

Taiwan's Green Energy Transition Under Way

Justin Chou, John A. Mathews

Abstract: The main elements in Taiwan's green power shift are reviewed, with focus on developments since the election of the DPP government in early 2016 and its commitment to phase out nuclear power in Taiwan by 2025. The drivers of the shift are identified, concentrating on solar PV power and the potential for offshore wind power. Like other countries in East Asia similarly pursuing a green shift, Taiwan is as much concerned with the business and export prospects for green industry as with reducing carbon emissions. The argument is developed that further progress in Taiwan is linked to liberalization of the electric power sector, creating genuine competition for the quasi-monopoly, TaiPower.

Keywords: Taiwan; renewable power; anti-nuclear; WWS (water, wind and sun); smart grid; electric power liberalization

Since the election of the DPP government led by Tsai Ing-wen, in Jan 2016, the goal of an energy transformation in Taiwan has been pursued vigorously. The most significant element of the shift is the phasing out of nuclear power, guided by the oft-repeated policy of achieving a nuclear-free homeland by 2025. But politics is never easy, and a major power outage in August, lasting for five hours, and caused by malfunction of a gas supply valve in a gas-fuelled power generator, prompted widespread debate and recriminations. Both the Minister for Economic Affairs (Lee Chih-kung) and the Chairman of the gas supply company CPC Corp. (Chen Chin-te) resigned in order to take symbolic responsibility for the disastrous incident.

Nuclear-powered electricity generation has

already shown signs of a sharp reduction, down from 400 TWh in 2015 to 300 TWh in 2016, and anticipated further reductions to zero by 2025 as no new starts are to be allowed. But debate over the possible future of nuclear power in Taiwan continues, and the power outage in August (the '815 incident') has prompted calls for the restart of nuclear reactors that have been shuttered.

The DPP government has pursued a strong commitment to raising the contribution of green sources (meaning: power sourced from water, wind and sun) to electric power generation. In proportional terms the contribution from WWS sources has risen from 4.8% in 2015 to 6.6% in 2016 (including 1.5% of pumped hydro storage), with a target of 20% to be reached by 2025, i.e. over the next eight years. Excluding nuclear, this is planned to come largely from a strong expansion of the solar PV sector, being raised from a capacity of 1.3 GW in 2016 to 20 GW by 2025. Over the same period wind power is to be raised in capacity from 755 MW to 4200 MW (4.2 GW). But again complexities in approvals processes mean that progress in actually installing the new capacity for solar PV and wind power is slow. It was a welcome development when a new offshore wind farm, the Formosa1 project, saw turbines installed and delivering power to the grid. Taiwan has attracted support from foreign renewable energy companies, notably the Danish energy giant DONG Energy as partner in the new Formosa1 wind farm project.

The DPP government has an energy security policy commitment which focuses on natural gas as interim bridging fuel while nuclear is

wound back and renewables are wound up – more or less as in the case of Germany’s energy transformation (Energiewende) program. The contribution of coal is to be wound back, with its proportional contribution being lowered from 45% down to 30% of electricity generated by 2025, while gas is seen as the bridging power source and is projected to peak at 50% of power generation by 2025.

The arresting feature of Taiwan’s green shift is that it is part of a comprehensive industrial strategy that sees new industries and innovation as the driver of the next phase of Taiwan’s industrial development. The present government’s strategy has morphed into what is called the ‘5+2’ industrial innovation plan. The aim is to shift Taiwan’s industrial base, which is still very strong in manufacturing industry, away from traditional reliance on contract manufacturing and focus instead on higher value-added service and green oriented business models. President Tsai’s election campaign in late 2015 had as one of its central elements the anticipated promotion of ‘Five Pillar Industries’ to drive growth in the future – the Internet of Things (IoT) (also known as the ‘Asian Silicon Valley’ project), biomedical industries, green energy, smart machinery and defence. Since the election of the DPP government in January 2016 the focus has broadened to encompass two new concepts, namely a ‘new agricultural paradigm’ and the ‘circular economy’ so that the project became known as the ‘5+2’ industrial strategy. It has since broadened even further to encompass the digital economy and cultural innovation – but the name ‘5+2’ remains. Taiwan is distinctive amongst industrial powers in its clear conception of linking green energy and wider economy goals with industrial development strategy.

Meanwhile there are moves to further liberalize Taiwan’s electric power market, reducing the monopoly control of Taiwan Power Co. (TaiPower) with its legacy commitments to

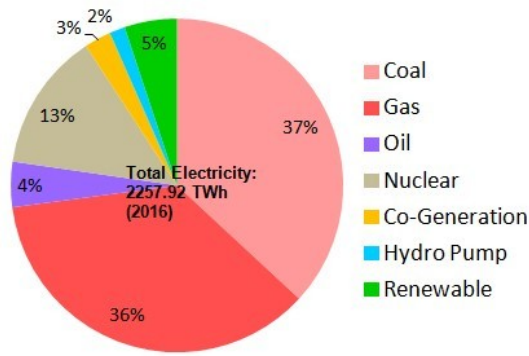
nuclear power and fossil fuels, in a bid to promote green entrepreneurial initiatives and innovation in the power sector.

Taiwan thus presents a fascinating case of the global green shift that is underway, where the commitment to move to a green power system is reinforced by a political shift to the DPP, and the government is taking every possible measure to strengthen its green shift with supportive industrial strategy aimed at building innovative green industries for the future. In this sense Taiwan is pursuing a renewable energy strategy that is common across East Asia – in China, Japan, Korea as well as Taiwan. To borrow the phrase used by DeWit in relation to Japan, this may be termed a strategy of building ‘energy resilience’.²

Clean energy targets: Green shift in electric power generation

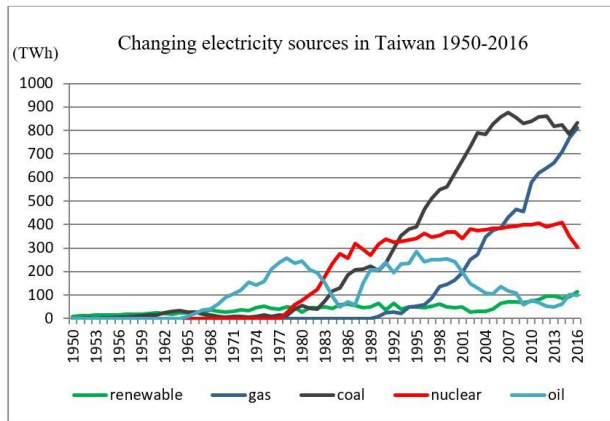
The situation in terms of electric power generation in Taiwan in 2016 is shown in Fig. 1 – the situation at the start of the country’s green shift. The legacy of thermal power (burning fossil fuels) and nuclear is clearly strong. Total power generation in 2016 amounted to 2257 TWh (or billion kWh), with 37% coming from coal and 36% from gas. The changes in Taiwan’s electric power generation, and anticipated changes in capacity, are shown in Figs. 2 and 3. and Table 1. Fig. 2 depicts the history of the changes in power sources and Fig. 3 the new renewable energy targets for 2025 (i.e. in 8 years’ time), in the proportions as anticipated and in the amounts generated, assuming only marginal growth in electric power generation overall due to efficiency improvements and direct solar power generation.

Figure 1. Taiwan’s electricity generation, 2016 Source: Based on data from TaiPower



Source: Based on data from TaiPower

Figure 2. Changing electricity sources in Taiwan, 1950-2016 Source: Based on Taiwan Power Company historical data, re-organized by Justin Chou



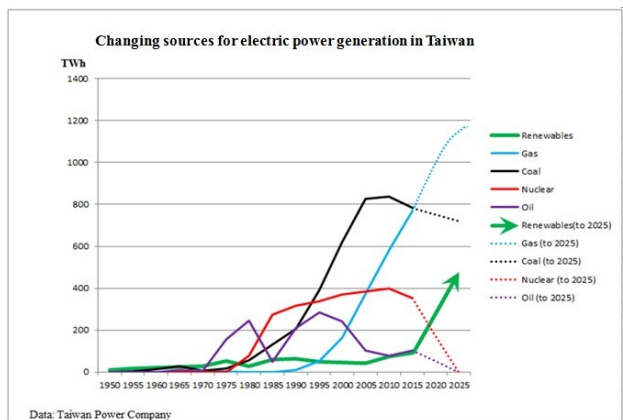
Source: Based on Taiwan Power Company historical data, re-organized by Justin Chou

Table 1. Renewable energy capacity expansion target, by Taiwan Bureau of Energy

Unit: MW				
Energy Source	2015	2016	2020	2025
Solar	842	1342	8776	20000
Inland Wind	647	747	1200	1200
Offshore Wind	0	8	520	3000
Geo Thermal	0	1	150	200
Biomass Energy	741	742	768	813
Pump Hydro	2089	2089	2100	2150
total	4319	4929	13514	27363

Figure 3 depicts the anticipated proportions in 2025, and probable actual generation levels, based on what we assume to be total generation in that year of 2400 TWh. This is plausible if consumption growth is constrained by energy efficiency measures and growth in direct solar photovoltaic (PV) generation.

Figure 3. Changing sources for electric power generation in Taiwan, 1950-2016



In October 2016 the Taiwan government (Executive Yuan) issued short-term targets for solar PV growth and again in June 2017 for wind power. The solar PV program is to be phased out over two years, raising solar PV capacity to 1.5 GW. Measures are to be taken

to release land needed for the development of solar PV farms, including rooftops in public buildings owned by the central government, factories, farms and agricultural production facilities, land used by the salt industry, aquatic areas such as reservoirs, irrigation ponds, fish farms (collectively known locally as 'floatovoltaics') and landfills. The program will also be addressing planning and regulatory controls that are inhibiting rapid shift to solar PV power.³ In addition to the national policy goals there is strong promotion of renewables at municipal level, particularly by Taipei, Tainan, Kaohsiung and Taoyuan local jurisdictions.

Wind power is to be promoted under a four-year plan that aims at enhancing domestic demand and taking a balanced approach to both onshore wind and offshore wind power. The target is to reach an extra capacity of 3 GW offshore wind power and 1.2 GW in onshore (land-based) capacity, making 4.2 GW of wind power over the period 2017 to 2020, and calling for investment of NT\$610 billion (US\$19.2 billion). In keeping with the tradition of formulating pragmatic industrial policies in Taiwan, the offshore wind power program is to be supported with promotion of special purpose piers and industrial zones in ports, by fleets of construction ships for building the offshore wind turbines, better grid connections via submarine cables and landing points, as well as harmonizing of offshore power regulations, standards and third-party certification.⁴

These programs are designed to connect with programs that go back to those of previous governments including the 'Thousand wind turbines and million solar roofs' project, under which feed-in tariffs are offered to promote household adoption of solar PV rooftop power.

The green shift industrial strategy

As noted above, Taiwan is distinctive in pursuing a green shift that is underpinned by a strong industrial policy. According to the New

Energy Policy, the Executive Yuan of Taiwan has taken decisive action in short term and long term strategy designed to achieve a non-nuclear homeland by 2025.⁵ This has included stabilizing thermal power supply with better efficiency, adopting demand respond (DR) and price differentiation on electricity, and planned reductions in energy consumption levels. In the medium - term, natural gas power generator will play the role of bridging fuel and will be expected to peak at 50% of power generation. Overall renewable energy sources are anticipated to reach 20% of the power generation by 2025. To achieve this goal, smart grid and metering have to be implemented and large energy storage solution such as more hydro pump is required.

By having a goal of strengthening the industry of Taiwan, MOEA aims to increase the manufacturing GDP share of green energy and emergent technology to 30% of total manufacturing in Taiwan by 2020⁶, which was only 4% in 2008. The Taiwanese government aims to export its green energy total solution worldwide to boost economic growth by first setting up large demonstration sites and creating a domestic market before seeking to penetrate foreign markets.

The green shift in Taiwan is being pursued across a number of fronts. Let us review progress made in the following sectors: manufacturing of solar cells; the Shalun greentech industrial park; green transport; smart grid promotion and liberalization of the electric power sector.

Manufacture of solar PV cells

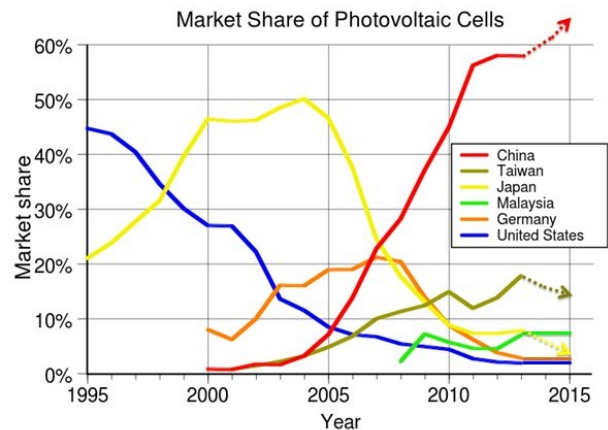
Taiwan has been a strong contender in manufacturing solar PV cells, and great efforts have been expended to generate a local value chain encompassing production of silicon and other components needed to produce solar PV modules. Yet as in other manufacturing activities, the Taiwan model of low-cost manufacturing (frequently without branding,

through contract manufacturing) has prevailed.

Taiwan had risen to second largest solar PV manufacturing country by 2008/9, when it overtook both Japan and Germany as a producer - through the efforts of companies such as Gintech, Motech, NeoSolarPower (NSP). Indeed, three companies - NeoSolar, Gintech and SolarTech - announced a merger in late 2017, to consolidate manufacturing in Taiwan. And there is diversification along the value chain: Motech recently announced its plan to build a 400MW solar farm in the south tip of Taiwan with PingTung county government, thus indicating a significant move for the company from manufacture to power generation.⁷

The situation in global solar PV cell manufacturing up to 2015 is depicted in Fig. 4. As the 2nd largest PV cell manufacturing nation, Taiwan has been facing price competition with China and USA's anti-dumping duty (ADs). Although the cell capacity is about 15% of the world market, Taiwan's module capacity only takes 2%, indicating that domestic PV installation demand is still weak.⁸ A new strategy led by DPP government with a goal of 20GW PV installation by 2025 is considered as antidote to increase domestic demand and create value-added products. Taiwanese PV manufacturing is leaving the price competition game with China (which rose to global dominance over the years 2005 to 2010) and moving towards higher efficiency PV cell production.

Figure 4. Global manufacturing of solar PV cells, 1995 to 2015 Source: JC, based on data from IEA PVPS



Source: JC, based on data from IEA PVPS

Shalun Green Energy Park

A green energy technology park has been launched in the south of the island, with a ceremony marking its inauguration being staged at the end of 2016. Now the Shalun Green Energy Technology Park (or Science City) is advancing, with vigorous promotion by the Tainan mayor. (This is a feature of the DPP's '5+2' innovation program, which features collaboration on each facet of the program between the central government administration and local cities.) The Shalun park is intended to promote a cluster of green industries spearheading green energy development, with key ministries designated as the Ministry of Economic Affairs (MoEA) and the Ministry of Science and Technology (MoST). A dedicated green energy research institute is to be established. The park is being laid out on a site spanning 23 hectares, located next to the Tainan high-speed rail station, thus linking it to the capital Taipei and the Hsinchu Science Park.

Green transport

In transport, electric vehicles and particularly two-wheeled vehicles (scooters and electric

bicycles?) are making great strides, stimulated by successive government programs of tax exemptions. The Taiwan government through the MoEA adopted a Smart EV Development Strategy and Action Plan, offering subsidies and incentives particularly a five-year exemption from the Commodity Tax for EV purchases, covering small passenger cars, motorcycles, taxis and buses available in Taiwan. This program builds on an earlier tax exemption policy introduced in January 2011, then extended a second time to January 2021. The Plan envisages extra sales of electric cars of 5,939 units, while sales of electric motor-scooters are anticipated to increase by 150,000. While some Tesla components are supplied from Taiwan, the tax exemption program also benefits Tesla suppliers by boosting green energy manufacturing GDP in Taiwan. With investment from National Development Fund, now new start-ups like Taipei-based Gogoro are leading the way. Gogoro is famous in Taiwan for its smart, stylish scooters, which have captured 8.3% of the market in Taiwan, and more than 10% in Taipei itself - according to an article published by the Hong Kong Trade Development Council.⁹

Promotion of the smart grid

Deployment of smart electricity consumption meters for households is expected to be rolled out from 2017, with a first round of 200,000 meters to be installed within two years and a total of three million to be installed by 2026 - thereby making the grid fit for coping with fluctuating power sources and facilitating demand-response energy conservation and efficiency improvement programs. These measures will facilitate the policy goal in Taiwan of integrating measures taken to improve energy generation, energy storage and energy conservation.

There are clear parallels between developments in Taiwan and those in other East Asian countries pursuing a green shift,

notably Korea, Japan and China. All these countries are promoting the smart grid as both a means of facilitating the input of fluctuating sources of renewable power, and as a means of building export platforms for the future. China is doing so perhaps most robustly of all, because the necessity to create energy security is so keenly felt as a political imperative. Japan is pursuing smart grid initiatives in the name of national energy resilience, while Korea has been pursuing such initiatives under the rubric of 'green growth' and most recently as a 'creative economy' initiative. But progress in Taiwan is widely viewed as being linked to liberalization of the electric power market, to reduce the quasi-monopoly control of TaiPower.

Liberalization of Taiwan electric power market

The heavily regulated monopoly of power generation and distribution maintained by Taiwan Power Co. (TaiPower) with its legacy of commitment to nuclear power and fossil fuels, has long been viewed as an obstacle to any green energy shift in Taiwan. Now there is some movement towards liberalization under way. In January 2017 the Taiwan legislature passed amendments to the Electricity Act, that regulates the power grid monopolized by TaiPower, allowing independent green power producers to sell their power direct to consumers, and not just to TaiPower. The rates at which such sales can be effected were stated in the feed-in tariffs that are promulgated from time to time. These changes to the law are now on the point of being put into practice. 'Power distributors will be able to start applying for permits to transmit and distribute power from renewable energy suppliers to customers at the end of next month at the earliest,' a Bureau of Energy official Lee Chih-yuan told the Taipei Times at the ministry in September.¹⁰

Greening of agriculture and the circular economy

To demonstrate the broad appeal of greening

strategies, Taiwan is also playing a lead role in developing new green approaches to enclosed systems of agriculture ('new agricultural paradigm') and the development of a circular economy to reduce waste generation and improve resource efficiency. Many of the agricultural initiatives were displayed at the first Asia AgriTech Expo & Forum staged in Taipei in September 2017, where vegetable growing in enclosed systems, using hydroponics and LED lighting, were demonstrating clean, green urban food production. One of the companies exhibiting was Tatung, with its 'Smart Farms' range of food production systems.

Incoming President Tsai Ing-wen announced in her inaugural address in 2016 that 'We will bring Taiwan into an age of circular economy, turning waste into renewable resources'. This is a welcome move where Taiwan can learn lessons from both Japan's and China's decade-long commitment to improve its resource efficiency via circular economy initiatives.¹¹ Some specific industrial ecological initiatives taken by companies include the following.

Semiconductors and electronic waste: Taiwan Semiconductor Manufacturing Co. (TSMC), the world's largest semiconductor contract manufacturer that is based in Taiwan, currently recycles 15% of its waste materials - and has published plans to raise this level to 61% by 2020. Often the manufacturing process requires so much water, TSMC is already turning waste sulfuric acid into electronics-grade acid and recycles water for 3.5 times use.

Steel: Taiwan's leading steel producer, China Steel Corp. (CSC), produces 5.6 million tonnes of waste products per year (e.g. blast furnace slag and waste refractory materials), and the company is increasingly re-using these as raw materials at its Linhai industrial park or supplying them to other firms. One project involves recovering iron by recycling

desulphurizing slag, a project completed in 2015 at a cost of NT\$ 2 billion (US\$64.5 million). CSC also shares energy resources - steam, heat and power - with other companies in the Linhai park.

Paper: Cheng Loong Corp. (CLC), a leading producer of packaging paper, states that 94% of the 1.69 million tonnes of raw material it uses each year is recycled paper. The company uses the recycled paper in producing, e.g. shoe boxes for Nike. Other circular flow initiatives include using sludge from papermaking to feed the steam power cogeneration system (along with other fuels) and recovering fly and bottom ash from its papermaking operations to be onsold to cement producers.

Tyres: Taiwan has as much as 120,000 tonnes of used tyres to be put away each year. The simplest ways are typically by burning or put to landfill. One company, Enrestec Ltd, invented a pyrolysis process that can thermally decompose tyre chips to useful materials such as pyrolysis oil, flammable gas, steel wire, and high grade carbon black from used tyres for reuse in new tyre making and printer cartridge, while the Jia Qian Rubber Tech Corp. transforms used tyres into rubber mats for playgrounds.¹²

Concluding remarks

Taiwan's green shift is now clearly getting under way, driven by a strong commitment by the incoming DPP government to a fresh industrial strategy with a focus on green energy and a greening more generally of the economy. But problems in terms of moving quickly to implement the medium-term solar and wind power goals, and upgrade the grid to enhance stability, resilience and to accommodate fluctuating power sources, are still clearly evident.

Despite a strong will led by DPP government to pursue the development of green energy economy, through green governance, the energy transformation is backed by a powerful

coalition of Taiwanese citizens. There is indeed a strong popular green movement in Taiwan, and this is what drives the anti-nuclear decisions of the DPP government and the new emphasis on shifting to green power systems. The short-term economic constraint from increasing electricity price and unstable grid service will require more advocacy, public support, and passion from local citizens so the progress of heading a green (circular) economy is continuously achievable.

The next phase in the green shift will likely be felt across several sectors, encompassing green power and energy storage, as well as transport (electric vehicles and fuel cell vehicles), industry and agriculture. After a slow start, Taiwan is now beginning to close the gap with the world's leaders in the green shift, including China and Germany.

Acknowledgment: Our thanks to Ms Carol Huang for assistance in preparing the graphics.

Related articles

- John A. Mathews, China's Electric Power: Results for first Half 2017 demonstrate continued green shift
- Feng Hao and Stam Lee, Chinese Coal Miners Will Need 2.3 Million New Jobs by 2020: Cutbacks in Mines (<https://apjff.org/2017/17/Feng.html>)
- John Mathews and Hao Tan, China's Continuing Shift in the Electric Power Industry: Evidence from 2016 data (<https://apjff.org/2017/10/Mathews.html>)
- John Mathews and Hao Tan, China's New Silk Road: Will it contribute to export of the black fossil-fueled economy? (<https://apjff.org/2017/08/Mathews.html>)
- Sung-young Kim and John A. Mathews, Korea's Greening Strategy: the role of smart microgrids (<https://apjff.org/2016/24/Kim.html>)
- Andrew DeWit, Japan's Bid to Become a World Leader in Renewable Energy (<https://apjff.org/-Andrew-DeWit/4385/article.html>)
- John A. Mathews and Hao Tan, The Greening of China's Black Electric Power System? Insights from 2014 Data (https://apjff.org/-John_A_-Mathews/4297/article.html)
- John A. Mathews and Hao Tan, "China's Continuing Renewable Energy Revolution: Global Implications" (https://apjff.org/-John_A_-Mathews/4098)
- John A. Mathews and Hao Tan, "Jousting with James Hansen: China building a renewables powerhouse" (<https://apjff.org/events/view/214>)
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- Andrew DeWit, Japan's Energy Policy at a Crossroads: A Renewable Energy Future? (<https://apjff.org/-Andrew-DeWit/3831>)
- Sun-Jin YUN, Myung-Rae Cho and David von Hippel, The Current Status of Green Growth in Korea: Energy and Urban Security (https://apjff.org/-Sun_Jin-YUN/3628)

Justin Chou is a doctoral candidate in the Institute of Technology Management at National Tsing Hua University in Taiwan, and currently also a consultant for fuel cell technology, assisting early technology adopters to realize future energy solutions (i.e. fuel cell and electromobility). His current research work is focused on Technological Innovation Systems of fuel cell and renewable energy technologies. He holds a B.Sc. in chemical engineering from Queen's University and M.S. in material science and engineering from National Tsing Hua University. He can be reached at justchouit@gmail.com.

John A. Mathews is Professor of Management, MGSM, Macquarie University, Australia, and formerly Eni Chair of Competitive Dynamics and Global Strategy at LUISS Guido Carli University in Rome. His research focuses on the competitive dynamics of international business, the evolution of technologies and their strategic management, and the rise of new high technology industries. He researches the development of the institutional capacities of firms and governments in the Asia-Pacific, internationalisation processes of firms and the theoretical explanations for latecomer firms' success. His work has focused in recent years on the emergence of the 'green economy' and the transition to renewable energies, and the institutional changes needed to provide industrial capitalism with genuine long-term sustainability. He is the author of *Strategizing, Disequilibrium, and Profit* (<https://www.amazon.com/Strategizing-Disequilibrium-Profit-John-Mathews/dp/0804754837/?tag=theasipacjo0b-20>), *Global Green Shift: When Ceres Meets Gaia* published by Anthem Press and *Greening of Capitalism: How Asia is Driving the Next Great Transformation* (<https://www.amazon.com/Greening-Capitalism-Driving-Great-Transformation/dp/0804791503/?tag=theasipacjo0b-20>) published by Stanford University Press.

Notes

¹ See John Mathew's contribution to this topic, with Mei-Chih Hu, via 'Taiwan's green shift: Prospects and challenges (<http://apjif.org/2016/19/Hu.html>)', *Asia Pacific Journal*, Oct 1 2016

² See Andrew DeWit, 'Japan's "National Resilience" and the Legacy of 3/11 (<http://apjif.org/2016/06/DeWit.html>)' *Asia Pacific Journal: Japan Focus*, March 15, 2016, Vol. 14, Issue 6, No. 1

³ See Executive Yuan, 'Two-year solar power promotion plan (http://english.ey.gov.tw/News_Hot_Topic.aspx?n=071C036B2AF976D7&sms=3893D3AA3EB6225A)', 22 September 2016

⁴ See Executive Yuan, 'Four-year wind power promotion plan to create clean energy (http://english.ey.gov.tw/News_Hot_Topic.aspx?n=5ADB01582332BC2E&sms=F3BE90509E8F5A16)', 9 June 2017

⁵ See here (http://www.ey.gov.tw/News_Content2.aspx?n=F8BAE9491FC830&s=5DC876427A861AE2) (in Chinese).

⁶ See here (http://www.moea.gov.tw/AD/Ad01/content/ContentDetail.aspx?menu_id=3571) (in Chinese).

⁷ See here (<http://pv.energytrend.com.tw/news/20170906-14308275.html>) (in Chinese).

⁸ The value chain for solar photovoltaics (PV) runs from silicon ingot to solar cell production to module assembly and then installation on rooftop or other insulated locations. The focus of manufacture in Taiwan has been on cell production rather than module production.

⁹ See 'Taiwan looks for pioneering role in Electric Vehicle development (<http://economists-pick-research.hktdc.com/business-news/article/International-Market-News/Taiwan-Looks-For-Pioneering-Role-in-Electric-Vehicle-Development/imn/en/1/1X000000/1X0A8UG2.htm>)', by Tammy Hsieh, *HKTDC Research*, 7 Feb 2017

¹⁰ See 'Applications to "green" energy suppliers to open (<http://www.taipeitimes.com/News/biz/archives/2017/09/19/2003678697>)', *Taipei Times*, 19 September 2017

¹¹ See the article in *Nature* by JM and Hao Tan, 'Circular Economy: Lessons from China (<http://www.nature.com/news/circular-economy-lessons-from-china-1.19593>)', *Nature*, March 2016

¹² These examples come from 'Greening the economy (<http://taiwantoday.tw/news.php?unit=8&post=114991>)' by William Kazer, *Taiwan Today*, May 1 2017