India-Japan Energy Cooperation
日印エネルギー協力

July 23, 2012
Yokohama, Japan

The Institute of Energy Economics, Japan

Outline 概要

- Opportunities for Cooperation
  協力の機会
- Areas for Cooperation
  協力可能な分野
  - Energy Efficiency and Conservation
    省エネルギー
  - New & Renewable Energy
    新･再生可能エネルギー
  - Fossil Fuel Power Generation
    火力発電
  - Nuclear Energy
    原子力エネルギー
- Next Step
  次のステップ

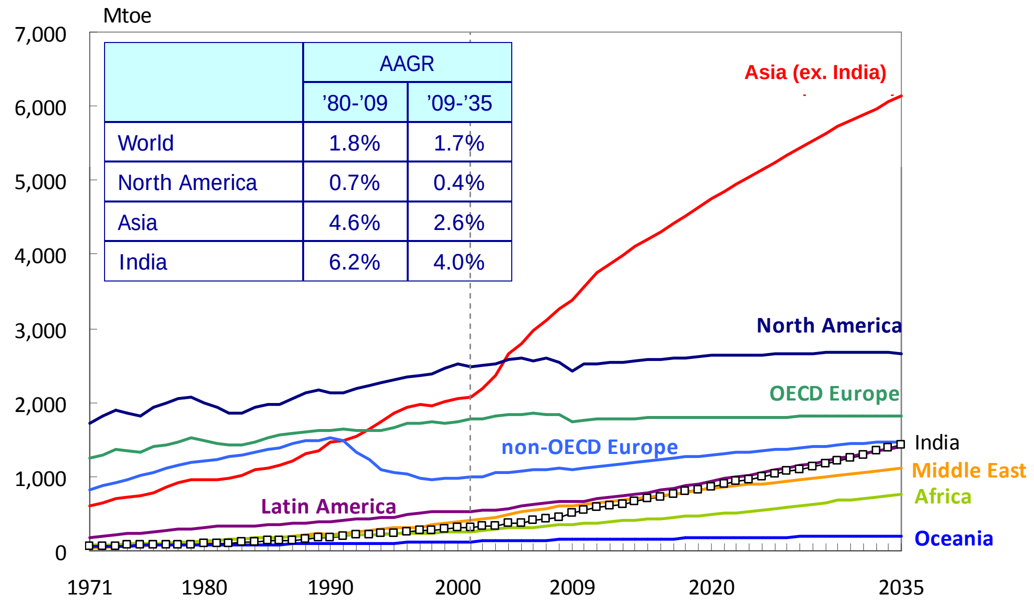
Opportunities for Cooperation

協力の機会

India in the World's Energy Market
世界のエネルギー市場におけるインド

- Reflecting the high economic growth of Asian countries, primary energy demand in Asia will double by 2035 from current levels: 3.9 billion toe (2009) ⇒ 7.6 billion toe (2035).
- Non-OECD countries, including India, will represent 90% of the increase in global energy demand.

World's Primary Energy Supply (reference scenario)



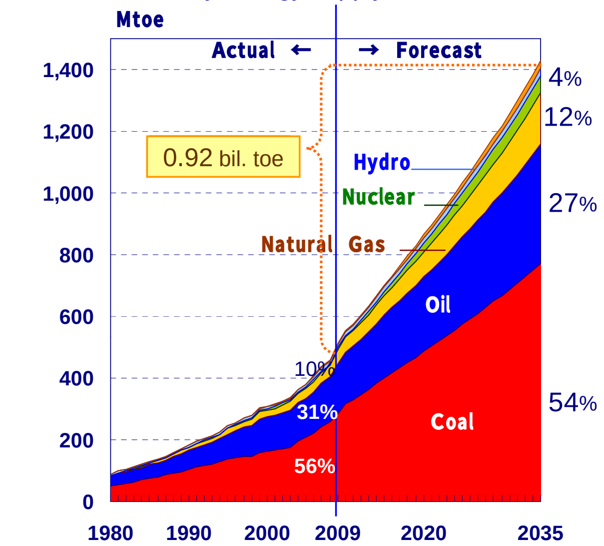
	AAGR	
	'80-'09	'09-'35
World	1.8%	1.7%
North America	0.7%	0.4%
Asia	4.6%	2.6%
India	6.2%	4.0%

Source: IEEJ, 2011

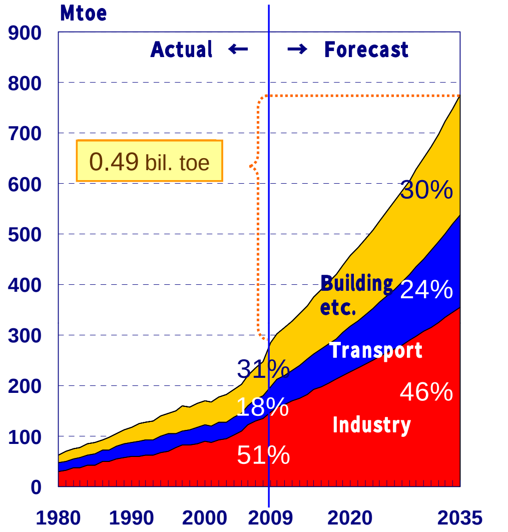
Growing Energy Demand in India (Reference scenario)
増加するエネルギー需要（自然体ケース）

- Final energy consumption will increase 2.7-fold from the current level: 285 million toe (2009) ⇒ 774 million toe (2035)
- Coal demand for power generation and oil demand for transport are the major drivers of the rapidly growing demand.
- Increasing use of “commercial energy” in the household sector is also pushing up the demand.
- Security of energy supply is a crucial policy issue.

India’s Primary Energy supply (reference scenario)



India’s Final Energy Consumption (reference scenario)

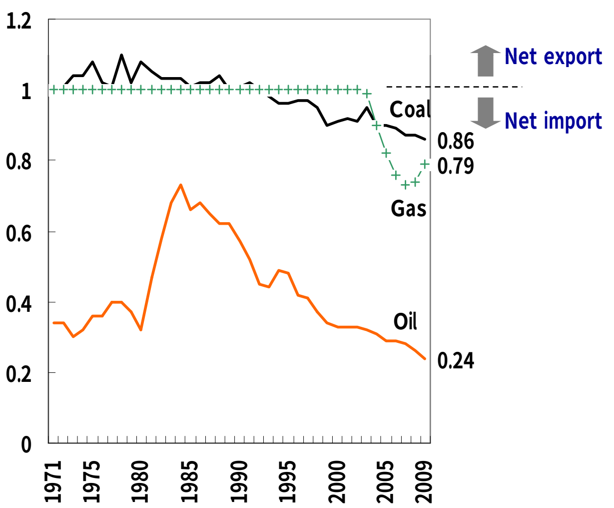


Source: IEEJ, 2011

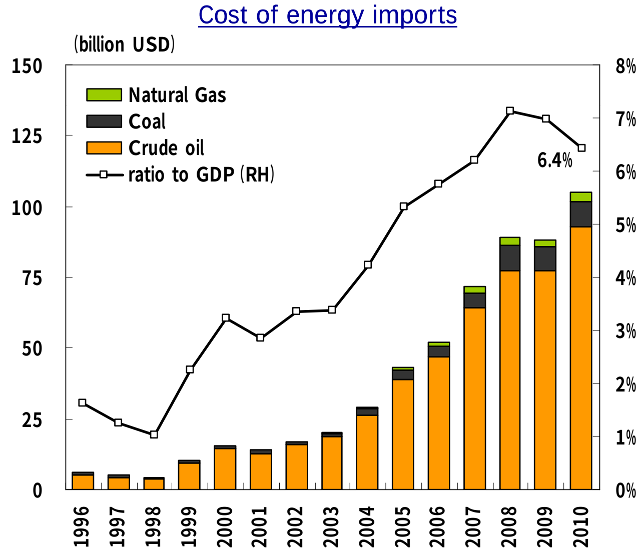
Declining Self-sufficiency
自給率の低下

- Self-sufficiency in fossil fuels is declining:
  - Low domestic selling price dis-incentivizes coal production.
  - Lower than expected natural production (KG-D6 field)
- Soaring amount and price of energy imports increase the cost burden for the people, industry and government:
  - Leads to insufficient investment.

Transition of self-sufficiency



Cost of energy imports



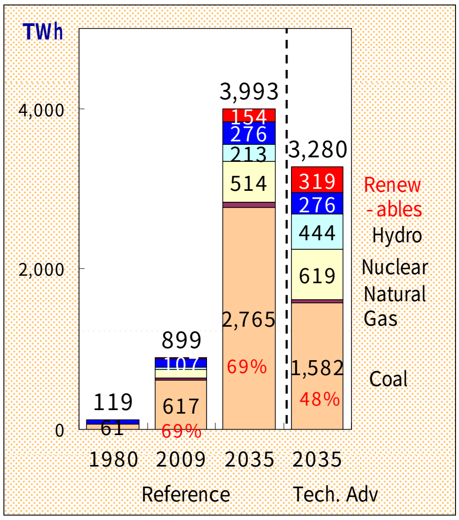
Source: IEA, 2011

Source: Department of Commerce, GDP: IMF

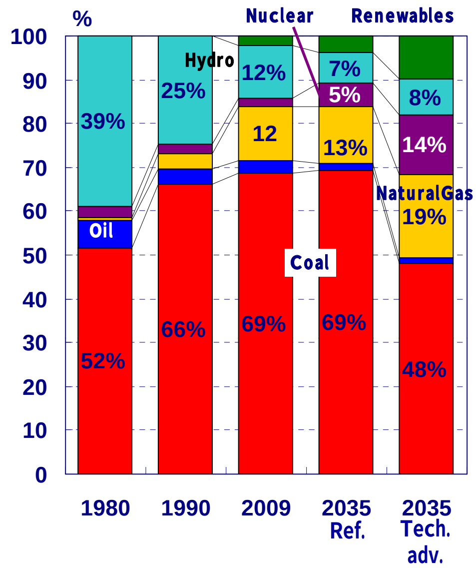
Needs for Power Development
電源開発への要請

- Economic growth and advance of electrification rate (25%, 288 million @ 2009, IEA) will drive rapid increase in power demand.
- Urgent necessity for large-scale power development including coal-fired, nuclear and renewables.
- Major obstacles include delays in execution of development plan and supply shortage of coal/natural gas.

Power generation by fuel



Share of each generation source

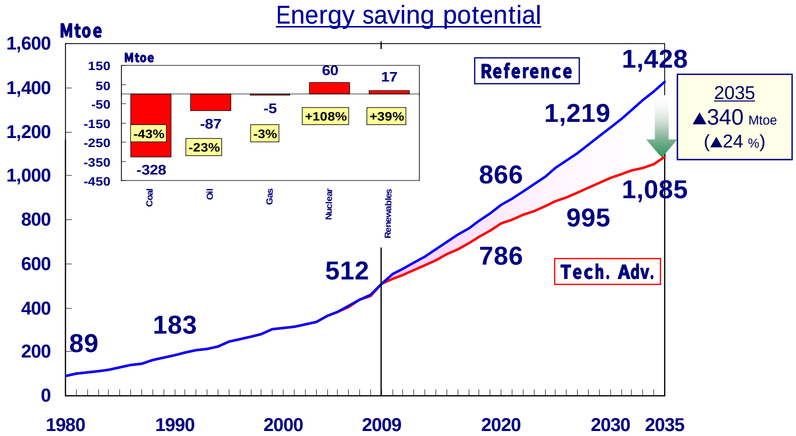


Source: IEEJ, 2011

EE&C, Key Measure for 3E
省エネルギー、3E達成のカギ

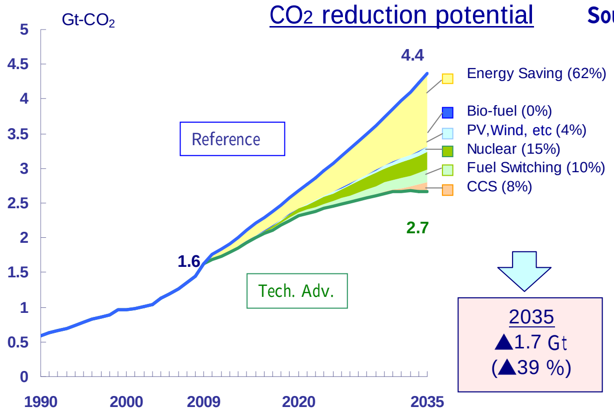
- "Energy Efficiency and Conservation: EE&C" is one of the most important and effective tools to achieve the 3E in India.
  - Enhance energy security
  - Maintain economic growth
  - Reduce environmental burden
- Large potential for energy saving; CO_2 emission reduction will follow.

Energy saving potential



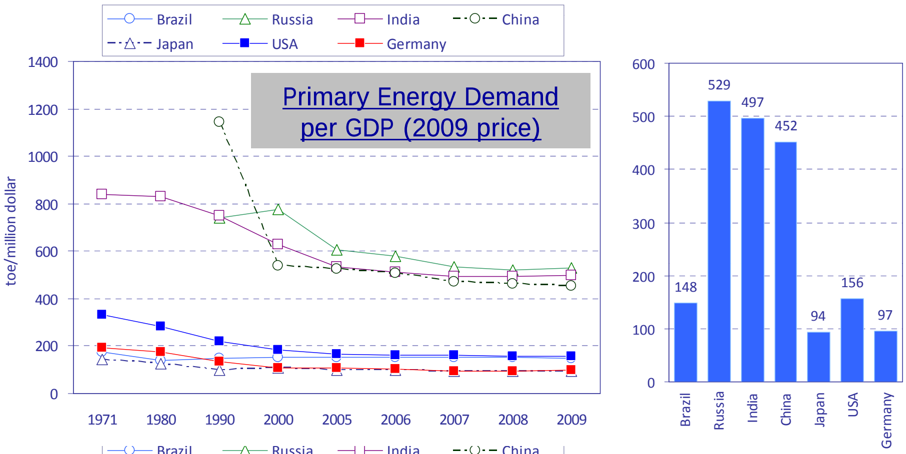
CO2 reduction potential

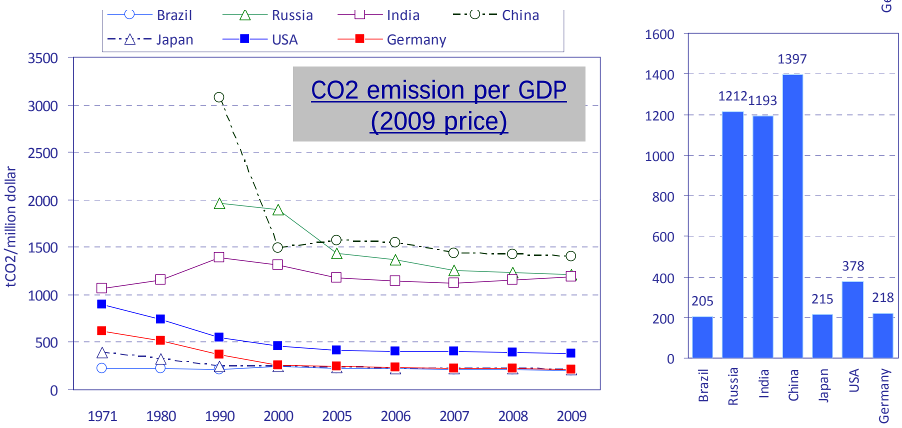
Source: IEEJ, 2011



Room for Improvement
改善余地の存在

- India has long improved its energy efficiency.
- However, compared with other countries, there is still room for improvement.



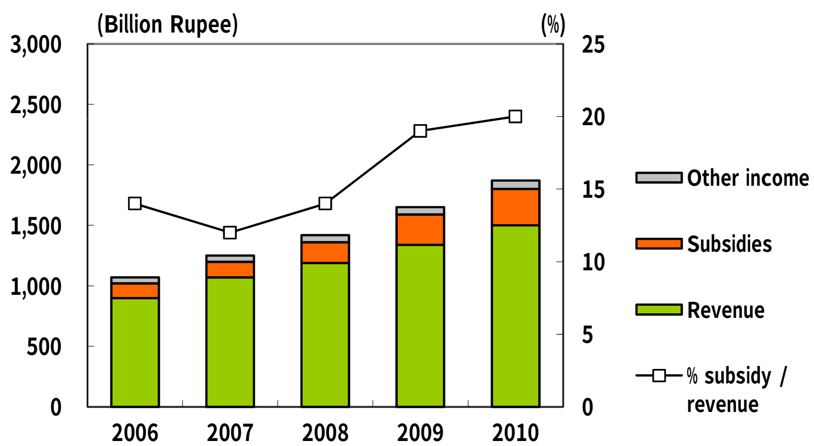


Source: IEA, 2011

Energy Price Issue
エネルギー価格問題

- Subsidies which reduce energy prices below actual cost are:
  - harming the fiscal soundness of the government
  - dampening incentives for energy-saving activities
  - discouraging foreign investment

Subsidy for Major Electricity Distribution Companies



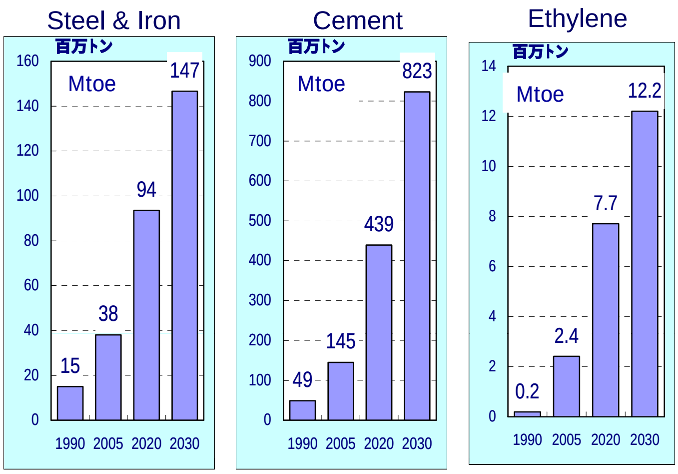
1 Rupee = 1.4 Yen
Source: Planning Commission, Dec. 2011

Areas for Cooperation
- Energy Efficiency and Conservation

協力可能な分野
- 省エネルギー

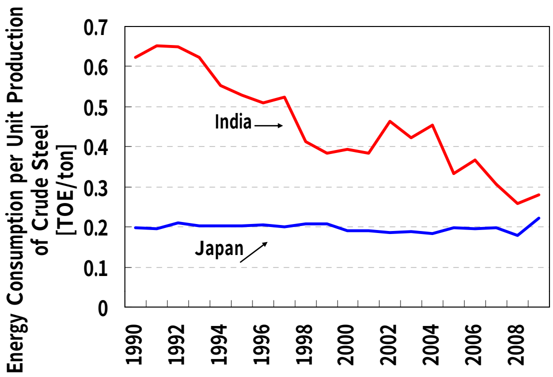
Energy Consumption by Industry in India
インドにおける産業部エネルギー消費の特徴

Outlook for Production by Industry



Source: IEEJ World Energy Outlook (2007)

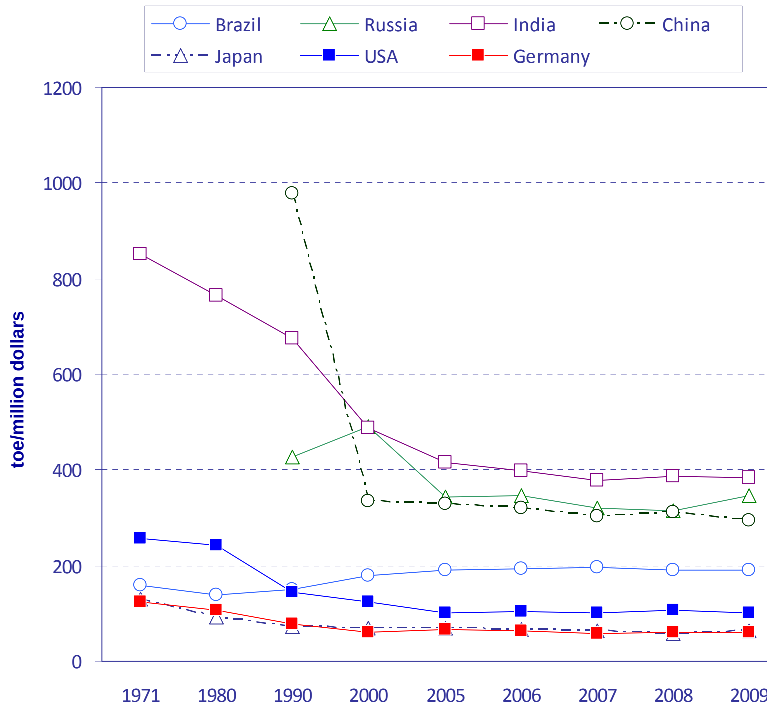
Energy Intensity
Iron and Steel

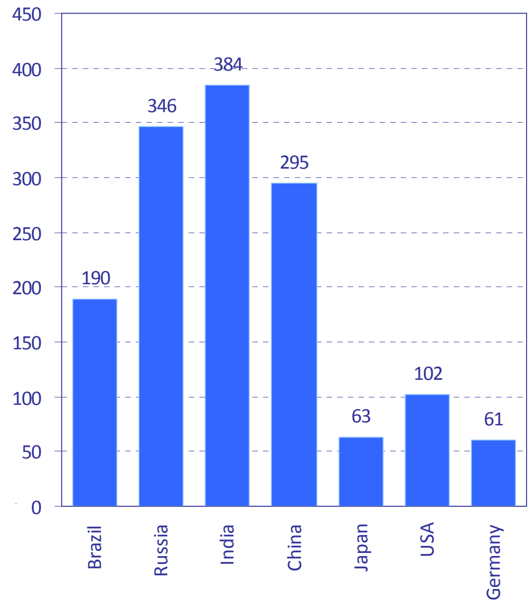


Source: IEA (2011) Energy Balance Table, Fourin (2011)

- Industry accounts for 30% of total final energy demand.
- Production in energy-intensive sectors, such as steel & iron, cement and ethylene, are expected to increase rapidly due to urbanization.
- Energy efficiency in such sectors in India has much room to improve; Japan can provide the latest advanced energy conservation technologies, such as TRT (Top-pressure Recovery Turbine) and CDQ (Coke Dry Quenching).

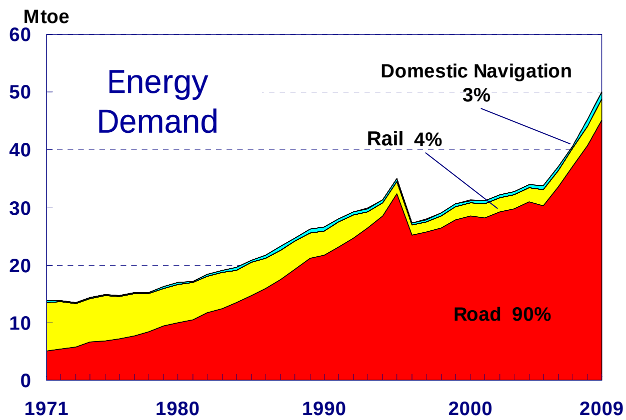
Industry Energy Consumption per Value Added (2009 price) among Major Countries
産業部門エネルギー原単位 (エネルギー消費/付加価値: 2009年価格) の国際比較



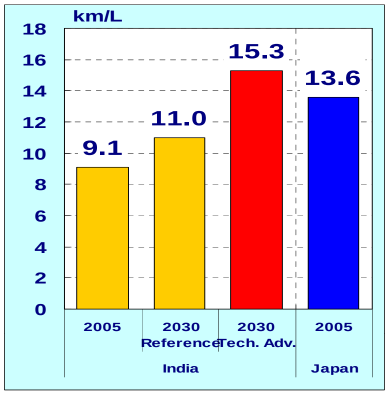


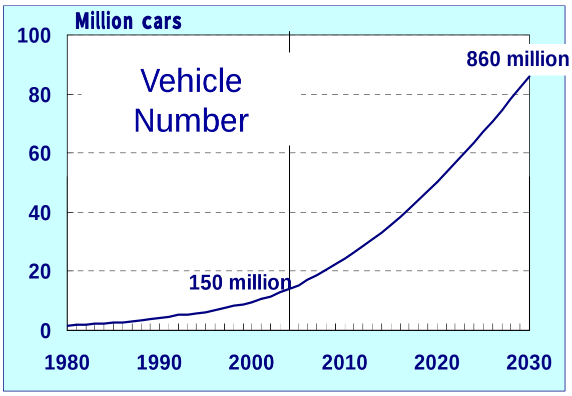
Source: International Energy Agency, Energy Balances of OECD and Non-OECD Countries
World Bank, World Development Indicators

Energy Consumption in Transportation Sector in India
インドにおける運輸部門エネルギー消費の特徴



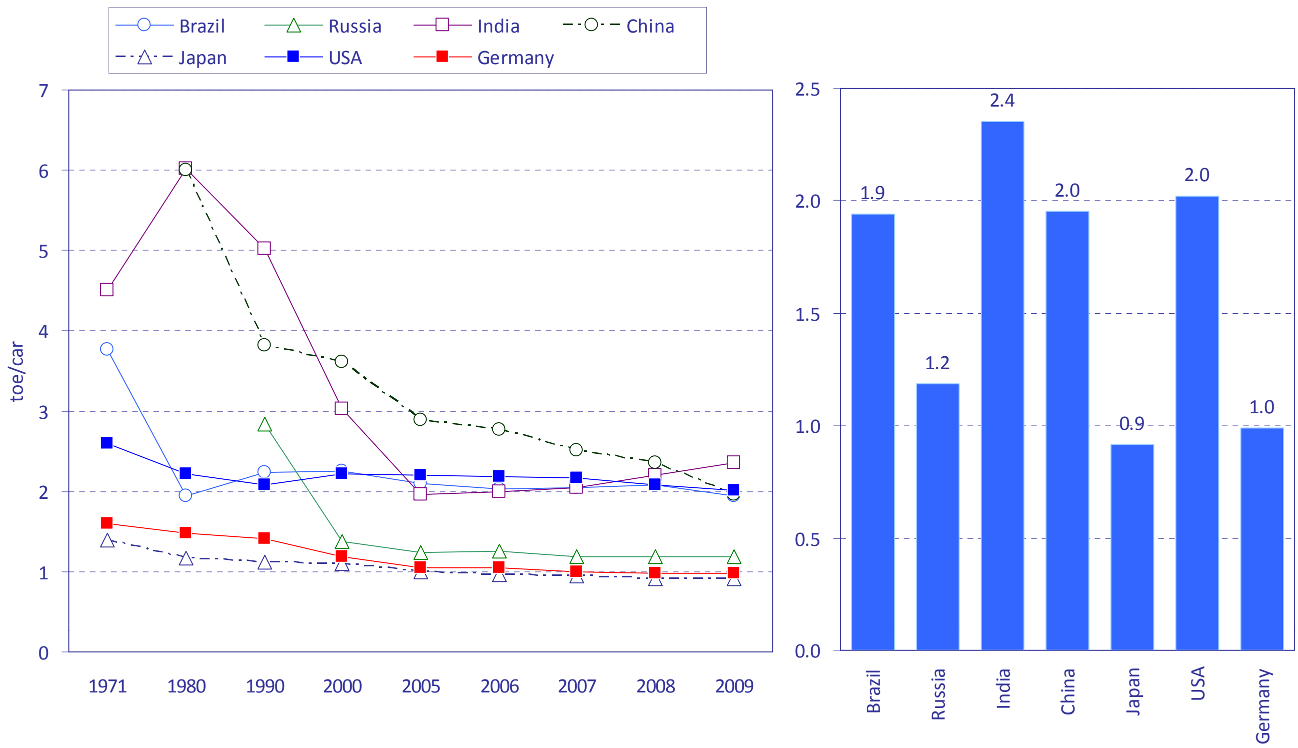
Car Fuel Consumption





- Transport accounts for 11% of total final energy consumption.
- The share is expected to grow as the number of vehicles increases (motorization).
- Japan can provide the latest advanced technologies covering not only traditional ICE (internal combustion engine), but also hybrid and electric vehicles.

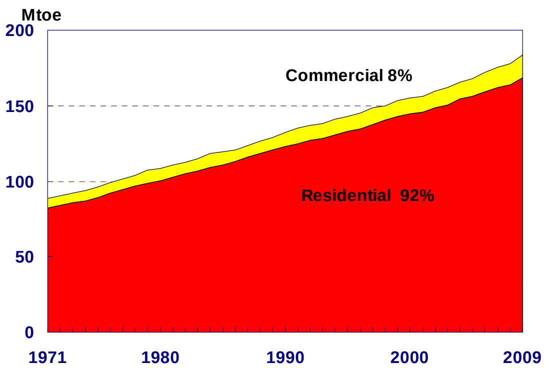
Road Energy Consumption per Vehicle among Major Countries
道路交通部門のエネルギー原単位 (エネルギー消費/自動車) の国際比較



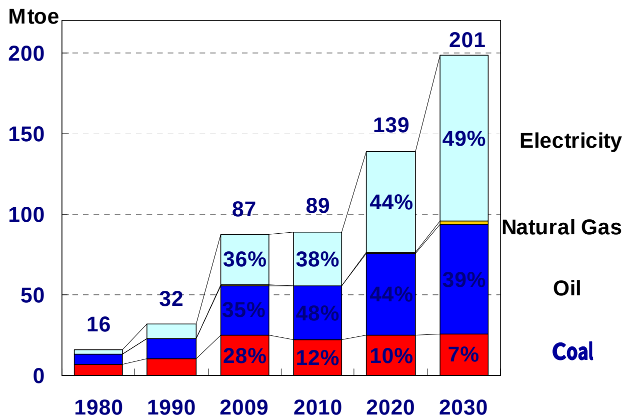
Source: International Energy Agency, Energy Balances of OECD and Non-OECD Countries
World Bank, World Development Indicators

Energy Consumption in Residential and Commercial Sector in India
インドにおける民生部門のエネルギー消費の特徴

Energy Demand in Residential and Commercial Sector



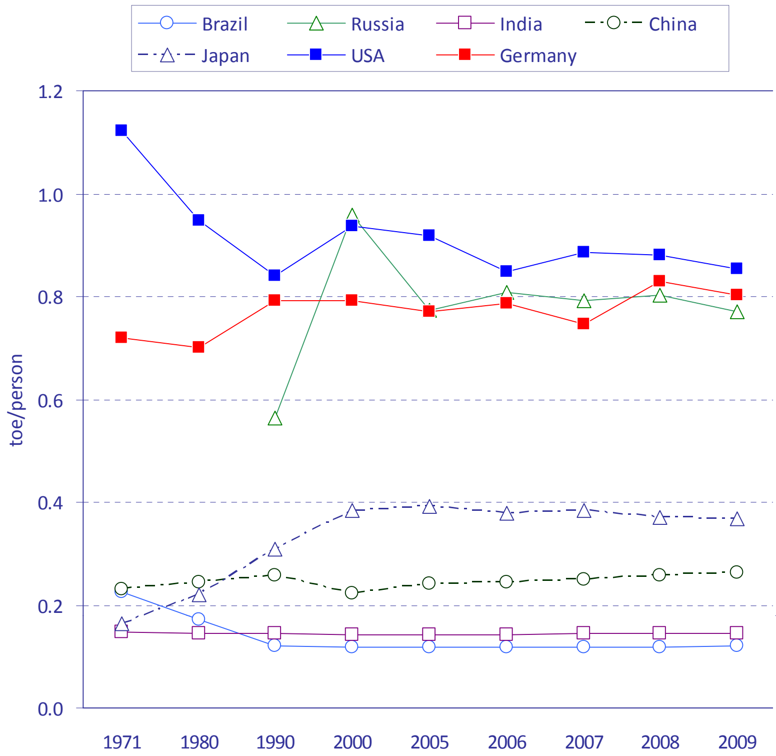
Res/Com Energy Demand Outlook by Energy

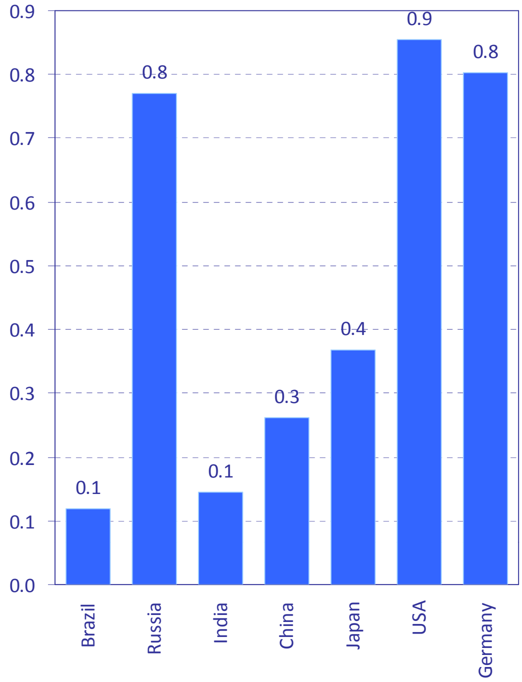


Source: IEA (2011) Energy Balance Table, Fourin (2011) World Vehicle Statistics
The energy demand from 2010-2035 is estimated by IEEJ.
(Note) Including bio-fuel and waste, which was about 130 million toe in 2009.

- The share of the residential and commercial sector energy demand is 41% of total final energy demand. Residential is the dominant energy consumer in the res/com sector.
- Electricity demand is expected to be the largest in the res/com sector in the future. Therefore, improving the energy efficiency for electricity will effectively reduce energy demand in the res/com sector.

Residential & Commercial Energy Consumption per Capita among Major Countries
民生部門のエネルギー原単位 (エネルギー消費/人口) の国際比較

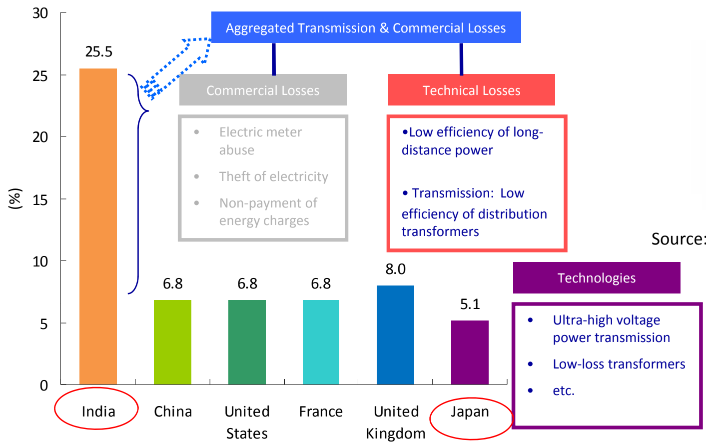




Source: International Energy Agency, Energy Balances of OECD and Non-OECD Countries
World Bank, World Development Indicators

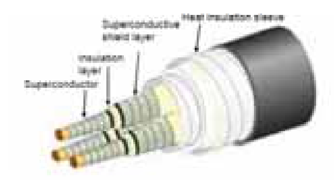
Technology for Reducing Power Transmission Loss
発電ロス改善技術

Electricity Losses



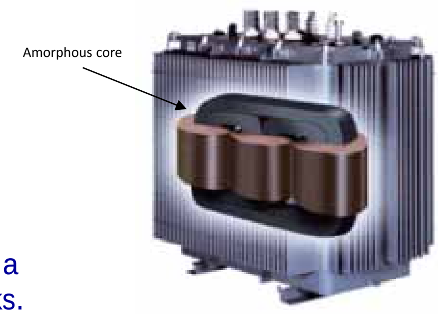
Source: Japan Electric Power Information Center (2011), CEA (2011) Monthly Review of Power Sector, China Electric Power Press (2011), China Electric Power Yearbook 2010

Superconducting Power Transmission



Source: METI Cool Earth-Innovative Energy Technology Plan

Amorphous Transformer



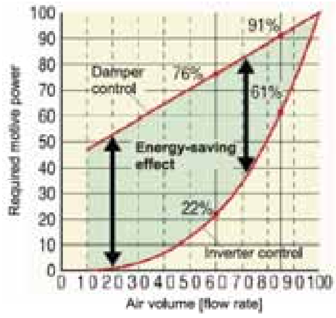
Source: Japanese Business Alliance for Smart Energy Worldwide (JASE-W)

- R&D on superconducting power transmission is underway aiming at lowering transmission loss. In the future, this is a valuable technology in constructing power supply networks.
- Amorphous transformer could reduce standby power to about 1/3. This technology is suitable for reducing distribution loss.

Various Japanese Technologies for Energy Efficiency
省エネルギーにおける日本の技術

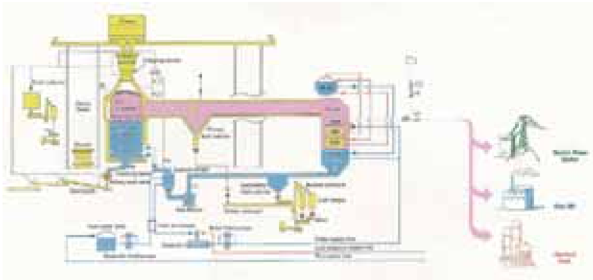
- Cross-cutting

Inverter system with electrical appliances



- Industry

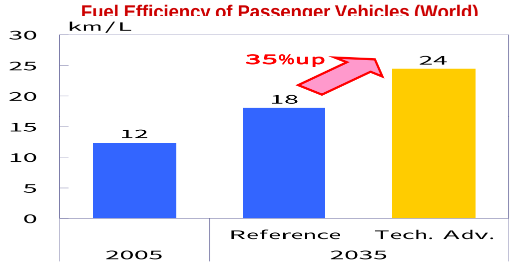
Coke Dry Quenching (CDQ) for iron and steel production process



When generating electric power by utilizing the steam produced by CDQ, one CDQ unit, which has a treating capacity of 100T/H, can generate about 18MW of electric power, thus effectively using energy that was dispersed into the atmosphere in the conventional wet quenching method.

- Transport

Next-generation automobile technologies



In 2035, the fuel efficiency of passenger vehicles in the Adv. Tech. Scenario will improve by 35% in comparison with the Reference Scenario.
(World Energy Outlook 2011, IEEJ)

- Residential/Commercial

Highly-efficient LED lamps

Source: Japanese Business Alliance for Smart Energy Worldwide (JASE-W)

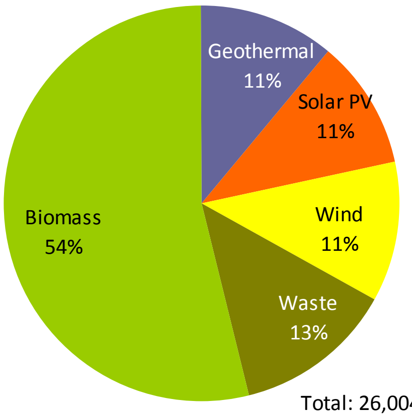
Areas for Cooperation
- New & Renewable Energy

協力可能な分野
- 新･再生可能エネルギー

Non-hydro Renewable Power
再生可能エネルギー (水力除く)

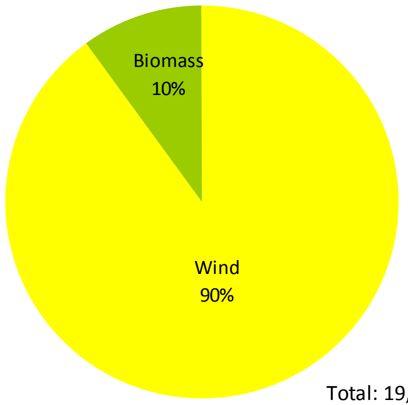
- In Japan, a major RE power source is biomass but geothermal, solar PV, wind and waste are also used.
- In India, most RE power is presently generated by wind.
  Recently, solar PVs are being installed.

Japan (2009)



Total: 26,004 GWh

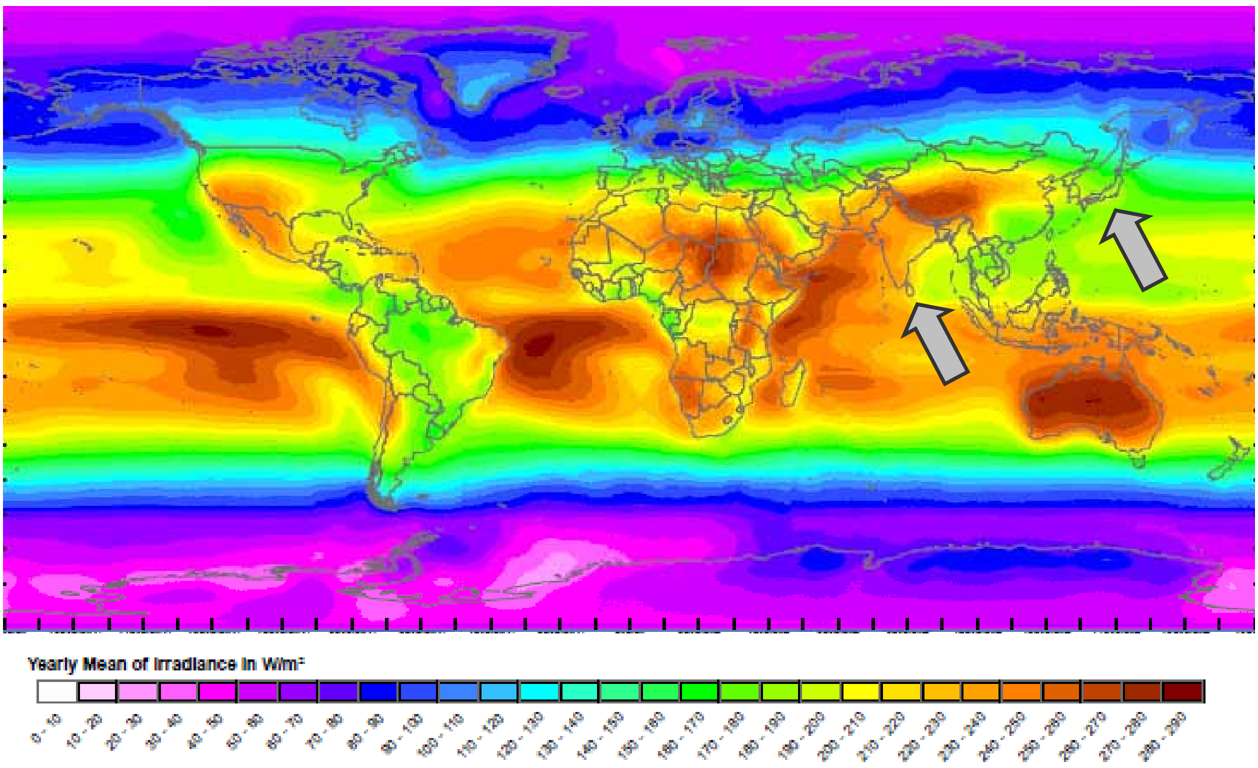
India (2009)



Total: 19,955 GWh

Source: IEA, 2011

Global Solar Radiation
世界の日照条件



Solar Mission
ソーラー・ミッション

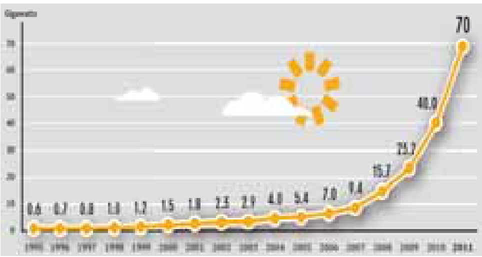
Jawaharlal Nehru National Solar Mission

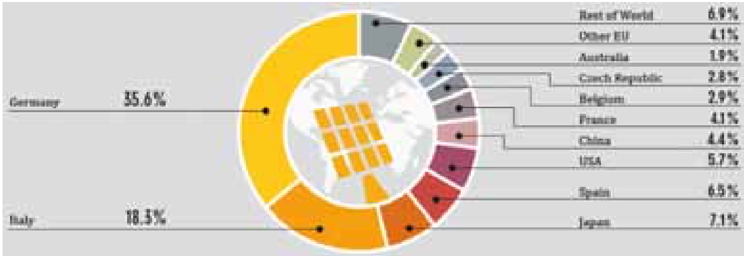
Aiming to achieve **22 GW**

20 GW on-grid and 2 GW off-grid solar power by 2022

Phase 1 (2010 - March 2013): 1,300 MW (0.7%)
Phase 2 (April 2013 - March 2017): 3,700 MW (2.0%)
Phase 3 (April 2017 - March 2022): 17,000 MW (9.2%)

"1/3 of world's total PV capacity in 2011" or
"Same capacity as Germany in 2011"



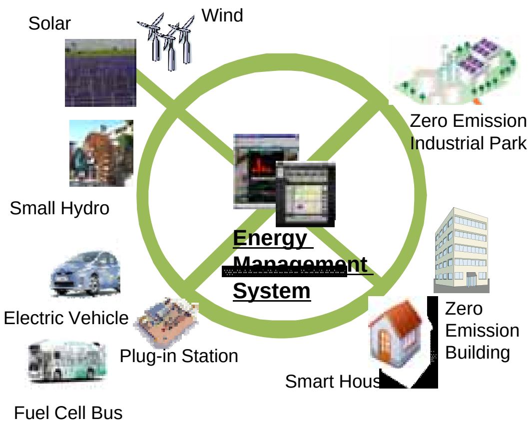


Source: Renewable 2012 Global Status Report, REN21

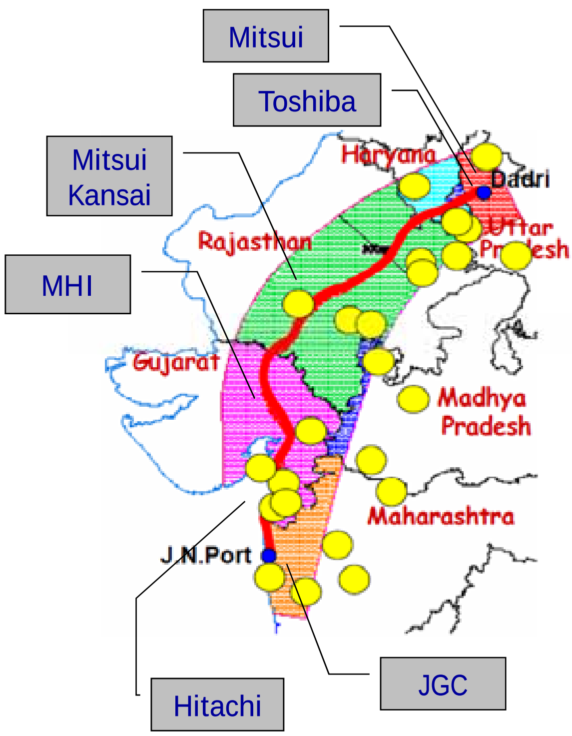
Smart Community
スマート・コミュニティ

- Several projects are advancing under the DMIC (Delhi-Mumbai investment corridor) framework.
- How to change a 'show case project' into a self-standing (profitable) business activity?
- How to disseminate to other regions?

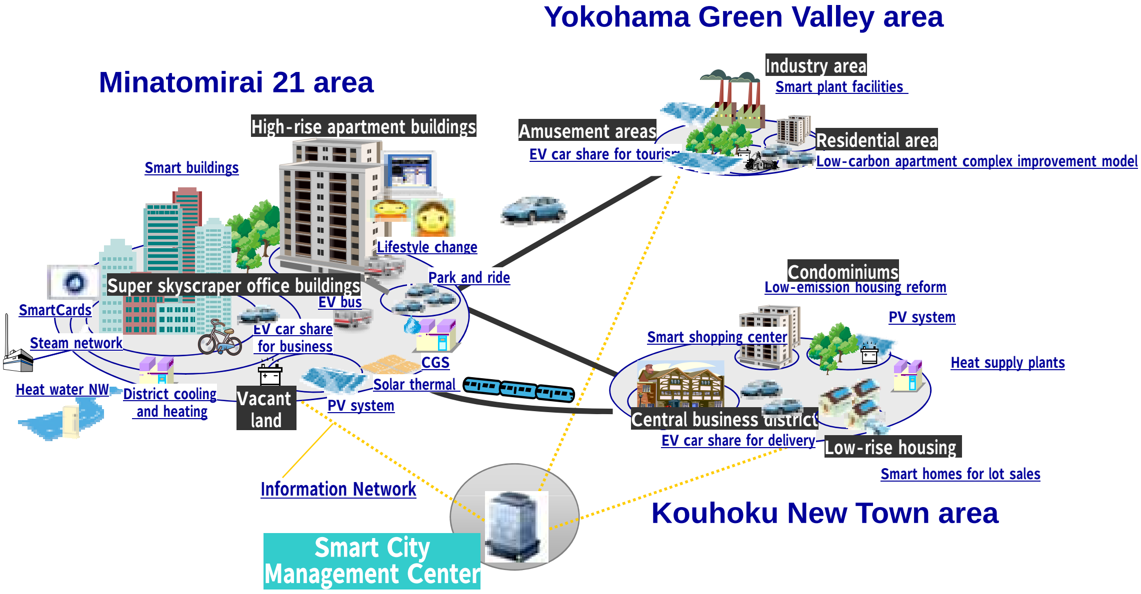
Image of Smart Community



Delhi-Mumbai Investment Corridor



Source: METI



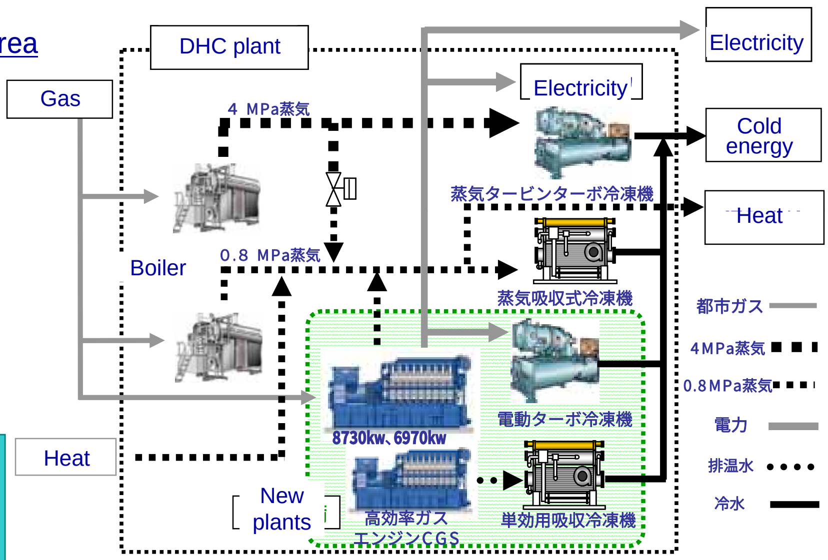
Project Members	City of Yokohama, Accenture, Tokyo Gas, Tokyo Electric Power Company, Toshiba, Nissan Motor, Panasonic, Meidensha, etc.
Project Areas	Minatomirai 21 Area, Kohoku New Town Area, Yokohama Green Valley Area, etc.
Area Statistics	Population 420,000, Approx. 60 km²

Source: Yokohama City

Significantly reducing CO2 by effective utilization of waste heat and electricity from CHP

Makuhari International Business Area

Heat supply area: 61.6 ha
Number of customers: 9 (660,000m²)
Systems:
chiller (28,000 RT)
boiler (136 t/h)



Energy reduction 24%

CO2 reduction 53%

Source: Tokyo Gas Co., Ltd.

Objectives

- Provide participants with a better understanding of the critical factors in the design of policies for promoting new and renewable energy (NRE).
- For all participants from various backgrounds (such as policy-makers, academic professors, engineers, etc.), increase their awareness of NRE utilization and knowledge of NRE technologies.
- Share Japan's experiences on NRE utilization and technology development with the participants by inviting them to visit factories and NRE facilities in Japan.
- Exchange information on successful examples of promoting NRE.

Past Seminars with India

#1 Jan. 9-13, 2007: 19 participants
#2 Jan. 21-25, 2008: 18 participants
#3 Jan. 25-29, 2010: 12 participants
#4 Sep. 27-Oct. 1, 2010: 9 participants
#5 Jan. 16-20, 2012: 13 participants

IEEJ's Cooperative Project with India: N&RE Seminar
IEEJ インド協力事業: 新・再生可能エネルギー・セミナー

5th seminar program

Presentation

Voltage and frequency compensation systems, grid stabilization tech., storage batteries, smart meters, other smart grid related tech.

Site Visit

Comprehensive R&D for PV, BEMS smart grid and smart house, a life-size experiment of a smart community, etc.

IEEJ's Cooperative Project with India: N&RE Seminar
IEEJ インド協力事業: 新･再生可能エネルギー･セミナー

5th seminar program

Discussion with Japanese Companies

Electric power companies, electric & renewable equipment manufacturers, trading companies, etc.

Meeting with METI

Policy measures implemented to promote its diffusion including the Feed-in Tariff system.
Share views on issues such as smart grid, smart community, and related topics

Areas for Cooperation
- Fossil Fuel Power Generation

協力可能な分野
- 火力発電

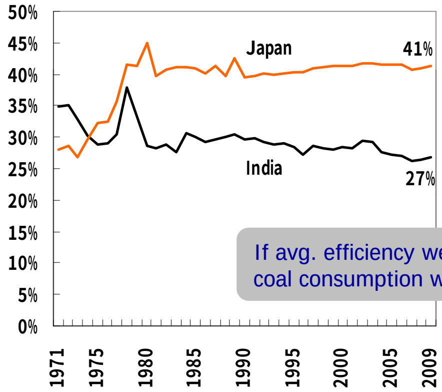
Clean Coal Technology
クリーン･コール･テクノロジー

- Thermal efficiency can be improved by introducing larger capacity, higher steam condition plants.
  - Over 600MW Super Critical, Ultra Super Critical
- How to burn high-ash coal more efficiently?
  - Gasification, IGCC technology
- How to maintain initial efficiency throughout the life of the plant?
  - Appropriate operation & maintenance techniques and rehabilitation technologies are required.

Challenges:

- Provide appropriate electricity price level to ensure economic rationality of highly efficient technology.
- Reduce cost of highly efficient technology.
- Customize technology to suit Indian coal.

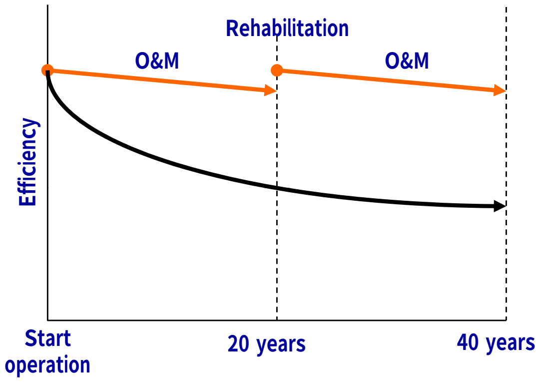
Efficiency of coal-fired power plant



Large potential to:
- ✓ reduce coal consumption
- ✓ conserve coal resources
- ✓ reduce coal imports
- ✓ reduce cost burden

If avg. efficiency were 41% in 2009 in India, coal consumption was **35% less** than actual.

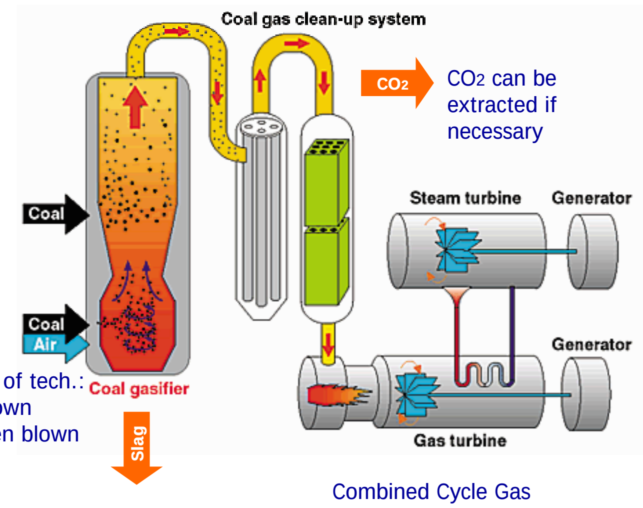
Effects of O&M and Rehabilitation



Source: IEA, 2011

Development of IGCC in Japan
日本のIGCC技術開発

IGCC technology



2 types of tech.:
- Air blown
- Oxygen blown

Ash is removed as slag during gasification process

Combined Cycle Gas Turbine (CCGT) technology provides higher efficiency than conventional boiler

Clean Coal Power R&D IGCC
- Air blown
- 250 MW
- Sept. 2008: 2,000 hours of continuous operation achieved

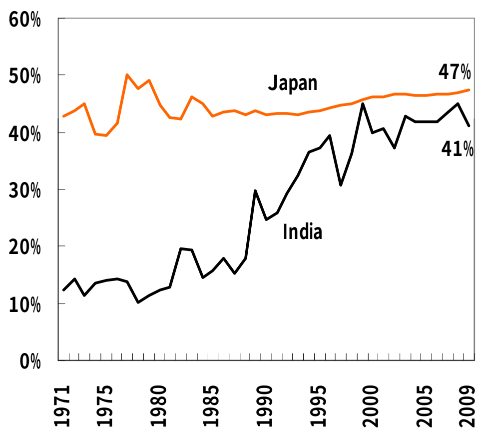
Osaki Coolgen IGCC
- Oxygen blown
- 167 MW
- CCS application
- Mar. 2013: construction work starts

Source: Center for Environment, Commerce & Energy

Gas Turbine Technology
ガスタービン技術

- Thermal efficiency of gas-fired power plant has rapidly improved, yet further improvements can be attained.
- Thermal efficiency of more than 50% (HHV) is already commercially available.
  - State-of-the-art 1600ºC class technology can deliver highest efficiency of around 54% (HHV).
  - 1,700ºC class gas turbine is at R&D stage to attain efficiency exceeding 56% (HHV).

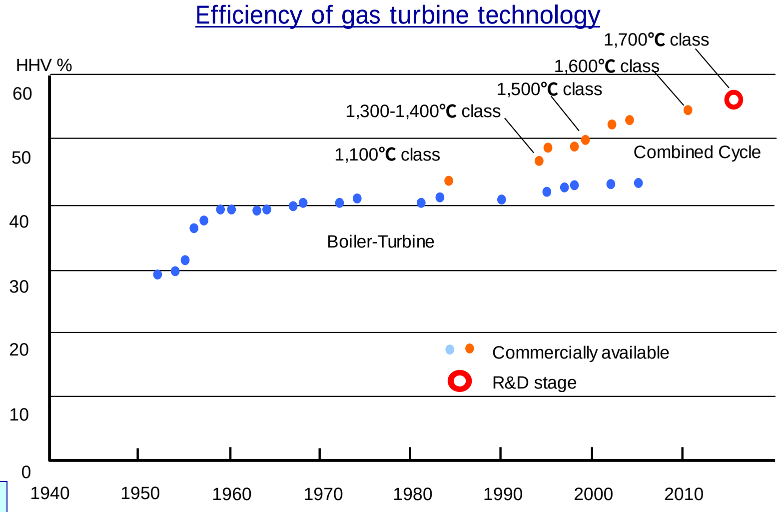
Efficiency of gas-fired power plant



If efficiency was 47% in India in 2009:	
LNG import amount	-2.1 million tons (-23%)
LNG import cost	USD -540 million

Source: IEA, 2011

Efficiency of gas turbine technology



Source: The Institute of Applied Energy, Mitsubishi Heavy Industries

Areas for Cooperation
- Nuclear Energy

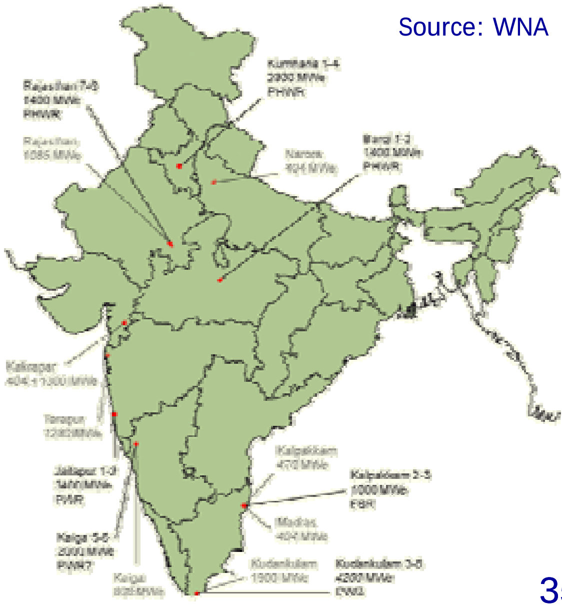
協力可能な分野
- 原子力エネルギー

Nuclear Power in India
インドの原子力発電

- Nuclear power – clean, large-scale and sustainable - is a crucial power source in India to match the increasing electricity demand.
- Estimated 14.6 GW on line by 2020 and 27.5 GW by 2024 (4.189GW @ end of 2010)
- Nuclear Suppliers' Group (NSG) decided in 2008 to exempt India from the rule banning the sale of enrichment and reprocessing technologies to countries that have not signed the Nuclear Non-proliferation Treaty.
- Since then, foreign technologies on nuclear plants and fuels have been expected to considerably boost India's nuclear development plans.

Nuclear power plants in operation, under construction and planning

Source: WNA



Outlook for nuclear power generation capacity in India

Unit: GW

	Reference Scenario	Advanced Technology Scenario
2010	4	4
2020	20	23
2030	33	63
2035	42	85

Source: IEEJ 2011

Way to India-Japan Nuclear Agreement
日印原子力協定への道のり

- India and Japan launched a dialogue on a bilateral nuclear agreement in 2010 after receiving clearance from the Nuclear Suppliers Group – not yet agreed.

--- Dialogue suspended after Fukushima Accident on March 11, 2011 ---

- On April 30, 2012, during the sixth Foreign Minister-level strategic dialogue in New Delhi, both sides agreed to reopen the dialogue on the nuclear agreement. However:
  - India has been protesting that its clean non-proliferation record is impeccable and sufficient for signing the pact, while...
  - Japan's Minister of Foreign Affairs, Koichiro Gemba, asked India to sign the Nuclear Non-Proliferation Treaty (NPT), as Japanese officials have always done.

"India is actually situated at an important place on the sea lanes of the communication which links Japan with the Middle East. We cannot overlook the geo-political significance of India."

Source: Ministry of Foreign Affairs, Japan
The Hindu, May 1, 2012

Recommended actions toward "Fukushima never again" by reasonable approaches such as:

1. Establishment of Severe Accident Management Procedures
   - Hardware preparation to protect safety systems, structures and components from tsunami
   - Preparation for variety of power sources, such as air-cooled gas turbine system
   - Additional ultimate heat sink by variety of cooling systems in addition to seawater cooling system
   - Assume that severe accidents will surely occur and:
     - ✓ Adequate consideration for Severe Accident Management (AM)
     - ✓ Hardware preparation for AM such as multiple wiring for power source
     - ✓ Training and education of AM

2. Operation of regulatory framework and organization
   - Drastic revision of the safety regulatory authority to enhance independency, transparency and rationality
   - Introduction of risk concept into the entire safety regulation

3. Cross-border cooperation
   - Internationally standardized safety criteria
   - Sharing best practices through cross-border cooperation in Asia and in the world

Next Step

次のステップ

How to Reinforce Our Cooperation?
どのように協力を強化するか？

- Provide appropriate incentives, while diminishing dis-incentives for investment.
  - Review energy price policy.
  - Facilitate administrative procedure (federal vs. state, sectionalism, land acquisition).
- Customize existing technologies to suit India.
  - Develop low-cost technology.
  - Develop 'India model' which sufficiently reflects the requirements of Indian customers.
- Secure finance for the technology.
  - Utilize public finance:
    - ✓ for large enterprises — JBIC, ADB, etc.
    - ✓ for micro, small and medium size enterprises — SIDBI, etc.
  - Consider the use of bilateral CDM.
- Capacity building of regulators and engineers.
- Enhance communication for mutual understanding.
  - Matching 'needs in India' and 'seeds in Japan' through closer communication both in the public and private sector.

Thank you for your attention.

ご清聴ありがとうございます。