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Renewable Energy Feed-in-Tariff System Design and Experience in Taiwan

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1. Introduction

Facing climate change, energy dependency and energy security and other significant environmental challenges, many countries try to seek environmental sustainability, promote a green new deal, and develop renewable energy. IPCC (2011) found that building a low-carbon city, developing low-carbon industry and promoting low-carbon life are the major means for most countries to achieve a low-carbon society.

The major renewable energy sources include solar energy, wind power, biomass, geothermal, hydro power et al. REN21 (2011) Renewables 2011 Global Status Report indicated that in 2009 global renewable energy sources supplied 16% of global final energy consumption. In 2011 additional investments of renewable energy in the world were US$211 billion and the top 5 new capacity investment countries were China, Germany, the United States, Italy, and Brazil, respectively. In terms of new investment in types of energy, China was among the top-ranking countries in wind power and solar heat; Germany was at the top in solar photovoltaic and biodiesel production sources, and the United States was tops in ethanol production.

In 2010 the worldwide total renewable energy capacity was 1,320 gigawatts (GW), and the largest 3 types of renewable energy capacity (REC) were hydro power 1,010 GW, wind power, 198GW and the energy PV 40GW. The top 5 countries of REC were China, the United States, Canada, Brazil, and Germany/India. China was ranked at the top in capacity of wind power and solar heat; the United States was ranked first in biomass and geothermal power, and Germany was number one in solar PV (REN21 2011).

In recent years the two most important renewable energy tools in the European Union (EU) have been the Feed-in Tariff (FIT) and the Quota/TGC (a quota regulation in combination with a tradable green certificate). Twenty out of twenty-seven EU member nations are using FIT as their main renewable energy tool (Klein, et al., 2008). Table 1 reveals that no matter the extent of economic growth or national income distribution, all countries in the world promote an FIT policy to deal with the impact of environmental change (REN21, 2011). Taiwan is located in a sub-tropical area with abundant sunshine, surrounded by seas with strong wind power and ample currents; therefore, the island is suitable for developing

renewable energy (Bureau of Energy, Ministry of Economic Affairs, 2009). Taiwan has implemented an FIT policy since 2009. The purpose of the policy is not only to develop renewable energy aggressively, but also to save energy, reduce carbon emissions as well as ease the threat of excessive dependency on energy imports.

A renewable FIT policy focuses on two objectives: an Access Objective and a Price Objective (PACT, 2011). The Access Objective implies that the local power company that uses renewable energy power generation equipment to produce electricity and operate a power grid shall have the obligation to provide parallel connections and wholesale rates. The system design focuses on ensuring a connection to the grid, extending and reinforcing the grid and sharing reasonable costs. The Price Objective emphasizes setting a tariff at a reasonable level, guaranteeing a price for a designated period of time, and offering a reasonable return on investment. The system focuses on a tariff (price), a wholesale period and a wholesale rate, and an adjustable mechanism are very important, too (PACT 2011, Mendonça, Jacobs and Sovacool, 2010, and Chou, Lin, and Chen 2010)

High-income countries	National level policy	Austria, Croatia, Cyprus, Czech Republic, Demark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Latvia, Luxembourg, Portugal, Slovakia, Slovenia, Spain, Switzerland, United Kingdom
	No national level policy	Australia, Canada, United States
Upper-middle income countries	Algeria, Argentina, Bosnia & Herzegovina, Bulgaria, Costa Rica, Dominican Rep., Kazakhstan, Lithuania, Macedonia, Malaysia, Panama, Peru, Serbia, South Africa, Turkey	
Lower-middle income countries	Armenia, China, Ecuador, Honduras, India, Indonesia, Moldova, Mongolia, Nicaragua, Philippines, Sri Lanka, Thailand, Ukraine	
Low-income countries	Kenya, Tanzania, Uganda	

Source: REN21 (2011), Renewables 2011: global status report, http://www.ren21.net/
Taiwan started to provide Feed-in-Tariff countries in 2009.

Table 1. Feed-In Tariff Countries

This chapter attempts to analyze the renewable energy FIT system design and practice in Taiwan. First, the chapter indicates the present status of energy consumption and supply in Taiwan; then it introduces Taiwan's Renewable Energy Development Law (REDL); a discussion of the financial mechanism of the FIT in Taiwan follows; finally, we examine the effectiveness of Taiwan's FIT. In the meantime, we also want to introduce Taiwan's FIT model to members of the international academic community who are interested in related topics.

2. The Present Status of Energy Supply and Demand in Taiwan

2.1 Energy Consumption

The population of Taiwan is more than 23 million. The growth of energy consumption was very rapid; from 1990 to 2010 the annual growth rate was 4.39%. Energy consumption in 1990 was 50.99 million kiloliters of oil equivalent (KLOE) and in 2010 was 120,308 KLOE. Per capita energy consumption in 1990 was 2,520 liters of oil equivalent (LOE) and the number increased to 5,223 LOE in 2010. Table 2 lists the economic indicators for energy.

Item / Year	Mid-Year Population (1,000 Persons)	Total Domestic Consumption Quantity (10^3KLOE)	Per Capita Energy Consumption (LOE)
1990	20,233.00	50,986.70	2,519.98
1995	21,215.00	68,472.50	3,227.55
2000	22,125.00	91,737.40	4,146.32
2005	22,652.40	111,168.30	4,907.57
2010	23,035.40	120,308.00	5,222.74

Note: 1. Domestic Consumption = Energy Sector Own Consumption + Final Consumption 2. Final consumption = Industrial Sector + Transportation Sector + Agricultural Sector + Services Sector + Residential Sector + Non-Energy Consumption
Source: Bureau of Energy, Ministry of Economic Affairs (2010).

Table 2. Economic Indicators for Energy

Table 3 illustrates energy consumption by sector in 1990 and 2010. Consumption in the energy sector was 6.97%, industrial sector 53.81%, transportation sector 12.91%, services sector 10.95%, residential sector 10.71%, agricultural sector 0.8% and non-energy use 3.8%. Table 3 reveals energy consumption by source in 1990 and 2010. Consumption of coal and coal products was 8.33%, petroleum products 40.23%, natural gas 2.46%, electricity 48.60%, solar thermal sources 0.09%, and heat 0.29% (Bureau of Energy, Ministry of Economic Affairs, 2010). For the same period electricity consumption increased 6.15% from 1990 to 2010, but oil consumption decreased 5.57%, which demonstrates that electricity consumption showed an upward trend while oil consumption showed a downward trend in the last decade.

By Sector	1990	2010
Non-Energy Use	5.13%	3.83%
Residential	11.66%	10.71%
Services	9.75%	10.95%
Agricultural	2.86%	0.82%
Transportation	15.71%	12.92%
Industrial	45.40%	53.81%
Energy Sector Own Use	9.50%	6.97%

Source: Bureau of Energy, Ministry of Economic Affairs (2010).

Table 3. Structure of Total Domestic Consumption (By Sector)

Unit:%

Year	Total	Coal & Coal Products	Petroleum Products	Natural Gas	Electricity	Solar Thermal Power	Heat
1990	100.00	9.10	45.80	2.61	42.45	0.04	-
1995	100.00	7.36	44.57	3.54	44.44	0.08	-
2000	100.00	7.06	39.90	2.58	50.37	0.08	0.00
2005	100.00	6.68	41.17	2.07	49.88	0.09	0.11
2010	100.00	8.33	40.23	2.46	48.60	0.09	0.29

Source: Bureau of Energy, Ministry of Economic Affairs (2010).

Table 4. Total Domestic Consumption (by Energy Form)

2.2 Energy supply

Table 5 illustrates that the energy supply increased almost 2.5 times from 1990 to 2010 and the total amount increased from 58.52 million KLOE to 145.56 million KLOE. The annual growth rate was 4.66% from 1990 to 2010. In 2010 the indigenous energy of Taiwan only accounted for 0.61% of the total energy, and imported energy accounted for 99.39%. The indigenous energy included crude oil (0.01%), natural gas (0.18%), conventional hydro power (0.28%), solar photovoltaic and wind power (0.07%), and solar thermal power (0.08%). Imported energy included crude oil and petroleum products (49.03%), coal and coal products (32.09%), liquid natural gas (9.98%) and nuclear power (8.28%).

Unit: 10^3KLOE

Item	2010		1990		Average Growth Rate %
	Quantity	%	Quantity	%	
Total Supply	145,560.90	100.00	58,520.7	100.00	4.66
By Indigenous & Imported					
Indigenous Energy	893.0	0.61	2,313.8	3.95	-4.65
Coal	-	-	325.2	0.56	-100.00
Crude Oil	14.2	0.01	182.4	0.31	-11.97
Natural Gas	263.3	0.18	1,173.9	2.01	-7.20
Conventional Hydro Power	401.0	0.28	610	1.04	-2.08
Solar Photovoltaic and Wind Power	100.2	0.07	2.7	0.00	19.86
Solar Thermal Power	114.3	0.08	19.6	0.03	9.21
Imported Energy	144,667.9	99.39	56,206.9	96.05	4.84
Coal & Coal Products	46,710.9	32.09	13,696.1	23.40	6.33
Crude Oil & Petroleum Products	71,375.5	49.03	32,137.2	54.92	4.07
Liquid Natural Gas	14,525.8	9.98	855.6	1.46	15.21
Nuclear Power	12,055.7	8.28	9,518.0	16.26	1.19

Source: Bureau of Energy, Ministry of Economic Affairs (2010).

Table 5. Taiwan's Energy Supply in 1990 and 2010

2.3 Energy Efficiency and Security

Table 6 shows the energy efficiency indicators of Taiwan from 1990 to 2010. Taiwan's Energy productivity (Real GDP / Domestic Energy Consumption) in 1990 was NT $104 /LOE, and in 2010 the number increased to NT $118 /LOE. The energy intensity of Taiwan (Domestic Energy Consumption / Real GDP) was 9.95 LOE/ NT $1,000 in 1990, and in 2010 the number went up to 8.46 LOE/ NT $1,000. Per capita electricity consumption in 1990 was 4,193 KWh and in 2010 the number increased to 10,312 KWh. The average electricity price was NT $2.1636 / KWh in 1990 and the price went up to NT $2.6098 / KWh (Bureau of Energy, Ministry of Economic Affairs 2010). The numbers indicate that energy efficiency in Taiwan increased from 1990 to 2010 gradually.

Item / Year	Energy Productivity (NT$/LOE)	Energy Intensity (LOE/NT$1,000)	Per Capita Electricity Consumption (KWh)	Average Electricity Prices (N.T.$/KWh)
1990	104.27	9.59	4,193.49	2.1636
1995	110.06	9.09	5,940.95	2.1859
2000	106.08	9.43	7,978.51	2.1133
2005	104.46	9.57	9,651.20	2.0533
2010	118.15	8.46	10,312.80	2.6098

Source: Bureau of Energy, Ministry of Economic Affairs (2010).

Table 6. Energy Efficiency Indicators

Table 7 illustrates Taiwan's energy security indicators. Taiwan's dependence on imported energy in 1990 was 96%; the value of energy imports to the value of total imports was 11.45%; the value of energy imports to GDP was 3.8%; dependency on imports oil was 99.43%, and the amount of per capita energy imports was NT $8,328. In 2010 those numbers increased to 99.3%, 20.06%, 11.74%, 99.97%, and NT $69,317, respectively.

2.4 Electricity Rate Adjustment

In order to reflect power generating and purchasing cost and the fluctuation of international electricity prices in a timely manner, the Ministry of Economic Affairs (MOEA) approved "Taipower Electricity Price and Fuel Mechanism" (TEPFM) of Taipower. The mechanism stipulates that the all basic electricity price rates shall be based on the rate as of October 1, 2008. The mechanism also allows Taipower to adjust the price when the average unit cost of fossil fuels (gas, coal, and oil fuel) changes and the electricity price could follow accordingly. Taipower also needs to publicly announce "the actual weight average fuel cost per KW" and "the relative weight average fuel cost per kWh" on a quarterly basis and file a report with the MOEA. According to TEPFM, the time to initiate an electricity price adjustment is as follows: when an absolute dollar amount per kWh electricity cost has grown (decreased) more than 1 percent of the average electricity selling price per kWh of the first half year average, then Taipower could initiate the price adjustment mechanism which allows

Taipower to add (deduct) "a fuel adjustment unit cost per kWh " to the basic electricity rate. If it is less than 1 percent of "the average electricity selling price per kWh" of the first half year average then the addition (deduction) shall be canceled.

Item / Year	Dependence on Imported Energy	Value of Energy Imports/ Value of Total Imports (%)	Value of Energy Imports/ GDP (%)	Dependence on Imports Oil (%)	Value of Oil Imports/ Values of Total Imports (%)	Value of Oil Imports / GDP (%)	Per Capita Energy Imports (NT$)
1990	96.01	11.45	3.80	99.43	9.14	3.03	8,328
1995	97.97	6.86	2.58	99.85	4.98	1.87	8,867
2000	98.74	9.03	3.88	99.93	7.08	3.04	17,875
2005	99.15	16.02	7.94	99.94	12.27	6.08	41,151
2010	99.30	20.06	11.74	99.97	14.90	8.72	69,317

Source: Bureau of Energy, Ministry of Economic Affairs (2010).

Table 7. Energy Security Indicators

After analyzing the range of Taiwan electricity price adjustments, in 1990 the average price per kWh was NT$2.1636; in 2010, the average price per kWh was NT$2.1636 and the growth rate was 20.62%. During the same period, the national income per capita, representing economic ability, was US$7,628 in 1990, and US$16,432 in 2010, and the growth rate was 115.41%. The consumer price index, representing living expenses, was 74.49% in 1990 and 105.48% in 2010, and the growth rate was 41.60%. The above comparison indicates that the range of electricity price increases is much narrower than those of national income per capital and the consumer price index. Therefore, whether the electricity price is fully reflected in energy costs and whether the external costs are reasonably internalized will affect the relative price, using the motivation of renewable energy as well as the willingness to invest in renewable energy equipment.

Year	Average electricity price (N.T$/kWh)	Per capita of national income	Consumer price index
1990	2.1636	7,628	74.49
1991	2.1629	8,473	77.18
1992	2.1847	9,843	80.63
1993	2.1943	10,244	83.00
1994	2.1851	11,068	86.41
1995	2.1859	11,882	89.58
1996	2.1905	12,330	92.33
1997	2.1575	12,652	93.17
1998	2.1605	11,419	94.73

1999	2.1071	12,279	94.90
2000	2.1133	13,299	96.09
2001	2.1221	11,821	96.08
2002	2.0945	12,077	95.89
2003	2.0682	12,549	95.62
2004	2.0520	13,602	97.17
2005	2.0533	14,412	99.41
2006	2.1046	14,724	100.00
2007	2.1484	15,192	101.80
2008	2.3010	15,194	105.39
2009	2.6070	14,271	104.47
2010	2.6098	16,432	105.48

Note: 2006 is the base year for the consumer price index.
Sources: 1. Bureau of Energy, MOEA (2011a), Energy Statistical Annual Reports.2. Directorate General of Budget, Accounting and Statistics (DGBAS) of Executive Yuan http://www.dgbas.gov.tw/ct.asp?xItem=393&CtNode=2850&mp=1

Table 8. Electricity Prices and Economic Index

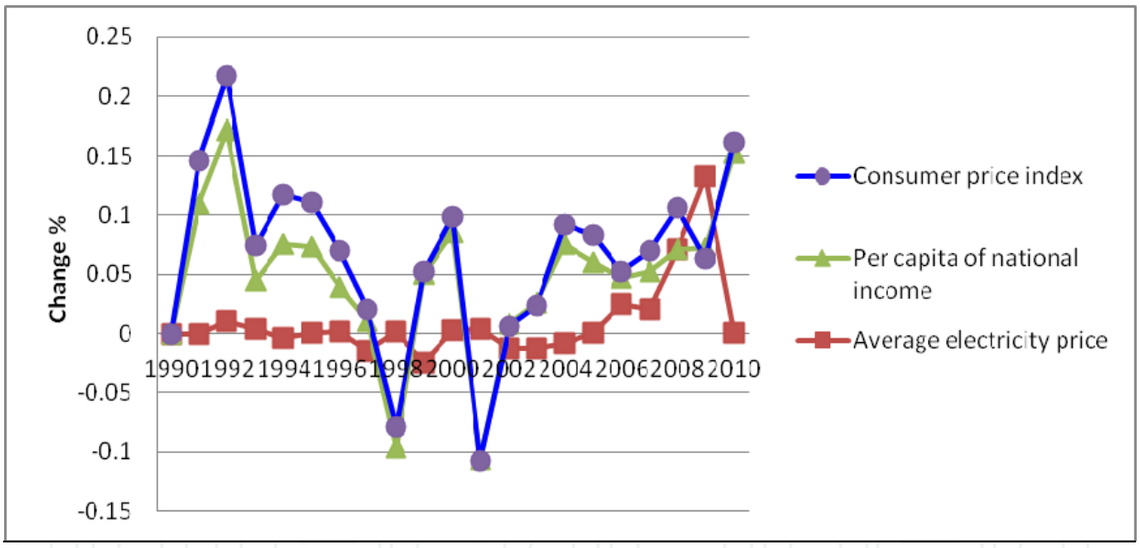


Figure 1. Annual rate of increase in electricity prices and economic index
1. Bureau of Energy, MOEA (2011a), Energy Statistical Annual Reports.
2. Directorate General of Budget, Accounting and Statistics (DGBAS) of Executive Yuan http://www.dgbas.gov.tw/ct.asp?xItem=393&CtNode=2850&mp=1

3. Introduction of Taiwan's Renewable Energy Development Law

In 2008 the Executive Yuan of Taiwan issued a Framework for Taiwan's Sustainable Energy Policy (Executive Yuan 2008). The objective of the policy is to build a win-win-win solution for energy, the environment and the economy, and to construct an energy supply system with clean, stable, and economical efficiency. The principles of the policy are "Two Highs, Two Lows": high efficiency, high value-added, low emissions, and low dependency. High

efficiency means improving energy consumption and transformation efficiency. High value-added means increasing the incremental value of energy usage. Low emissions means adopting energy supply methods and consumption practices that ensure low-carbon emissions and low pollution. Low dependency means decreasing Taiwan's dependence on fossil fuels and imported energy. The framework for the policy is "Clean and Reducing" and developing a carbon-free energy and extending the potential usage of renewable energy, so that in 2025 clean energy sources can reach 8% and more of the total energy supply. Therefore, the policy of renewable energy development and promotion is consistent with our expectations.

In order to systematically promote renewable energy, in August of 2002, the Executive Yuan submitted the "Renewable Energy Development Law (REDL)" to the Legislative Yuan, where it remained for 7 years. In June 2009 the Legislative Yuan finally passed the act, which was promulgated by the ROC President in July 2009. The "Renewable Energy Development Law" is comprised of 23 articles and was enacted to promote the utilization of renewable energy sources, increase energy diversification, improve environment quality, energize the industry and drive national sustainable development. (Article 1)

The REDL denotes the total capacity of renewable energy power generation equipment, the target percentage of all types of renewable energy, the power connection and cost allocation of the power industry, the setting of wholesale prices, and the creation of a price-adjusting mechanism. Therefore, the core strategy of REDL is a Feed-in-Tariff system.

First, regarding the promotion of renewable energy, the government shall make steady growth on the installation of renewable energy power generation equipment. The government (MOEA) shall consider the climate and environmental factors, the characteristics of electricity demand and the economic benefits, and the stability of the power supply, while at the same time considering each type of renewable energy development potential, the economic benefits, and key technologies. The government also needs to set promotion goals and the percentage of each category every two years. Taiwan sets the reward capacity for renewable energy power generation equipment as the total capacity between 6,500,000 KW and 10,000,000 KW (Article 4, Article 6).

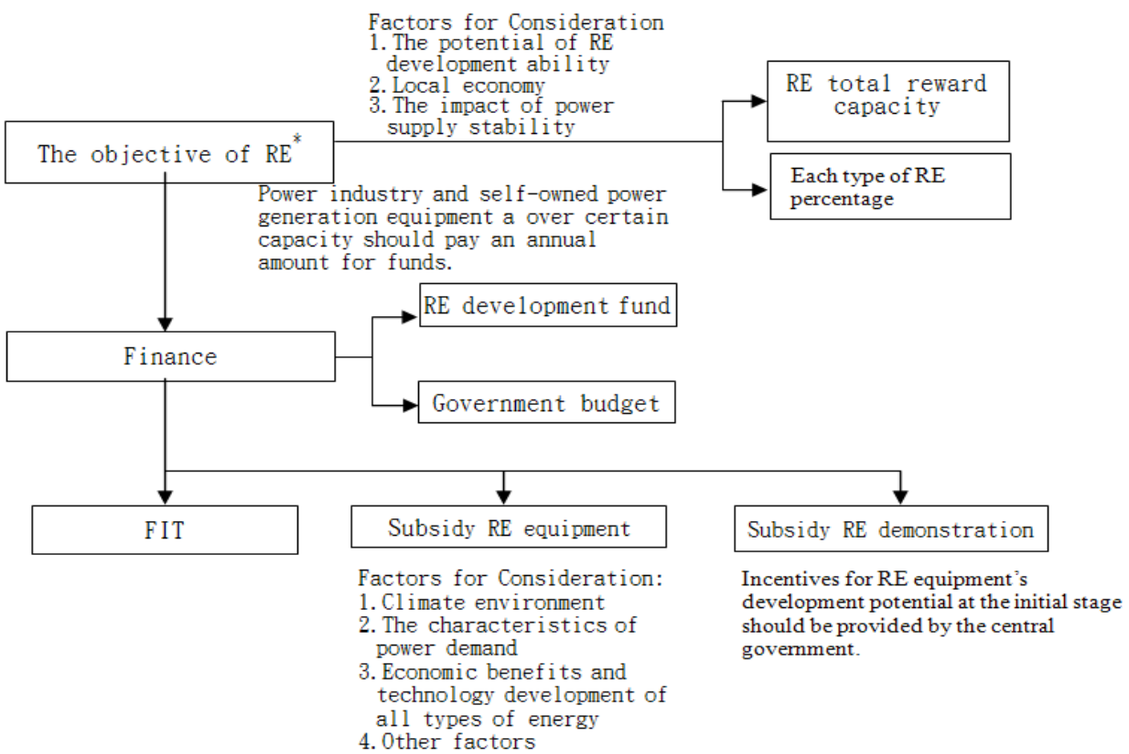
Second, regarding the executing level of renewable energy, the energy generated by renewable energy power equipment related to power parallel connections, wholesale obligations, and cost sharing shall be interrelated and sold at a wholesale rate by the local power company. The local company shall provide a stable grid and reasonable costs as well. Beyond the existing lines, the cost of installing enhanced power grids is shared by the power company and the operator of the renewable energy power generation equipment. The lines connecting the renewable energy power generation equipment and the power grids shall be built, installed and maintained by the operator of the renewable energy power generation equipment; if necessary, the power company with parallel connection to the power generation equipment shall provide any required assistance; the incurred cost shall be paid by the operator of the renewable energy power generation equipment (Article 8).

Third, regarding the source of the fund, Taiwan's government oversees the renewable energy development fund providing and usage. The power company or the institution

operating the self-owned power generation equipment that reaches a certain level of capacity shall pay a certain amount into a fund according to the non-renewable energy portion of the total power generation and the fund is used for renewable energy development. The fund is to be used as follows: to provide subsidies for electricity generation from renewable energy; subsidies for equipment to generate renewable energy, and subsidies for the demonstration of renewable energy and promotion of its use.

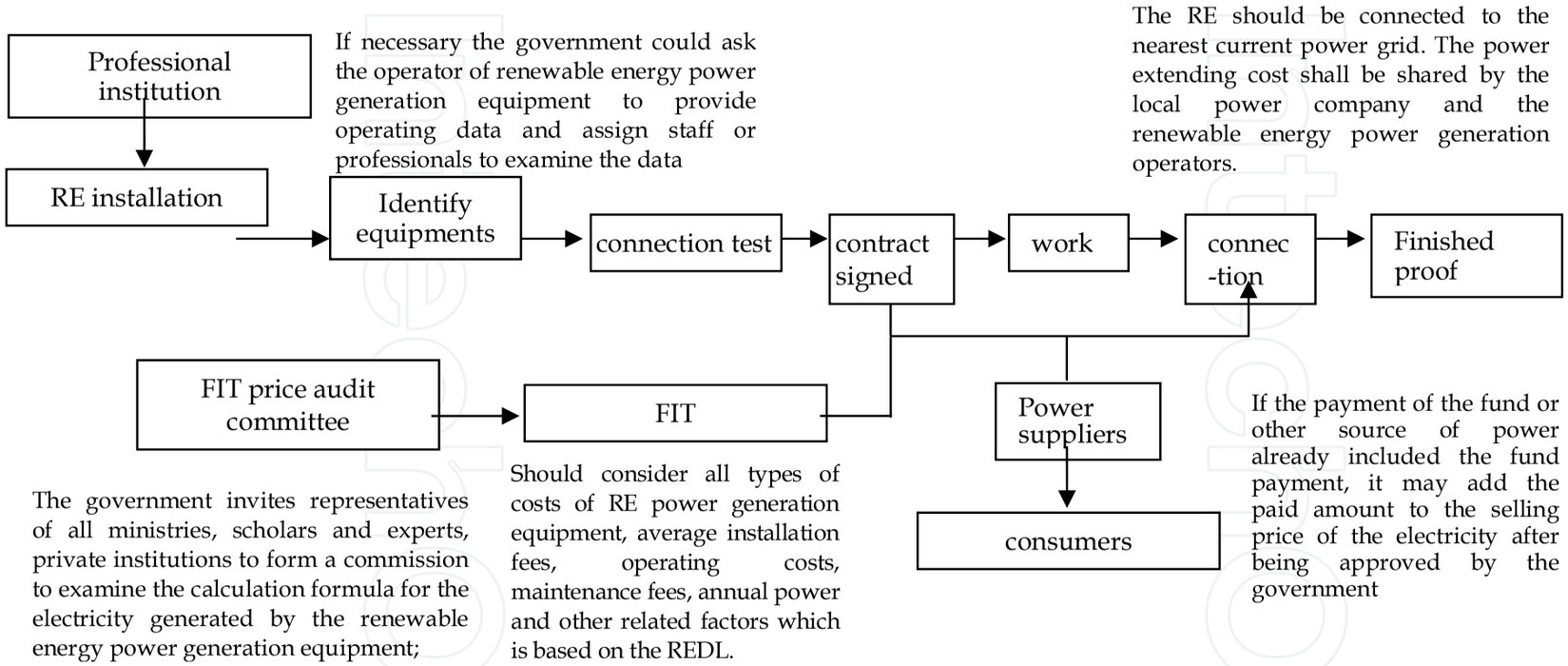
The fund-providing subjects includes the power company and the institution that installs the self-owned power generation equipment with certain capacity and has paid the fee to the fund; it may add the paid amount to the selling price of the electricity after approved by the government (Article 7).

In 2011the total budget of renewable energy development fund was NT $2,098,832 thousands. The budget usage of the fund stipulates that the establishment of a data fund on renewable energy basic power generation equipment, renewable energy fund collection and subsides of operators, and renewable energy wholesale price research, et al., were 37,000 thousands; funds for renewable energy usage demonstration and promotion were NT $580,000 thousands, renewable energy subsidies were NT $675,000 thousands, and general administration funds were NT $6,432 thousands (Bureau of Energy, Ministry of Economic Affairs, 2011a).



Note: RE= renewable energy
Source: Drawn by the authors based on the Renewable Energy Development Law

Figure 2. Flowchart of the Renewable Energy Development Law



Source: Drawn by the authors based on the Renewable Energy Development Law

Figure 3. Flowchart outlining Taiwan's renewable energy FIT electricity price operation

4. Financial Mechanism of Taiwan's Renewable Energy Feed-in-Tariff

4.1 The Renewable energy wholesale rate examination commission

The government invites representatives of each ministry, and scholars and experts from private institutions to form a commission to examine wholesale rates and the calculation formula for the electricity generated by the renewable energy power generation equipment. If necessary, it shall follow the Administrative Procedure Act to hold hearings and make public announcements; it shall review and revise the rate and the calculation formula every year with respect to advances in power-generating technology, cost variation, progress in reaching goals, and other relevant factors for each category of renewable energy. The above formula for calculating rates is determined by the government, taking into account average installation costs, maximum operating life, annual power generation capacity and other relevant factors of power generation equipment for each category of renewable energy on an individual basis. To encourage and promote pollution-free green energy and increase investment in renewable energy, the wholesale purchase rate shall not be lower than the average cost of the generation of domestic fossil fuels (Article 9).

4.2 Formula for the wholesale rates of renewable energy

According to an announcement made by the Bureau of Energy, Ministry of Economic Affairs, the formula for the wholesale rates of renewable energy is based on all kinds of factors, including installation costs, operating years, maintenance costs, annual power generation capacity, capital cost rate, and reasonable profit rates. The rates are set by the nature of the individual sources such as wind power, river-type hydraulic, geothermal energy, biomass energy, waste, and solar energy, respectively. The rates are effective from January 1st 2011 to December 31st 2011. Starting from 2011 any electricity from new renewable energy power generators will be purchased at this rate for 20 years. In 2011 the reasonable profit rate is 5.25%. Table 9 states the formula for the rates renewable energy.

$$\text{WholsaleRate} = \frac{\text{BICost} \times \text{CRRate} + \text{AOCost}}{\text{AESold}}$$

$$\text{CRRate} = \frac{\text{ACDRate} \times \left(1 + \text{ACDRate}\right)^{\text{WholesalePeriod}}}{\left(1 + \text{ACDRate}\right)^{\text{WholesalePeriod}} - 1}$$

$$AOCost = BICost \times \frac{AOCost}{BICost}$$

Note: BICost = Beginning Installation Cost , CRRate = Capital Revert Rate,
AOC = Annual Operating Cost , AESold = Annual Electricity Sold,
ACDRate = Average Capital Discount Rate
Source: Bureau of Energy, Ministry of Economic Affairs, (2011).

Table 9. Formula for renewable energy wholesale rates

4.3 Wholesale rates

The present renewable energy strategies in Taiwan include those for the short run and the long run. The short-term strategy is to prioritize land-based wind power electricity, which has a relatively mature technology and higher economic benefits. The long-term strategy is to encourage the development of offshore wind power electricity. "The wind power generation equipment" can be classified as an offshore wind power system and a land-based wind power system. The offshore wind power rate is 5.5626 NT$ per KWh. Land-based wind power can be divided into two levels: 1 KW to 10 KW and 10 KW and up and the wholesale rates are NT $7.35/KWh and NT $2.61/KWh, respectively.

Category of Renewable Energy	Type	Capacity Level	Wholesale Rate (NT dollar/KWh)
Wind Power	Land-based	1 KW and up 10 KW less	7.3562
		10Kw and more*	2.6138
	Offshore	Indifference	5.5626
River-Type Hydraulic,	Indifference	Indifference	2.1821
Geothermal	Indifference	Indifference	4.8039
Biomass	Indifference	Indifference	2.1821
Waste	Indifference	Indifference	2.6875
Other	Indifference	Indifference	2.1821

Source: Bureau of Energy, Ministry of Economic Affairs, (2011).

Table 10. 2011 Renewable Energy Power (except solar power) Wholesale Rate

The cost of solar photovoltaic electricity generation is much higher than the cost of other sources of renewable energy. Solar photovoltaic generation equipment can be divided into rooftop and ground-mounted. Considering the utility of public land as well as the limited resources of Taiwan, the government has prioritized the development of rooftop solar photovoltaic generation rather than ground–mounted equipment. Residents are encouraged to establish a solar photovoltaic system that can generate from 1 KW to 10 KW of electricity. Rooftop models can be set at 4 different levels: 1 KWto 10 KW, 10 KWto 100 KW, 100 KWto 500 KW, and 500 KW and up. The wholesale rates are NT $ 10.3185/ KWh, NT $9.1799/ KWh, NT $8.8241/ KWh, and NT $ 7.3297/KWh, respectively. Table 9 indicates the 2011 wholesale rates for solar photovoltaic generation equipment.

4.4 Solar photovoltaic bidding mechanism

In order to encourage residents to implement solar photovoltaic generating systems, in 2011the house owners could install a rooftop solar photovoltaic system that generates from 1 KW to 10KW with the wholesale rates on a first come, first served basis at the completion rate and no need to go through the bidding process. Those interested in other types of solar photovoltaic systems are required to go through the bidding process.

Category of Renewable Energy	Type	Capacity Level	Maximum Rate (NT $/KWh)
Solar Photovoltaic generation	Rooftop	1 KW to 10 KW	10.3185
		10 KW to 100 KW	9.1799
		10 KW to 500 KW	8.8241
		500 KW and up	7.9701
	Ground-Mounted	1 KW and up	7.3297

Source: Bureau of Energy, Ministry of Economic Affairs, (2011).

Table 11. 2011 Solar Wholesale Rates for Photovoltaic Generation Equipment

The solar photovoltaic bidding mechanism uses a discount rate in quoting prices. The highest discount rate gets the bid first. The wholesale rate is equal to the completion publicized rate (1-discount rate). Because of limited land availability, the government does not encourage ground-mounted solar photovoltaic systems. If the ground-mounted type of solar photovoltaic generation has the same discount rate as the rooftop version, then the latter is preferred to the ground-mounted type. A rooftop type and a lower capacity are prioritized.. The capacity of each application is limited to the range 1 KW to 2,000 KW.

When applicants make a bid, they must make a deposit. The deposit is based on 1000 times the capacity level, and the deposit should be between NT$ 10,000 and NT $1,000,000. Table 12 denotes the upper limit of the bidding rates and the first period of the 2011 bidding rates for solar photovoltaic generators.

Unit: KW

Period		Rooftop	Ground Mount
First Period		12,000	3,000
	Period Total Upper Limit		15,000
Second Period	First phase	5,000	1,000
	Second phase	5,000	1,000
	Third phase	7,600	1,000
	Period Total Upper Limit		17,600

Source: MOEA (2011) Solar Photovoltaic Generator operating menu modified by the authors.

Table 12. 2011 Upper Limit Bidding Rates

The discount rate of the first period must be greater than 0.00%, but the second period shall be no less than the same level of the first period's average bidding rate. Furthermore, the same period is divided into different bidding phases which keep increasing the average discount rate so that the bidding process requires investors to install renewable energy equipment as soon as possible and to participate in the bidding process. Table 13 indicates the lowest discount rates for all types of solar photovoltaic generators at all levels.

Category of Renewable Energy	Type	Capacity Level	The Same Level of Average Bid Winning Rate
Solar Photovoltaic	Rooftop	1KW to 10 KW	1.24%
		10 KW to 100 KW	2.64%
		10 KW to 500 KW	3.19%
		500 KW and up	0.00%
	Ground-Mounted	1 KW and up	0.31%

Source: Bureau of Energy, Ministry of Economic Affairs (2011b) modified by the authors

Table 13. The First Period of 2011 Discount Rates for Solar Photovoltaic Generators

Table 14 lists the 2011 bidding results for solar photovoltaic generators. According to the table, for the second period the number of applications and winning bids as well as bidding capacity all dramatically increased from the first period. Since the policy encouraged rooftop systems and restricted the ground-mounted version, the number of rooftop systems is far greater than ground-mounted systems.

4.5 The Structure of Renewable Energy Capacity

Currently, the type of renewable energy in Taiwan with the largest capacity is a river-type hydraulic generator. Taipower and private companies generate 197.5 MW. Biomass ranked number 2 and generated 80.94 MW. This is followed by wind power at 52.93 MW and solar photovoltaic power at 4.48 MW, respectively. The solar photovoltaic system generated 1.1 MW before the renewable energy development law was passed. After the law was passed the capacity was increased to a range from 2.08 MW to 3.13 MW. In June 2011 the total capacity of renewable energy was 336 MW which comprises 6.9% of total power capacity. Table 15 illustrates the capacity generated from each type of renewable energy source.

5. Conclusion and Recommendations for Taiwan's Feed-in Tariff

Designing a reasonable wholesale rate is the most important issue with respect to a renewable energy feed-in tariff system. One must consider average installation cost, operating life, maintenance cost, annual power generation capacity and relevant factors for different types of power generation equipment separately and set wholesale rates for each category of the renewable energy so that the price not only can ensure an optimal developing opportunity for each type of renewable energy,; one also can reduce the incentive of higher profitable technologies and avoid shifting a heavy cost burden to consumers (Chou, Lin and Chen 2010). To arrive at a reasonable wholesale rate, one also needs to consider size and location. Different locations and sizes generate different electricity costs so and command different wholesale rates. The larger the size is, the more economical the scale. Generating equipment of a larger size has lower average electricity production costs. Therefore, in order to ensure adequate profits, renewable energy generating

Unit: KW

	Type	Number of Applications	Number of Bids	Bidding Capacity	Average Discount Rate
The First Period	Rooftop	126	123	12,173.123	2.62%
	Ground Mounted	2	2	1,379.400	0.31%
	Sum	**128**	**125**	**13,552.523**	**-**
The Second Period Phase 1	Rooftop	43	40	2,583.181	2.95%
	Ground Mounted	1	1	248.640	0.31%
	Sum	44	41	2,831.821	-
Phase 2	Rooftop	48	38	4,840.830	3.12%
	Ground Mounted	1	1	110.400	0.31%
	Sum	49	39	4,951.230	-
Phase 3	Rooftop	-	87	7,235.874	3.37%
	Ground Mounted	-	0	0	0.00%
	Sum	100	87	7,235.874	-
The Second Period	**Total Sum**	**193**	**167**	**15,018.925**	**-**

Source: Bureau of Energy, Ministry of Economic Affairs (2011b) modified by the authors
Table 14. 2011 Bidding Results for Solar Photovoltaic Generating Equipment

Item	Wind Power		Biomass			Total	Percentage of Total Electricity Power
	TP	Private	Municipal Solid Waste	Agriculture & Industry Solid Waste	Biogas		
Capacity (Million W)	28.88	24.05	62.25	16.75	1.94	336	6.91%
Sum	52.93		80.94				
Item	River-Type Hydraulic		Solar Photovoltaic				
	TP	Private	Finished Before Law*	Finished after Law	TP Self-owned		
Capacity (Million W)	193.6	3.9	1.1	3.13	0.25		
Sum	197.5		4.48				

Note: 2011/6/30, Law* Refer to the Renewable Energy Development Law
Source: Industrial Technology Research Institute Renewable Energy(2011).
Table 15. Capacity of Each Type of Renewable Energy

equipment of a larger capacity should be paired with a diminishing marginal rate. One location might have greater wind power; therefore, when a wind power generator is land-based or offshore, different costs different capacities of electricity ensue. Usually, the government assigns a higher wholesale rate to a priority location to increase incentives to produce more renewable energy.

The present renewable energy strategies in Taiwan include those for the short run and the long run. The short-term strategy prioritizes land-based wind power electricity, because the technology is relatively mature and the economic benefits are higher. The long-term strategy is to encourage the development of offshore wind power electricity. In terms of solar photovoltaic sources, when one considers the total utilization of land and the limited land resources of the nation, Taiwan prioritizes rooftop solar photovoltaic systems and discourages the implementation of ground-mounted systems. A resident owner who installs a rooftop solar photovoltaic system with a capacity from 1 KW to 10 KW qualifies for a priority subsidy and the highest wholesale rate.

The "wholesale rate guarantee period" is another important design feature. The longer the guarantee period is, the lower the investment risk is. The length of wholesale rate is determined by the time of the return on investment, the operating life of renewable energy equipment,, equipment renewal speed, and loan provisions. In Taiwan there is a guarantee period of twenty years for those who are already in the system and for whom the risk is low. The FIT price is reexamined every year; however, for those who have not entered the system the risk is high. Therefore, Taiwan publically discloses the FIT electricity price every year so that the public can examine and discuss the rate.

In order to create an environment capable of developing competitive renewable energy sources, the government provides incentive mechanisms such as capital subsidies, investment tax credits, et al. (REN21, 2011). Capital subsidies refer to government subsidies awarded to those who install renewable energy systems to reduce their capital burden and increase investment opportunities. Investment tax credits means the government permits investors to deduct their investment in renewable energy equipment from their tax liabilities to lower the investors' tax burden. Furthermore, an energy tax is another means for supporting such measures. An energy tax is imposed on those using traditional fossil fuels that increase greenhouse gases. The tax may force investors to internalize the social costs which lower the cost of the renewable energy and allow consumers to choose from different sources of renewable energy. Taiwan's government has also set regulations for renewable energy subsidies regulation and implemented a renewable energy tax credit act. However, the energy tax in Taiwan has not been passed; the bill still needs to be negotiated. In the future, the burden of energy costs need to be fairly distributed and the rights of socially vulnerable groups should be protected.

By all accounts, renewable energy FIT can bring about environmental, economic, and social benefits, and can promote the renewable-energy industry as well. By applying REDL, Taiwan is going to initiate a new opportunity of renewable energy investment and is moving toward the creation of a low-carbon society.

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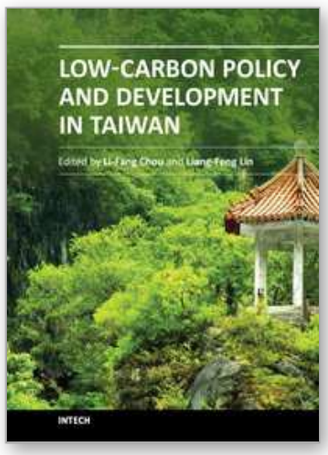

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Taiwan a typical small Asian country with few energy resources is well known for its high-tech industry in the last 20 years. However as a member of the global village Taiwan feels the responsibility to reduce carbon emissions. The book tells you how Taiwan transforms itself from a high-tech island to become a low carbon island. The book address Taiwan's low-carbon developmental policies of the past 10 years, applies an econometric approach to estimate Taiwan's sector department CO2 emissions, shows how environmental change affects the economic growth of Taiwan, and provides two successful examples of low-carbon pilot regions in Taiwan. Stephen Shen, the Minister of the Environment Protection Agency of Taiwan, believes that the book arrives at the right time, because this is the time to educate the people of Taiwan, about the necessary action for achieving a low carbon society.

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