International Institute for Carbon-Neutral Energy Research

Powering the Future
Internationalizing Research – PART II of V

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New Value Chains and the Rise of Open Innovation in Asia
Stanford University

KYUSHU UNIVERSITY

Japan's Current Energy-Related Concerns

World Trends

- Economic rise of emerging nations and advance of economic globalization
- Fossil fuels continue to be a primary energy source
- Introduction of renewable energy with better performance, reduced cost, and improved stability
- Heating of competition for natural resources , energy and food
- Nuclear power continues to be a major electricity supplier with continuously increasing safety

Japan's Concerns

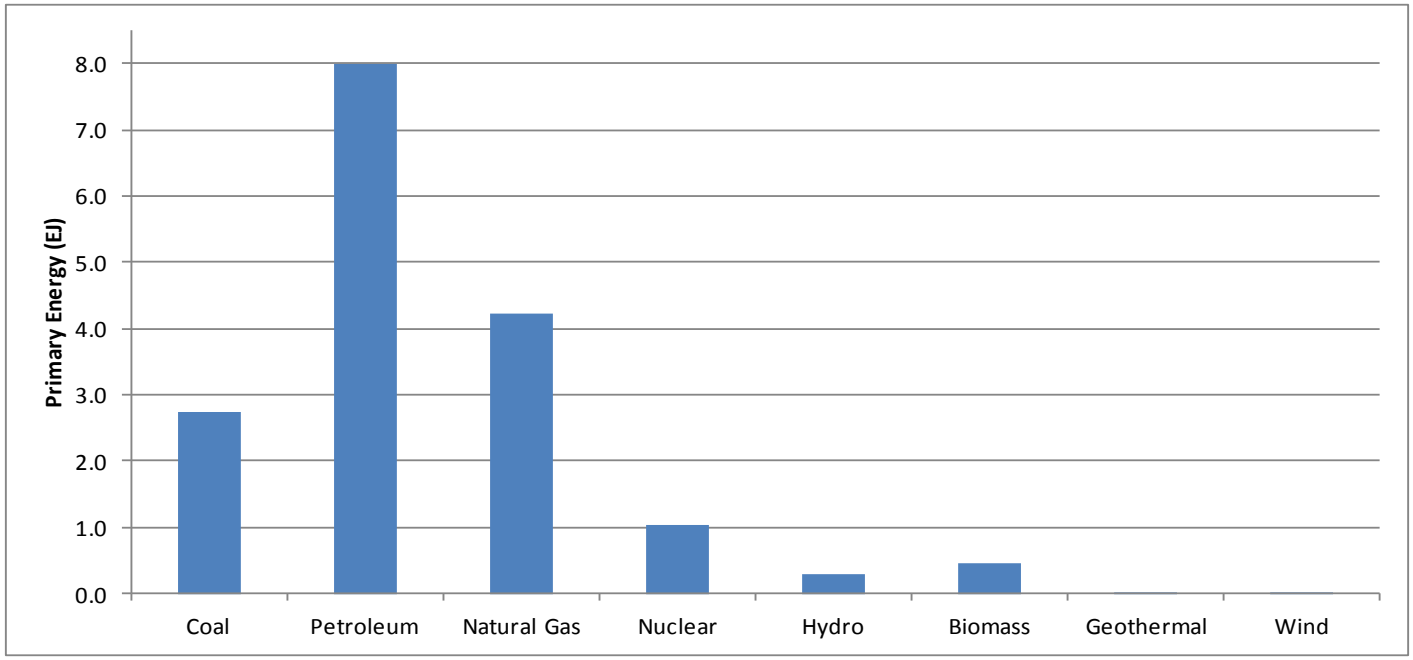
- Direct and Indirect damage by the East Japan Earthquake and the Fukushima Daiichi Nuclear Power Station
- Decreasing energy self-sufficiency
- Increasing trade deficit due to soaring prices of fossil fuels and increased imports
- No definite pathway to meet the pledge for GHG emission reduction in 2020 or 2030
  - Slash emissions 25% from the 1990 levels, by the year 2020 (abandoned)
  - Slash emissions 80% from the 1990 levels, by the year 2050?
- Rapid spread of low-price imported photovoltaic panels into the Japanese market while the domestic supply is declining
- Long downward trend of industrial competitiveness
- Aging and decreasing population due to low birth rates

Japan's National Energy Policy

- Reduce total energy consumption by prioritizing funding for
  - efficiency improvement, energy conservation, leveling of supply and demand, etc.
- Facilitate renewable energy introduction into the market
- Promote clean and efficient use of natural gas and coal for stable power supply for the near future
- Promote distributed energy systems to raise total efficiency
- Rebuild mid- to long-term GHG emission reduction scenario and take initiative in the international arena
  - Slash emissions 80% from the 1990 levels, by the year 2050?
- Secure a stable and sustainable energy supply by diversifying energy resources
- Reduce nuclear energy as a supplementary energy, while drawing technology safety lessons from the Fukushima accident
  - Promote R&D on nuclear fuel cycling as a critical factor in order to reach some confident technological conclusion within prescribed time frame
- Actively disseminate quality energy-related technologies to other countries contributing to global disparity adjustment and GHG emission reduction

N. Kasagi, Center for Research and Development Strategy, Japan Science and Technology Agency

Japan Primary Energy Supply 2010



Primary Energy Source	EJ
Coal	2.7
Petroleum	8.0
Natural Gas	4.2
Nuclear	1.0
Hydro	0.30
Biomass	0.47
Geothermal	0.01
Wind	0.01
Total	**16.8**

Excludes Products

No solar
Almost no wind
Small biomass

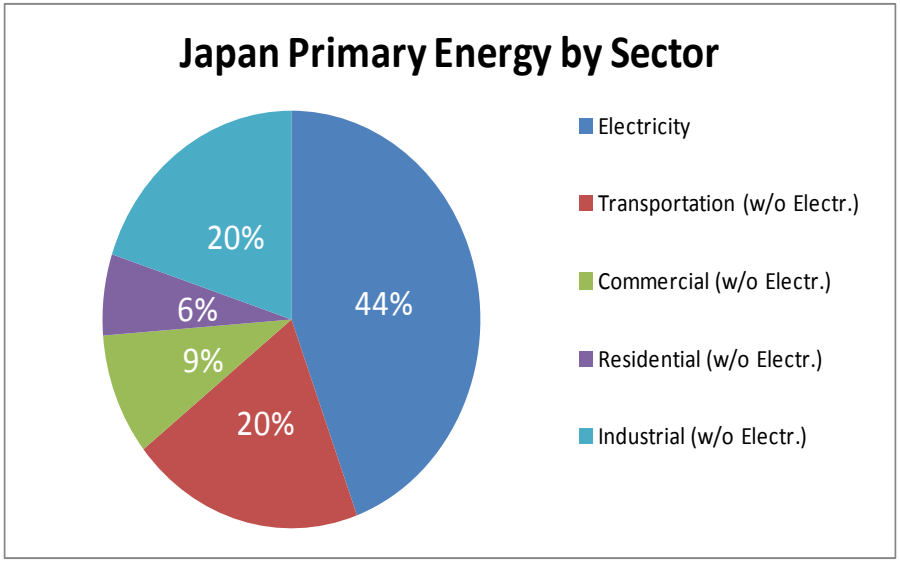
EDMC Handbook of Energy and Environmental Statistics in Japan (2012) [non-biomass renewables and nuclear adjusted to 100% efficiency]

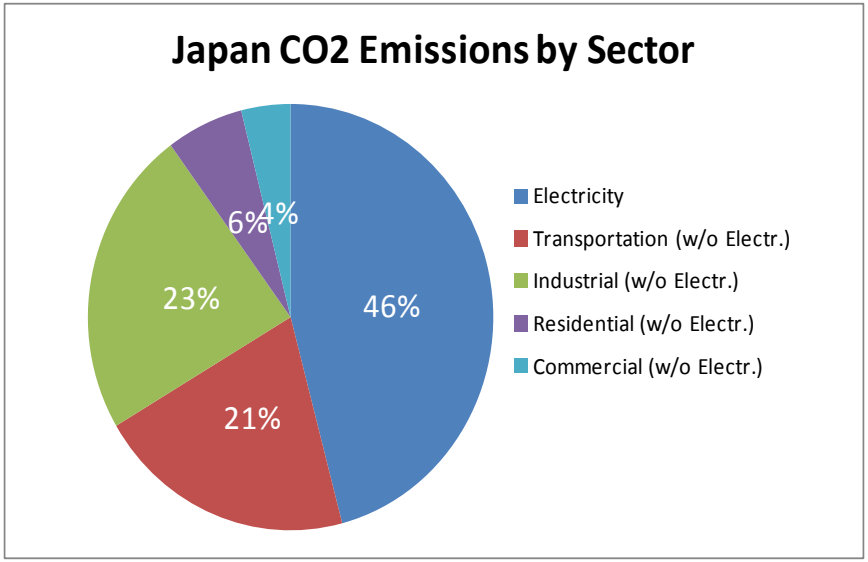
Japan Energy and CO_2 Emissions 2010

Sector	Primary Energy (EJ)	Primary Energy	CO_2 Emissions M tonnes	Share of CO_2 Emissions
Electricity	7.5	44%	515	46%
Industrial (w/o Electr.)	3.4	20%	263	23%
Transportation (w/o Electr.)	3.4	20%	231	21%
Residential (w/o Electr.)	1.1	6%	69	6%
Commercial (w/o Electr.)	1.6	9%	44	4%
Total	**16.8**		**1,122**	**100%**

Excludes Products

Transportation is all petroleum





Less than 10% of renewables for electricity production

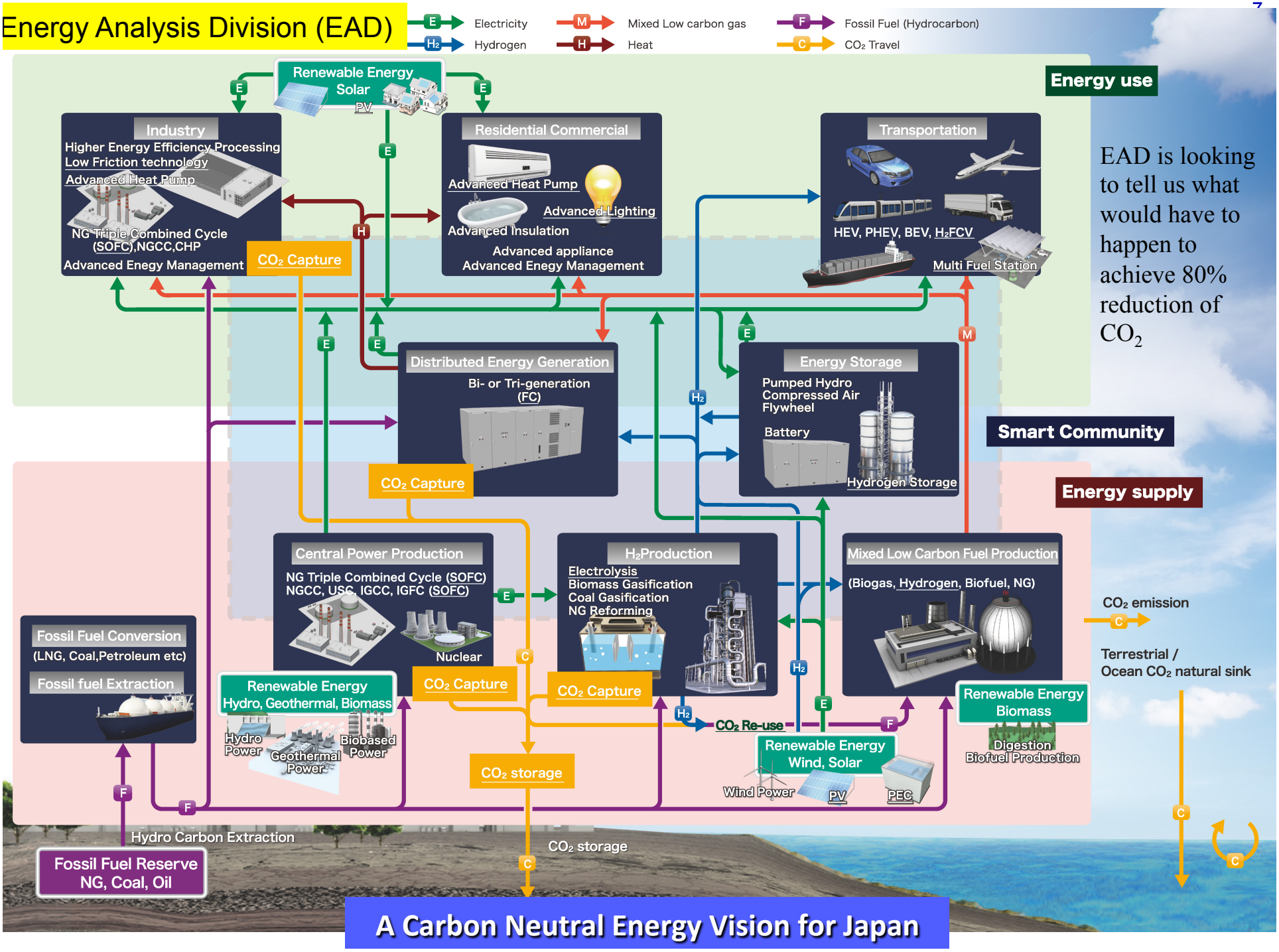
EDMC Handbook of Energy and Environmental Statistics in Japan (2012) [non-biomass renewables and nuclear adjusted to 100% efficiency]

Japan Renewable Energy Potential

	Current situation			Economically Feasible (*1)	Operating ratio condition(*2)	Economically Feasible (*1)
	GW	TWh	EJ	GW	%	EJ
Geothermal	0.54	2.632	0.01	5.73	80	0.14
Hydro (All)	48.11	90.681	0.33	52.41	45	0.74
PV for residential	4.91	0.022	0.00	N/A	60	??
PV for Non-residential				72-102	12	0.33
Wind on-shore	2.56	4.016	0.01	27.37	20	0.17
Wind offshore				14.11	30	0.13
Biomass	N/A	N/A	0.30	N/A	80	??
Renewable Total			**0.65**			**1.52 + ??**
Nuclear	48.96	288.23	1.04	??	70	??

(*1)Source: Study of Potential for the Introduction of Renewable Energy by Ministry of Environment (2011)

- **Potential use of renewable-based electricity is substantial**
  - Japan 2010 electricity consumption: 3.9 EJ (1,100 TWh) and is projected to be the same or less by 2050
  - Requires efficient cost acceptable renewable energy technology
- **Intermittent wind and PV requires**
  - Efficient spinning reserve (NG plant or flexible coal)
  - and/or energy storage (pumped hydro, compressed air, batteries, H_2 storage system, V2G?)

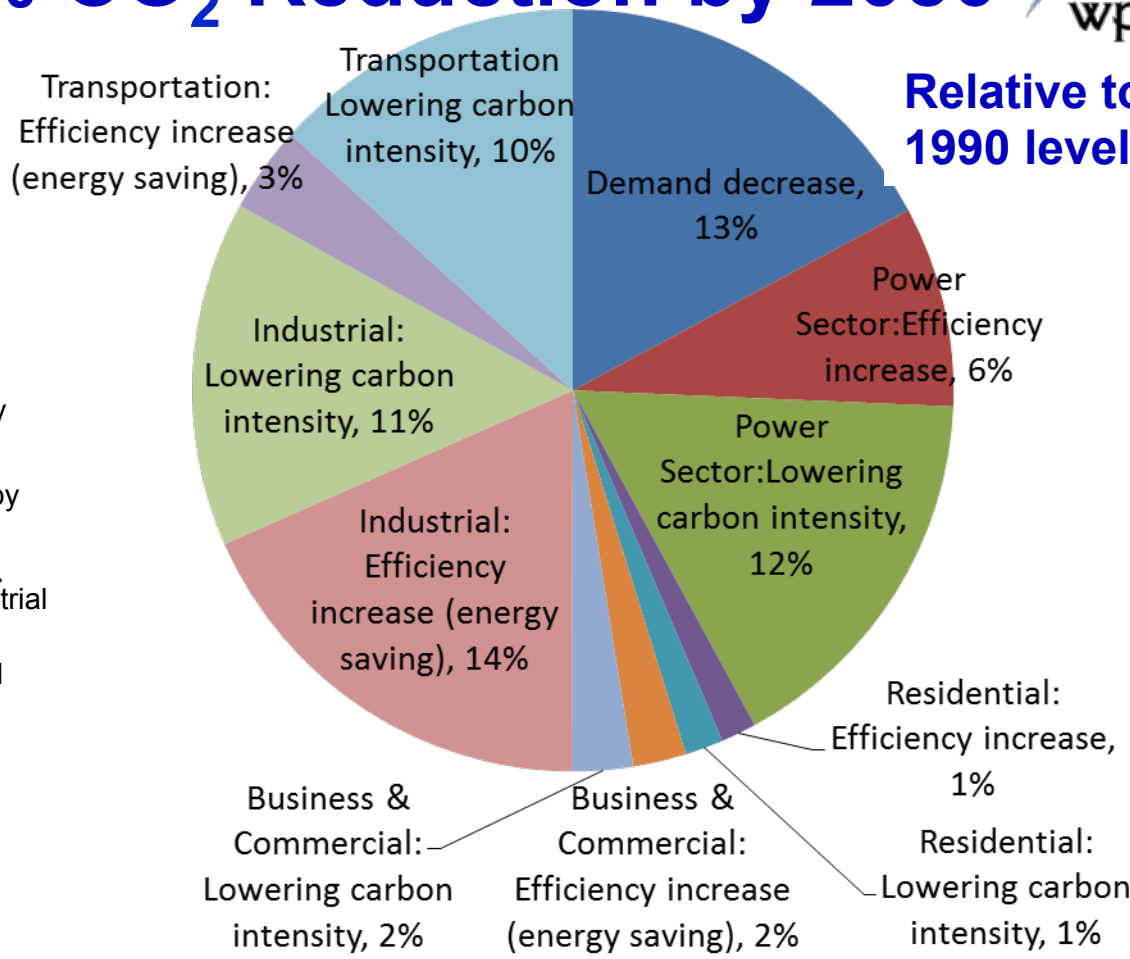

Energy Analysis Division (EAD)
E Electricity
H₂ Hydrogen
M Mixed Low carbon gas
H Heat
F Fossil Fuel (Hydrocarbon)
C CO₂ Travel
Energy use
Renewable Energy
Solar
PV
Industry
Higher Energy Efficiency Processing
Low Friction technology
Advanced Heat Pump
NG Triple Combined Cycle (SOFC),NGCC,CHP
Advanced Enegy Management
CO₂ Capture
Residential Commercial
Advanced Heat Pump
Advanced Lighting
Advanced Insulation
Advanced appliance
Advanced Enegy Management
Transportation
HEV, PHEV, BEV, H₂FCV
Multi Fuel Station
EAD is looking to tell us what would have to happen to achieve 80% reduction of CO₂
Distributed Energy Generation
Bi- or Tri-generation (FC)
CO₂ Capture
Energy Storage
Pumped Hydro
Compressed Air
Flywheel
Battery
Hydrogen Storage
Smart Community
Energy supply
Central Power Production
NG Triple Combined Cycle (SOFC)
NGCC, USC, IGCC, IGFC (SOFC)
Nuclear
H₂Production
Electrolysis
Biomass Gasification
Coal Gasification
NG Reforming
Mixed Low Carbon Fuel Production
(Biogas, Hydrogen, Biofuel, NG)
CO₂ emission
Terrestrial / Ocean CO₂ natural sink
Fossil Fuel Conversion
(LNG, Coal,Petroleum etc)
Fossil fuel Extraction
Renewable Energy
Hydro, Geothermal, Biomass
Hydro Power
Geothermal Power
Biobased Power
CO₂ Capture
CO₂ Capture
CO₂ Re-use
Renewable Energy
Wind, Solar
Wind Power
PV
PEC
Renewable Energy
Biomass
Digestion
Biofuel Production
CO₂ storage
Hydro Carbon Extraction
Fossil Fuel Reserve
NG, Coal, Oil
CO₂ storage
A Carbon Neutral Energy Vision for Japan

Scenario: 75% CO_2 Reduction by 2050

A very aggressive scenario

Assumptions

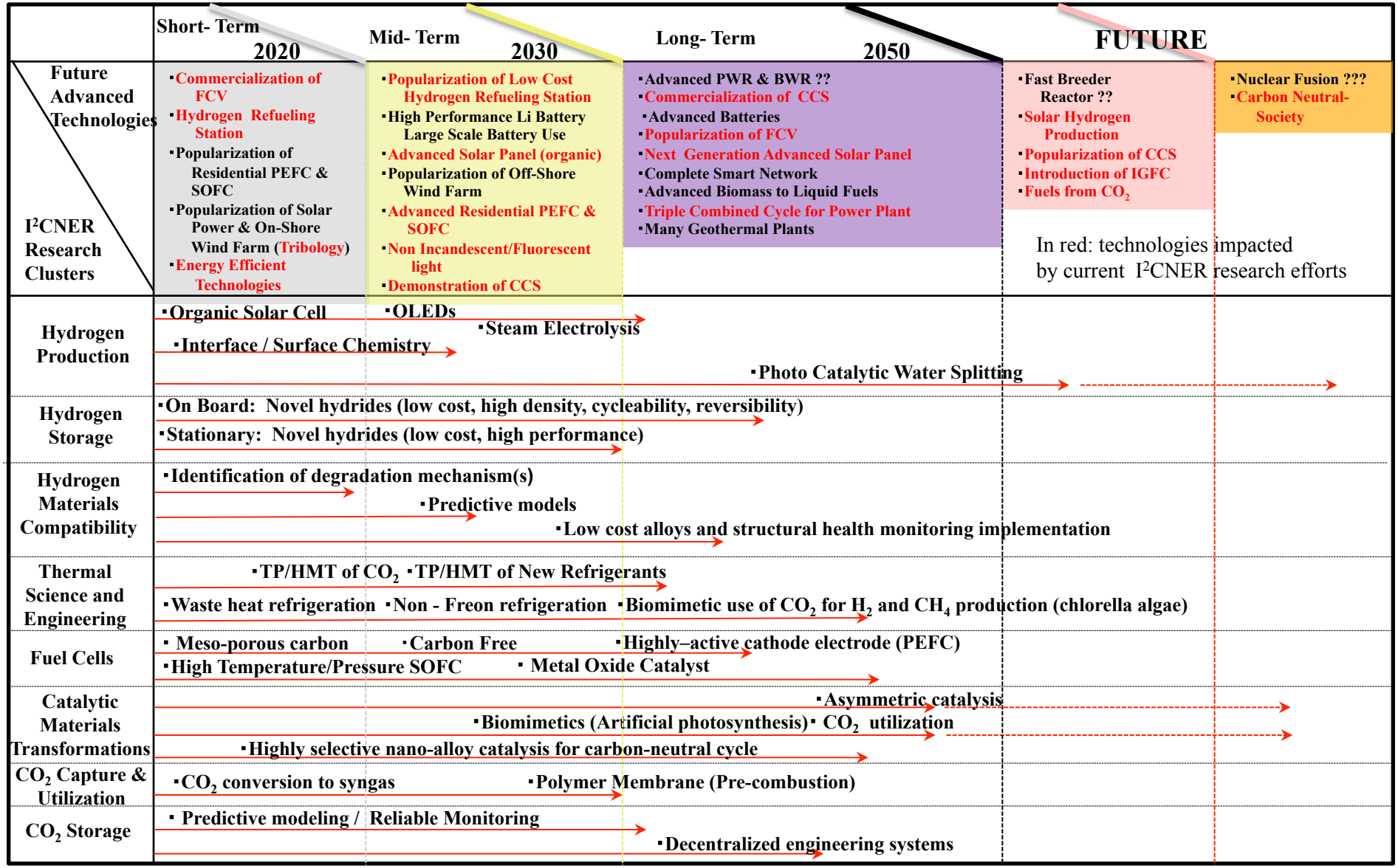
- 25% population decrease by 2050
- No change in electric power demand per capita
- No change in heat demand per capita
- Nuclear power decrease significantly
- Nuclear power is replaced by renewable energy
- No oil-fired thermal power generation
- Oil-fired thermal power generation is replaced by natural gas and coal fired power generation
- CCS is significantly introduced (100% for coal、more than 60% for NG, and most of large industrial sources)
- Low carbon hydrogen is significantly introduced
- FCV replaces compact and standard size car
- EV replaces mini car
- City gas is replaced by low carbon mixed gas



Key strategy elements

- The key strategies for achieving a large emission reduction are: increase of efficiency in energy conversion and energy use, and reduction of carbon intensity (renewables and/or CCS) in the secondary energy supply.
- For the industrial sector, large point sources such as steel furnaces need to be taken care of by CCS or other low carbon process technologies.
- For the transportation sector, a large deployment of FCV or BEV (or bio fuel) using low carbon secondary energy is essential.

I²CNER Roadmap



TP =Thermophysical properties, HMT=Heat and Mass Transfer, OLED=Organic light emitting diodes

I²CNER's Vision
Hydrogen-Powered Transportation Sector