BUILDING ENERGY EFFICIENCY IN JAPAN: A BENCHMARK FOR MALAYSIA IN THE DEVELOPMENT OF RENEWABLE ENERGY TECHNOLOGY

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ABSTRACT: Governments throughout the world, including Malaysia, began to look at diverse options in energy conservation and new energy resources, and energy efficiency technology. Malaysia ratifying the Kyoto Protocol in September 2003 has opened the way for Malaysian renewable energy project developers to seek financing under the Clean Development Mechanism. Another opportunity is emerging because Malaysia as one of the fastest growing building industries in the world, from which a corresponding increase in energy demand can be expected every years. Japan as a highly industrialized nation has faced serious pollution and two oil crises, and was obliged to bear environmental regulations and energy conservation measures over the short term. However, as result of the concerted efforts of the public and private sectors in response to the strict environmental and energy restrictions, Japan's energy efficiency has improved over the past 30 years and oil consumption has decreased even though the GDP has doubled. The objective of this paper is to discuss about existing energy efficiency technology in Japan and challenges, lessons, and current development of participation from public and private sectors toward clean energy policy by Japanese government, which can even be follow by the developing countries with some modifications. This study can contribute to our understanding on the applicability of the energy efficiency method in Japan, one of the countries that succeeded in adopting renewable energy in its national energy scenario, to become a benchmark to a country such as Malaysia.

Keywords: Energy efficiency, Renewable energy, Building, Energy policy

1. INTRODUCTION

World may have recollections of the volatility of energy prices these days, which affected all energy users, and most of all the electricity generation sectors. It also led to concerted efforts to improve energy use efficiency and to look for alternative energy sources, which can reduce greenhouse gas emission that contribute to global warming.

Governments throughout the world began to look at diverse options in energy conservation and new energy sources. One of the nations that achieved considerable success in these efforts was Japan.

Japan has been one of the countries that succeeded in adopting energy efficiency and renewable energy in its national energy scenario. Private sectors with the support from government agencies have been involved in supporting various

projects affecting energy efficiency issues. This has extended to develop an effective policy and strategy initiatives on energy efficiency and renewable energy.

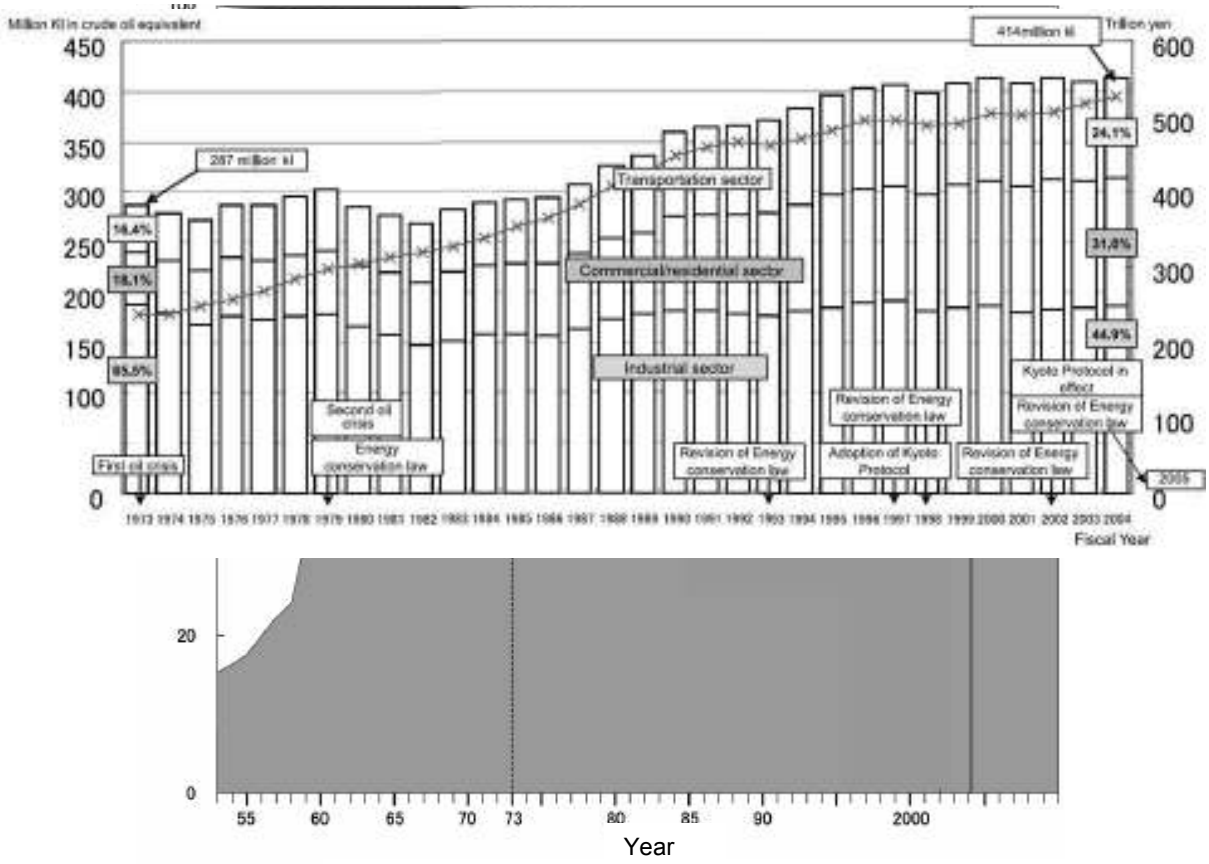
In the future, increased efficiency of energy systems and reduced end-use energy demand will be important in attaining the 6% curtailment of greenhouse gases targeted by the Kyoto Protocol. Reduced energy consumption in the residential sector is particularly important, because energy demand in this sector is notably increasing.

2. CURRENT STATUS OF JAPAN ENERGY SECTOR

As shown in the Figure 1, Japan's oil share among the primary energy supply total has been significantly lowered since the highest level (approximately 77 %) marked in 1973 to the current lowest level (approximately 49 %). As shown in Figure 2, Japan's energy consumption has been steadily expanded especially in commercial/residential and transportation sectors since the 1970's oil crises period, largely due to convenience-thriving and energy-needing lifestyles.

Figure 1. Transition of distribution of Japan`s primary energy supply (1955-2010)

Figure 2: Japan`s Energy Consumption and GDP



(Source: Japan Energy Conservation Handbook (2007)

3. RENEWABLE ENERGY TECHOLOGY: PHOTOVOLTAIC

New energy has various advantages including smaller load on the environment. In order to promote its introduction, both economical and technical subjects need to be addressed.

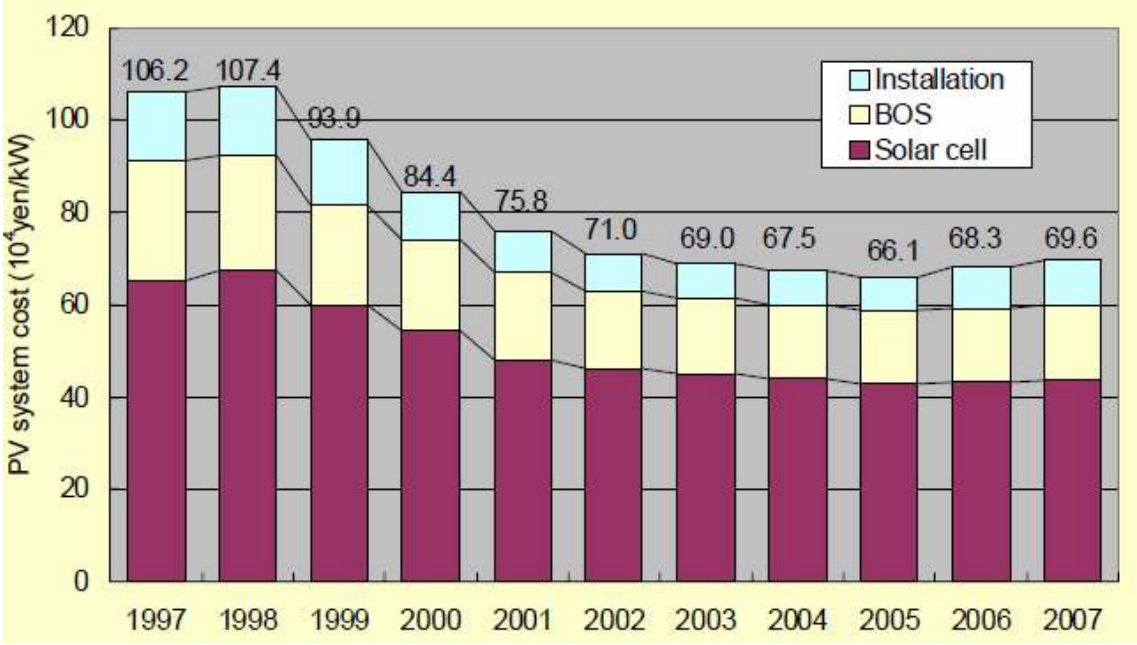
From an economical standpoint, new energy from photovoltaic is higher in cost compared to existing power sources, thereby causing difficulty in expanding its dissemination. It is necessary to reduce the cost of new energy to an affordable level for residential use, in order to achieve the targets for FY2010.

Nevertheless, active technological development and implementation of introduction-promoting measures to date have been reducing equipment/power generation costs of new energy. The equipment cost for residential photovoltaic power generation has been reduced by about 75% in the last decade (Figure 3).

Status of Japan`s Photovoltaic Technology

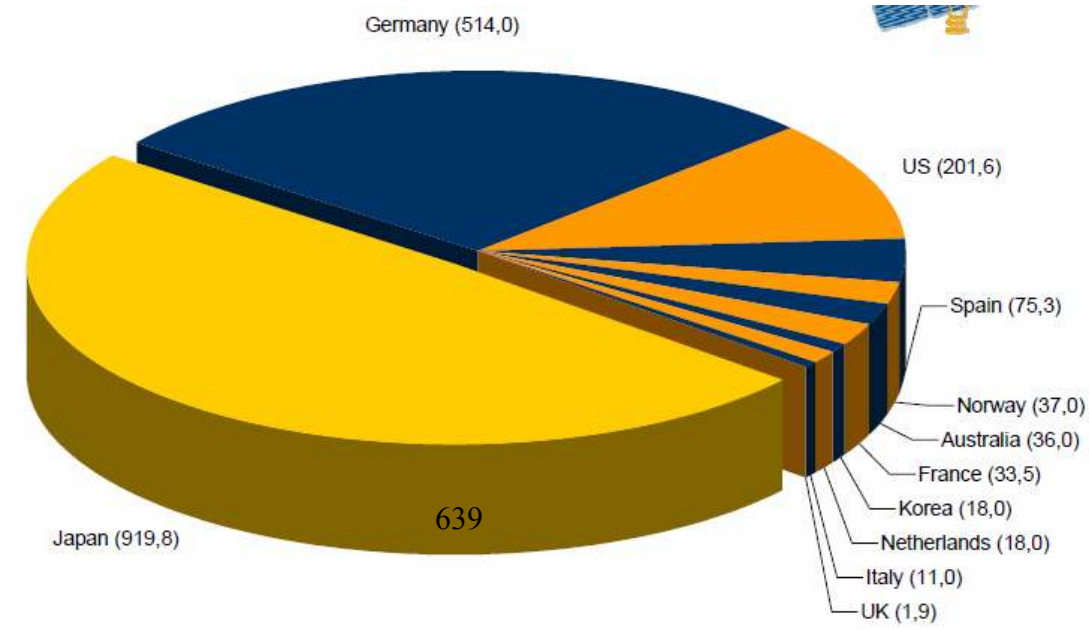
Photovoltaic power generation is a new source of energy not only being highly anticipated but also regarded as the most advanced in Japan. The production of solar cells in Japan is the largest in the world: the domestic shipment of solar cells is 287.1 MW, and the production capacity is 919 MW occupying approximately 49% of world solar cell production in 2006.(Figure 4).

Figure 3. Average PV system price in Japan (1997-2007)



(Source: NEF Homepage at http://www.solar.nef.or.jp/system/html/taiyou_sys080508.pdf, in Japanese)

Figure 4. PV cell production (MW) by country in 2006



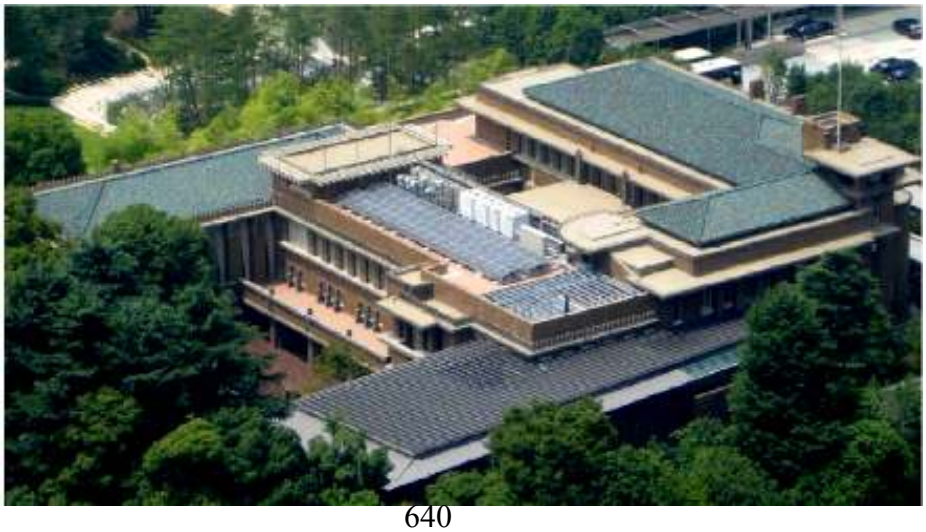
(Source : IEA Photovoltaic Power Systems Website, http://www.iea-pvps.org)

Installed PV power

While grid-connected PV systems continued to dominate the PV market in Japan since a decade, total annual installed capacity of the PV system remained roughly flat in 2006, in reversal to the steady increase observed in the past. The total annual installed capacity in 2006 was 287 100 kW. The growth rate slightly decreased by a 1.4 % from 2005 (291 114 kW). The breakdown of installed PV systems in 2006 is 2 mW for off-grid application, 6.3 mW for on-grid application, mainly residential PV systems. Primary factors of the flat growth in 2006 were termination of the budget for “Residential PV System Dissemination Program” and shortage of silicon feedstock for solar cell. [JPEA].

Culture Influence

Countering the effects of global warming is a mainstay of Japanese government policy. Economics for PV plays a secondary role as compared to national goals of meeting the Kyoto Protocol. The Prime Minister’s residence, as well as the Japanese Parliament and many key government buildings, all have 30-50 kW PV arrays mounted on their rooftops. There is about 500 kWp installed on key government buildings in downtown Tokyo. There exists a total commitment to making Japan a solar nation, from the government officials and planners, industry leaders, and the public. Japan has an integrated solar development approach. Also, there is a sense of need for energy independence. Since grid electric costs are the highest in the world in Japan, there is also an economic return for residential PV.



(Source : NEDO Official Homepage at www.nedo.go.jp)

Customer, cost and prices

Most of the Japanese PV systems are installed on single family residences to average homeowners. These are typically a middle-aged Japanese family with a couple of children. The typical household income in Japan is 6.02 million ¥ per year [MHLW]. Most of the Japanese PV systems (about 3/4) are installed as retrofits on existing homes. Typical household electricity consumption in Japan is 290.5 kWh/month [JAERO]. In Japan, a PV system annually generates on average about 1,050 kWh/kWp [Kaizuma].

Figure 5. Installed grid-tied PV array on Japanese Prime Minister`s Official Residence showing to the country the government`s deep commitment to PV

While the majority of PV systems are installed as retrofits on existing homes, there are also some prefabricated homes that offer PV as part of a package deal. There is no standardized specification, and manufacturers are free to partner with PV companies who offer them the best deals. More and more of the prefabricated homes will offer a PV option in the future.

The prices of PV modules and PV systems have been steadily decreasing owing to the Government's support measures on research and development (R&D) and dissemination measures for PV systems and enhancement of production capacity by PV manufacturers for past years. However, the average price of PV modules for residential PV system in 2006 increased by 1,1% from 428 JPY/W in 2005 to 433 JPY/W due to the price hike of silicon feedstock and other raw materials for solar cell, parts and components. [IEA-PVPS]

Government Support

The Japanese government supports PV development throughout, from the Prime Minister and Parliament down to the different implementing agencies. The Ministry of Economy, Trade and Industry (METI) began a subsidy program for residential PV systems in 1994. At first, the subsidy covered 50 percent of the cost. The subsidy was for PV modules, BOS, and installation. The program was open to participants from residential homes, housing complexes, and collective applications. In 1997, METI grew the program to encourage mass production of PV systems. After achieving their price goals, the Japanese government rolled back the subsidy

program in 2003. [Sakata].

Budgets and subsidies are shrinking for residential PV installations as the government has now created a largely self-sustaining market. METI's 2005 new energy promotion budget includes funding for PV, mostly at the regional level, with measures including community support, creation of small and medium-sized businesses, and regional activities for prevention of global warming. However, this budget, which had grown from under ¥30 million in 2001 to almost ¥70 million in 2004, has also fallen by over 30 percent in 2005. The Japanese government is now shifting focus and subsidies to commercial and utility scale systems. It is anticipated that government budgets and subsidies will be growing for this sector [RTS] .

There are also municipality and city support programs. For instance, in Ohta city (NEDO (New Energy and Industrial Technology Development Organization) clustered PV program, will be discuss later in this paper), over 150 homes have received a subsidy from throughout the city to install PV systems. They receive a ¥$100,000/kW coupon to install a PV system, with a maximum allowance of ¥$400,000 [Inokoshi]

The largest portion of government funding goes to PV systems deployment and field testing. While support for residential PV installations is dropping, support is growing for PV installations at public and industrial facilities [Sakata]. This trend is expected to continue.

4. FINANCING

METI's original subsidy program for residential in 1994 covered 50 percent of PV system costs. The subsidy was for PV modules, BOS, and installation. The program

Unit: Billion Yen

Budget Item / Year	2001	2002	2003	2004	2005
Residential PV System Dissemination Program	23.51	22.20	10.50	5.25	2.60
Field Test Project on ne PV Technology	-	-	3.50	5.03	9.23
PV Field Test Program for Industrial Use	1.99	4.50	0.26	0.14	0.11
PV Field Test Program for Public Facilities	0.07	-	-	-	-

Table 1: PV related program subsidies by NEDO

(Source : Robert Foster, October, 2005)

was open to participants from residential homes, housing complexes, and collective applications. In 1997, METI grew the program to encourage mass production of PV systems. After achieving their price goals, the Japanese government greatly reduced the subsidy program in 2003.

The Government Budget for 2007 was passed in December 2006 with a 4% increase compared to 2006. The METI Budget for photovoltaic increased by 31% 2006 Y18.758 billion to Y24.60 billion, and the Ministry of Environment (MOE) add a budget of Y4.8 billion for the “Solar Promotion Programme” and Y3.302 billion for the “Project for developing technology to prevent global warming” [Ikki 2007].

There are no special provisions in the financial sector for PV systems. The typical finance interest rate in Japan varies from about 2.5 to 3.0 percent. There are no special energy finance for PV installations. On new homes, the PV system is just part of the overall home price, and also can be incorporated as part of the overall home finance.

5. PV SYSTEM CHARACTERISTIC

Overall, Japanese PV systems are professionally installed and exhibit excellent workmanship with dedication to detail. The image of PV in Japan is a positive one and that the technology works. The industry is not highly regulated and the Japanese companies are entrusted to design and install PV systems. There are some general guidelines for grid-tied installations as recommended by JET; while these are not law, they are generally followed by the industry.

PV companies and electrical contractors design PV systems in Japan. Utilities sometimes may get involved in the design a few of a large scale system, but typically not for the smaller residential systems. Residential PV systems generally range from about 3-4 kWp and average about 3.6 kWp [Kaizuma].

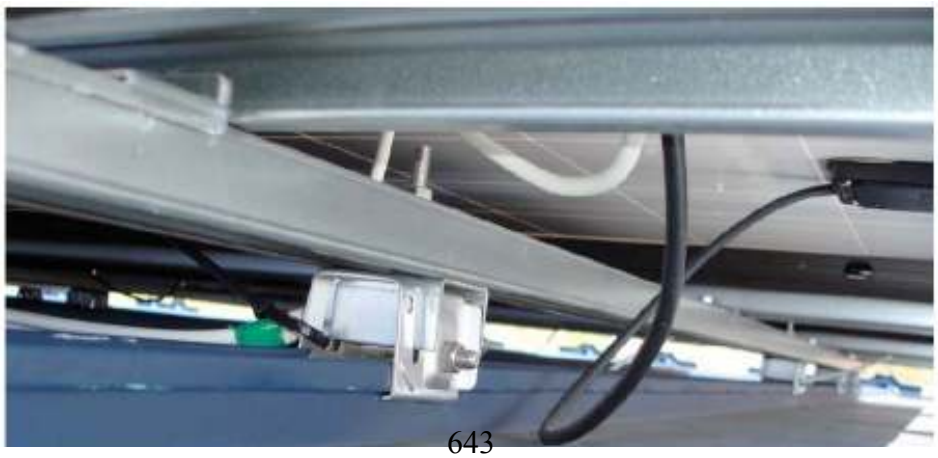


Figure 6. Underside of typical Japanese PV array clamp mounting on metal corrugated roof without roof penetration.

(Source : Robert Foster, October, 2005)

Figure 7. Japanese homes with PV arrays facing east, south and west in Ota City

(Source : NEDO Official Homepage at www.nedo.go.jp)

i. Design

PV arrays are often mounted directly onto reinforced corrugated metal roofs without any roof penetrations. Most roofs in Japan are metal or a traditional style ceramic for high-end roofs. There is a great deal of concern in Japan that PV systems withstand typhoon force winds which are common during the late summer months. Often commercial PV installations in Japan are not optimally tilted for solar energy production but are tilted in favor of better wind survivability. System profiles are installed low to the roof to reduce wind loading. Local codes typically call for PV systems to withstand winds of 36 m/sec in Tokyo, 46 m/sec in Okinawa, and even 60 m/sec in some places such a Kanazawa City [Nitta].

The unique aspect for some Japanese PV installations is that many systems are installed with PV arrays facing south, east, and west on the same roof. This is due to the limited roof space of smaller Japanese homes. The west and eat arrays typically produce about 80 percent of the energy as a south facing array.

ii. PV Modules

Crystalline PV modules are by far the most popular in Japan, representing over 80 percent of PV modules produced and installed in the country. Modules normally

carry a guarantee on performance from 10 to 25 years, depending on the manufacturer. Thin film modules are slowly gaining in popularity, but still greatly lag sales of crystalline modules. Cadmium telluride (CdTe) modules will not be found in Japan due to the society's disdain for using toxic materials. A lot of thought has been made in Japan on how to recycle a PV module, thus toxic materials are quickly eliminated from consideration of use in PV modules.[RTS Corp.]

iii. Labor

PV installations in Japan exhibit excellent workmanship and are done by certified electricians. Industry is responsible for training their own installers. Some module manufacturers, like Kyocera, also install PV systems, while others rely on electrical contractors. On new homes, often the same electricians that install the home's wiring system also install the PV system.

Overall installation costs for PV systems in Japan are generally inexpensive as systems have simpler BOS requirements and more streamlined installation procedures (e.g., no roof penetrations). Systems can be installed efficiently, in only a couple of days for 3-4 kWp. Electrical crews generally consist of 2-3 electricians. PV installations are normally completed within 2-3 days.

iv. Manufacture

Japan leads the world in PV manufacturing and innovation. Residential system needs have helped promote higher cell efficiencies and smaller sizes. Larger

Figure 8. Building integerated see-through PV modules by Sanyo at Ohta City Hall building.

(Source : Robert Foster, October, 2005)

commercial systems have led to innovation in PV for building integration that requires flexible, lightweight, light-transmitting or bifacial products for facades and large area installations. A number of office buildings now have see-through PV on their south facing windows. There are some prefab homes using PV, but only 25 percent of installed residential systems are on new construction. There is continuing research and development at expanding the use of PV on pre-fab construction. The factory will offer PV systems packages for delivery. Most assembly is still done in the field.

Japan is also shifting home construction towards a “mass customization” approach. A future homeowner is given a wide menu of standardized options to customize their prefab home design. Customized modifications can be significant on homes and gets the homeowner involved with their home design. The manufacturers do offer standardized systems, but these vary from manufacturer to manufacturer.

Systems manufacturers do buy components from different companies. Some of the PV manufacturers also make their own inverters (e.g., Sanyo, Kyocera) and also install their own systems at times.

v. Research and Development

In the end of FY 2005 (March, 2006), 3 R&D projects; “Development of Advanced Solar Cells and Modules”, “Development of PV System Technology for Mass Deployment” and “Investigation for Innovative Photovoltaic Power Generation Technology”, conducted under “5-Year Plan for Photovoltaic Power Generation Technology Research and Development (FY 2001 – FY 2005)” by New Energy and Industrial Technology Development Organization (NEDO) were completed. In FY2006, new “4-Year Plan for Photovoltaic Power Generation Technology Research and Development (FY 2006 - FY 2009)” was launched, based on a roadmap for technological development of the PV system, “PV Roadmap toward 2030 (PV2030)”. Under the 4-Year Plan, 2 new projects, “R&D for Next Generation PV systems” and “PV System Technology for Mass Deployment, Phase II” were started as successive projects. As for new demonstrative research projects a couple of new 5-year projects, “Verification of Grid Stabilization with Large-Scale PV Power Generation System” and “Development of an Electric Energy Storage System for Grid-connection with New Energy Resources”, started in 2006. “Demonstrative

Project on Grid-Interconnection of Clustered Photovoltaic Power Generation Systems" and "Demonstrative Project of Regional Power Grids with Various New Energies" were also continued until now.

New Energy and Industrial Technology Development Organization (NEDO)

NEDO is Japan's largest public R&D management organization for promoting the development of advanced industrial, environmental, new energy and energy conservation technologies. They are under the auspices of METI (Ministry of Economy, Trade and Industry). NEDO was established by the Japanese government in 1980 to develop new oil-alternative energy technologies. Eight years later, in 1988, NEDO's activities were expanded to include industrial technology research and development, and in 1990, environmental technology research and development. Activities to promote new energy and energy conservation technology were subsequently added in 1993. Following its reorganization as an incorporated administrative agency in October 2003, NEDO is now also responsible for R&D

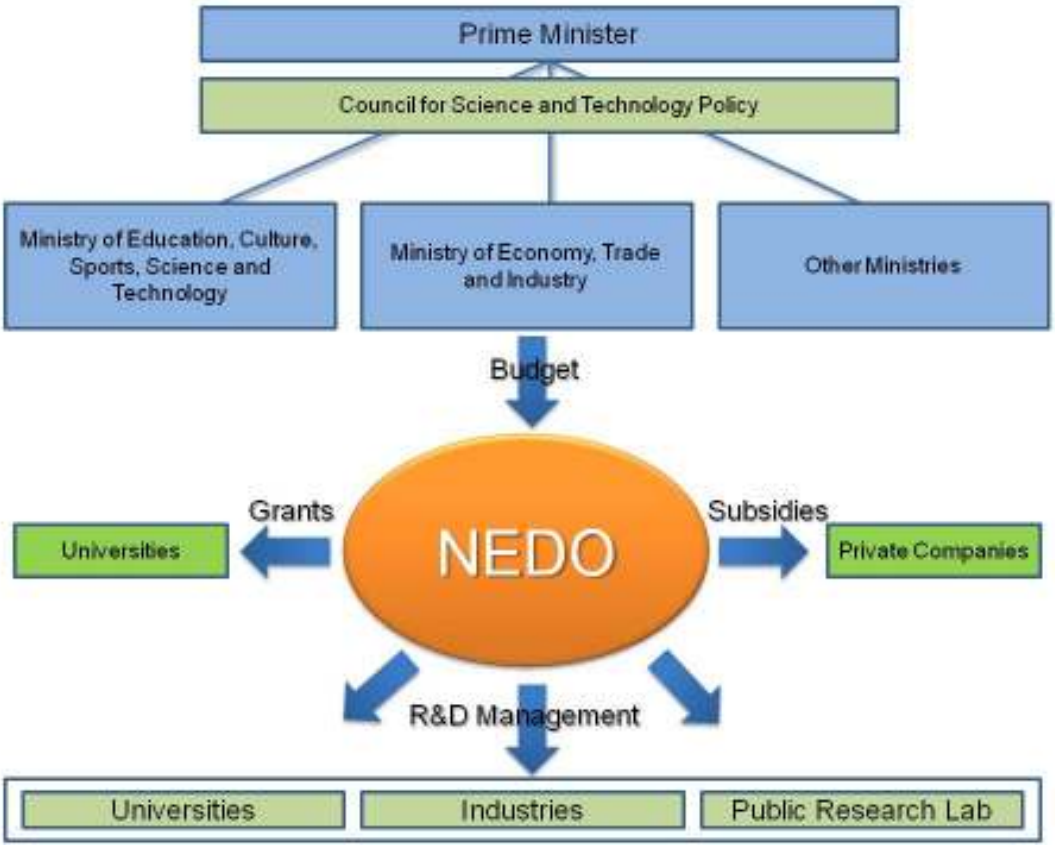


Figure 9. NEDO`s R&D Promotion Scheme

(Source : Satoshi Morozumi, et al.,(2007)

project planning and formation, project management and post-project technology evaluation functions.

In 2005, Japanese government subsidy support for PV installations shifted appreciably from residential to public sector and industrial systems. PV budgets have increased for development of new technology for PV power generation, as well as international co-operation and demonstration projects for grid-connected PV systems, especially for Asian developing countries. The budget for field test projects for advanced PV power generation technology is nearly half of the 2005 budget request. Japanese government assistance for PV development is shifting from R&D to field testing [Sakata].

NEDO will focus on deployment through 2010, with R&D focus on a-Si and CIS. No research is conducted in Japan on CdTe modules due to sensitive national concerns related to cadmium contamination (cadmium waste problems in Japan's history caused many deaths). Inverters in Japan are considered to be a mature technology. NEDO is not focusing any research funding on inverters [Sakata].

NEDO Project: Demonstrative Project on Grid-Interconnection of Clustered Photovoltaic Power Generation Systems

Jvosai Town PV Demonstration Area

Ohta-city is an industrial city in the Kanto area with approximately 220 thousand populations. Many factories are located in the area including Fuji heavy industry, which is a major automobile company in Japan. Jyosai town, the demonstration site of the PV project, is a new residential area in the central part of Ohta-city.

In 2002, NEDO initiated a new R&D program for PV grid interconnection. The objective of this program is to demonstrate that a power system of several hundred residences, where each residence has a PV system, can be controlled by the technologies developed in this program without any technical problems. Stakeholders from various fields joined this research project. The leader of the project was Kandenko company ltd, an electrical engineering and construction company. Meidensha company (Electronic manufacturer), Electric Power Engineering Systems company ltd (Power consultant), Shin-Kobe Electric Machinery company ltd (Battery manufacturer), Matsushita Ecology Systems Company Ltd. (Electronic manufacturer), Tokyo University of Agriculture and

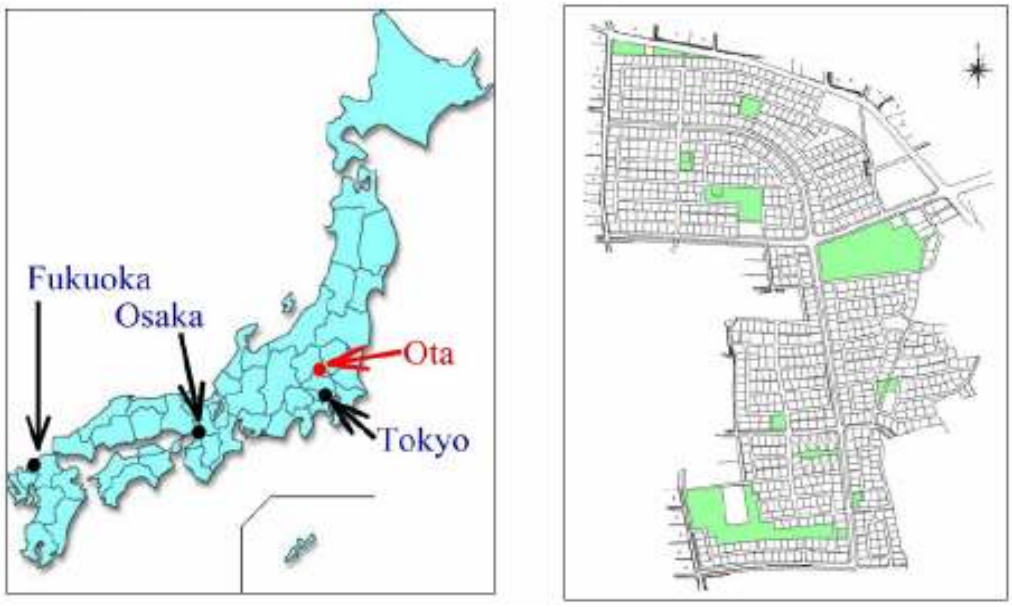


Figure 10. Location of Ohta City and site map of the demonstration area (Jyosai

(Source : NEDO Official Homepage at www.nedo.go.jp)

Technology (Academic), and Ota-city (Local government) were the other members who joined this project from the beginning. Omron Company (Electronic manufacturer), Nihon University (Academic), and JET (Official testing organization of electronic devices) joined afterwards. The demonstration site was selected as having the following two factors:

- Adequate possibilities of certain levels of voltage rise in which output control function of power conditioner will operate.
- Reasonable schedules for the construction and installation of the test devices are possible.

Description of the PV program

All the PV systems were installed on the roofs of the residential houses. The number of houses equipped with PV is 553. Most of the houses were newly built houses but there are also a few cases where PV systems were installed on existing houses. The capacity of the PV systems is 2.16 MWp in total. The first PV system in the project started operation in December 2003, and the installation of the PV systems had completed in May 2006. The development project of the demonstration-site, Jyosai town, was originally planned as a normal housing area development. In order to shift the concept of the project to the solar development

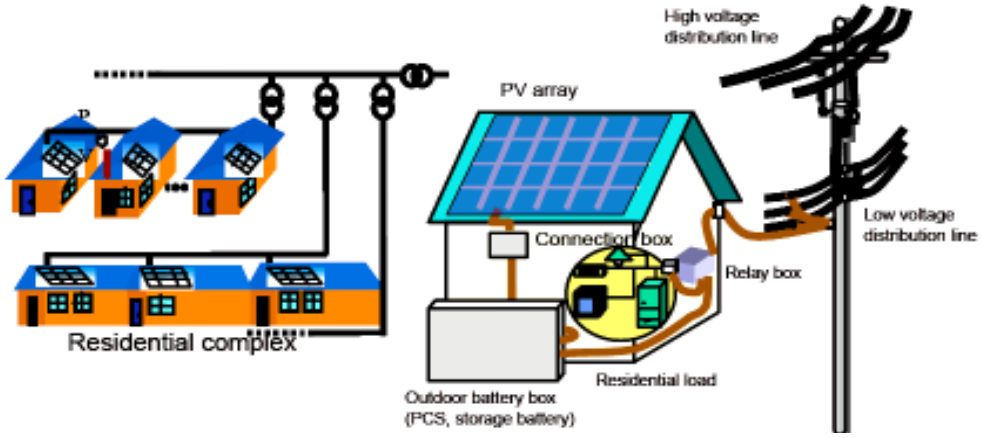


Figure 11. System Configuration of NEDO`s Grid-Interconnection of PV Generation System

(Source : NEDO Official Homepage at www.nedo.go.jp)

and align with the needs for the research on PV grid connection, the local government was also included in the project team. In addition, the concept of this project had been explained to the potential owners of the houses. The development plan was modified so that it matched with the research project. Since this project is aimed at the development of new PV grid interconnection technology, NEDO paid all the costs related to the PV installation.

Summary of problems, barriers, solutions and recommendations

Negotiation with utility company

In order to implement this research, a number of PV systems needed to be connected to the normal grid (without special protective devices); therefore, various questions were raised by the utility company from the security perspective. Examples of the questions are:

• Is the system designed to regulate the output when excessive voltage rises occur by the electricity reverse flow, so that the voltage can be controlled within a certain range?

• Is the system designed to disconnect from the grid within a given length of time if an accident happens on the distribution line?

• Can the system be disconnected promptly along with utility's instruction in the case of intentional blackout for distribution line maintenance?

• How will the system respond if an accident happens on the system side?

In order to assure the security of the system, a site office was set up and

monitoring staff were stationed at the office on a full-time basis. In addition, an integrated control system was developed so that the staff could monitor and control the system.

Cooperation with the house owners

As this project is focused on research, cooperation with the house owners was essential. Conflict with residents in the area could lead to a serious risk for the project.

Explanatory meetings for the house owners were held many times to ask for cooperation of the residents. In addition, official contracts were made to avoid troubles.

This project was aimed at research and all the PV costs were paid from the research budget, therefore, it might be quite different from a general development project. In addition the organization, structure, and mindset of the utility companies in Japan are quite different from that in other countries. In Japan, it is very important to understand the utility's intention through prior consultation.

6. CONCLUSIONS

In Japanese society, the use of PV as an alternative energy is seen as important and necessary from a social, cultural, and ecological perspective. Likewise, Japanese leaders and industry see PV as a revolutionary technology that can make significant contributions to the electric power sector while making good business sense.

A Combination of R&D support and installation subsidies support has proven an effective strategy to promote PV technology introduction. Government involvement has been important at the initial stage of technology introduction. Markets subsidies help create initial markets. The Japanese PV system market will continue to benefit and expand beyond that of any other country even as government subsidies for the residential sector are greatly reduced. The leading market sector will continue to be residential installations for the rest of the decade. However, there will be greater emphasis and PV systems growth in the public, industrial, and business facilities sectors.

Balance of systems such as inverters are considered to be a mature technology. Japan future government R&D technology development will focus on thin-film PV technologies, excluding CdTe. However, the Japanese government's largest budget focus will continue to be on field deployment for the commercial and utility sectors, which will be a crucial role to develop residential PV market more to the public.

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