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Renewable Energy vs. Nuclear Power: Taiwan's energy future in light of Chinese, German and Japanese experience since 3.11 再生可能エネルギー対原子力—3.11以降の中国、ドイツ、そして日本の経験に照らして台湾のエネルギー政策を考える

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Abstract

This article reviews the current debate in Taiwan over the future of nuclear power in the country's energy mix. Rather than debate a pro- or anti-nuclear stance, the authors develop the argument that Taiwan has more to gain in promoting renewable energy industries than in sticking with the nuclear option, both in terms of energy security and of building export platforms for tomorrow. Taiwan is justifiably proud of its achievement in building three 'pillar industries' in semiconductors, flat panel displays and PCs. Now it should be getting ready to add a fourth pillar industry, of comparable success – concentrated solar power (CSP) plants, solar PV, wind power, and wider renewable energy sources industry – utilizing all the institutional and entrepreneurial strategies perfected in Taiwan's earlier development.

Introduction

Taiwan is presently wracked by debate over the prospect of a referendum on the country's Fourth Nuclear Power facility, currently under construction but subject to a ban on further works. The debate is focused on the risks of nuclear power on an earthquake-prone island (with reference to the Fukushima disaster in Japan) and the supposed cost of moving off a nuclear trajectory in terms of electricity prices and reliability of supply. It has also become side-tracked by a long debate over the legalities of the referendum process in Taiwan, and whether the present government is to be trusted in the framing of the referendum question(s).

What is missing in this debate is the recognition that Taiwan has more to gain in promoting renewable energy industries than in sticking with the nuclear option, both in terms of energy security and in terms of creating jobs and building export platforms for tomorrow. Taiwan is justifiably proud of its achievement in building three 'pillar industries' in semiconductors, flat panel displays and PCs. Now it should be getting ready to add a fourth pillar industry of comparable potential success – concentration solar power (CSP) plants, solar PV, wind power, and wider renewable energy sources – utilizing all the institutional and entrepreneurial strategies perfected in Taiwan's earlier development.

The model for such a strategy is close to hand. In China we find the world's most strenuous and dedicated promotion of renewable energy industries, in an extraordinarily successful industrial policy. Renewable energy industries were considered playthings – marginal players – until China got serious in promoting them, in the mid-2000s. In one sector after another – first in wind, then in solar photovoltaics (PVs), tomorrow probably in concentrated solar power (CSP) – China has been pursuing relentless promotion of a 'green' option to balance, complement, and eventually replace its pursuit of a 'black' coal and oil-fired option. Its industrial policies, grounded in the need to build energy security and reduce reliance on costly fuel imports from troubled countries, have been spectacularly successful, as it has exported its renewable energy products all around the world. But China is also exporting its green development 'model' to other countries such as India and Brazil, and it is now being emulated as well by advanced countries such as Germany.

China's relevance as an energy model for the Taiwan nuclear debate is clear. China not only has an effective industrial policy to support the development of new industrial sectors such as renewables, but it is also effectively promoting the drastic upgrading of the grid to make it able to accommodate a variety of decentralized renewable inputs, through investments in IT (a smart grid) and high-tension long-distance HVDC power lines (a strong grid). The power lines are needed to allow power to be generated from renewable wind and solar sources in the west of the country and transmitted over 2000 km to the eastern seaboard. The state-owned China Grid Corporation sees these upgrades as promoting energy security, resilience and lower priced power for the whole of Chinese industry. This is a very different perception of the future from that of Taipower and some Taiwan big firms, which anticipate that renewables will be costly and unreliable. China knows full well that the opposite is the case.

In this article we first review the nuclear option in Taiwan, focusing on its real industrial drivers, and then sketch an alternative development pathway that would build a fourth system – not a fourth nuclear reactor but a fourth pillar industry of renewables. We will provide evidence for the salience of this alternative pathway in terms of activities and investments currently under way in China and Germany (where the non-nuclear energy revolution is well advanced, termed the *Energiewende* or *Energy Transition*), and use these to rebut the usual claims made to minimize the contribution that renewables could make. We frame our arguments in terms of industrial strategy (something that Taiwan understands very well) rather than climate change and carbon emissions – although it is a very fortunate implication of the strategy that we advocate that it is also a low-carbon strategy and one that will garner much international support for Taiwan. Finally, we depict the green option as one that could provide a new national development goal for Taiwan involving its high-tech institutions such as ITRI and the Hsinchu Science Park and its extensions in the Central and Southern parks, and building on the achievements already recorded, to give the people of Taiwan a sense of possessing a strong future. This is very different from the climate of fear and insecurity projected in the current pro- vs. anti-nuclear debate that is engulfing the country.

The nuclear debate in Taiwan

Taiwan's nuclear industry is four decades old; construction of the first reactor began in 1972. The country's six nuclear reactors now provide 19% of Taiwan's electric energy, from a capacity base of 4.9 GW, or 11% of Taiwan's installed power generating capacity. Altogether there are six reactors, operating at three sites – Chinshan 1 and 2; Kuosheng 1 and 2; and Manshan 1 and 2. Two of the reactors are Westinghouse pressurised water reactors (PWRs) and four are General Electric (GE) boiling water reactors– the kind that succumbed at Fukushima in Japan. The reactor designs date from the 1950s. The fourth nuclear facility projected, at Lungmen [Gongliao, New Taipei City], is designed to consist of two 1350 MW Advanced Boiling Water Reactors (ABWR), sourced once again from GE-Hitachi (reactors) and from Mitsubishi (turbines). While ABWR technology is Generation III, apart from the contracting business involved in actually building the reactor, there is very little Taiwan contribution or spin-off from the technology. No doubt there has been considerable pressure from

American sources to ensure that Taiwan continues to implement US-made nuclear technology. This is where the contrast with a 'Taiwan-first'renewables industrial strategy would be most telling.

The nuclear facilities are all operated by Taiwan Power Company (Taipower), the state utility with monopoly control of generating facilities. Taipower is clearly deeply committed to nuclear power – and so if Taiwan is to pursue an industrial strategy independent of nuclear power, then alternative entrepreneurial sources need to be developed. This too would be an important aspect of developing a domestic Taiwan market for renewable energy sources, through the use of instruments such as feed-in tariffs, which have proven their worth in Germany and are now being trialled in a serious way in China and, on a smaller scale, in Japan.

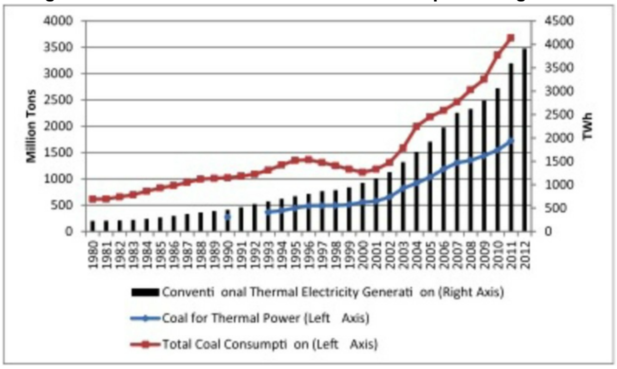
The contribution of renewables to Taiwan's current energy mix is woefully low, making Taiwan a severe laggard in moving to a new green development model. Power generation in 2012 involved over 99% reliance on fossil fuels and nuclear. This is a sorry record that does not stand up to comparison with China and Germany, as we demonstrate now.

China's energy strategy

Taiwan need look no further than China to see a powerful model of an industrial strategy focused resolutely on building green renewable energy industries as a means of promoting energy security and export-oriented industries of tomorrow. The green aspect of China's strategy complements its build-up of 'black' energy industries in the short run. More important, China's rapid build-up of renewable energy industries and projected phase out of reliance on fossil fuels – within the next couple of decades – has captured the world's attention. China's motives for effecting this energy industrial revolution have more to do with national energy security than any concerns over the global environment (although these concerns are certainly prominent). Just what is driving China's energy strategy?

Charts 1 and 2 tell the story in terms of electric power generation (which accounts for 50% of China's carbon emissions).[1] The first reveals that China has been building a vast electric power 'machine' rated at more than 1 TW by 2011, and generating close on 5 trillion kWh by 2012 – of which 3.9 trillion kWh came from burning coal. The serious build-up in energy capacity began after China joined the WTO in 2001. The steep upward curve in coal consumption and energy production since 2001 is evident.

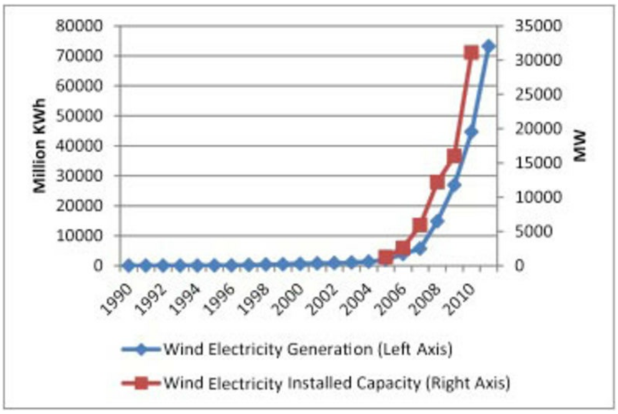
Fig. 1. China's black face in power generation



Source: Mathews and Tan

At the same time, China has been building up its renewable energy industries – initially hydro as the main source, and to some extent nuclear (slowed after Japan's Fukushima disaster), but increasingly, wind and solar. Chart 2 shows that China's build-up in wind power started around 2005 and doubled every year, becoming by far the largest wind power practitioner in the world in terms of its production of turbines and their installation in wind farms. (Electricity generated is shown on the left axis (million kWh) and electric power capacity on the right axis (MW). China's wind power companies, including Goldwind, Sinovel and the latest, privately-owned addition, Ming Yang, are now globalizing at a rapid rate, and moving to the top of the world's leading wind energy companies. China's wind power companies are indeed moving rapidly from imitation to innovation.[2]

Fig. 2. China's green face: Chinese build-up of wind power



Source of primary data for Figs 1 and 2: U.S. EIA International Energy Statistics Database; for coal consumption, National Bureau of Statistics, China

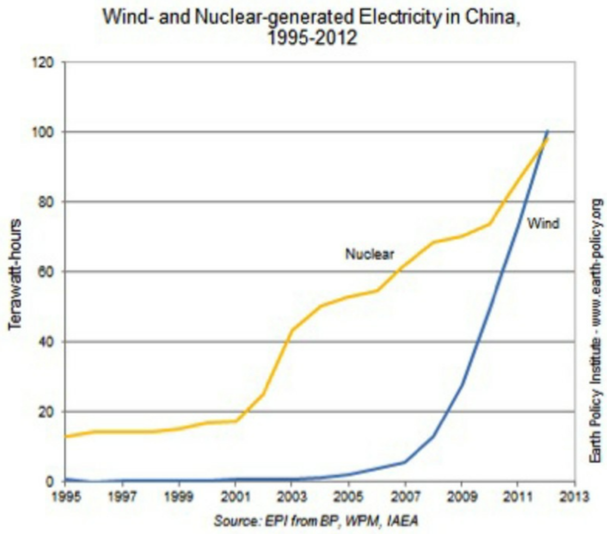
A similar story can be told for solar photovoltaics, where early leaders (some of whom are now in financial difficulties) are being joined by later arrivals such as Hanergy and Giga Solar, which are growing and globalizing rapidly. China has yet to make its mark in concentrated solar thermal, but initial interest could rapidly translate into world leadership, taking over from Spain. Indeed the National Development and Reform Commission (NDRC) has recently set a target of China adding 3 GW of CSP capacity by 2015 (more than doubling global capacity to this point) and up to 10 GW by 2020 – meaning that CSP technology would be driving down the cost reduction curve as production expands – with beneficial results for China and for other countries looking to involve themselves in renewables. Taiwan should be among them.

While the choice between nuclear and 'new' renewables has not yet been made definitively in China (as it has in Germany, to be discussed in a moment), it is clear where the trends are taking China. In Fig. 3 we compare electricity generated from nuclear with that from wind power, demonstrating that wind surpassed nuclear in 2011. Even if grid-connection for wind power in China is problematic, China's targets are for an ever-increasing proportion of electricity to come from wind, far surpassing whatever might be derived from nuclear sources.

Strong and smart grid

China is not just building new energy-generating products (and energy-efficiency improving systems) but is also investing vast sums in updating the electric power grid to accommodate a variety of such sources. China calls this the 'smart and strong' grid, in that it will be IT-enabled and be able to carry prodigious quantities of electric power from the deserts of the west, where wind and solar power abound, to the eastern seaboard, through new High Voltage Direct Current (HVDC) cables. The targets for investment in grid upgrading by the State Grid Corporation of China (SGCC) are emblematic of the huge push being made to accommodate renewables. SGCC is the world's largest utility, and one of the 10 largest companies worldwide – yet it is still barely known outside China.[3]

Fig. 3. Wind- and nuclear-generated electricity in China, 1995-2012



Source: Earth Policy Institute ([link](#))

The major element of China's upgrading is the building of long-distance power lines utilizing advanced HVDC technology, which loses much less power in transmission than conventional AC lines. In Fig. 4 we reproduce a chart from China that shows how the grid will change as the SGCC investments are implemented. The upgraded grid will have several east-west and north-south 'trunk routes' for carrying ultra-high voltage cables (depicted as red and blue). Clearly provinces that are not depicted as being connected to these HVDC long-distance links will nevertheless be connected to the upgraded grid. And the grid can be expected to be modular and cellular, making it eminently robust and resilient. China clearly sees vast new business opportunities opening up with its smart grid, and is already gearing up the technical standards that will fashion international competition in this sector.

Fig. 4. China's projected strong and smart electric power grid

Source: the State Grid Corporation of China (SGCC), available at Caixin.com

There are several reasons to expect that these changes unleashed in China will be permanent and will lead to still further changes favouring renewables over both fossil fuel and nuclear power systems. The first concerns industrial dynamics. China's build-up of renewables is unlikely to follow a simple linear progression, and instead can be expected to follow logistic, or S-shaped, industrial dynamics. This means that as investments in renewable systems accumulate, they will become self-reinforcing, and lead to further such investments as they drive down the price. Taiwan has direct experience of this process in the way that its build-up of the semiconductor, flat panel display and PC/IT industries all followed logistic industrial dynamic pathways.

Other countries have built renewable energy markets – such as Germany's efforts to enhance consumer demand for renewables via feed-in tariffs. But China has, from the start, focused on **building the industries** that produce renewable energy systems; together with the value chains of components and materials suppliers. The 12th Five Year Plan states explicitly that China's seven targeted industries for its clean technology revolution will account for 8% of GDP by 2015, rising to 15% by 2020 and expanding rapidly thereafter. Only Korea has formulated a comparable green growth industrial strategy, focused on the building of green industries as platform for the future. In these comparisons, Taiwan lags far behind.

Now the remarkable thing is that China is not alone in effecting an energy revolution. It is being paid the compliment of emulation by none other than Germany, pre-eminent industrial power of the EU, with its *Energiewende* ("energy transformation"), through which nuclear power is being phased out and renewables are being installed at a rapid rate.

Germany's *Energiewende*

The Fukushima nuclear disaster struck Japan on March 11, 2011. While Japan was still clearing away the rubble, Germany was already rebuilding its energy system. Within a month the Chancellor, Angela Merkel, had reversed an earlier decision in favor of slowly phasing out nuclear power, and in June the German parliament voted to abolish nuclear power altogether. This marked the beginning of the most fundamental transformation in energy infrastructure unleashed by any advanced industrial power.

Nuclear power is now a dead issue in Germany. Generation of nuclear power still accounted for 16% of total German electricity in 2012 – but it is falling (down from 17.2% in 2011) and will continue to fall. Seven reactors were shut down immediately as a result of the Chancellor's announcement. No new reactors are to be brought on stream, and all existing reactors will have been completely phased out within ten years. Following the turnaround on this issue by the Christian Democrats and Chancellor Merkel, there is no longer any political support for reviving the nuclear industry in Germany.

To plug the gap, renewables are being ramped up at a tremendous pace. Generation of solar PV electricity increased 48% to 27.6 TWh in 2012, while wind power held steady at 46 TWh – making for 11.9% of all electricity in 2012. Other renewables (bio and hydro) also increased, meaning that total renewables rose to 21.9% in 2012 – and they are rising fast. The proportion of renewables in capacity additions for 2012 is much higher – indicating that renewables will be taking more and more of the load. It is notable that Germany's promotion of renewables has moved on from market expansion policies (like feed-in tariffs) to industry promotion policies – taking a leaf out of China's book. German industry supports this shift.

True, in the interim there are 'bridging' power arrangements that have involved marginally more coal being burnt – with brown coal (lignite) rising 1% to 25.6% of German electric power generation in 2012, and black coal rising 0.6% to 19.1%. Coal thus accounts now for 44.7% of electricity – but it is destined to fall quickly as the renewables are ramped up, and fewer new coal-fired power stations are envisaged. Gas has been forced out of the German (and mostly European) electricity market because of high prices, and because there has been no 'fracking' revolution (as yet) in Europe. To claim that the *Energiewende* means simply that more coal is being burnt – and more carbon emitted – is to miss the point that fossil fuels are marked for elimination.[4]

As in China, the national power grid is being drastically upgraded, to enable it to accommodate higher and higher levels of fluctuating (renewable) power sources. Official estimates are that 20 billion Euros will need to be invested in grid upgrading over the course of the next decade, with the Bundestag opting for three major north-south connections to be built first – consisting of high-voltage (380kV) lines.[5] Installing and equipping the smart grid is recognized as the huge new growth opportunity in Germany.

So there is no doubting the scale of the changes unleashed by the *energiewende* – and their long-term impact. Within the next decade Germany will have shifted from a coal-and-nuclear powered industrial economy with four large, centralized power producers to a thriving, decentralized system generating power from renewable sources all over the country, and managing it all through a modernized and IT-enhanced smart grid. All the indications are that this is supported by German industry. There is little complaint coming from industry that this will lead to higher electricity prices or to lack of reliability in supplies (the usual arguments in Taiwan). On the contrary, it is a fossil-fuelled energy future that is seen as unreliable and prone to rapid price fluctuations.

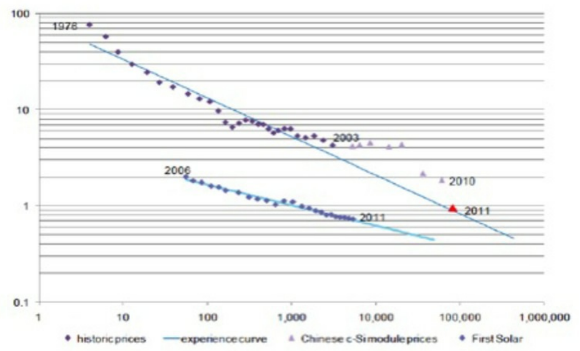
All of this is being done in the name of the low-carbon economy. Yet it is striking how quickly 'low-carbon' becomes marginalized as a goal once the industry-promotion stakes are entered. The new Green growth strategies emerging in China and Germany will prove to be far more effective at lowering carbon emissions than the Kyoto treaty with its nominal carbon reductions. And this is as it should be: the cleaning of the industrial economy was always going to be a state-mandated industry-policy driven strategy.

Declining costs – learning curves

Many governments (and international organizations) still harbour an outdated view that renewable energy, and in particular solar PV energy, is more expensive than traditional thermal (coal-fired) energy. But in reality the costs have been falling at a rapid rate. In many parts of the world the cost of generating electric power from wind or solar PV is now less than or comparable to the cost of producing power from gas, and will very soon (by 2015) be comparable with the cost of power from the cheapest, dirtiest coal.[6] The view that the choices are difficult because of the costs is now outdated.

The data that now need to be considered in framing any energy strategy are those relating to the falling costs of power produced from renewable sources. The Bloomberg/New Energy Finance team in London produced a White Paper on 'Re-considering the economics of photovoltaic power' (Bazilian et al. 2012) where they make some very important points. Consider Fig. 5 showing falling costs for solar PV over the past 35 years.

Figure 5. PV module experience curve, 1976-2011



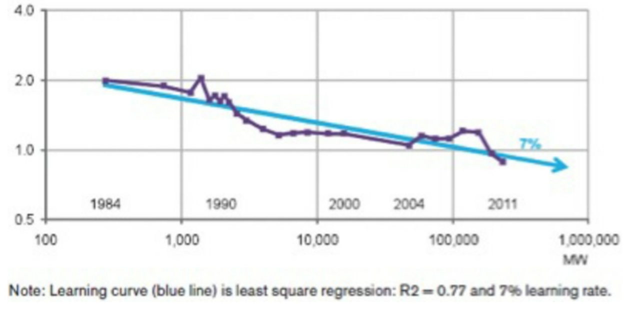
Source: BNEF Bazilian et al (2012), Fig. 1

In this chart, based on and updating the chart on experience curves contained in the recent IPCC report on Renewable Energies (IPCC 2012), the overall experience curve is shown in the upper blue line, indicating that costs had fallen to the **long anticipated point of $1 per watt** by the end of 2011, bringing solar photovoltaic (PV) power within the range of mainstream power production. The years immediately preceding this show that costs hovered for several years (2004 to 2008) at around four times this level ($4/W) – a phenomenon now understood to be due to suppliers being able to command feed-in tariff rates locked at these levels, while restricted silicon supplies meant that there was little price competition. It was this that led many to believe that costs of renewable energies would always exceed those of conventionally fuelled power. But as silicon supplies became more widely available, manufacturers reduced their prices, which in turn reduced input costs for solar cell producers, and their prices fell as well. The message is clear: the costs of solar PV cells are falling at around 45% per year.

The second blue line in the chart represents the cost curve for thin-film (TF) solar cell producers, dominated by the US firm First Solar, but now featuring Chinese firms like Hanergy which is acquiring TF PV assets around the world (e.g. Solibro from distressed Q-Cells in Germany and Mia Sole in Silicon Valley in the US). Because TF PV cells utilize much lower quantities of silicon, their costs have always been lower – but do not yet enjoy the economies of scale of amorphous silicon cells. And because TF solar cells use a production process very similar to flat panel displays, there is vast experience in Taiwan in this approach which could be exploited in building a 'next generation' thin-film solar PV industry.

Wind energy as well exhibits powerful learning curve advantages, with costs declining for onshore wind at the rate of 7%. The experience curve for wind is shown in Fig. 6, revealing how wind power is well on the way to having a generating capacity of 1,000,000 MW, or 1 TW – the size of the current entire US or Chinese generating capacity overall. As it does so, the 7% cost reduction curve will make wind power more and more attractive for countries endowed with the resource. Again, such cost reductions make it inevitable that this power source will eventually be adopted as a default option, ousting its fossil fuel competitors in areas suitable for wind power.

Figure 6. Wind costs decline, 1984-2011



Source: Bloomberg NEF

An alternative Taiwan renewables strategy

With this as background, we can now sketch a quite different strategy from the one being pursued by both political camps in Taiwan – the KMT with its pro-nuclear stance and the DPP with its anti-nuclear stance. Our approach is one that views renewables as the next 'pillar industry' of Taiwan. This is based on extending the successful Hsinchu model that has been the backbone of Taiwan success in high-technology industries.

To illustrate our proposition, let us suppose that the Taiwan government said today that the entire nuclear power fleet would be phased out over five years, and would be replaced by a series of concentrated solar power (CSP) plants, rooftop solar PV, and wind power. The scare stories are that this would cover Taiwan in photovoltaic cells and wind turbines; that it would be prohibitively expensive; and that it would be unreliable since power could be generated only when the sun shines or the wind blows. All these claims are false. The reality is that just a few mirror farms using molten salt technology as heat sink would be needed, taking advantage of the fact that China is now committed to CSP and will be driving down the costs. (See our article on CSP (co-authored with Ching-Yan Wu) at Japan Focus here) The land area needed in Taiwan would be no more than 62.5 square km (a square of sides less than 8 km) – which is as nothing when compared with Taiwan's land area of 32,260 km^2, and comparable to the land currently devoted to Taiwan's advanced science and technology parks. The Hsinchu park totals 650 hectares; the Central Taiwan park 1400 hectares; the southern Taiwan park 1608 hectares – totalling 3900 ha or 39 km^2. CSP plants generating half the entire nuclear output would occupy an area only marginally larger than this – and generate power 24/7 in a way that is infinitely more reliable and safer than the current nuclear facilities. And – this is the central point – this would catapult Taiwan into a world-leading position as supplier of CSP key technologies and equipment while creating domestic job opportunities as well. Such a strategy would also facilitate Taiwan's urgent need for industrial transformation from a lower to higher value-added innovator.

How do we get the 62.5 km^2 figure? Consider the world's currently most advanced CSP facility (in terms of scale and output), the Shams1 plant, commissioned in the United Arab Emirates that came on stream early in 2013. This is a 100 MW installation, covering 250 hectares in parabolic mirrors and tubes carrying oil for heating. (An even more advanced design utilizes molten salt as the heat conductor, as in the Spanish Gemasolar plant involving a power tower, built by Torresol; the UAE has announced plans to build CSP plants also utilizing this more advanced molten salt technology). The Gemasolar plant is shown in Fig. 7.

Fig. 7. Gemasolar power tower plant in Spain

Source: Gemasolar

If 100 MW needs 250 hectares, then 1 GW needs 10 times this (2500 ha) and 2.5 GW needs another 2.5 times (6250 ha, or 62.5 km^2). This is actual data based on current real operating conditions – not abstract or theoretical calculations. The total of 62.5 km^2 is 1/512 of the land area of Taiwan – or 0.02%. If the required land could be dispersed across several sites, and could be supplied from land currently held by the military (in the name of energy national security) there would be no land resource obstacle standing in the way of substituting the entire output of the current nuclear sector in Taiwan by CSP installations utilizing currently available technology (particularly molten salt for heat storage).[7] But of course, we do not see CSP as the sole alternative to nuclear. In practice, there would be rooftop installations all over Taiwan utilizing solar PV, as well as (off-shore) wind power and other sources, together with upgrading of the grid to accommodate these fluctuating sources comfortably.To supply 2.5 GW of electric power from rooftop solar PV would be well within the capacity of the Taiwan solar PV industry. It is also the goal of the Taiwan government – which would need only modest market development stimulus policies such as feed-in tariffs to translate this into actuality.[8] Integrating the CSP, rooftop solar PV, and wind turbines together simply demonstrates the ways in which Taiwan could fruitfully move off the nuclear pathway.

Extending the Hsinchu Model

Taiwan's high technology industrial success rests on a capacity to leverage resources and pursue a strategy of rapid catch-up; it is what we have called a 'fast follower' strategy, aimed at providing complementary capability (i.e. process innovations) for the international leaders that excel in product innovations -- along the whole value chain. Taiwan's firms tap into advanced markets through various forms of contract manufacturing at the beginning, and are able to leverage new levels of technological capability from these arrangements so as to create a market niche and become (process) innovators in the global value chain.[9] This is an advanced form of *technological learning*, in which the most significant players have not been giant firms (as in Japan or Korea), but aggregated small and medium-sized enterprises whose entrepreneurial flexibility and adaptability enabled their specialization at each stage of the value chain. The *collective* process innovations composed of the flexible and specialized supply chain as a whole became the key to Taiwan's success. Underpinning this success were the efforts of public sector research and development institutes, such as Taiwan's Industrial Technology Research Institute (ITRI), and the creation of the Hsinchu Science park.

Hsinchu Science Park

Since its founding in 1973, ITRI and its laboratories have acted as a prime vehicle for the leveraging of advanced technologies from abroad, and for their rapid diffusion or dissemination to Taiwan's firms. This cooperation between public and private sectors, to overcome the scale disadvantages of Taiwan's small firms, is a characteristic feature of the country's technological upgrading strategies, and the creation of new high technology sectors such as semiconductors. We see ITRI as playing a central role in helping to build Taiwan's next step to a 'green development' industrial strategy.

Hsinchu itself was a conscious attempt on the part of the Taiwan government to seed a new kind of advanced technology cluster, with the government playing the role initially of collective entrepreneur, both in leveraging technology from likely sources (particularly in Silicon Valley) through the institutional vehicle of ITRI, and in leveraging venture capital, again through vehicles initially established expressly by the Taiwan government. The steady hand of government as collective entrepreneur is needed to make the breakthroughs necessary, and to provide the 'new shoots' (*hsinchu*) of industrial development to maintain the pressure in the long process of change from imitation to innovation, and from contract manufacturing to full-branded enterprise – as well understood in East Asian countries including Taiwan.[10]

In China the influence of the Hsinchu model is unmistakeable. All the Chinese high-tech industrial parks – from Suzhou to Tianjin to Beijing and Shanghai – treat the Hsinchu approach to collocation of flagship firms, plus complementary suppliers and design firms, with national R&D institutes and leading universities, combined with access to venture capital and various kinds of government-mandated subsidies, tax concessions and inducements, as a template.

If the 1980s was the founding decade for Taiwan's move up the value-added ladder to encompass industries such as electronics, IT and semiconductors, and the 1990s was the decade when the IC industry flourished in the Hsinchu park, followed by the flat-panel display industry flourishing in the following decade, then what of the 2010s? There are already clues as to the new direction to be taken in Taiwan – in the form of new R&D alliances and industry promotion efforts in such sectors as solar photovoltaic cells (PVs) and concentrated solar power (CSP) systems, in Electric Vehicles (EVs) and associated energy storage (e.g. lithium-ion batteries), in energy-efficient lighting (e.g. LEDs) and other energy-efficient optoelectronic systems(PVs and LEDs) are perfect complements: one converts light into electric current, the other converts electricity to light; they also share several manufacturing steps.[11] What is common to all these sectors is a new focus on renewable energy and energy efficiency, combined with new industries for a low-carbon emissions future.

So far there are promising signs of 'new shoots' in these directions – but not yet any sense of a comprehensive commitment on the part of the Ministry of Economic Affairs (MoEA) and its IDB to launch a new industrial revolution in Taiwan, one that will take the island's industries beyond the 20th century and into a new low-carbon emitting, energy-efficient and renewable energy system – or 'green business' for the new century.

What the new industrial paradigm would require is not just promotion of new industries (as is being done for solar PVs, LEDs and EVs) but promotion of a domestic market as test-bed for the new products and services. Here it has to be said that Taiwan is lagging behind its giant competitors including China, Germany and Japan, in the formulation of such conceptual tools as the Feed-in Tariff needed for an energy industrial revolution. All of this would encourage entrepreneurial initiative and creativity in the service of building a new industrial system for the 21st century, one that is expanding in terms of opportunity while maintaining a sustainable relationship with its natural setting – an economy of sustainable enterprise. Here is a grand project for Hsinchu and the new Science-based industry parks to focus on for the next decade and the following century.[12]

In summary, our vision for Taiwan is neither pro-nuclear nor anti-nuclear. Our vision is pro-green, and we urge that the country's existing institutions and development experiences be utilized in fashioning a new green development model that will both solve Taiwan's power and energy problems and also create a technology and production platform for the next century. From the perspective of a decade hence, when Taiwan could be expected to have a thriving solar PV industry and a concentrated solar power industry, as well as a world-class smart and strong grid, the current debates over the nuclear option will seem irrelevant.

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• Andrew DeWit and Sven Saaler, Political and Policy Repercussions of Japan's Nuclear and Natural Disasters in Germany

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Notes

[1] See the contribution by John Mathews and HaoTan to *Asia-Pacific Journal*, in December 2012, here.

[2] For example, Sinovel's direct traction wind turbines, eliminating the use of gears, are cheaper and more reliable than their more complex competitors.

[3] SGCC has committed 4 trillion yuan investment over the course of the 12th and 13th Five Year Plans (i.e. up to 2020) – that is around US$642 billion, far more than is projected by any other country.

[4] Europe's dirty secret: The unwelcome renaissance, *The Economist*, Jan 5th 2013, here.

[5] Dagmar Dehmer, 'The German Energiewende – the first year', *The Electricity Journal*, Jan/Feb 2013 (26 (1)): 71-78, here.

[6] The Deutsche Bank has lent its name to such a prediction; see Becky Beetz, 'Deutsche Bank – Sustainable solar market expected in 2014', pv-magazine, 28 Feb 2013, here.

[7] Although Taiwan does not appear on world charts on the most insulated regions best suited to CSP, the technology has been shown to work extremely well in temperate zones that are much cooler than Taiwan. In any case, observed solar irradiance in Taiwan under less than ideal conditions is 1000 kWh/m2, which is well above the 5 kWh/m2 considered a minimum level of irradiance. See Chang (2009).

[8] In 2012, the MOEA launched the 'Million Rooftop PVs and Thousand Wind Turbines'program, aiming at installing 3GW rooftop PVs and 4.2 GW wind turbines by 2030.

[9] One of the key examples is Foxconn, the world's No.1 EMS (Electronic Manufacturing Services) company, which specialized first in OEM activity, and eventually came to leverage and recombine various resources to build its niche in optimizing supply chain efficiency (e.g. global sourcing, logistics, and sales service management) in the global electronics industry.

[10] The shift up the value curve from OEM to ODM to OBM has stalled at several junctures in Taiwan, and this remains the single biggest obstacle to further industrial advance on the island. Chinese firms are able to utilize their global reach to build (or acquire) global brands, but this avenue has not been available to Taiwan firms, as yet. For a discussion of the issues involved, see Chu (2009).

[11] On the emergence of Taiwan's solar photovoltaic (PV) industry, in comparison with what is happening in China, see Mathews, Hu and Wu (2011).

[12] The Ministry of Economic Affairs has announced substantial programs for support of low-carbon industrial initiatives (e.g. MoEA Green Energy Industry Promotion program) and new Greenhouse Gas emissions reduction targets. But the targets for renewable energies (e.g. 3 GW for wind power by 2015) are puny compared with comparable targets being set in China, and Taiwan remains dependent on fossil fuels for over 99% of its primary energy requirements. One major obstacle to modernization and decentralization of the grid appears to be the monopoly position of the State-owned power company Taipower.

DeWit in AJP Japan Focus (here) shows well the tremendous the Japanese electric power giants, above all TEPCO . . . but he also shows how local governments and smart private capital have been moving ahead.