrupt climate change (THC, WAIS, GIS)
- Difficulty of monetizing non-market losses
- How to deal with “fat-tail” issues (Martin Weitzman)
- Risks always exist (perfect safety never exists)
- Finding causes of accident to prevent recurrence, and establish measures in case of the accident

Appendix: Additional Cost (Solar 160GW)
Difference of cost, Yen 28/kWh

	MkW																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
2011	16	16	16	16	16	16	16	16	16	16										
2012		16	16	16	16	16	16	16	16	16	16									
2013			16	16	16	16	16	16	16	16	16	16								
2014				16	16	16	16	16	16	16	16	16	16							
2015					16	16	16	16	16	16	16	16	16	16						
2016						16	16	16	16	16	16	16	16	16	16					
2017							16	16	16	16	16	16	16	16	16	16				
2018								16	16	16	16	16	16	16	16	16	16			
2019									16	16	16	16	16	16	16	16	16	16		
2020										16	16	16	16	16	16	16	16	16	16	
	16	32	48	64	80	96	112	128	144	160	144	128	112	96	80	64	48	32	16	

	MkWh																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
2011	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2										
2012		16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2									
2013			16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2								
2014				16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2							
2015					16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2						
2016						16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2					
2017							16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2				
2018								16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2			
2019									16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2		
2020										16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	16819.2	
	16819.2	33638.4	50457.6	67276.8	84096	100915.2	117734.4	134553.6	151372.8	168192	151372.8	134553.6	117734.4	100915.2	84096	67276.8	50457.6	33638.4	16819.2	

	Billon Yen																			
Yen/kWh	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
28	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	0	0	0	0	0	0	0	0	0	0
28	0	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	0	0	0	0	0	0	0	0	0
28	0	0	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	0	0	0	0	0	0	0	0
28	0	0	0	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	0	0	0	0	0	0	0
28	0	0	0	0	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	0	0	0	0	0	0
28	0	0	0	0	0	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	0	0	0	0	0
28	0	0	0	0	0	0	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	0	0	0	0
28	0	0	0	0	0	0	0	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	0	0	0
28	0	0	0	0	0	0	0	0	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	0	0
28	0	0	0	0	0	0	0	0	0	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	470.9376	0
	470.9376	941.8752	1412.813	1883.75	2354.688	2825.626	3296.563	3767.501	4238.438	4709.376	4238.438	3767.501	3296.563	2825.626	2354.688	1883.75	1412.813	941.8752	470.9376	0

2011-2020 (10years) 25901.57 47093.76

Sensitivity test: Difference of Yen 1 increases (decreases) total cost by 2 trillion yen.