Preparing a Solar Take-Off: Solar Energy Demonstration and Exhibitions in Japan, 1945–1993

Hiroki Shin
Birkbeck College, University of London

Abstract

When the first oil crisis hit Japan in 1973, the country was highly dependent on imported oil as the source of electric power. The dire prospect of an oil cut-off gave sufficient and immediate impetus for Japan to begin searching frantically for alternative energy sources. Starting in 1974, the state-sponsored Sunshine Project, which originated from concern about the country's excessive oil dependency – rather than being a direct response to the oil crisis – mobilised the technological and financial resources for finding viable energy alternatives and implemented a number of state-funded projects. One of the most successful enterprises was the development of solar photovoltaic (PV) power generation, and, as a consequence, the household solar PV panel penetrated into the consumer market in the 1990s, comparatively earlier than most of the developed nations. The existing literature tends to focus on the economic incentive provided by state subsidy. However, the diffusion of the solar panel in Japan calls for a more nuanced explanation. A certain degree of social acceptance was needed before a large number of consumers embraced a new energy technology to the extent that they were willing to pay for the initial cost. The social acceptance for using a new technology was, in turn, based on pre-existing knowledge about the technology. This paper aims at shedding light on the pathways through which the knowledge about solar energy proliferated in the Japanese society, by focusing on solar energy demonstration and exhibitions – these forms of knowledge circulation had their roots in the penetration of the solar water heater in rural areas of Japan in the immediate post-WWII period.

Introduction

Overshadowed in the last decade or so by the progress of renewable energy in countries like Germany, Japan's solar power utilisation seems to have lost the place it once had in the world of solar energy development. Back in the mid-1990s, Japan's solar photovoltaic (PV)

electricity generation capacity surpassed that of the United States, the world's largest solar user until then, and during the next ten years or so, Japan prided itself on having both the largest solar cell production and domestic penetration of PV systems. In the early 2000s, however, Germany introduced a new feed-in tariff scheme (a reformulated version of the relatively modest previous scheme), while China significantly increased its production of PV cells and modules. In contrast, Japan's domestic solar utilisation stagnated for most of the 2000s, and the country lost its status as the world's leader in commercial solar technology.[1] The belated introduction of feed-in tariffs in 2009 and 2012 has contributed to revitalising Japan's solar market, but the country has far to go to regain its lost ground.

This paper focuses on the early history of solar energy in Japan, from the 1940s to the first take-off of the solar PV market in the 1990s. There are some reasons for concentrating on this early period. First, the significant growth of Japan's solar market in the 1990s is often attributed exclusively to the introduction of a state subsidy in 1994.[2] However, this explanation only tells part of the story. Even with the subsidy, which reduced the initial cost of solar panel installation by half, the price of solar electricity was much higher than that of the existing sources of power. In 2003, for example, solar was still nearly twice the price of conventional electricity.[3] Moreover, the subsidy was only available to a limited number of users — only one in five or six applications was subsidised. Therefore, for most consumers who installed solar panels in the 1990s, solar electricity did not make much economic sense. This leads us to widen our investigation beyond the economics of solar energy. If the penetration of solar energy was not due entirely to economic incentives, consumers' *willingness* to use alternative energy was a crucial factor. Such an extra-economic factor is often linked to environmental awareness, but in this paper I would like to take a slightly different perspective. As a precondition of adopting solar energy, there must first be a certain level of understanding about alternative energy ('alternative energy' or 'new energy' was the popular term for renewable energy in 1970s–80s Japan) needed to exist. This was particularly true with the adoption of the solar panel. Unlike most other

[1] International Energy Agency, Photovoltaic Power Systems Programme, "Trends 2014 in Photovoltaic Applications," 67–8, accessed November 3, 2015, http://www.iea-pvps.org.
[2] Cf. Yu Zhang, Junghyun Song and Shigeyuki Hamori, "Impact of Subsidy Policies on Diffusion of Photovoltaic Power Generation," *Energy Policy* 39.4 (2011): 1958–1964.
[3] In 2003, the estimated price for solar electricity was 40 JPY/kWh while conventional electricity was 22 JPY/kWh. Osamu Kimura and Tatsujiro Suzuki, "Taiyōkō Hatsuden Gijyutsu (PV) no Dōnyū ni okeru Seifu Shiensaku no Keisei to Actor no Taiō," in *Energī Gijyutsu no Syakai Ishi Kettei*, ed. Tatsujiro Suzuki, Hideaki Shiroyama and Miwao Matsumoto (Tokyo: Nihon Hyōron Sha, 2007), 82.

modern energy products, rooftop solar panels were visible to users. They occupied a part of the living space, if outside of the house. Though consumers still did not know exactly how they worked, some form of socio-technical knowledge had been established prior to the adoption, to the extent that it enabled them to accept the intrusion of such technology into — or onto — their homes.

The adoption of a relatively new technology as household appliance is usually achieved through a wider network of knowledge beyond the fairly closed network of the producer and the consumer. As the existing literature especially on early electrification in the first half of the 20th century has demonstrated, marketing and other promotional activities have played an important role in convincing consumers to accept the idea of using electricity and gas in their home.[4] Scholars such as K. G. Beauchamp, David Nye and Nina Möllers, for example, have pointed to the role of exhibitions and world's fairs in propagating the knowledge about energy, thereby mediating the gap between everyday life and technology.[5] As much as the existing research is instructive when we trace the modern energy's entry into the home, it tends to focus on the USA and Europe. Though largely neglected in the literature, one can find a parallel development in early 20th century Japan, when the country was trying to catch up with the West. In that country, exhibitions played a similar role in diffusing the knowledge about electricity and helped bringing modern energy life to Japanese homes.[6] In fact, the theme of two national expositions, held in 1918 and 1926, was electricity.[7] When one compares the story of electrification in the early 20th century and the creation of socio-technical knowledge about solar energy in the late 20th century, there are some striking similarities. With regards to late 20th century energy exhibitions, most historians have been focused on nuclear energy. Yet, nuclear energy was not the only form of energy that appeared in the flourishing exhibition and exposition

[4] For instance, Graeme Gooday, *Domesticating Electricity: Technology, Uncertainty and Gender, 1880–1914* (London: Routledge, 2008).

[5] Kenneth Beauchamp, *Exhibiting electricity* (London: Institution of Engineering and Technology, 1997); David Nye, "Electrifying Expositions, 1880–1939," in *Fair Representations: World's Fairs and the Modern World*, ed. Robert W. Rydell, Nancy E. Gwinn and James Burkhart Gilbert (Amsterdam: VU University Press, 1994), 140–156; Nina Möllers, "Electrifying the World: Representations of Energy and Modern Life at World's Fairs, 1893–1982," in *Past and Present Energy Societies: How Energy Connects Politics, Technologies and Cultures*, ed. Nina Möllers and Karin Zachmann (Piscataway, NJ.: Transcript Verlag, 2012), 45–78.

[6] Shunya Yoshimi, *Hakurankai no Seijigaku* (Tokyo: Chūō Kōron Sha, 1992).

[7] Makoto Momozaki, "Waga Kuni Hakurankai no Rekishi to Hensen," in *Ad Studies* 13 (2005), 7; Shinya Hashizume, "Illuminēsion to Hakurankai," in *Nippon Denkashi*, ed. Hashizume Shinya and Nishimura Kiyosi (Tokyo: Japan Electric Association, 2005), 153–165.

culture in Japan.[8] Historians of renewable energy have yet to fully appreciate the role of cultural institutions in the long-term development of modern energy culture from the early electrification to the recent turn to alternative modes of generating electricity from renewable sources. The aim of this paper, in short, is to link up the literature about demonstrations and exhibitions with those on the more recent history of alternative energy.

How 'New' was the Solar Power?

Although solar energy was regarded as a 'new' energy in 1970s Japan, the utilisation of solar energy has a long history. Even when we limit ourselves to the modern solar energy, its roots date back at least to the 19th century. At any rate, in the pioneering phase of the modern solar technology, Japan did not play a particularly important part. Its market was relatively slow to develop, compared to countries like the USA, where there was a market for solar appliances, though small, by the early 20th century.[9] After WWII, the use of solar power saw a rapid development in Japan, a country with the tradition of frequent bathing, paving the way for the later technological development.

One of the earliest evidence of Japan's solar energy use can be found in the 1930s, when some farmers responded to occasional fuel shortages by using sunlight for water heating.[10] This was largely a phenomenon in rural areas. But even in Tokyo – where networked supplies of gas and electricity were expanding – some suburban households installed a simple form of solar water heater, consisting of dark-colour cloths and metal plates as heat absorbing elements that heated up the water tank.[11] The post war expansion of solar water heating dwarfed the modest beginning. The serious fuel shortage in the post-WWII period gave ample motivation for similar simple technology to spread more widely. The first mass-produced solar water heater in Japan was inspired by the practice in the rural area, mentioned above, and its production started in 1948. For its low installation cost, the mass-produced water heater was particularly popular in agrarian areas, where people wanted to have a bath after a day's hard work. With the water heater, the water

[8] Shunya Yoshimi, *Yume no Genshiryoku: Atoms for Dream* (Tokyo: Chikuma Shobō, 2012); Morris Low, "Displaying the Future: Techno-Nationalism and the Rise of the Consumer in Postwar Japan," *History and Technology* 19.3 (2003): 197–209.
[9] Geoffrey Jones and Loubna Bouamane, "'Power from Sunshine': A Business History of Solar Energy," Harvard Business School Working Paper, No. 12-15 (2015).
[10] Ken Butti and John Perlin, *Golden Thread: 2500 Years of Solar Architecture and Technology* (London: Marion Boyars, 1981), 242.
[11] Ichimatsu Tanishita, "Taiyō Onsuiki no Kako to Genjyō," *Kūki Chōwa-Eisei Kougaku* 50.4 (1976): 13.

temperature could be – on a fine day – up to 55 degrees Celsius during summer, and around 20–25 degrees Celsius even at the height of winter.[12] In these areas, where rice straw and firewood had been the traditional fuel for water heating, and the solar bath, as it was called, could lead to a substantial saving of fuel.[13] An improved 'closed' type of solar water heater made of soft vinyl plastic further popularised the solar bath, as it was cheaper than the previously available heaters, and about 260,000 of the closed solar water heater had been sold by the end of the 1950s.[14] In the 1960s, aluminium or copper made solar heater was introduced into the market, now penetrating into both urban and rural areas. The total sales of solar water heaters in Japan reached 3.7 million by the end of the decade.[15] Japan's solar heater market was quite unique for its sheer size compared to those in countries such as the USA, Israel, Australia and India, where the sales of solar appliances amounted to only 10,000 to a few hundred thousand.[16]

To some extent, the spread of solar water heaters in Japan was helped by state subsidies and low-interest loans.[17] The state supported the introduction of solar power into the rural area largely because it formed part of the nation's drive to rationalising rural fuel use. The deforestation resulting from Japan's war effort and the slow development of energy supply capacity made the government particularly keen on reducing fuel use in the rural areas, where traditional inefficient fuel practice was still prevalent. The fuel rationalisation was closely linked with the interest in agricultural production and rural life improvement. With the introduction of solar water heater in rural households, the need for burning rice straw for water heating vanished, and rice straw thus saved could be used to improve agrarian productivity by using it as animal food or fertiliser. The use of solar bath would also reduce the drudgery of preparing bath water. When traditional fuel was used for that purpose, a person – usually the housewife – needed to start the fire and watch over it for more than an hour.[18] Thus the introduction of solar water heater was regarded as

---

[12] Kazumasa Kojima, "Taiyō Buro," *Nōgei* 6.5 (1953) : 14.
[13] Mieko Tsuji, "Kairyō Kamado Tenpi Tanku wa Konna Jisseki wo Agete iru," *Ringyō Shin Chishiki* 50 (1957).
[14] Butti and Perlin, *Golden Thread*, 245.
[15] Butti and Perlin, *Golden Thread*, 246–7.
[16] Tanishita, "Taiyō Onsuiki," 17; R. Sobotka, "Solar Water Heaters," in *Proceedings of the United Nations Conference on New Sources of Energy, vol. 5, Solar Energy II* (New York: United Nations, 1964), 96.
[17] Kojima, "Taiyō Buro," 15.
[18] Jiro Ono, "Seikatsu wo Yutaka ni suru Taiyōnetsu no Riyō," in *Nōgyō Sekai* 51.6 (1956): 176; "Tenpi Tanku no Fukyū de Shufu Rōdō no Keigen," *Nōgyō Sekai* 57.7 (1962): 197.

particularly beneficial in rural areas, where modern networked energy such as electricity or gas had yet to replace the traditional fuel.[19] In the 1940s and 1950s, rural life improvement was a sizable movement supported by the state and municipal authorities.[20] While various subsidies were provided for the installation of the solar bath, life improvement 'instructors' went around rural villages to preach its benefits[21], along with the improvement of kitchen facilities and water supply.[22] Consequently, the early proliferation of knowledge about solar energy saw a wide circulation in rural areas.

Some contemporary advertisements show that the solar water heater was intended mostly for those who lived in a conventional Japanese house, and not for those in a modern western-style house or in an apartment block. However, even though the use of solar power was less widespread in urban areas, the urban residents were not totally left behind in the general development of solar technology. In 1956, a 'Solar and Life' exhibition was held in a department store in Tokyo. Co-organised by the City of Tokyo, Tokyo Chamber of Commerce, the Inventors' Association of Japan, and the Japan Society of Mechanical Engineers, the exhibition was held for fifteen days, attracting a large crowd.[23] The exhibits ranged from the now familiar solar water heaters to technological devices such as silicon solar cells and more futuristic solar electricity generators, giving the public a sneak preview of the wide range of solar technology. This exhibition is particularly interesting as it was held as part of the 500th anniversary of the establishment of Tokyo. Though it is unclear why the solar technology was chosen as the subject of the exhibition, one can assume the Society of Mechanical Engineers took strong encouragement from the first international conference on the use of solar energy held in Tucson in the USA in the previous year.[24] The theme of the exhibition 'solar and life' might also indicate that the solar technology was not located exclusively in the high-tech realm of energy science, but it was also closely connected to the familiar domain of household technology.

---

[19] Japan Ministry of Agriculture and Forestry, *Taiyōnetsu Riyō no Onsuiki* (1960), 2–3.
[20] Senichi Tanaka, "Seikatsu Kaizen Sho Undō ni Tsuite," in *Kurashi no Kakumei–Sengo Nōson no Seikatsu Kaizen Jigyō to Shin Seikatsu Undō*, ed. Senichi Tanaka (Tokyo: Nohbunkyo, 2011), 11–27; Sheldon Garon, *Molding Japanese Minds: The State in Everyday Life* (Princeton, N.J.; Chichester: Princeton University Press 1997), 167; Jordan Sand, *House and Home in Modern Japan: Reforming Everyday Life 1880-1930* (Cambridge, MA: Harvard University Press, 2005), 433 fn. 21.
[21] Kagawa Prefecture, *Kagawa Ken Shi* vol. 7 Gendai (Kagawa, 1989), 487.
[22] Tomoko Iwata Ichida, "Seikatsu Kaizen Fukyū Jigyō no Rinen to Tenkai," *Nogyōsōgō Kenkyū* 49.2 (1995), 29.
[23] JSME's solar power utilisation section, set up in 1944, predates its counterpart in the USA. Ichimatsu Tanishita, "Taiyōnetsu Riyō no Saikin No Shinpo," *Nihon Kikai Gakkai Shi* 60 (1957): 705.
[24] Ichimatsu Tanishita, "Taiyōnetsu Riyō," 705.

The Sunshine Project

The popularity of the solar water heater saw a culmination in the late 1960s, but it declined thereafter. This was largely caused by the impact of the so-called energy revolution, the transition to oil that took place in Japan from the late 1950s. Aided by low price of oil from the Middle East, oil heating rapidly penetrated into both urban and rural areas.[25]

The decline of the solar water heater turned out to be fairly short-lived, as it received a major boost in the 1970s. In Japan, what initially stimulated a fresh turn to solar power was the realisation of the country's excessive reliance on imported energy – by the end of the 1960s, more than 90% of its energy needs relied on importation.[26] At the end of the 1960s, Japan's energy providers had already begun their search for alternative to oil. This is where the technological fix by alternative energy development came in.

The development of the solar technology in Japan was partly dependent on institutional politics. In the early 1970s, the Electrotechnical Laboratory – a major energy research institution in the country – was re-organised and its scientists suddenly faced the challenge of drawing up new long-term research plans. Solar energy was put forward through this reorganisation, not as a short-term, practical topic, but as a long-term research agenda. A pilot programme on solar energy was started at the Electrotechnical Laboratory in 1971.[27] The funding body for the scientific research, the Agency for Industrial Science and Technology (AIST) – an agency of the Ministry of International Trade and Industry (MITI) – supported the project, but not from the same long-term perspective the scientists initially embraced. Although, solar PV was not yet seen as a viable alternative to conventional sources of electricity at the time, AIST wanted to see the practical benefits of the project, if not directly from the development of solar technology.

The first oil crisis helped to secure a significant scale of state funding for the Sunshine Project, which was formally proposed to AIST several months before the OPEC's oil embargo. The combination of scientific ambition, energy security policy, and the energy crisis contributed equally to the formation of this unprecedented national project.[28] And the energy situation was a decisive element in the shaping of the project. Despite the strong

[25] Butti and Perlin, *Golden Thread*, 243.
[26] Laura Hein, *Fueling Growth: Energy Revolution and Economic Policy in Postwar Japan* (Cambridge, Mass.: Harvard University Asia Center, 1990), ch. 11; Minoru Shimamoto, *Keikaku no Souhatsu–Sunshine Keikaku to Taiyōkō Hatsuden* (Tokyo: Yūhikaku, 2014), 55–58.
[27] Kimura and Suzuki, "Taiyōkō Hatsuden Gijyutsu," 62.
[28] Kimura and Suzuki, "Taiyōkō Hatsuden Gijyutsu," 63.

institutional support given to the development of alternative energy, the scientists' earlier focus on solar PV was pushed aside by the necessity to produce tangible results in a relatively short term and, accordingly, solar thermal replaced PV as the mainstay of the project,[29] since solar thermal was then considered as being closer to commercial application. Both solar thermal and PV used solar power, but they were different forms of technology. Solar thermal energy production involved a relatively simple operation of turning concentrated solar heat into steam. The steam would then drive turbines to generate electricity. Solar PV energy production employed a semiconductor material to produce an electric current from sunlight. While the use of semiconductors to generate electricity was still in its early stages, the use of solar thermal energy already had a number of precedents. At any rate, neither of these methods had reached the stage of being commercially viable in the 1970s. Through the early discussion, AIST decided to hedge the risk of technological development by incorporating geothermal, coal liquefaction and hydrogen energy within the purview of the Sunshine Project.[30] Concerning the solar technology, the main challenge was to reduce the solar thermal system's unit cost and scale up its production.

With the above-mentioned objectives in mind, the first pilot plant was built and started its operation in 1981. But the results were rather disappointing. It turned out that solar irradiation characteristics in Japan was not well suited for generating electricity with the existing solar thermal generator. In the country, solar irradiance was often diffused by clouds, which made it difficult to attain sufficient temperatures for generating high-pressure steam. Also, it was deemed unlikely that the cost of the electricity generation by solar thermal would be reduced to a commercially viable level, even after scaling up the facility.[31] The adversity encountered by solar thermal technology actually benefitted solar PV technology, as experts' and policymakers' attention was now turned towards solar PV. Even though scientists and engineers were doubtful about solar PV's commercial introduction within a short period of time, solar PV did not require the high level of direct solar irradiation that was crucial for a solar thermal system.[32] Without much hesitation, there was a shift away from solar thermal technology towards solar PV technology. Even

[29] Kimura and Suzuki, "Taiyōkō Hatsuden Gijyutsu," 63.
[30] Osamu Kimura, "Taiyōkō Hatsuden Gijyutsu no Kaihatsu Fukyū ni Kansuru Shien Seisaku no Rekishi," *IEEJ Transactions on Fundamentals and Materials* 131.2 (2011): 64.
[31] Kimura and Suzuki, "Taiyōkō Hatsuden Gijyutsu," 64–5.
[32] Kimura and Suzuki, "Taiyōkō Hatsuden Gijyutsu," 65–6. Shimamoto argues that the bureaucratic habit of retaining the pre-existing budget was at work in the case of transfer of research budget from thermal to PV. Shimamoto, *Keikaku no Souhatsu*, 173.

before the solar thermal pilot plant was built, the Comprehensive Energy Investigation Committee recommended in 1979 to focus on PV rather than solar thermal.[33] The shift coincided with – or rather was caused by – the second oil crisis which made the development of alternative energy even more urgent. In the face of dire prospects of import dependency, the target share of alternative energy (within ten years) was revised from previous 1.6% to 5%,[34] while the budget of the Sunshine Project – now managed by the newly created New Energy Development Organisation (NEDO)[35] – was more than doubled to achieve this target.[36] The research budget for solar thermal was almost entirely transferred to solar PV development and it tripled to approximately ¥40 billion in 1981.[37] This led to the construction of a solar PV pilot plant in 1981 (its full operation started from 1986) and, thereafter, the Sunshine Project constantly fed a significant proportion of its funding into solar PV technology.

The national effort paid out, to some extent, as the PV cell's sunlight engineering efficiency went up while its unit price came down. By the end of the 1980s, manufacturing PV cells of over 10% efficiency in an industrial scale became possible, while the price of solar cells had come down from initial ¥20,000–30,000/watt to ¥1,000/watt, though it was still expensive.[38] As the residential PV panel market was almost non-existent in the 1980s, apart from small-scale installation at official and commercial buildings, the demand in the PV market was depending on research activities – the scale economy was largely achieved through the expansion of the state project. The slow development of the consumer PV market frustrated companies which had been involved in the project. Companies such as Hitachi, Toshiba and NEC dropped out from the Sunshine Project by 1990. The problem of consumer market growth was partly created by the regulatory system of the energy industry. For example, an electrical engineer needed to be stationed where a solar system was installed, even in an ordinary house, and moreover, there was no coherent guideline for connecting a small electricity generator to the grid. Some solar engineers were appealing to the government and the power industry for allowing the reverse flow of electricity in order to enable consumers to sell excess electricity to the utilities. The companies were not

[33] Minoru Sawai, *Tsusho Sangyo Seisaku Shi*, vol. 9 (Tokyo: Keizai Sangyō Chōsa Kai, 2011), 254.
[34] Sawai, *Tsusho Sangyo Seisaku Shi*, vol. 9, 253.
[35] In 1988, renamed as the New Energy and Industrial Technology Development Organization (NEDO). Sawai, *Tsusho Sangyo Seisaku Shi*, vol. 9, 286.
[36] Takeo Kikkawa, *Tsusho Sangyo Seisaku Shi*, vol. 10 (Tokyo: Keizai Sangyō Chōsa Kai, 2011), 60.
[37] Shimamoto, *Keikaku no Souhatsu*, 174.
[38] Kimura and Suzuki, "Taiyōkō Hatsuden Gijyutsu," 68.

forthcoming, fearing that electricity input from the users' end would jeopardise the stability of the electricity grid. The problem at the end of the 1980s was not only technological, but also institutional. The way out of this could partly be found in political lobbying, but as the regulatory change was meant to create a robust consumer market, it had to involve the public.

Diffusion of Solar Knowledge

Recently, some scholars have argued that, in advancing renewable energy technologies, publicly funded demonstration projects and trials (DTs) have played a crucial role.[39] And Japan's Sunshine Project is often referred to as one of the exemplary cases of DTs, even though whether it was successful or not in the long run is still a contentious topic. Perhaps two points can be added to the DT perspective. First, the proponents of DTs tend to assume that such activities communicate unequivocal knowledge about the technology, but this can well be a naïve assumption. Second, technological demonstrations do not exist in isolation. With an eye to future commercial introductions, demonstration projects were usually conducted in collaboration with commercial marketing and public events, such as exhibitions. If we are to analyse the process of innovation up until the commercial application of technology, a discussion of DTs needs to incorporate activities involving the public, the potential consumers of technology. By addressing these two points, probably we can draw a more nuanced picture of the historical development of the solar PV market.

NEDO – like its predecessor AIST – was a coordinator of various DT activities of the Sunshine Project. The DTs were contracted out to private companies, research institutions (such as the Central Research Institute of Electric Power Company) and regional electric power companies, or the combination of these. At the same time, the sub-projects were dispersed across the country according to the geographical, climatic and technological requirements of specific technologies and experiments. Many sub-projects involved a substantial amount of investment coming from the state. Hence, municipal authorities were keenly interested in the location of pilot projects. For that reason, when, in the mid-1970s, the project for constructing a solar thermal pilot plant was announced, a number of municipal authorities put themselves forward, enticed by the prospect of investment,

[39] Paul Harborne and Chris Hendry, "Commercialising New Energy Technologies: Failure of the Japanese Machine?" *Technology Analysis and Strategic Management* 24.5 (2012): 497–510.

employment, local economic regeneration and prestige.[40] The town of Nio, a small seaside town located in Kagawa prefecture in the Shikoku Island, was among the eight applicants for the site of the solar thermal plant. The town of Nio was formerly known for its salt fields, but the post-war re-organisation of the salt industry led to their closure. With the disappearance of its staple industry, the town was left with a vacant large tract of land. The initial idea of the town authority was to make use of the former salt fields as industrial park. However, the first oil crisis and ensuing economic downturn made the land hard to sell. Once the mayor of the town became aware of the siting for the pilot plant, he started a vigorous campaign to bring the project over to Nio, by soliciting the support of prefectural government, MITI and the regional electric power company. The town's claim of being the sunniest town in Japan was certainly an exaggeration, but Nio managed to secure the project in 1977.[41]

In terms of direct investment, the pilot plant did not bring much financial benefit to Nio – the site was rented and not purchased by the state, for example – but the town did not fail to cash in on the Sunshine Project. The town drew up a plan to hold the so-called Solar Exposition in the adjacent land to the pilot plant. Local businesspeople were the driving force, forming themselves into an Expo organisation committee. The Expo opened in March 1981 and continued until 1983. It was an enormous success, bringing 1.25 million people to this obscure seaside town with a population of barely 8,000.[42] The main building of the exposition, called the Solarium, was dedicated to the solar science, and in the corporate pavilion, various solar-related appliances were on show. Children were entertained by model trains and model cars – the latter, at least, were operated by solar electricity. The highlight of the Solar Expo was the tour around the pilot plant, where the heat from the sun was converted into steam that drove turbines to create 1 MW electricity.[43]

Ironically, when the Solar Expo was celebrating the opening of the solar thermal pilot plant, the solar thermal technology had already fallen out of scientists' and

---

[40] Shizuoka, Wakayama, Okayama and Shimane were applied. Sankei Shimbun, *400 Man Nin no Denryoku* (Osaka: Sankei Shimbun, 1976), p. 114.
[41] Sankei Shimbun, *400 Man Nin*, 419. Nio Chō, *Shinshū Nio Chō Shi*, 419; "Gendai no Prometheus: Taiyōnetsu Hatsudensho," *Shikoku to Denki*, 1 April 1982, 2; Jones and Bouamane, "Power from the Sunshine," 35.
[42] "Jinkō no Genjyō to Suii," accessed July 6, 2015, http://www.pref.kagawa.jp/seisanhoken/tyousahoukoku/kakusyutoukei-kannnai/jinnkou.pdf
[43] Nio Taiyō Haku, "Nio Taiyō Haku Stamp Book," 1981, Kagawa Prefectural Library, K5437/N1; "Nio Chō Taiyō Haku to Taiyō Netsu Hatsuden Sho," *Chiri* 26.12 (1981): 1, 74–8.

policymakers' favour. Already in 1979, the focus of the Sunshine Project was shifted to PV. The results from the Nio pilot plant plainly confirmed that solar thermal could not be developed into a viable alternative source of electricity in the foreseeable future. What is interesting in this episode is that, even though the scientific and policy community was abandoning solar thermal, the changing experts' views were not automatically fed into public knowledge. The pilot site kept operating, and the Solar Expo still attracting a large number of visitors until it was closed in 1983, touting the bright future of solar – thermal – energy.[44]

The day the Solar Expo opened, in the neighbouring prefecture of Ehime, there was another exposition opened to the public, and one of its themes was energy technology. The pre-opening report in the local newspaper mentioned the Solar Expo now opened in Nio, but at the same time – here, one can sense a feeling of local pride and rivalry – it announced that there was an on-going plan of bringing a solar experiment to their own prefecture.[45] What was referred to was the new PV pilot plant to be built in Saijo city as part of the new phase of the Sunshine Project. The story of the siting of the pilot plant was quite similar to that of Nio. The old castle city of Saijo was looking for ways to modernise its economy in the post-WWII era, and when it was officially designated as a 'new industrial city' in 1964, it started an ambitious reclamation project, hoping to build factories by the coast. Just as the reclamation project was completed, the oil crisis in 1973 scared off potential tenants. For Saijo city, which was desperately needing a new project to fill up the reclaimed land, the new PV pilot plant was extremely attractive. Strenuous efforts were made by the municipal authority and the mayor to entice the project to the city, by appealing to the prefectural governor, the regional and central MITI officials, the local electric utilities and the city parliament. A year-long campaign bore fruits in 1981, when Saijo was officially announced as the site of the pilot plant.[46]

As a technological experiment, Saijo's pilot plant achieved much more than Nio's thermal plant did. When the Saijo plant started its 1 MW operation, it was the world's third largest PV system and from 1986 until its closure in 1992 it constantly produced 1.2 MWh

[44] A year after the Solar Expo was concluded, the site was redeveloped into an amusement part, the Nio Sunshine Land. In the transformation, it lost most of its solar theme and it was closed down in 1995.
[45] *Ehime Shimbun*, November 19, 1980.
[46] Information based on the official record of Saijo City Council.

of electricity per annum, equivalent to the electricity requirement of 400 households.[47] The degree of technological success did not necessarily define public perception, however. Despite its limited technological achievement, Nio was apparently better than Saijo in presenting solar technology to the public. In contrast, there was no major public event in Saijo, and during the twelve years of PV experiment, the number of people who visited the Saijo PV plant was only 36,000, whereas Nio achieved 1.25 million in *three* years. This is not to say that the public event was an essential component of technological development, but still, the low key of Saijo experiment is quite perplexing at first glance. While Nio's experiment was widely publicised, Saijo's much more successful experiment was hardly advertised outside the expert world. The local people in Saijo seem to have been fairly indifferent to the ongoing experiment, even though some records suggest that the pilot plant actually provided electricity to nearby houses. One possible explanation is that the publicity of Saijo experiment was toned down because the regional electric utility feared that solar power's progress might inversely affect the image of nuclear energy. In the early to mid-1980s, the construction of a third nuclear plant in Ehime was a highly sensitive issue in the region. Ehime's geographical location – only a narrow inland sea separates Ehime from Hiroshima – was probably the reason why nuclear electricity was never popular in that place. The Chernobyl accident in 1986 strengthened the case for the anti-nuclear public opinion.[48] For the regional electricity company, celebrating the virtue of solar energy would risk undermining nuclear power's public image.

From a wider perspective, Nio's extravagant celebration of solar power was not necessarily idiosyncratic. When the Nio Solar Expo was running for its second year in 1982, the World's Fair in Knoxville, also known as Knoxville International Energy Exposition, took up the theme of 'Energy Turns the World'. Solar energy played a symbolical role, being embodied in the edifice called Sunsphere erected in the exhibition site. Not surprisingly, the Expo site was littered with solar technology: Australian solar windmills, Saudi Arabian solar energy collectors and a solar-driven Chinese dragon boat.[49] In a sense, Nio's Solar Expo was reflecting the contemporary discourse of future energy in which solar power was regarded

[47] *Ehime Shimbun*, April 6, 1993; *Mainichi Shimbun*, April 6, 1993.
[48] *Ehime Shinbun*, September 25, 1981; June 7, 1986. Also, Sankei Shimbun, *400 Man Nin*, 126–48.
[49] Beauchamp, *Exhibiting Electricity*, 290; Martha Rose Woodward, *Knoxville's 1982 World's Fair* (Charleston, S.C.: Arcadia Publishing, 2009). However, behind all these solar exhibits, there was a decisive U-turn in the US energy policy, which was already felt at the Knoxville exposition. Möllers, "Electrifying the World," 70–73.

as a central piece of energy technology. Furthermore, the first half of the 1980s was a time when Japan's electric power companies strengthened their PR effort, using public exhibitions at museums. Kyūshu Electric Power Company opened its corporate museum in 1982, followed by Tokyo Electric Power Company in 1984 and Chūbu Electric Power Company in 1986. It is important to note, though, these museums were possibly part of the effort to mitigate the public antagonism against the construction of new power plants, especially nuclear plants. At any rate, knowledge about renewables was featured in these corporate museums, if not as a major element. Some private firms also took part to energy exhibitions such as Kyocera's Solar Energy Centre opened in 1984. The efflorescence of energy exhibitions in the early 1980s shows that, on the way to the alternative energy technology which would take-off in the following decades, exhibitions undoubtedly played a role in propagating the knowledge and visions about new energy.

The fact that the climax of the solar technology in the early 1980s was followed by a period of downturn, at least in the international context, was an additional factor that explains the different levels of public exposure of the two solar pilot projects in Nio and Saijo. In the US, the declining popularity was based on the political decision under the Reagan administration, which significantly reduced the solar subsidy until it was almost eliminated in the late 1980s. In Japan, the equivalent of Reagan, Prime Minister Nakasone, who did not hesitate to express his strong support for nuclear, did not resort to a similar drastic action, but the boom period of the solar technology only lasted until the mid-1980s, and the Saijo PV experiment came little too late to riding the tide of the solar boom.

Taking Off

The low-ebb of the solar energy did not condemn the solar PV technology in Japan. Even though some companies left the Sunshine Project, others continued to rest their hope on the PV electricity. The Saijo plant gave evidence of the improving technology, and in Kobe, another pilot project successfully demonstrated that linking solar houses to the grid was less problematic than some electric utilities assumed. Another major factor was the growing acceptance of environmental thinking. In the 1990s, Japan's relatively late coming environmental modernisation started to connect with the technological vision of renewable energy.[50] Demonstration projects like those in Nio and Saijo likely sowed the seeds for

[50] Kimura and Suzuki, "Taiyōkō Hatsuden Gijyutsu," 71, 87.

increased environmental awareness, but Japan's environmental activism was generally inactive during the 1980s. It was only during the 1990s that these seeds started to germinate. In the early 1990s, energy experts' appeals for regulatory change were picked up by the mass media. These social and cultural changes swayed public opinion in favour of some sort of state involvement in the creation of a PV consumer market.

Just as the guidelines for grid connection of micro electricity generators were discussed by a government sponsored council in 1992, the electric power companies initiated a programme to purchase excess electricity from residential solar users.[51] In 1994, the state-funded New Energy Foundation began its solar subsidy scheme, which was to bear half the cost of PV panel installation for private homes. Even though the scale of the subsidy scheme was limited – in its first year, only 700 homes were subsidised – the state support was taken by consumers as well as PV manufacturers as a positive sign of the market expansion.[52] The growth of the market was conspicuous. The PV installation increased from 19MW in 1992 to 50MW in 1998, pushing Japan to the world's foremost solar PV appliances manufacturer and user of solar energy.[53]

The solar PV take-off in the early 1990s had problems. The purchase of excess electricity was criticised for being the electric power companies' half-hearted nod towards renewables while showing little willingness to embrace greater change. The critics have pointed out that the excess electricity purchase was introduced to fend off a more vigorous scheme of feed-in tariff, which had been discussed at the National Diet at the end of the 1990s. In spite of a sizable cross-party support for the new scheme, feed-in tariff was dropped from political agenda by 2000.[54] A Renewable Portfolio Standard was introduced in 2003, but the constraint upon electric power companies was too small to encourage them to invest more in renewables.[55] While Japan procrastinated in consolidating the conditions for further growth of the solar PV market, other countries started to catch up. The ending of the state subsidy scheme in 2005 gave a serious blow to Japan's PV market. The realisation

[51] Kimura and Suzuki, "Taiyōkō Hatsuden Gijyutsu," 72. The scheme was similar to the US net metering. Tetsuya Iida, "Saisei Kanou Enerugī Seisaku no Kyūtenkai," in *Shin Tsūshi Nihon no Kagaku vol. 1*, ed. Hitoshi Yoshida (Tokyo: Hara Shobō, 2011), 524.
[52] NEDO was also subsidizing industrial solar PV electricity generation.
[53] Sawai, *Tsusho Sangyo Seisaku Shi*, vol. 9, 258.
[54] Iida, "Saisei Kanou Enerugī Seisaku," 524–5.
[55] Unlike the RPS scheme in the UK, for example, the target of Japan's RPS was too low (1.35% by 2010, compared, for example, to the UK's 10%) to oblige the electric power companies to expand their renewable portfolio. Iida, "Saisei Kanou Enerugī Seisaku," 526–527.

of a missed opportunity, along with pressure from international environmental movements, pushed the government to finally introduce a feed-in tariff in 2009. The ambitious target, set up in 1990, of installing PV panel to half of Japanese houses by 2010[56] was far off the mark – the actual penetration rate of the residential PV panel in 2010 was a mere 3.3%.[57]

Looking back at the early 1990s, researchers now try to find the causes of Japan's failure to put the PV market on a stable growth path, and some blame the supply-oriented market.[58] This is a moot point. Between 1994 and 1996, for the 700 to 1,000 subsidies granted, the total applications were usually five to six times more numerous – the allegedly supply-led market was matched by sizable consumer demand.[59] At the same time, there was a segment of consumers who were installing PV panels without subsidy. In the late 1990s, the sale of solar panels was a thriving and fairly competitive market. The existing literature does not tell us why there was a fairly large potential market already in existence at the beginning of the state subsidy in 1994.[60] A broad perspective, incorporating the long development of solar utilisation in Japan, could help illuminate this hitherto neglected aspect of the creation of Japan's PV market. Demonstration activities were certainly important as they helped to raise consumers' awareness of the technology prior to its introduction into the consumer market. Indeed, the pilot projects in Nio, Saijo and several other places – though to varying degrees – played a role in producing as well as spreading the knowledge about solar technology among consumers and electric suppliers. Yet, most of the official demonstration activities were conducted within the realm of experts and were not visible to the potential customers of the technology. The gap between technological demonstration and consumer knowledge was filled by exhibitions and educational efforts. In that sense, 'public' demonstrations, as opposed to expert demonstrations, were crucial in preparing potential consumers to use and pay for the technology. Bridging the distance between technological/expert demonstrations and public knowledge was particularly important because the adoption of a residential solar PV system required users to welcome new technological appliances into their private living spaces, i.e. the home. A possible effect

---

[56] Kimura, "Taiyōkō Hatsuden Gijyutsu," 68.
[57] "Taiyō Seikatsu News", July 12, 2011, accessed July 6, 2015, http://taiyoseikatsu.com/news/201107/tn201107-06.html
[58] Espen Moe, "Vested Interests, Energy Efficiency and Renewables in Japan," *Energy Policy* 40 (2012): 260–273.
[59] Kimura and Suzuki, "Taiyōkō Hatsuden Gijyutsu," 81.
[60] Michael Rogol, "Why Did the Solar Power Sector Develop Quickly in Japan," unpublished Master thesis, Massachusetts Institute of Technology (2007).

of long-term development can be found in the link between the early penetration of solar water heaters and the later adoption of solar PV panels. Only two decades separate solar hot water from the age of PV technology. This is especially true in agrarian areas, where the solar water heater penetrated strongly in the 1950s and 60s. A survey conducted in 1994 on the profile of solar system purchasers found that there was an unmistakable correlation between the ownership of a solar water heater and the purchase of a solar PV system.[61] This might indicate the importance of the familiarity factor in adopting alternative energy (even though, strictly speaking, solar water heating and solar PV were different technological applications).

If familiarity was a factor in creating demand in the PV market, the public's encounter with solar PV technology at public events needs to be taken more seriously. Even the somewhat misdirected celebration of Nio's Solar Expo helped prepare consumers for the new era of renewable energy. In fact, Kagawa prefecture, where Nio is located, saw a strong penetration of PV panels in the 1990s.[62] Admittedly, it is impossible to determine, at least in objective terms, the effect of public exhibitions on the later adoption of solar technology, but it is highly likely that witnessing the technology at exhibitions and showrooms made it easier for consumers to accept the idea of adding PV panels to their roofs. A 1994 energy opinion poll showed that the public regarded solar energy as 'the form of energy that would bring the greatest benefit to the country'. Nuclear energy came second, followed, by a considerable margin, by hydro, petroleum, wind and other types of energy.[63] The general preference for solar energy cannot be solely attributed to considerations of its environmental benefits, as the respondents' ratings of other renewables – wind, ocean, hydro and geothermal energy – were quite low. The high expectations for solar and nuclear energy at the time may have been the result of public exhibitions because these two forms of energy were most frequently featured in Japan's energy exhibitions in the late 20th century. Exhibitions like the Nio Expo (there were similar events, bigger and smaller than Nio Expo, featuring solar energy) provided a link between the state's scientific projects and the public knowledge. While these demonstrations and exhibitions drew heavily upon

[61] Masanao Iuchi, Akira Konakayama, Toru Ohkawara, and Tomoko Tsuchiya, "Jyūtaku Taiyōkō Hatsuden System no Dōnyū ni kansuru Ishiki Bunseki," CRIEPI Research Report Y96004 (1996), 15.
[62] "Nendobetsu Todōfukenbetsu Jyūtakuyō Taiyōkō Hatsuden Sisutemu Dōnyūjyōkyō", accessed July 5, 2015, http://www.solar.nef.or.jp/system/html/taiyou_sys080421.pdf
[63] Research Organization for Information Science and Technology, "Enerugī/Genshiryoku ni kansuru Yoron Chōsa," 1994, accessed November 3, 2015, http://www.rist.or.jp/atomica/data/dat_detail.php?Title_No=10-05-01-04

positive images of solar energy as clean and plentiful, they also helped to establish solar energy as the preferred energy of the future. From the long-term view presented in this paper, the solar PV market's take-off in 1990s Japan cannot be attributed to a sudden conversion of the country's energy users towards solar energy as an ecologically modern energy choice; furthermore, these energy users were not simply lured by the (not very attractive) economic incentives. Rather, it was the grounded on a historical development, a process in which future users of the technology were not totally excluded. Consumers witnessed and sometimes even experienced the solar PV technology in demonstrations and exhibitions well before solar panels were sold in consumer markets. Thus the solar PV market in Japan in the 1990s was the result of interactions, that spanned nearly half a century, involving technology, demonstrations, exhibitions and consumers