Asia Program

Taiwan's Energy Conundrum

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ABSTRACT: This Special Report explores the complex set of opportunities and challenges inherent in Taiwan's energy profile. **Ssu-li Chang** describes the profile, and also considers the possible impact of changed pricing mechanisms and increased reliance on nuclear energy. **Herng-Shinn Hwang**, outlines the promise of alternative "green" energies. **Chiyuan Liang** surveys Taiwan's energy security, comparing Taiwan's performance in energy usage with major nations around the world. And **Hongyi Lai** examines the possibility of energy cooperation and the potential consequences on the island's energy supply of conflict between Taiwan and mainland China.

INTRODUCTION

BRYCE WAKEFIELD

In June 2011, anti-nuclear rallies assembled outside the Legislative Yuan, Taiwan's parliament, protesting the government's approval of a \$486 million budget to continue construction on the island's fourth nuclear power plant in New Taipei City. Along with protests over the preceding months that attracted more than 100,000 people, the rallies demonstrate that the failure of the Fukushima power plant after the tsunami in Japan in March of that year energized opposition to such facilities in Taiwan. Indeed, opposition groups staged similar protests across the island on the first anniversary of the disaster in Japan.

However, anti-nuclear sentiment in Taiwan is nothing new. In 2000, for example, public pressure prompted the government led by President Chen Shui-bian of the Democratic Progressive Party (DPP) to halt construction of the New Taipei City plant. After achieving office in 2008, the administration of the Nationalist Party's (KMT) Ma Ying-jeou restarted the project.

The government's willingness to ignore public discontent by building the new power plant highlights Taiwan's energy conundrum. As reflected by the papers in this report, penned by the participants of a seminar held at the Woodrow Wilson Center, Taiwan's geography looms large in considerations of its energy strategy. Taiwan has practically exhausted the indigenous fossil fuels that three decades ago supplied 15-20 percent of its energy, while industrialization has increased demand for power. Because

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its insular geography precludes direct electricity imports from foreign grids, Taiwan now has to import over 99 percent of the energy resources it either uses to generate electricity or consumes raw. Even if statistics are adjusted to count nuclear fuel—with its low volume-to-energy ratio—as an indigenous resource, the figure for Taiwan's energy resource imports still stands at 90 percent.

Taiwan's geographical isolation and lack of natural resources are enough to give leaders in Taipei significant headaches over the issue of energy security. However, concerns about supply are compounded by the presence, and potential threat, of mainland China. China's increased energy demand to fuel its supercharged economy is placing upward pressure on the prices of the fossil fuels that also dominate Taiwan's energy profile. Also, many Taiwanese view energy as an issue over which, in times of political friction, the Chinese Communist Party (CCP) on the mainland could gain a strategic chokehold on their island, which the CCP views as an errant province belonging under Beijing's jurisdiction.

Nevertheless, there have been recent moves by CCP leaders on the mainland and the KMT in Taiwan to explore areas for energy cooperation. Such moves serve the Ma administration's broader strategy of fostering good relations with Beijing. However, cooperation requires sustained commitment by both the mainland and Taiwan, something that cannot be guaranteed. For example, deteriorating ties under the former DPP government between 2000 and 2008 effectively meant that a 1994 agreement for energy cooperation with the mainland was put on hold, and this may again happen under future governments.

Another area where China matters in the context of Taiwan's energy profile is in Taipei's commitment to climate change regimes. The island's ambiguous status in the international community—that is, its desire for sovereign recognition from other states despite a lack of formal independence—has led Taiwan to seek ways to carve out "diplomatic space" by voluntarily adhering to global norms. Taipei has attempted to do this in part by adhering to the 1997 Kyoto protocol, an international agreement on greenhouse gas emissions. Taiwan has no standing within the United Nations Framework Convention on Climate Change, the treaty framework to which the protocol was an addition. Its voluntary adherence to Kyoto, then, is designed to enhance its status as a responsible international citizen. Taiwan will likely adopt a similar approach to any post-Kyoto framework aimed at reducing greenhouse gases. This commitment to reducing its carbon footprint only increases the island's need for alternatives to fossil fuels.

The following chapters discuss these dynamics in greater detail. Ssu-li Chang, professor at the Institute of Natural Resource Management at National Taipei University and Taiwan Director of CPC Corporation, describes the challenges confronting Taiwan in light of its energy profile, and also considers the impact that changed pricing mechanisms and increased reliance on nuclear energy may have on that profile. To deal with the supply issues thrown up by Taiwan's isolation and lack of indigenous resources, Chang explains the Taiwanese government's new energy policy, which is focused on maintaining efficiency, cleanliness, and stabilization of supply. There are plans to drop energy intensity levels to 20 percent of 2005 levels by 2015, and to lower carbon dioxide (CO₂) emissions to 2005 levels by 2020, while constructing an energy supply system to meet the demands of development that would accompany the government's target of 6 percent annual economic growth.

How might Taiwan attain the dual goals of economic development and cleaner energy? Chang suggests that increasing the nation's nuclear energy output is a partial solution. However, Herng-Shinn Hwang, director of Songya Technology, LLC, who advised the previous DPP government on energy issues, believes that nuclear power plants generate unwelcome problems, such as waste and safety concerns. Hwang sees more promise in alternative "green" energies. Southern Taiwan receives about 300 days of sunlight a year, making solar energywhich may require massive initial outlays, but is virtually free once panels are installed-an attractive option for the future. Taiwan also has ample wind, and as an island will be able to take



advantage of wave power technology once this energy source becomes economically feasible. Taiwan, according to Hwang, has the technological prowess and the motivation to become a leader in the field of alternative energy, and thus should seriously reconsider the development of any more nuclear facilities.

However, while noting the importance of renewable energy, Chi-yuan Liang, a former minister without portfolio in Taiwan's Executive Yuan, points out that green technologies are not a sufficient replacement for inefficient and polluting fuels-such as coal-already used by Taiwan. While Liang stresses that research and development in green technology is necessary for Taiwan to increase its long-term competitiveness in renewable energy industries, like Chang he argues that modified pricing systems and a restructuring of the energy sector will be crucial. The promotion of less energy-intensive sectors, such as service industries, and government regulations to ensure offsets for energy-intensive industries can also promote efficiency and curb CO₂ emissions. Liang also believes that Taiwan and the United States should explore avenues for technical and political cooperation on energy and climate change, such as the joint development of green and nuclear technologies, and the promotion of environmentally friendly practices in the Third World.

Hongyi Lai, associate professor at the University of Nottingham, tackles the always contentious issue of Taiwan's relations with the Chinese mainland, placing them within the context of Taiwan's energy strategy, and outlining several areas for cooperation on energy-related issues between Taiwan and the mainland. Lai outlines failed attempts to foster cross-Strait cooperation on coal and oil development issues, as well as a number of successful joint development efforts. Taiwan, with its advanced technological base, has much to teach China, which is suffering the environmental consequences of its rapid development, and there is scope for cooperation in the development of nuclear and green technologies. At the same time, Taiwan's extensive reliance on oil and natural gas means that the island would be highly vulnerable to Chinese blockades, should there be future friction or even war between Taiwan and China.

Taiwan's political debate on energy security therefore revolves not so much around objectives as on strategies for achieving these objectives. Both major parties seek clean solutions to energy scarcity. DPP supporters want to see less reliance on nuclear energy, while at the same time shunning cooperation and development of other energy opportunities with mainland China that could offset Taiwan's level of nuclear dependence. The KMT, meanwhile, proclaims the need for non-polluting power, but is committed to building nuclear power plants whose waste-management and safety practices will elicit public concern. In addition, the KMT's policy of cooperation with China may not be politically sustainable under future governments. Taiwan's energy conundrum looks set to last into the future.

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AN OVERVIEW OF ENERGY POLICY AND USAGE IN TAWAIN

SSU-LI CHANG

ith limited land area, of which three-quarters is non-arable, Taiwan is poorly endowed with indigenous energy as well as non-energy natural resources. Yet Taiwan has long been renowned for its remarkable economic performance, in which the sufficient and stable supply of energy has been a crucial factor. However, Taiwanese industry has entered a period of slowdown in recent years in response to the rapid rise of China. Taking advantage of more attractive business conditions on the mainland, Taiwanese manufacturers have accelerated the shift of their production footholds to China to regain lost international competitiveness. This trend, in turn, has aroused concern that Taiwanese industries will be hollowed

out. Nevertheless, recent amicable cross-Strait relations have presented Taiwan with new economic opportunities, and Taipei has made vigorous efforts to attract overseas Taiwanese enterprises back to the island to revitalize industry.

This trend has such far-reaching implications for national energy policy that both the constraints and barriers underlying the island's energy strategy deserve further examination. This paper outlines Taiwan's energy profile, before reviewing the evolution of energy policy in Taiwan and major issues presented by this policy, as well the energy challenges and opportunities that Taiwan's economy will face in the future.

Key Data		% of World	Rank
Area (sq. km)	36,189.00		
Population (Millions)	22.86	0.3456%	49
GDP (million U.S. dollars [USD], 2009 nominal) ¹	378,969.00	0.6541%	25
Per capita GDP (million USD, 2009 nominal) ¹	16,392.00		38
Merchandise exports (Billion USD, 2009) ²	204.00	1.6000%	17
Merchandise imports (Billion USD, 2009) ²	175.00	1.4000%	18
Total Primary Energy Consumption (Quadrillion Btu) ³	4.75	0.9815%	21
Total CO ₂ Emission (Million Metric Tons)	308.01	1.0310%	22

Sources: 1. International Monetary Fund, *World Economic Outlook Database*, April 2011. Data for the year 2010. Available from http://www.imf.org/external/pubs/ft/weo/2011/01/

2. World Trade Organization, "Trade to expand by 9.5% in 2010 after a dismal 2009, WTO reports," Press Release 598, 26 March 2010, available from http://www.wto.org/english/news_e/pres10_e/pr598_e.htm
3. Btu refers to British thermal units. U.S. Energy Information Administration, *International Energy Statistics* 2004-2008. Available from http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3. cfm?tid=44&pid=44&aid=2

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THE CURRENT ENERGY SITUATION AND SALIENT ENERGY FEATURES OF TAIWAN

Table 1 provides some key statistics related to economic, energy, and environment (3E) performance, and assigns Taiwan a world ranking in key indicators used to measure its economy and energy use. Taiwan's population comprises 0.35 percent of the world total, ranking 49th globally. Taiwan ranks 25th globally in terms of gross domestic product (GDP) per capita, according to 2010 International Monetary Fund data, sharing 0.65 percent of the world total in 2009. However, it consumes 0.98 percent of world's total primary energy and emits 1.03 percent of the world's total anthropogenic energy-related carbon dioxide (CO₂). While its volume of merchandise exports declined by 20 percent in 2009, World Trade Organization figures in 2010 indicated that Taiwan remains the 17th largest exporter and 18th largest importer in the world, exporting a total of U.S. \$204 billion, 1.6 percent of the world total, and importing U.S. \$174 billion, 1.4 percent of the world total. It is clear that Taiwan's high level of exports relative to population require a steady supply of energy.

Indeed, Taiwan's total final energy consumption has increased by a factor of 2.35 over the past two decades, from 48.04 million kiloliters of oil equivalent (KLOE) in 1989 to 113.09 KLOE in 2009, with an average annual growth rate of 4.37 percent. The industrial sector consumes the largest share of final energy, 52.48 percent in 2009, followed by the transportation (13.16 percent), residential (11.64 percent), and service (11.48 percent) sectors (See Fig. 1). In terms of final energy use, energy from coal contributed to 6.81 percent of consumption in 2009; petroleum products provided 41.35 percent; natural gas accounted for 2.2 percent; electricity constituted 49.28 percent, and 0.36 percent was generated from geothermal sources and heat recovery from waste.



Source: Bureau of Energy, Ministry of Economic Affairs, *Energy Statistics Handbook*, 2009, (Taipei: Ministry of Economic Affairs, 2010).





Source: Bureau of Energy, Ministry of Economic Affairs, *Energy Statistics Handbook*, 2009, (Taipei: Ministry of Economic Affairs, 2010). Available from http://www.moeaboe.gov.tw/opengovinfo/Plan/all/WorkStatisticsAll.aspx



Sources: 1. Bureau of Energy, Ministry of Economic Affairs, Energy Statistics Handbook, 2009, (Taipei: Ministry of Economic Affairs, 2010). Available from http://www.moeaboe.gov.tw/opengovinfo/Plan/all/WorkStatisticsAll.aspx
 2. Environmental Protection Administration website, available from http://unfccc.epa.gov.tw/unfccc/chinese/



Seen from the supply side, 138.06 KLOE of primary energy was provided in 2009, greater than a 2.6 fold increase from 1989 levels. The average annual growth rate from 1989 to 2009 was 4.92 percent. Fossil fuels continue to dominate the supply structure. Shares of coal, oil and LNG accounted for 30.5 percent, 51.8 percent and 8.6 percent, respectively, of total supply in 2009. In comparison, nuclear (8.7 percent), wind (0.06 percent) and solar and thermal (0.08 percent) energy comprised the rest of the energy supply (See Fig. 2).

There was a clear drop in both total energy consumption and primary energy supply, by 3.9 percent and 3.1 percent, respectively, in 2008 and 2009. This was due to the growth rate of -1.87 percent in real 2009 GDP following the world-wide economic downturn. This drop highlights the close relationship between energy and the economy where changes in one will often cause fluctuations in the other. Two decades of data confirm the close correlation among energy demand, GDP, and energyrelated CO₂ emissions (Fig. 3). Wide-reaching attempts at promoting sustainable development, an evolving concept that has risen to prominence in recent years, have sought to weaken this correlation. Nevertheless, policies geared towards extensive economic revival after the global economic downturn will still challenge attempts to mitigate CO₂ emissions in Taiwan.

Indeed, the challenges Taiwan confronts are especially difficult, given the unique features that define its energy profile—the island's high import dependency, its isolated electricity supply system, and high concentration of fossil fuels.

High import dependency

Taiwan imports almost all of its energy for both direct utilization and energy transformation. In 2009, it was dependent on exports for 99.27 percent of its fuel needs. Oil contributed the largest import share (51.8 percent) of Taiwan's energy profile, followed by coal (30.45 percent), natural gas (8.39 percent), and nuclear fuel (8.72 percent). Fuel sources are also highly concentrated. The Middle East is Taiwan's major supplier for petroleum, accounting for 81.6 percent of total imports in 2009. Meanwhile, Australia (43.3 percent), Indonesia (40.4 percent), and China (7.6 percent) together provided 91 percent of Taiwan's imported coal.

Isolated electricity supply system

Power grids in many countries or regions are interconnected so that electricity costs can be lowered by reducing the need for generating capacity and by substituting expensive fuel for cheaper fuel, as well as by diversifying generation methods to minimize risks of supply and price volatilities. However, Taiwan's insular geography means its power supply is isolated. As a result of the lack of interconnectedness with other regions, the island requires much higher generation reserve margins than elsewhere in order to ensure reliability in the case of a transmission grid outage, to protect system safety, and to ensure continuous operation. Furthermore, with a mandatory renewable electricity target of 8 percent by 2025, and with 50 percent of total renewables expected to come from wind power dependent on favorable weather conditions, there is likely to be more uncertainty in the operation of the power system. According to a 2008 report from Taipower, currently the reserve margin is about 28 percent and the back-up capacities are generally fossil-based. The relationship between economics and environmental implications-in other words, between fuel price volatility and CO₂ emissions—is therefore particularly acute and will require further discussion as Taiwan crafts its future energy policies.

High concentration on fossil fuel supply

As indicated above, Taiwan's supplies of primary energy are also highly concentrated on traditional fossil fuels, of which oil, natural gas and coal continue to be the dominant sources. Due to the decline of nuclear energy from 15.5 percent of Taiwan's total supply in 1999 to 8.4 percent in 2009, fossil fuels contributed 90.6 percent of total primary energy supply in 2009, which is significantly higher than the share of 84 percent contributed in 1993 (See Fig. 2). There is little opportunity to see a significant change in this trend in the future. Nuclear power is and remains a very sensitive subject that the former ruling party (i.e., the Democratic Progressive Party, DPP) invoked with its "nuclear-free homeland" policy in 2002. This policy, which seeks to eliminate all nuclear generation on the island, is still binding and, as indicated by previous protests, any attempt to alter it may provoke economic as well as political disputes, seriously affecting internal political stability. Taiwan's carbon intensive energy profile thus poses a large obstacle to efforts to delink economic development from CO₂ emissions. Energy diversification and de-carbonization of energy supplies have topped the list on both public and private sector energy priorities, however nuclear power remains highly contentious.

ENERGY POLICY EVOLUTION

In light of the challenges presented by Taiwan's energy profile, it is necessary to consider the development of Taipei's energy policy and review its fundamental principles. The competent authority currently in charge of energy policy in Taiwan is the Bureau of Energy (BOE). Its predecessor can be dated to 1968, when the "Energy Development Group" was established subordinate to the International Economic Cooperation and Development Council under the Executive Yuan (branch of government). It then was renamed in January, 1970, the "Energy Policy Deliberation Group" and placed under the Ministry of Economic Affairs (MOEA). The economic difficulties Taiwan suffered during the two international oil crises of the 1970s prompted the government to institute concrete energy policies as well as to establish a permanent organization for the formulation and implementation of persistent and long-term energy strategies. As a result, the government implemented its "Energy Policy in Area of Taiwan" in 1973. In 1979, an "Energy Commission" was also established, following a revision of policy to cope with the second oil crisis. The Energy Commission became the Bureau of Energy in 2004. Four divisions are included in the bureau, in charge of, respectively, energy planning, petroleum and gas, electricity, and energy technology affairs.

The fundamental goal of Taiwan's current energy policy is to establish a liberal, orderly, efficient, sustainable, and clean energy supply and demand system. Meanwhile, its strategies include: stabilizing the energy supply; increasing energy efficiency; deregulating the energy market; emphasizing energy security and environmental protection; enhancing energy research and development; and promoting energy education.

On 5 June 2008, the Ministry of Economic Affairs released the *Framework of Taiwan's Sustainable Energy Policy*. The framework presents a "win-win-win" solution for addressing problems related to energy, the environment, and the economy. It addresses the constraints that Taiwan faces in terms of its insufficient natural resources and limited environmental carrying capacity. It states that sustainable energy policies should support the efficient use of the economy's limited energy resources, the development of clean energy, and the security of the energy supply. The framework includes the following goals:

1. Improving energy efficiency by bringing down energy intensity by 20 percent of 2005 levels by the



year 2015, and by 50 percent by the year 2025;

- 2. Expanding the share of clean energy to lower nationwide CO_2 emissions to return emissions to their 2008 level between 2016 and 2020, and to their 2000 level by 2025.
- 3. Increasing the share of low carbon energy in electricity generation from the current level of 40 percent to 55 percent by 2025.
- 4. Securing a stable energy supply by constructing a secure energy supply system to reach the annual GDP growth rate of 6 percent between 2008 and 2012 and a per capita income of U.S. \$30,000 by 2015.

The policy schemes as planned form an agenda for the energy sector and the economy as a whole and are intended to create four trends:

- 1. High efficiency: to increase energy consumption and energy transformation efficiency.
- 2. High added value: to increase the value derived from energy consumption.
- 3. Low emissions: to adopt energy supply methods and consumption practices that ensure low carbon emissions.
- 4. Low dependence: to decrease dependence on fossil fuels and imported energy.

Are the Policy Objectives Realistic?

The framework introduces a new vision as well as laying down aggressive goals for a future energy policy direction. It is apparent that the promulgated low carbon energy target has



Source: Bureau of Energy, Ministry of Economic Affairs, *Energy Statistics Handbook*, 2009, (Taipei: Ministry of Economic Affairs, 2010). Available from http://www.moeaboe.gov.tw/opengovinfo/Plan/all/WorkStatisticsAll.aspx



imposed heavy responsibilities on the electricity sector. However, there are other difficulties that need to be recognized and tackled if Taiwan is to face these challenges successfully. These difficulties are mainly related to Taiwan's unique energy profile outlined above. Special attention in this section is focused on possible impediments to the future development of the energy sector.

As shown in Fig. 4, the electricity sector has held the largest share in domestic final energy consumption since 1996. In 2008, over 51 percent of domestic energy consumption was from electricity. This percentage dropped to 49.28 percent in 2009, but electricity still remains the predominant type of end-use energy consumed domestically. Comparing the annual growth rate of final energy demand for each of the fuel types for the period from 1989 to 2009, electricity demand grew faster (5.19 percent) than petroleum (3.8 percent), coal (2.63 percent) and liquefied natural gas (LNG, 4.66 percent), which reflects a shift away from energyintensive heavy manufacturing towards lighter industries and services. This trend is expected to continue in the future. However, despite other alternatives, coal will remain the main fuel for power generation (see Fig. 5), not least because of the "nuclear free homeland" policy.

Constrained by limited land space and the lack of suitable sites for large-scale renewable energy projects, the share of renewable energy in power generation will quickly reach its maximum, despite the government's ambitious targets. LNG is categorized as a low carbon fuel due to the levels of its CO_2 emissions per unit of energy use, which is about two thirds that of coal.¹ The utilization of LNG in Taiwan has limitations, however, due to the fact that imported natural gas in its liquid form is shipped from Indonesia and the Middle East to domestic receiving terminals for storage and distribution. There are currently two receiving terminals for LNG, Yuan An and Taichung,



Source: Bureau of Energy, Ministry of Economic Affairs, *Energy Statistics Handbook*, 2009, (Taipei: Ministry of Economic Affairs, 2010). Available from http://www.moeaboe.gov.tw/opengovinfo/Plan/all/WorkStatisticsAll.aspx



with a total handling capacity to 19.6 million tons per year. Land space requirements and the availability of the suitable sites for receiving terminals limits any greater use of LNG, provoking some uncertainty about Taiwan's undertaking to expand its LNG usage.

OPPORTUNITIES FOR A MORE RATIONAL ALLOCATION OF ENERGY RESOURCES

However, despite these constraints, Taiwan's previous experience suggests that there may be solutions to the problem of providing clean, affordable energy. Two issues in particular—energy pricing and nuclear policy—are worth further scrutiny.

Energy Pricing

According to basic economic theory, the market economy depends on price signals to correctly allocate its scarce resources to attain efficiency. Incorrect pricing leads to market distortion and misallocation of resources. However, energy pricing in Taiwan has long been subject to government intervention so that in recent years there has been a great deal of price rigidity for both electricity and petroleum products despite the global energy market being highly volatile.²

Previously, both the electricity and petroleum refining industries were state-owned monopolies. In 2000, a second petroleum refining company, the Formosa Petrochemical Corporation entered the market. The electricity market opened up with the entrance of independent power producers (IPPs) in 1995. Currently, Taiwan Power Company (Taipower) remains the only state-owned integrated utility, with eight IPPs, and with producers of renewable energy also in the market. Under such a market structure, government control of domestic energy prices in Taiwan has long been used as one policy tool to maintain export competitiveness and a low-cost domestic energy supply. Underpricing of electricity and petroleum products has greatly distorted the behavior of industrial and household consumers of energy.

The true cost of imported energy is therefore hidden from the Taiwanese consumer, and there has been little incentive to implement clean energy projects and to establish low-carbon structures in both energy demand and supply. Cheap fuel has also led to a high rate of growth in demand, pressing domestic energy suppliers to continue to expand their capacity to meet their commitments to a sufficient and stable supply. This has led to a vicious circle in that the artificially low domestic price of energy has impaired the financial performance of the stateowned Taipower and CPC Corporation. This, in turn, has weakened these providers' ability to retain capital requirements for reinvestment into new and alternate sources of energy to increase supply and lower costs.

Attempts to reform the system have not improved this situation. Although MOEA authorized CPC to adopt a floating fuel-pricing mechanism at the beginning of 2007, an unofficial mandate for the price of gasoline and diesel to remain at a level lower than Taiwan's neighbors is still in effect. Meanwhile, the pricing mechanism for electricity is controlled by the government rather than based on the generation cost. Currently, Taipower's proposal for electricity price adjustments is designated to be reviewed by a price advisory committee formed by MOEA.

Under current pricing mechanisms, doubt has been cast on the ability of the government to achieve the high efficiency and low emission targets underlying the sustainable energy policy. Energy price rationalization is thus an even more pressing issue. In the process of a recent energy tax debate in Taiwan, issues regarding the role of government and policy instruments toward market intervention have been reexamined. However, due to a lack of consensus on the issue, a law drafted on an energy tax is still pending for legislation.

The CO₂ Emission Factor and Nuclear Policy

As international pressure to lower CO_2 emissions keeps mounting, Taiwan has developed various climate change mitigation strategies aimed at reducing greenhouse gases and building a low carbon society. Consumers throughout the world have demanded detailed information on CO_2 emitted during the life cycle of various products and their journey through the supply chain. Major markets, such as the European Union and the United States have adopted a voluntary product labeling system to disclose carbon footprint information. This trend indicates that the competitiveness of a particular product in the global market depends not only on its cost, but also on its carbon footprint.

Since electricity is an essential input factor in the production process, emissions from electricity generation are often deemed as the critical factor in calculating the carbon footprint of a particular product. Realizing that Taiwan's competitive advantage is at risk due to its higher electricity emissions per kilowatt hour (kWh) compared to its foreign competitors (see Liang in this volume), there is an urgent demand for Taipower to significantly lower emissions from electricity. However, this is not an easy task. As previously mentioned, all possible alternative energy resources other than fossil fuels have known limitations for large scale application in Taiwan.

Some Taiwanese are now arguing that the nation's nuclear policy should be revised because nuclear generation can be treated as a zero-carbon energy source. Nuclear power also holds an advantage as a quasi-indigenous energy that will dampen the risk of electricity price volatility when it is used as a substitute for LNG and coal in power generation. Demands for exceptions and even reversal of the existing "nuclear-free homeland" policy have been rising. However, due the political sensitivity of the issue, there is little consensus yet.

CONCLUSION

For a small, open economy with limited indigenous natural resources, the challenges embedded in the targets Taiwan has set itself are extremely rigorous. Though energy policy has been recognized as an important factor in replicating Taiwan's past impressive economic growth, the appearance of CO_2 mitigation issues, combined with highly volatile energy prices in the international market, brings a new form of risk for Taiwan's energy planners.

The objectives pledged in the Framework for Sustainable Energy Policy are inherently problematic in the way that they emphasize GDP growth, energy consumption and CO_2 mitigation as three simultaneous goals, and thus realization of the framework will be a colossal, if not impossible, task. The energy policy of Taiwan is thus at a crossroads. Compromises need to be made in the assessment of the 3E objectives and two particular but contentious positions—rationalization of energy prices and a reconsideration of nuclear policy—may be the only viable options for realizing the goals of the framework.

Removing intervention in the pricing will remove distortions around energy demand and industrial structure, and will create new incentives for the development of clean technologies and the shift to cleaner fuels. As well as supply issues, the price for each type of energy should convey the full cost that the energy imposes on society. In this regard, the nature of market selection will mean that demand will dictate when it is right for new technologies to enter the market and will also dictate the optimal scale of deployment of such technologies. Such a market environment will improve overall national competitiveness. But it will require professional involvement as well as political wisdom



and boldness to effectively put the above policy objectives into practice.

ENDNOTES

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PROGRESS AND PROSPECTS FOR RENEWABLE ENERGY IN TAIWAN

HERNG-SHINN HWANG

n 2000, Democratic Progressive Party (DDP) leader Chen Shui-bian was elected as the president of Taiwan on, among other factors, a promise to eventually remove nuclear power plants from the island. This election, and Chen's re-election in 2004, meant that the Taiwanese government would begin to explore potential new sources of energy and energy-efficient technologies in order to offset nuclear power generation. Energy efficiency was also seen as important because Taiwan had voluntarily made a commitment to adhere to developed-country guidelines of the Kyoto protocol on climate change, a move that Taipei hoped would gain the island recognition as an international player in environmental regimes. To reach these goals, several renewable energy projects were initiated in 2005.

However, after Nationalist Party (KMT) leader Ma Ying-Jeou was elected as new president in 2008, the government's new energy policy was refocused toward nuclear power generation. Therefore, the budgets for various renewable energy projects which were initiated in 2005 have been either greatly reduced or eliminated, and the government's ambition to eventually create various renewable energy industries for Taiwan has been redirected and delayed.

This chapter summarizes briefly some of these projects and reflects on developments after 2005.

TAIWAN'S ENERGY CONUNDRUM

As noted in other chapters of this report, Taiwan's location off the southeast coast of China between Japan and the Philippines, and its relatively small size (about 36,000 square kilometers) for its population of about 23 million residents, have contributed to its energy profile. As an island, Taiwan needs to generate its own energy from either fuel imports or its own indigenous sources in order to maintain the worldwide reputation of its semiconductor, personal computer, and integrated circuit industries.

In 2009, only 0.63 percent of Taiwan's total energy consumption was supplied from domestic sources.¹ Further analysis of the energy consumed indicates that oil, coal, and natural gas, all largely imports, constituted 30.45, 51.82, and 8.62 percent of energy consumption, respectively, while hydropower constituted 0.26 percent, photovoltaic and wind power 0.06 percent, and solar and thermal power 0.08 percent of Taiwan's energy profile. It is clear, then, that the majority of Taiwan's energy needs were supplied by fossil fuels. Fossil fuel power plants and vehicles such as automobiles and motorcycles are the main contributors to Taiwan's CO₂ emissions, which comprise the third largest per capita volume in the world, behind only the United States and Australia

Taiwan's overreliance on fossil fuels has taken its toll on the environment. Before 1970, Taiwan was a beautiful agricultural island. After the rapid industrialization of the last several decades, industrial pollutants, many of which were the result of the burning of fossil fuels, and pollution from increased traffic, have affected natural habitats and some animal species. From an environmental point of view, new genera-

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tions must work to decontaminate the island for the future generations.

Moreover, Taiwan's large emissions volume is an obvious international problem for the island. Taiwan is eager to gain voice in the international community as a recognized political entity. In order to be seen as a responsible global citizen, it has therefore voluntarily agreed to restrictions on emissions that nation states have established by treaty. Failure to meet self-imposed targets will make a mockery of Taipei's attempts to be counted as an international member of climate change regimes.

Taiwan's current overreliance on fossil fuels and the environmental and political need to reduce emissions and other forms of pollution have prompted some to position increased nuclear power as a sensible option for Taiwan's future. Currently, Taiwan has three nuclear power plants (with a total output of 4884 megawatts [MW]) in use, and a fourth (2700 MW) is scheduled to be in regular service at the end of 2011. The first and second plants have been operating for over 20 years, and they are near the end of their original designed service life. If the safety of these two plants is upgraded and if dry storage technology can successfully be developed to increase their waste storage capacity, their useful service life can be extended for additional 20 years.²

However, nuclear power is not a credible long-term solution for political and technical reasons. First, the high population density on Taiwan means there is already little free space between the island's cities and current nuclear power plants. These space limitations create potential safety problems, especially related to the question of storage of spent fuel. Second, Taiwan is located in a zone where frequent and major earthquakes are common, increasing public anxiety about nuclear power. The tsunami that battered the Fukushima nuclear power plant in Japan in March 2011, resulting in partial meltdown in the plant's reactor cores, has only reconfirmed the notion in Taiwan that the edge of a tectonic plate is not the best place to build a nuclear reactor. Finally, the People's Republic of China (PRC) currently aims over 1,000 missiles at Taiwan, and even a non-nuclear PRC strike on Taiwan's nuclear power plants would not only cripple Taiwan's power infrastructure, it would cause radiation to spread to the surrounding community. It is no wonder, then, that the public is averse to the notion of more nuclear plants.

Furthermore, if the costs of constructing a new nuclear power plant, storing spent radioactive fuel safely on an extremely long-term basis, and cleaning up potentially radioactive waste materials after a plant accident or natural disaster are included in the calculations, the cost per kilowatt hour of electricity generated by a nuclear power plant may not be as competitive as solar and wind power plants in the future, after these renewable energy technologies are fully developed and can be mass produced.

PLANNING FOR A SUSTAINABLE FUTURE

Responding to concerns about Taiwan's energy supply and Taipei's ability to meet its Kyoto commitments, the Chen administration, after carefully considering the energy technology options, passed an important renewable energy plan in 2005. This plan focused particularly on the scope for developing commercial solar, wind, fuel cell, and biofuel energy technologies. The goal of the plan was to generate 6.5 GW-about 10 percent of Taiwan's energy needs and enough to replace existing nuclear power plants-from renewable sources by 2020, and simultaneously to create renewable energy industries for the island. Due to Taiwan's size and lack of resources, combined efforts from industry, the academic world, and other research organizations were required to achieve these common goals.

In the plan, the government and the National Science Council (NSC) decided to convert the Institute of Nuclear Energy Research (INER) into an environmental and energy research and development center. The INER has been a government research center for over 30 years and normally has over 1,200 employees. One of their main functions has been to deal with the various safety issues related to the existing three nuclear power plants on Taiwan. By converting INER into an environmental and energy center, the NSC hoped the center will develop new renewable energy industries for the island by conducting research on new materials, new processes, new specifications, and system modeling for the future solar, fuel cell, and wind industries. The INER also currently plans to convert buildings to demonstrate various green energy technologies.

Developing alternate energy sources

In addition to the plan, the DPP administration conducted a review to establish the feasibility of alternative power sources for Taiwan. It found that Taiwan had an abundance of solar, wind, and ocean resources that could be harnessed to generate electricity. Because Taiwan is located in the sub-tropics, plenty of sunlight is available throughout the year, especially in the South, where there are over 300 days of strong sunlight per year. On the west coast of the island and in the Taiwan Strait, strong winds, especially in the winter, make wind energy an attractive option. Strong deep Pacific Ocean currents mean that wave and ocean-current power is an option if turbine technology can be developed in this area. Meanwhile, ample hot springs throughout the island mean that geothermal energy can be developed for the electricity generation.

However, because they are reliant on favorable weather conditions, solar and wind power generators are not reliable energy sources and these sources must therefore be supplemented from time to time.³ Fuel cells should be an extremely attractive option for Taiwan. Some of the greatest technological leaps in recent years have occurred in the development of fuel cell technology. Since 1990, most of the world's advanced nations have directed investment capital and crafted policy with the aim of developing more thermally efficient fuel cells. Because they have a higher degree of thermal efficiency than traditional fossil fuel power plants, the fuel cells can generate electricity and simultaneously supply hot water as a by-product. Their greater use would reduce CO_2 emissions, making them an attractive option for Taiwan. Among several types of fuel cell technologies, the proton exchange membrane fuel cell is suitable for Taiwan's 3C (i.e. computer, cellular phone, and camera) industries, and the potentially cheaper solid oxide fuel cell (SOFC) would be an excellent choice for distributed power generators.⁴

Biofuels can be another resource for Taiwan's isolated energy market, because Taiwan has a history of agricultural development and it has the technology to produce bioethanol from crops such as rice, yam, and sugar cane. Moreover, low domestic demand for agricultural products has meant that some fertile areas of land in Taiwan have fallen fallow, allowing more space for growing new biofuel crops. Furthermore, Taiwan can also develop technologies to convert cellulosic waste from agriculture products such as rice straw and bagasse into useful biofuels.5 Since bioethanol produced from agricultural products has net zero CO₂ emissions according to the Kyoto protocol, biofuels are an attractive option for offsetting some of Taiwan's energy imports.⁶

Starch and sugar produced by algae via photosynthesis can also be processed into bioethanol or biodiesel, at the same time as these algae remove CO_2 from the atmosphere through the photosynthetic process. Several species of algae can grow faster than trees, grass, or vegetable plants. Therefore, growing algae can be an efficient way to capture and recycle the atmospheric CO_2 . Since Taiwan has plenty of ocean space available for this application, technologies should be developed to select the appropriate type of algae, to grow the algae in the marine farms, and to harvest and produce the biofuels from it.



The main purpose of the projects initiated in 2005 was to search for new energy sources to eventually replace Taiwan's nuclear power plants. Some of the projects described were exploratory in nature and have made very little progress since their inception five years ago. However, other projects have managed to produce excellent technologies, such as: catalytic reforming for production of hydrogen from bio-ethanol; solid oxide fuel cell stacks; various pilot and laboratory test units for producing bio-ethanol from bagasse and rice straw; small (greater than 25 kilowatts [kW]) and mid-size (150 kW) wind turbine generators; and the 1 MW Kaohsiung High-Concentration Photovoltaic (HCPV) solar demonstration plant. With further developments to advance the mass production techniques and to reduce manufacturing costs, these technologies can reach commercial stages in the near future.

Reconfiguring the Power Supply

The Renewable Energy Plan also called for the government to upgrade power distribution capabilities by developing more nimble power generation technologies. As depicted in Fig. 1, distributed small power generators such as solar panels, wind generators and fuel cells can be connected to the main (smart) power grid. Intelligent control software can be used to manage power generation and usage from various power sources. For example, a large building or a large shopping mall requires a large amount of electricity, and will get a major share of electricity needs from the main nuclear, hydro, coal, oil and/or gas fired power plants. But for a smaller grocery store, a 200 kW fuel cell power generator can supply the majority of its electrical needs, and the main power plants from the grid can be used to supply additional energy needs during peak hours.



For a typical home, a 5 kW fuel cell generator can usually supply both the electricity and hot water to the home most of the time, although the home may occasionally require additional electricity from the main grid at the peak hours. Fuel cells can also provide energy for mobile forklift trucks and motorcycles. For a typical home equipped with a 1 kW solar panel, the solar panel can often supply over 30 percent daily electrical needs. If one million homes are equipped with one 1 kW solar panel each, the total electricity generated can theoretically reach 1,000 MW, which is almost equal to a small hydropower plant or nuclear plant. In other words, the construction of major new power plants can theoretically be replaced by installing large numbers of small renewable power generators.

Additional Technology Options for Reducing CO, emissions

In order to meet its self-imposed targets, the Taiwanese government also needs to develop ways of reducing CO₂ emissions at the level of energy generation. Existing gas, oil, and coal power plants should be upgraded to improve thermal efficiency by adopting new technologies such as the integrated gasification combined cycle (IGCC) for coal plants.7 This process turns coal into "synthesis gas" and then removes impurities from the gas to turn into reusable byproducts. There is room to develop Taiwan's oil and gas plants, as well as factories to take more advantage of combined cycle technology-a design principle that recycles exhaust gas from regular industrial production and makes use of energy generation processes to recover heat and to generate more electricity. In the future, potential clean coal power plants, which combine the IGCC and SOFC technologies, should be used instead of regular coal plants.

Energy conservation is also an area where Taiwan needs to direct more attention. With very few natural resources, it is not feasible for Taiwanese companies to build any new powerhungry industries such as cement or steel plants. In addition, any lighting devices (i.e. home, office and street light bulbs), household appliances, and office equipment should be replaced by energy efficient devices and equipment. An accumulation of a large number of small savings can add up, and again, can potentially eliminate the need for the construction of major new polluting power plants.

Indeed, in the area of new plant construction, the need for renewable energies means that Taiwan can afford to experiment with bold new ideas. One idea that has already been broached is that of constructing plants which harness wind, solar, and wave energy while at the same time producing raw material for biofuels.8 The vast ocean area beyond Taiwan's west coast is suitable for "marine energy farms." Such farms would consist of wind turbine generators, carrying thin-film solar panels on and suspended between their poles. Meanwhile, algae and fish could be farmed in the sea below the turbines. With proper selection of algae species, bioethanol or biodiesel could be produced from the fast growing algae as a way of recycling atmospheric CO_2 . Biofuels produced from the algae on site could be combined with fuel cells to generate electricity. As discussed previously, all of these methods can produce electricity with virtually zero net CO₂ emissions.

Moreover, there is no reason why these farms would be exclusively used offshore. Currently in central and south Taiwan, large numbers of small fishponds are being used to grow fish for human consumption. A smaller scale of solar panel, wind turbine and algae farm can be installed in these ponds as distributed power generators to generate electricity for local applications.





Source: Gou-Chung Chi, "Taiwan's Situation and Countermeasures: Materials for Clean Energy Production and CO2 Reduction" (presentation, Science and Technology Interchange Committee, Association of East Asian Relations (Taiwan), Lisbon, Portugal, November 2007); L.F. Lin, "Analysis of Taiwan's Renewable Energy Potential"; Institute of Nuclear Energy Research Report 16503 (Oct. 4, 2008).

CONCLUSION

Distributed small-scale power generators such as those that rely on solar, wind, and biomass as resources, and fuel cell technologies, can produce electricity with minimum pollutants and with almost net zero CO₂ emissions. As described previously, on a large enough scale, these power generators can be used to replace fossil or nuclear power plants. Taiwan currently has three nuclear plants, and the fourth plant is scheduled to be in service in 2011. Given the island's dense population and very little space between the cities and the nuclear power plants, radiation leaks, emergency evacuations, and other safety issues can potentially create a big problem. These problems were brought sharply into focus with the unfolding Fukushima crisis. Nevertheless, the Taiwanese government approved the budget for the new power plant in June 2011, despite fierce opposition, and after DPP proposals to scrap the budget altogether.

There is another short-term solution. Instead of constructing new nuclear power plants, the government should consider extending the life of the old plants by 20 years, simultaneously increasing capacity for the waste and dry storage for the plants and improving the design safety of the plants to combat floods, earthquakes, and other potential natural disasters. For the time being, the cost of renewable energy such as solar, wind, and fuel cell technologies is still too high to be competitive. Therefore, there should be a renewed focus on developing technology to reduce the production costs for these renewable energy sources to eventually phase out the nuclear plants.



Taiwan should also aim to expand its capacity to produce renewable energies that are already competitive. With current crude oil prices approaching \$100 per barrel and higher, bioethanol and biodiesel produced from agricultural products are currently an attractive option to replace diesel and gasoline in transportation applications. Future technologies will allow increases in the production capacity of bioethanol from cellulose, animal, and industrial wastes, potentially reducing the production cost further.

Successfully developing these new energy technologies will require a lot of time and effort. Since Taiwan is small with limited resources, it can accelerate its progress in research and development on renewable projects by sharing its development results and costs with leading international technology companies as development partners.

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ENERGY SECURITY AND POLICY IN TAIWAN

CHI-YUAN LIANG

subtropical island in the western Pacific, Taiwan lacks natural resources and is highly dependent on fossil fuel imports for its energy demands. Aware of the nation's particular vulnerability to fluctuations in global energy prices, the Taiwanese government is pushing various programs and legislation that will develop cleaner, greener energies, promote efficiency, and reduce greenhouse gas emissions. International cooperation must also be pursued as another means of enhancing Taiwan's energy security. This chapter compares Taiwan's energy security to that of major nations and investigates Taiwan's energy policy framework. It also proposes possibilities for cooperation in energy development between Taiwan and the United States.

INTERNATIONAL COMPARISONS OF ENERGY SECURITY

In quantitative comparisons of energy security and global warming, the key conventional indicators are imported energy ratio, energy concentration ratio, carbon emissions per capita, and carbon intensity. This section compares Taiwan's energy security with those of nine major countries, including France, Germany, Italy, Japan, the People's Republic of China (PRC), Spain, South Korea, the United States, and the United Kingdom.

Imported energy ratio

Imported energy ratio (IER), defined as the amount of imported energy divided by the total energy supply, indicates the stability of a country's energy supply. As such, a country with a lower IER generally depends less on foreign energy, as it owns more indigenous energy resources to satisfy domestic demand. Maintaining a lower IER can mitigate the impact of fluctuating international energy prices, which in turn stabilizes domestic prices and promotes industrial development.

A comparison of IERs among the ten countries surveyed here in 2007 showed that Taiwan had the highest ratio of imported energy (99.32 percent), followed by Japan (98.9 percent), South Korea (97.8 percent) and France (92.3 percent). Meanwhile, those with the lowest ratios included the PRC (19.2 percent), the United Kingdom (27.7 percent) and the United States (30 percent).¹ If nuclear energy were considered a quasi-indigenous energy (as in countries like Japan) and excluded from measures of imported energy, Taiwan's IER would still be the highest at 90.0 percent, compared with Japan at 83 percent, France at 56 percent and the United States at 30 percent.²

Over the past several decades, Taiwan's IER has seen a steady increase from 86.2 percent in 1982 to 99.33 percent in 2008—a clear indication that its energy security has declined. Taiwan has also grown more vulnerable to politi-

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cal uncertainty in the Middle East. In 2000, Taiwan depended on the Middle East for 60.34 percent of its crude oil imports, and this figure increased to 81.15 percent in 2007.³

Energy concentration ratio

Another important measure of energy security is energy concentration ratio (ECR). Energy can be harnessed from a diverse range of sources, including coal, crude oil, natural gas, nuclear power, hydropower, solar photovoltaics (PV) and wind power. However, if a country is highly dependent on only a few concentrated sources, any shortages of these sources will have a pronounced impact on economic growth. Hence, the higher the energy security. In 2007, Taiwan had a relatively high ECR (61.4 percent) compared with the PRC (69.3), Italy (58.9 percent), the United States (52.1 percent), and Germany (49 percent).⁴

Carbon dioxide emissions

Carbon dioxide (CO_2) is the largest contributor to greenhouse gas emissions around the world. Among the countries surveyed here in 2007, the PRC and the United States were the two highest emitters of CO_2 while Taiwan was the lowest with 276 million metric tons (t). Since populations differ widely from country to country, a more equitable indicator would be CO_2 emissions per capita. High CO_2 emissions per capita indicates that a nation's residents are engaging in more carbon-intensive economic activities, or that the country is consuming excessive amounts of energy that is heavily reliant on carbon for production.

In 2007, Taiwan emitted 12.1 t of CO_2 per capita, second only to the United States (19.1 t). This may be attributed to the fact that exports account for 70 percent of Taiwan's gross domestic product (GDP).⁵ The production of these

exports demands a relatively high energy intensity relative to GDP, and also a high energy consumption/GDP ratio.⁶

However, if indirect net energy exports were excluded from domestic energy consumption, Taiwan's CO₂ emissions per capita in 2007 would be 9.43 t instead of 12.1 t, and Taiwan would be the sixth-highest rather than secondhighest emitter per capita. Rather than simply measuring emissions at the point of production, this method, as described by Davis and Caldeira (2010), measures the emissions at the point of consumption, in other words holding those responsible for creating demand as responsible for emissions.⁷ Under this approach, the United States would remain the highest emitter per capita (21.4 t) in 2007, followed by the United Kingdom (12.52 t), Germany (12.39 t), Japan (11.85 t), South Korea (10.45 t), Taiwan (9.43 t), Italy (9.23 t), Spain (9.2 t), France (8.32 t) and the PRC (3.56 t).

Looking at emission trends in Taiwan over the past three decades, CO_2 per capita increased from 1982 to 2007 as economic growth caused excessive consumption of high-carbon energy and low energy efficiency. Only the recent global economic slowdown and energy efficiency improvements contributed to a lowering of emissions from 2007 to 2008.

Carbon dioxide intensity and energy intensity

Carbon dioxide intensity (CO₂ per unit of GDP) and energy intensity (energy per unit of GDP) are measures of a country's energy efficiency. The two refer respectively to the units of CO₂ emitted, or the units of energy required, to produce one unit of GDP. A country with higher carbon and energy intensities generally has lower energy efficiency.

In 2007, the PRC registered the highest carbon intensity (2.52 kilograms per U.S. dollar, in 2000 prices [kg/USD]) among the 10 countries, followed by Korea (0.69kg/USD), Taiwan





Source: International Energy Agency, OECD. 2009. Key World Energy Statistics.



Source: International Energy Agency, OECD. 2009. Key World Energy Statistics.



(0.66kg/USD), and the United States (0.5kg/USD). Meanwhile, Japan (0.24kg/USD) and France (0.25kg/USD) showed the lowest carbon intensities (see figure 1).

Since carbon emissions come mainly from energy consumption, countries ranked similarly in terms of CO_2 intensity and energy intensity (see Figure 2). Japan, France, and the U.K. still demonstrated high energy efficiency.

From 1982 to 2004, Taiwan's carbon and energy intensities declined until the turn of the millennium, when both indicators began rising again. This trend can be explained by the share of total energy consumption attributable to energy-intensive industries, which also decreased and increased over the same time. Since 2004 however, carbon and energy intensities have improved again due to the rise in world energy prices.

In summary, the above comparisons suggest Taiwan's energy security is relatively low as shown by its high imported energy ratio and energy concentration ratio. Taiwan is also more susceptible to climate change problems as indicated by its high CO_2 emissions per capita, CO_2 intensity, and energy intensity.

Measures to strengthen Taiwan's energy security

To better manage problems of energy security and global warming, the government released the Framework on Taiwan's Sustainable Energy Policy in June 2008, outlining the nation's goals of cutting CO_2 emissions to the 2008 level between 2016 and 2020, to the 2000 level by 2025, and further to half the 2000 level by 2050.⁸ To achieve these goals, the government is proposing the following measures: energy restructuring, re-evaluation of the "nuclearfree homeland" policy, rational energy pricing policies, tighter efficiency regulations, and industrial restructuring.

Energy restructuring

To promote the use of renewable energy, the government promulgated the Renewable Energy Development Act in July 2009 with the goal of increasing Taiwan's renewable energy generation capacity to 6,500-10,000 megawatts by 2030. However, it is worth noting that even if Taiwan fulfils this goal by doubling the amount of renewable energy generated by electricity installations from 2008 to 2025, renewable energy will still only account for 3 percent of the total primary energy supply, according to the Energy Development Guideline drafted July 2010 by Taiwan's Bureau of Energy. This is much less than the European Union's goal of 20 percent of total primary energy supply. Taiwan's difficulties in developing renewable energy lie in the following:

- Renewable energies are more costly than traditional fuels.
- Renewable power supplies are unstable.
- Taiwan has limited renewable resources.
- Hydro energy is scarce (accounts for only 0.3 percent of total energy supply).
- Taiwan's high population density (637 people/km²) limits the space available to deploy renewable energy.
- Three-quarters of the nation's territory is mountainous.⁹

To overcome these limitations, stronger research and development is essential for increasing the long-term competitiveness of Taiwan's renewable energy industries. The island already possesses excellent advantages in the information and communication technology (ICT) industries, which are vital for developing green energy. In 2008, Taiwan ranked first or second worldwide in production value for 14 ICT products and services, including integrated



chip (IC) fabrication, mask read-only-memory chips, IC packaging and testing, IC design and organic light-emitting diode (LED) panels. For green products such as LED chips and solar PV, Taiwan ranked first and fourth, respectively. Moreover, domestic ICT enterprises are keen to develop their "process innovation"—ways to combine information technology and human resources to improve business performance and help drive down the cost of new energy technologies. Such successful experiences and policies in promoting high-tech industries can serve as important references when developing renewable energy industries.

Furthermore, the government promulgated the Industrial Innovation Act in April 2010 to grant tax breaks to corporations for research and development, and amended the Income Tax Act in May 2010 to lower the corporate income tax rate from 25 percent to 17 percent, one of the lowest in East Asia. And in June 2010, Taiwan signed the Cross-strait Economic Cooperation Framework Agreement with the PRC to expand trade with the mainland.¹⁰ All of the above developments will enhance the international competitiveness of Taiwan's energy industries.

Rational energy pricing policies

Taiwan has one of the lowest energy prices in the world¹¹ with its oil and electricity markets dominated by the CPC Corporation and the Taiwan Power Company. As state-owned monopolies, these two companies often yield to public pressure to stabilize energy prices, at times seeking government intervention to manage rising import prices. From 2000 through 2008, Taiwan's government took strong intervention measures, even freezing energy prices from November 2007 to May 2008 as crude oil prices rose drastically from U.S. \$80 to U.S \$147 per barrel. Under this policy, however, CPC and Taipower respectively suffered losses of 120 billion new Taiwan dollars (NT \$ - U.S. \$3.8 billion) and NT \$75 billion (U.S. \$2.4 billion) in 2008.¹²

In June 2008, the new presidential administration unfroze energy prices and adjusted oil prices upward by 15 percent, electricity by 25 percent and natural gas by 30 percent. As a result, the public cut back on power consumption and Taiwan's energy intensity decreased by 7 percent in the second half of 2008.¹³ It is clear in this situation that energy prices should fully reflect the internal and external costs of energy consumption.

Further, to control the external costs of greenhouse gas emissions, the government should implement of a carbon tax (or energy tax) designed to promote environmental protection, encourage energy conservation and stimulate economic development. But to soften the economic impact of this policy, the government should only levy this tax through a progressive approach after the economy recovers and international energy prices become more stable.

Revenues generated from this tax can be used to benefit overall society by (1) reducing personal and business income tax rates, (2) replacing commodity, entertainment and automotive fuel taxes, as well as automobile and cement excise taxes, (3) easing employers' social welfare burdens (including pension and health care), (4) subsidizing energy expenses for lowincome families, (5) purchasing carbon credits from abroad, and (6) providing tax rebates to companies that demonstrate outstanding energy efficiency. Except for the last, all of these measures were proposed in resolutions at Taiwan's National Energy Conference in 2009.

Tighter efficiency regulations

There is also plenty of room to improve energy efficiency. The government should continue to tighten minimum energy efficiency standards laid out in the Energy Management Act for energy-consuming products (such as motors, boilers, electronic appliances and automobiles). The efficiency standards should reflect currently available technology, and products that do not conform should not be legally sold. This



will increase energy efficiency by keeping lowefficiency products off the market.

Also, Taiwan can adopt the Top Runner program adopted by the government of Japan. The program is designed to stimulate the continuous improvement of selected energy-consuming products, such as electric appliances and vehicles. After identifying the best energy-performing product on the market as the top runner, authorities introduce energy performance requirements for similar products based on that top runner's efficiency standards. Meanwhile, Taiwan's government began introducing comparative energy labels for selected products this year. A voluntary measure, these labels can encourage consumers to buy high-efficiency products, thus increasing their demand. By combining the top runner concept with energy labeling, Taiwan will be able to raise the benchmark for energy efficiency and accelerate the development of energy-saving technologies.

There are a number of technologies, however, that already exist and could be put to use. In Taiwan, 52 percent of roadway lights are fitted with mercury vapor light bulbs, which consume 40-60 percent more electricity than LED bulbs. Another 35 percent of roadway lights use high pressure sodium (HPS) bulbs, which can be replaced by LED bulbs for 40 percent less electricity and significantly longer service lifetimes. Recently, Taiwan's Academia Sinica research institution replaced old mercury lights on its campus with LED lights. The high-efficiency bulbs will save 40 percent on energy bills and are expected to pay for themselves in five years.

Taiwan's government should also promote a green building labeling system and raise energy efficiency standards to reflect current construction technology. Using low-emitting windows and insulation in ceiling and walls will improve building insulation and provide significant savings on air conditioning bills. The government can also provide a variety of financial incentives to promote high-efficiency vehicles. Examples include lowering the commodity tax on fuelefficient vehicles, establishing vehicle recycling systems, and raising costs on exhaust emission tests for older, less efficient vehicles.

Many Taiwanese companies, meanwhile, have already made strides over the past decade to reduce carbon dioxide emissions. Before a carbon trading market is officially established in Taiwan, which would occur only after the passage of the Greenhouse Gas Reduction Bill, the government can invite these companies to make a one-time application for carbon credits for past emission reductions. These credits can be calculated from carbon emission intensity (grams of CO₂ per dollar GDP) instead of the carbon emission factor (grams of CO₂ per unit of material produced). Establishing such a carbon trading platform will encourage companies to increase energy efficiency and produce more high value-added products, which in turn will spur the research and development of high-efficiency technologies.

Industrial restructuring

As mentioned previously, Taiwan's energy prices are among the lowest in the world and do not fully reflect internal and external costs. In such an artificial pricing system where energy prices are set by the government, the price signals do not provide enough incentive for consumers and suppliers to reduce energy consumption or restructure the industry. This pattern of economic development conflicts with environmental considerations. As one remedy to the problem, Taiwan's government amended the Energy Management Act in July 2009 to promote energy saving mechanisms, and proposed promoting non energy-intensive industries such as the service sector, green energy, biotechnology, and medical care, and requiring energy-intensive industries (such as steel, cement and petroleum chemicals) to provide CO₂ offset plans when investing in new projects.

Additionally, Taiwan is in the process of legislating the Greenhouse Gas Reduction Bill



that, when approved, will establish a domestic carbon trading system. The country is also applying for entry into the United Nations Framework Convention on Climate Change (UNFCCC) to connect with international efforts on carbon reduction. These policies are key to helping Taiwan achieve its emission reduction targets.

mechanisms to support emission mitigation in developing countries. For example, Taiwan initiated a lamp program in the African country of Burkina Faso to install solar panels at schools for the purpose of recharging small, portable lamps. The lamps encourage reading, and since they must be recharged at school, keep the children returning to classes.

PROPOSED COOPERATION ON ENERGY DEVELOPMENT AND GLOBAL WARMING

U.S.-Taiwan cooperation on energy development and global warming could include technology transfer and cooperation agreements. Collaborations between the United States and Taiwan can begin with materializing the existing U.S.-Taiwan agreement on technology transfer and cooperation in clean coal and advanced power technology. The two governments should also consider signing agreements on renewable energy, electric vehicles, advanced batteries, energy efficiency and other areas.

Nuclear waste treatment is another area where the two can work together. The resurgence of interest in nuclear energy has been accompanied by a growing need for sustainable solutions to nuclear waste. At Taiwan's Nuclear Power Plant No. 1, the storage pool may not have sufficient capacity for the next batch of spent nuclear fuel. Cooperation between the U.S. and Taiwan can lead to an earlier solution to this problem.

The clean development mechanism (CDM) allows emission-reduction projects in developing countries to earn carbon credits that may be sold to industrialized countries. This mechanism promotes sustainable development in developing countries while giving industrialized countries more flexibility in meeting their carbon reduction targets. Under the UNFCCC framework, Taiwan can cooperate with the U.S. on CDM projects in developing countries in Asia.

Aside from bilateral cooperation, the U.S. and Taiwan can consider multilateral financial

CONCLUSION

Comparisons of four energy security indicators among ten select major nations indicate that Taiwan's energy security is relatively low. This is attributable to the country's lack of domestic energy resources, high concentration of energy consumption, high CO_2 emissions per kilowatt-hour of electricity generation, high share of exports in GDP, and low energy efficiency.

To improve Taiwan's energy security, the government should: (1) increase the use of lowcarbon energies such as renewable resources, natural gas, and nuclear power; (2) materialize a rational energy pricing policy; (3) implement carbon tax and green tax reform; (4) reform industrial structure; and (5) tighten efficiency regulations on energy-consuming products, vehicles and buildings.

International cooperation is also vital for increasing Taiwan's energy security. This paper suggests the United States and Taiwan cooperate on technology transfers, nuclear waste treatment, CDM projects and emission mitigation in developing countries. These collaborative efforts will bring about a win-win future for all.



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TAIWAN-MAINLAND CHINA ENERGY TIES: COOPERATION AND POTENTIAL CONFLICT

HONGYI LAI

n order to survey the interaction between Taiwan and mainland China over energy, it is necessary to examine their past and recent cooperation and potential consequences of friction or conflict. A brief overview of Taiwan's energy profile is presented below to provide a backdrop for an analysis of potential cross-Strait dynamics. This is followed by a detailed examination of attempts at cooperation between mainland China and Taiwan on the management of major energy sources (i.e., oil and gas, coal, nuclear, and renewable energy) in the 1990s and especially 2000s. However, any analysis of cross-Strait energy ties will not be complete without a discussion of the most likely worst-case scenario of cross-Strait interaction, namely, a military blockade of Taiwan imposed by the mainland and the implications of such a blockade for Taiwan's energy supply. Such a scenario is examined at the end of this chapter.

TAIWAN AND MAINLAND ENERGY COOPERATION

Given China's large energy demand and its reliance on external energy resources, there should be plenty of scope in Taiwan for cooperation with the mainland in obtaining conventional and renewable energy resources. Both mainland China and Taiwan share several concerns and in many ways have a complementary energy profile. They each rely on large crude imports and are actively seeking overseas oil and gas resources. Both have also been attempting to develop their respective renewable energy sectors in recent years. In addition, China has one of the largest coal deposits in the world and can become a supplier of coal to Taiwan. On the other hand, Taiwan has longer experience in civilian nuclear power and can help the mainland to rapidly develop its much-needed nuclear power capacity. Nevertheless, the need for cross-Strait energy cooperation is subject to political influence and possible security considerations.

Oil and Gas

As already noted in earlier chapters of this report, oil is the largest energy source for Taiwan (49.0 percent of the energy supply in 2010), and Taiwan is eager to find oil fields near the island. The Tainan Basin of the Taiwan Strait is one of the areas near Taiwan where oil reserves are believed to exist. According to some estimates, recoverable oil reserves in the basin amounted to 300 million barrels and natural gas reserves to 41.7 trillion cubic feet. These amounts are equivalent to 94.7 percent of Taiwan's imported crude and 84.3 percent of the natural gas consumption in 2010.¹

In the 1990s there were several occasions when Beijing invited Taipei to participate in exploration of the mainland's offshore oil or gas. In 1993, the mainland's state-owned China National Offshore Oil Corporation (CNOOC) opened the exploration of the East China Sea to foreign investors and invited Taiwan to explore oil and gas near the Diaoyu (Senkaku) Islands. The Taiwanese authorities declined to discuss the issue. In 1999, CNOOC contacted Taiwan about its interests in taking over the equity of the Atlantic Richfield Company in oil exploration

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in Bohai Bay. Because of Taiwanese President Lee Teng-hui's policy of caution towards the mainland, Taiwan failed to take advantage of this opportunity. Two years later, the large Nanbao oil field was discovered in the area. In 2001, CNOOC invited the Chinese Petroleum Corporation (CPC), Taiwan's national oil company, to bid for rights at an oil field in the Pearl River Mouth Basin. Although it was in the CPC's commercial interest to move forward, the company failed to bid because of strong opposition by the Democratic Progressive Party (DPP), then the ruling party of Taiwan. In 2006, other companies successfully explored the area, discovering a large oil field.²

Cross-Strait oil and gas cooperation materialized between 2003 and 2005. In 1994 the mainland and Taiwan started to explore the possibility of joint oil and gas exploration near the middle line of the Taiwan Strait. In July 1996 the CPC and the CNOOC signed an agreement to explore a 6,000 square mile area in Taichao in the Tainan Basin and to share the costs and profits of any extraction. The agreement was approved by the Legislative Yuan of Taiwan in May 2002. The pact came into effect in January 2003, providing for four years of joint exploration and 15 years of joint production. Meanwhile, the CPC inked a deal with China Aviation Oil, a Singapore-based subsidiary of the China National Petroleum Corporation (CNPC). According to the deal, from September 2002 onwards the CPC would refine crude oil and transport diesel and liquid fuel via another area to the mainland. In December 2002 the CPC decided to work together with the Great Wall lubricant company under the CNPC to take advantage of the lubricant oil market on the mainland.³ In 2005, in line with the Taochao oil agreement, the CPC and the CNOOC drilled a well in Taichao but failed to find oil. Afterwards, joint exploration was terminated after cross-Strait ties deteriorated under the DPP.⁴

In 2008, with the Nationalist Party (KMT) returning to power in Taipei, cross-Strait rela-

tions improved, leading to the renewal of cooperation over oil resources. In 2009 the CPC and the CNOOC signed four documents in Beijing. The first was a letter of intent for cooperation in the following areas: exploration abroad; transfers of ownership of oil fields abroad; joint bidding overseas; exploration of natural gas; refinery of crude oil; trade of crude oil and oil products; technological exchange; and training. The second document was the renewal of the Taichao oil agreement signed in 1996 and valid until 2010, which also expanded the area for joint exploration from 15,400 square kilometers to 38,000 square kilometers. The third document was an agreement on joint exploration in the Nanri Island basin, the third largest island of Fujian Province on the other side of the strait from Taiwan. The last was an agreement regarding the transfer of 30 percent of the rights and interests of Block 9, a subdivision of an oil reservoir in Kenya, from a subsidiary of the CNOOC to the CPC.⁵

There is one area where cross-Strait oil and gas cooperation seems promising. Taiwan has the capacity for refining 120 million barrels of crude a day, including capacity for refining high sulfur crude from the Middle East, but consumes only 800,000 barrels a day.⁶ Mainland China, on the other hand, seeks to expand its capacity for refining high sulfur crude. Therefore, Taiwan has something to offer the mainland in future deals on cooperation.

Coal

In 2010, coal constituted 32.1 percent of Taiwan's energy supply. However, Taiwan has very scarce coal resources. In fact, domestic coal production came to a halt in 2000. Total coal consumption grew from 17.2 million metric tons in 1990 to 62.9 million metric tons in 2010, an average annual increase of 6.7 percent.⁷ In 2010 73.3 percent of the coal consumed was for power generation, 13.6 percent for industrial and other departments, and 11.1 percent was for



coking. Until 2005, mainland China remained the top source of coal supplies for Taiwan, accounting for 31 to 41 percent of Taiwan's coal imports from 2002 to 2005. ⁸ Since then, however, imports from China declined, whereas those from Australia and Indonesia rose sharply (see Figure 1). In 2010, the top sources of coal for Taiwan were Australia (45.4 percent of coal consumed) and Indonesia (37.4 percent), followed by mainland China (6.2 percent) and South Africa (4.1 percent). Other countries — Russia (1.8 percent), Canada (1.2 percent), the U.S. (0.4 percent), and all other sources (3.6 percent)—were much less significant.

As early as 2004 the DPP government in Taiwan imposed administrative restrictions on imports from mainland China.⁹ It seems that this drop in coal imports from the mainland went hand in hand with the severed cross-Strait oil exploration and had much to do with the DPP's pro-independence stance and general hostility toward the mainland. After 2007, rapid economic growth generated strong demand for energy sources in mainland China, including coal, also resulting in decline in its coal exports.¹⁰ These two factors could be the causes for the relative drop of the mainland's coal exports to Taiwan.

Nuclear Power and Electricity

Taiwan has a much longer experience with nuclear power than mainland China. Taiwan started to use nuclear power in 1977, fourteen years ahead of the mainland. It has considerable experience in the construction and safe operation of nuclear power plants. In 2010, nuclear power accounted for 8.3 percent of energy production in Taiwan. In contrast, nuclear power constituted merely 0.8 percent of the mainland's energy consumption back in 2008.¹¹ Taiwan can



Source: Bureau of Energy, Ministry of Economic Affairs, Energy Statistics Handbook, 2010, (Taipei: Ministry of Economic Affairs, 2011). p. 51.



thus provide useful experience for the mainland and cooperate with the mainland in the use and development of nuclear power.¹² In the wake of Japan's nuclear power station explosions and leakage in March 2011, the mainland and Taiwan have paid more attention to the issue of nuclear safety. In May 2011, at the Cross-Strait Economic, Trade and Culture Forum in Chengdu, the capital of Sichuan Province, the mainland and Taiwan jointly proposed to establish information sharing mechanisms to ensure the safety of nuclear power.¹³

Renewable Energy Sources

Rising energy prices (especially for oil and coal) in Taiwan in recent years (especially around 2007-2009) have prompted Taiwanese authorities and business to scramble for cheaper and alternative energy sources, including renewable energy sources. Renewable energy sources comprise biomass, hydropower, geothermal, wind, and solar power. In 2010 hydropower provided 0.28 percent of Taiwan's energy production, photovoltaic and wind power supplied 0.07 percent, and solar and thermal power 0.08 percent. Altogether, renewable energy constituted less than 1 percent of energy production.

In 2008 the government of Taiwan announced a "Framework of Taiwan's Sustainable Energy Policy." It aimed to decrease energy intensity by 20 percent from 2005-2015, cut CO_2 emissions to the 2000 level in 2025, and increase the share of low carbon energy in electricity generation from 40 percent (of 2008 levels) to 55 percent in 2025. It also proposed to increase the share of renewable energy in the electricity system to 8 percent by 2025.¹⁴

In contrast, in 2009 renewable energy constituted 4 percent of China's total power generation. In recent years China has invested heavily in renewable energy sources. From 2008 onwards, partly as a stimulus measure after the global financial crisis, the Chinese government decided to accelerate investment and development of the renewable energy industry.¹⁵ The mainland's large markets and relative abundant resources can offer windfall opportunities for the development of technology and markets for Taiwan.

In July 2009, the joint recommendation at the conclusion of the fifth annual Cross-Strait Economic, Trade and Cultural Forum stated that Taiwan and mainland China would work together in the environmental and renewable energy industries. The recommendation also emphasized the following areas for cooperation: "strengthening mutual cooperation in the research, development, and application of environmental and renewable energies; encouraging enterprises on both sides of the Taiwan Strait to cooperate in the research and development of environmental and renewable energies; holding of regular conferences; establishing regular channels of communication; and promoting societies that conserve energy and preserve their environments."¹⁶

Taiwan and mainland China are two big industry players in wind power equipment. Taiwan's wind power generation industry is still developing at its initial stage. In contrast, back in 2008 China was already one of the four major nations in production of wind power technology. More than almost any other nation, it also has access to wind as a power resource, mainly off shore. At the Taiwan-China Wind Energy Forum organized in Taipei on August 17-18 2009, Huey-Ching Yeh, director of the Bureau of Energy of the Taiwanese Ministry of Economic Affairs (MOEA) expressed hopes that Taiwan's suppliers of wind power-generating equipment and services and their Chinese counterpart companies would work together to set product standards, conduct personnel training, and gain access to the global market. Taiwanese businesses can take advantage of mainland markets as well as the mainland's leverage in the world markets. Both Chinese and Taiwanese companies have decided to cooperate on off-shore power generating farms.¹⁷

Until recent years photovoltaic industries on the two sides of the strait have long competed



against each other. Now the Taiwanese government has made the photovoltaic industry one of the six top industries in order to revitalize Taiwan's economy and has opened the solar energy industry to mainland Chinese investment. The mainland has apparent strengths in that it has both abundant deposits of materials for crystalline wafers and a sizable market for solar energy. Taiwan, on other hand, has far more advanced semiconductor and flat panel industries, enabling it to develop solar devices like wafers, cells and modules. In March 2009, 600 solar energy manufacturers, photovoltaic scientists, and energy regulators from Taiwan and mainland China attended a two day seminar in Taipei, which was reportedly the largest ever cross-Strait event addressing the photovoltaic industry. High profile attendants included the National Development and Reform Commission Vice Chairman Zhang Guobao from the mainland and Director Yeh. Participants discussed issues including industry policy, technology trends and the establishment of standards. They also sought substantial cooperation, starting from 2011.¹⁸

In June 2011 the cross-Taiwan Strait Information and Communication Technology (ICT) Forum was held for two days in Taipei. Taiwan's Sinocon Industrial Standards Foundation Chairman Steve Chen and Hu Yan, chairman of the Beijing-based China Electronics Standardization Association, signed three memorandums of understanding (MOUs) to promote bilateral cooperation in the standardization of technologies in the fields of LED lightening, photovoltaics, and flat-screen monitors.¹⁹

Cross-Strait Conflict over Energy

Mainland China strenuously opposes Taiwan's independence. The most likely trigger for cross-Strait conflict is a Taiwanese declaration of independence. Should conflict erupt, mainland China is likely to impose a naval blockade of Taiwan. A report published by Michael C. Grubb in the *Naval War College Review* analyzed the implications of a possible blockade by mainland China for Taiwan's economy and politics.²⁰ Much of this section draws its data from that report, which was current to about 2004. I have updated the energy supply, consumption, and imports data.

Coal, which next to oil is the second pillar of Taiwan's imported energy supply, is an energy resource that Taiwan directly imports from the mainland. As already noted, the share of coal coming from the mainland has sharply decreased in recent years to about 6 percent of total imports. Should the coal supply from mainland be cut off, Taiwan can make up for it by increasing its imports from elsewhere in the global coal market, such as Australia, Russia, Indonesia, and the United States. However, during any potential cross-Strait tension involving a blockade from the mainland there will be a rise in demand in Taiwan for dry bulk carriers for importing coal as demand for important agricultural bulk cargoes such as wheat, grain, corn and soybeans will also rise.²¹

The third pillar for Taiwan's energy is liquefied natural gas (LNG). In 2010 Taiwan imported a total of 14.5 billion cubic meters (equivalent to probably 10.95 million tons) of LNG, and the average annual growth rate in imports of the gas between 1990 and 2010 reached a very high 15.2 percent. According to Grubb, only one LNG tanker in the Taiwanowned merchant fleet-the Liberian-flagged M/T Golar Mazo was under long-term contract to provide LNG to Taiwan. The ship was co-owned by Golar LNG Company and CPC. The Golar Mazo could meet only 23 percent of the import demand around 2004, leaving the remaining 77 percent of the LNG shipping capacity to be filled by foreign-owned LNG tankers. On the other hand, during 2004-08 only four average-sized LNG tankers were needed to meet Taiwan's total import demand, thanks to Taiwan's close geographic proximity to its natural gas exporters, such as Indonesia (supplying 34 percent of Taiwan's natural gas

imports in 2008) and Malaysia (30.4 percent). By 2010, the percentage of Indonesian and Malaysian LNG supplied to the Taiwanese market declined to 17.9 percent and 25.6 percent, respectively, while those of Qatar and Nigeria rose to 23.8 percent and 7.6 percent, respectively. Therefore, a slightly higher number of LNG tankers may be needed to cover the longer distance. Meanwhile, these tankers would constitute such a large proportion of Taiwan's LNG trade, and each tanker would become a high-value target in any military conflict. As LNG provided 17.2 percent of the electricity generation in Taiwan in 2010, the loss of even one tanker would quickly disrupt the operation of Taiwan's electrical system.²²

In 2010 Taiwan consumed 55.4 million kiloliters of oil equivalent of liquefied petroleum gas (LPG), supplied mostly to residential and commercial markets.²³ Taiwan relied on six LPG tankers in the ROC-owned fleet, none of which flies the Republic of China (ROC) flag. In peace time these six LPG tankers met most of Taiwan's LPG import demand.

The most important pillar for Taiwan's energy supply is oil. Taiwan has proven in-ground petroleum reserves of four million barrels and 8,400 barrels daily domestic production. Thus the vast majority of Taiwan's oil consumptionover one million barrels per day-has to be met by imports. Taiwan's regulations require that petroleum refiners maintain at least a sixty-day supply of product, and the Taipei government established a 30-day oil stockpile in 2001. There were indications that around 2004 the Taiwan Power Company (TaiPower) had a sixty-day supply of coal and that the Chinese Petroleum Corporation (CPC) had a seven-day supply of LNG in storage. However, in March 2008 it was reported that the oil stockpile shrunk to only enough oil to supply 20 days of Taiwan's energy needs, causing alarm on the island.²⁴

In 2010 Taiwan imported 316.7 million barrels of crude. As much as 79.4 percent of Taiwan's crude imports came from the Middle East, and 12.6 percent from West Africa.²⁵ Virtually all of the imports were handled by one of two major petroleum players in the Taiwanese market, primarily the CPC and after 2001, the Formosa Petrochemical Company. These two companies collectively own and operate fleets of around forty oil tankers, which make up 65 percent of the ROC-owned tanker fleet (sixtytwo ships) and 70 percent of its total deadweight (5.49 million metric tons). Taiwan's tanker fleet comprised seventeen very large crude carriers (tankers of 150,000-299,999 deadweight metric tons, commonly referred to as VLCCs), supplemented by forty-five hulls, including smaller shuttle tankers, chemical tankers, and petroleum product tankers. These smaller tankers could be vital transporting platforms in a blockade scenario.

Forty percent of the tanker fleet that Taiwan owns (or 30 percent of the total tanker deadweight) flies the ROC flag. Only six out of the seventeen VLCCs owned by CPC were domestically flagged. If international carriers were to stop their port calls to Taiwan as the result of a Chinese blockade, the domestic-flagged fleet would be the key to Taiwan meeting its oil import needs. The fleet, however, could meet only 31 percent of the monthly oil import demand around 2004. Even taking into account both ROC-owned and foreign-flagged tankers, any losses of tankers, especially any loss or damage of VLCC, would disrupt Taiwan's energy supply.

According to the aforementioned report, in the case of a mainland blockade, it is unlikely that regional and global shipping interests would use Taiwanese ports. Although Taiwan owns 767 vessels, only 213 (28 percent) of them are registered under the ROC flag. In terms of deadweight tonnage, these ROC-registered vessels amount to 4.96 million tons, or 17 percent of the Taiwan fleet total. In the event of a blockade, the sinking of ships, the bombardment of ports, cranes, and other facilities at the ports, and LNG stations will hamper the flow of sea shipping, increase costs, and cause a halt a significant portion of cargo shipping to Taiwan.



Therefore, a blockade is likely to lead to a halt of major imports of goods into Taiwan.²⁶

Fortunately, thanks to the efforts on the both sides of the Strait since 2008 to defuse tensions, the likelihood of cross-Strait conflict has remained low. This opens the gateway for cross-Strait energy cooperation. The Taiwan-Mainland Economic Cooperation Framework Agreement (ECFA) conceived by the Taiwanese President Ma Ying-jeou calls for cross-Strait strategic alliance between stateowned corporations in energy, steel and telecommunication.²⁷ In fact, mainland China is willing to make economic concessions and allow Taiwanese business to reap disproportional benefits in energy deals in order to forge closer cross-Strait relations. In the near future Taiwan can reap peace dividends in the cross-Strait energy cooperation.

CONCLUSION

Over the past two decades, energy relations between Taiwan and the mainland followed overall relations. When cross-Strait political ties were smooth, energy cooperation continued on an upswing. On the other hand, when Taiwanese leaders made ostensible pro-independence moves, cross-Strait political ties were strained and cross-Strait energy cooperation was scaled back. In the early 1990s and in the mid-2000s the Taiwanese government rejected the mainland's invitations for oil exploration in areas off the coast of the mainland and in the Taiwan Strait. Since 2008, with the Nationalist Party returning to power in Taiwan, cross-Strait energy cooperation has apparently become warm again. Joint efforts have expanded into new areas such as renewable energy sources.

The biggest potential area of cross-Strait energy conflict is a military confrontation between Taiwan and mainland China. The conflict could erupt if Taiwan proclaims or edges toward de jure independence. Should this conflict occur, the mainland will put a hold on cross-Strait energy cooperation and energy exports to Taiwan. Taiwan's ability to sustain sufficient energy imports to fuel its domestic economy and vital social operations will be severely handicapped or undermined.

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