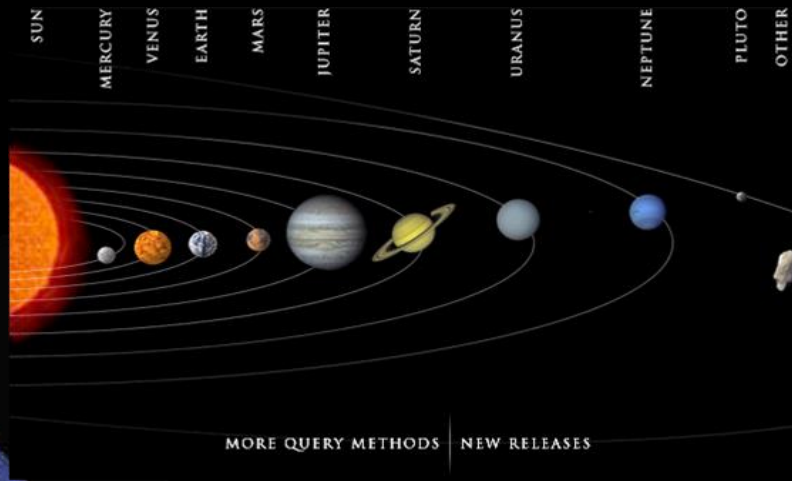
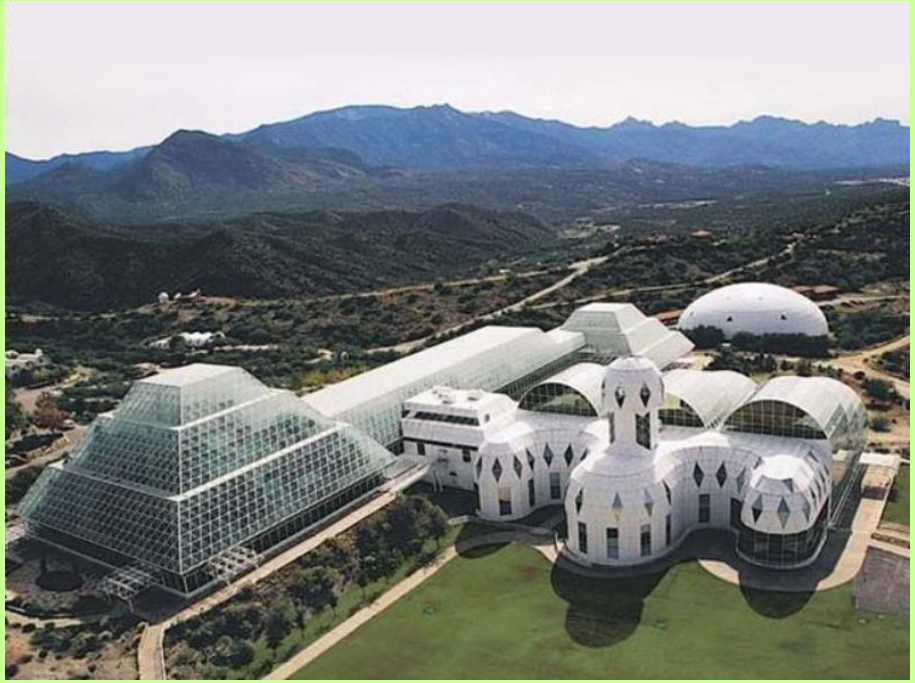
綠色能源的展望

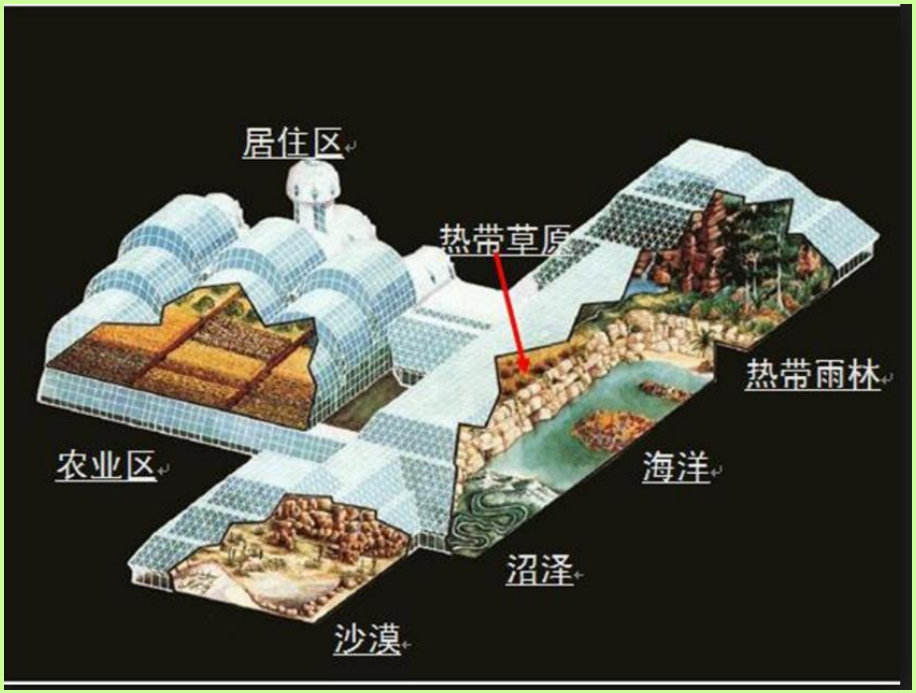
紀國鐘
國立交通大學


SUN
MERCURY
VENUS
EARTH
MARS
JUPITER
SATURN
URANUS
NEPTUNE
PLUTO
OTHER
MORE QUERY METHODS
NEW RELEASES

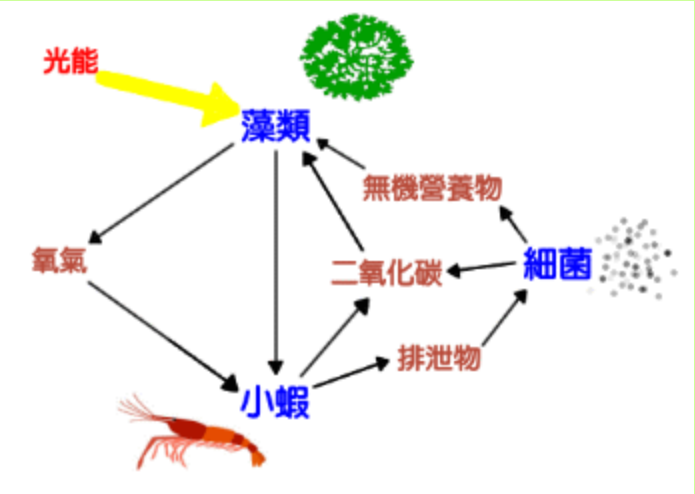
Biosphere 2



生物圈2號



微小生物圈



地球上能源還可使用多久?

- 依據英國石油公司出版的「世界能源統計(1997)目前世界能源蘊藏量統計

  — 石油：1兆38億桶：41年

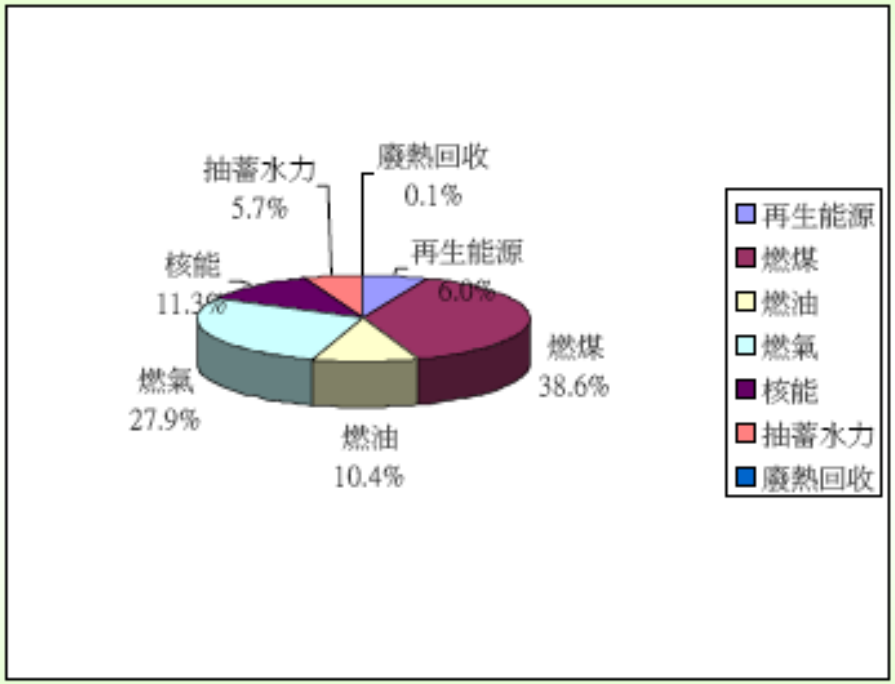
  — 煤炭：1兆32億公噸：219年

  — 天然氣：144.8兆立方尺：64年

  — 鈾礦：253.5萬公噸：74年（將用過核燃料再處理可提高年限至數十倍）

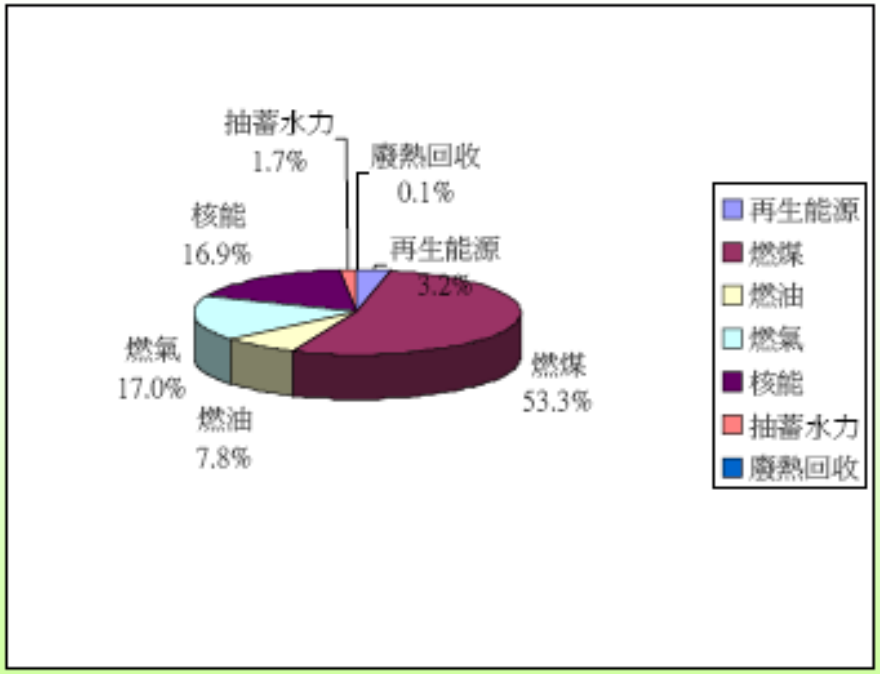
一、前言-台灣電力總裝置容量與發電量

96年全國總裝置容量，共45.72 GW



註：95年全國總裝置容量，共45.09 GW

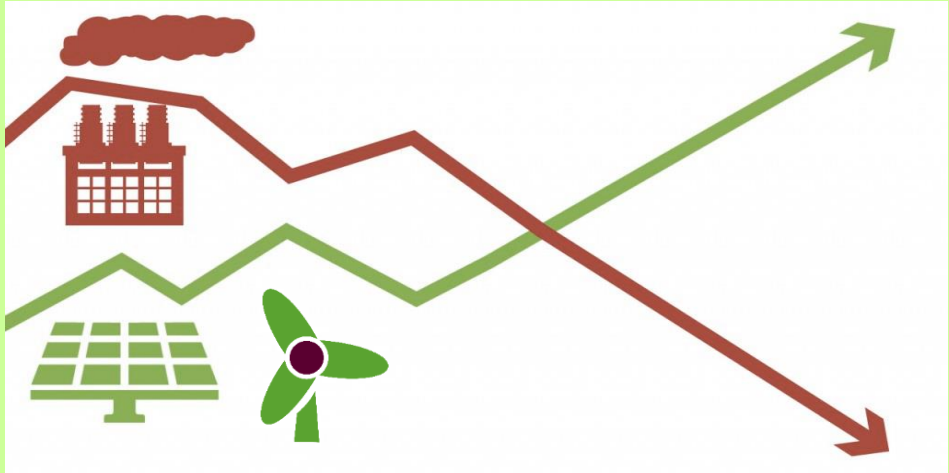
95年全國總發電量，共226,950 GW-hr



資料來源：台電公司，2007

2025 Energy Policy Target

- To reach the balance among energy security, environmental sustainability and green economy，while constructing an energy demand and supply system with security, stability, efficiency, and tidiness as well as initiating the value of sustainability in order to go towards to nuclear free homeland by 2025.
- The policy goal of nuclear free homeland **by 2025 that the energy mix** will **be 30% by coal, 50% by gas and 20% by renewables.**



2025		51.5(TWh)
Solar PV	**Wind**	**Other green enery**
25 (TWh)	**14** (TWh)	**12.5** (TWh)

(1 TWh=10億度)

Comparison of CO_2 Emission indicators

	Taiwan	Korea	Japan	Germany	OECD	World	Taiwan-World	
							ranking	%
CO_2 Emission (Mt of CO_2)	261.28	448.91	1214.19	813.48	12910	27136	20	**0.96%**
Population (millions)	22.89	48.29	127.76	82.46	1172	6432	-	**0.36%**
GDP per capita (2005 US$)	15223.76	16443.76	35671.58	33864.68	29895.39	6947.81	-	-
CO_2 Emission per capita (t CO_2 per capita)	11.41	9.30	9.50	9.87	11.02	4.22	15	-
CO_2 per GDP (kg CO_2 per 2005 US$)	0.75	0.57	0.27	0.29	0.37	0.61	-	-
CO_2 per GDP PPP (kg CO_2 per 2005 US$)	0.40	0.42	0.31	0.33	0.60	0.44	-	-
CO_2 per TPES (t CO_2 per toe)	2.47	2.10	2.29	2.36	2.33	2.37	30	-

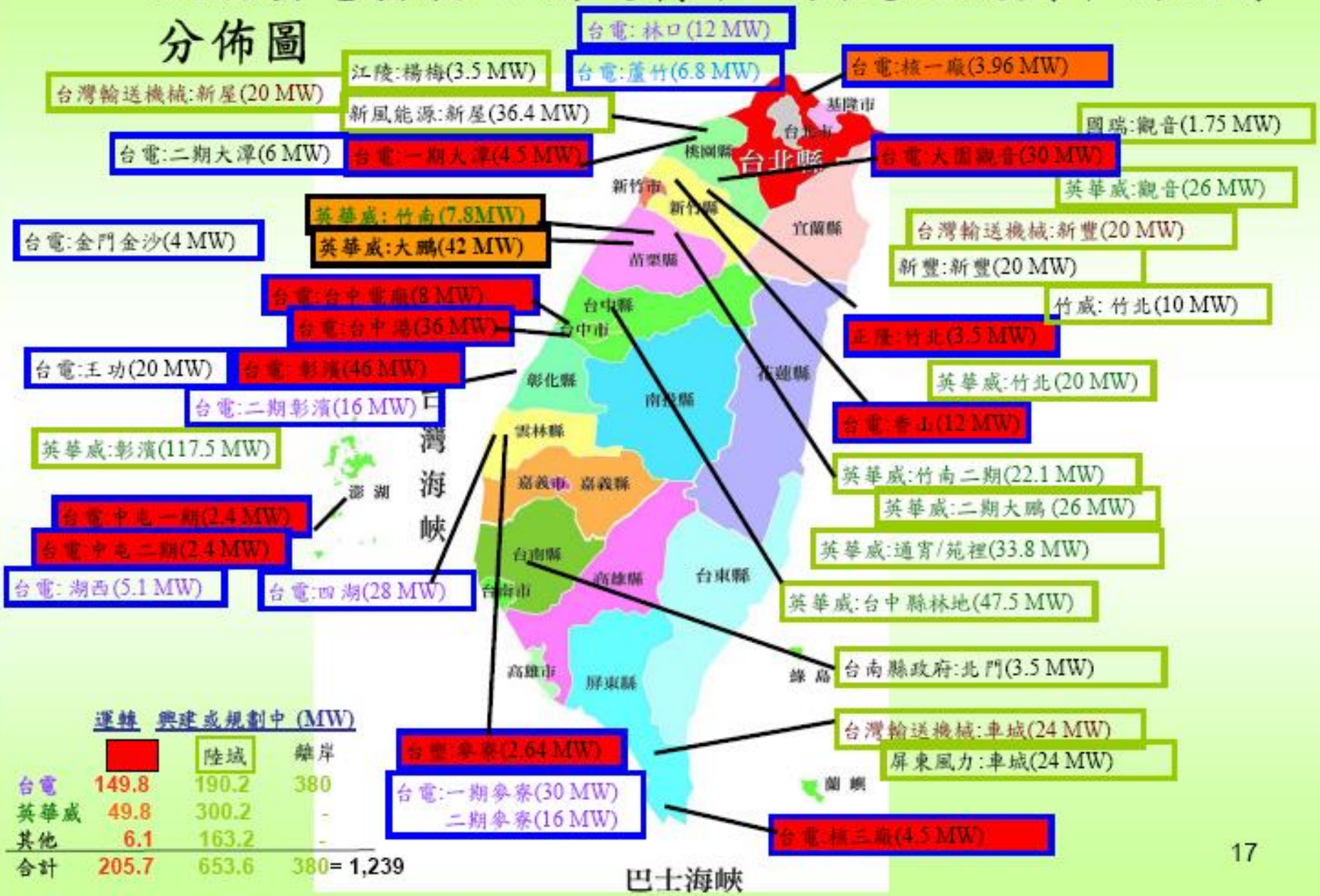
Reference : 1. IEA key world energy Statistics 2007
2. IMF Data and Statistics

一、前言-台灣潛在能源

能源種類	能源等級	潛在能源 (PJ/Y)	蘊藏量 (GW)
風能	中等	86~429	3~15
太陽能	中等	156~2340	12~180
生質能	-	251	—
地熱	最佳	>551	>7.5
海洋溫差	佳	221~1841	3~25
甲烷水合物	-	1000	可使用至少 460 年
重砂提鈾/海水提鈾	-		500 噸 鈾/鈾
IGCC	-		60

IGCC: Integrated Gasification Combined Cycle.
CCS: Carbon Capture & Storage.

二、風能發電發展-目前運轉中、興建及規劃中的風場分佈圖



運轉 興建或規劃中 (MW)		陸域	離岸
台電	149.8	190.2	380
英華威	49.8	300.2	-
其他	6.1	163.2	-
合計	205.7	653.6	380= 1,239

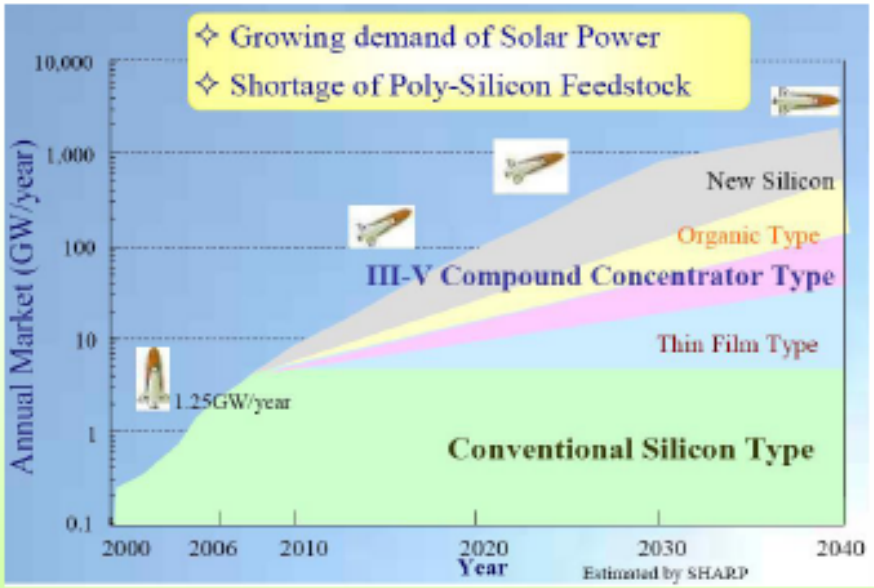
三、太陽光電發展現況

技術	材料	公司	國家	效率		價格（USD/W_p）	
矽晶型	Mono Si	Sharp	JP	module	~14.2%	module	~4
	Poly Si	Solar World	DE	module	~13.4%	module	~3
薄膜型	a-Si	Kaneka	JP	module	~6.3%	module	~2.5
	CdTe	First Solar	US	module	~10.4%	module	~1.25
	CIGS	Global Solar	US	module	~8%	module	~2
聚光型	GaAs	Solar Systems	AU	cell ~40%	system ~20%	system (154MW	~2.31 ~2013)
	GaAs	Isofoton	ES	cell ~38%	module ~20%	system (700kW	~6 ~2008)
	GaAs	INER	TW	cell ~36%	module ~25%	system (1MW Demo	~8 ~2008)

三、太陽光電發展趨勢

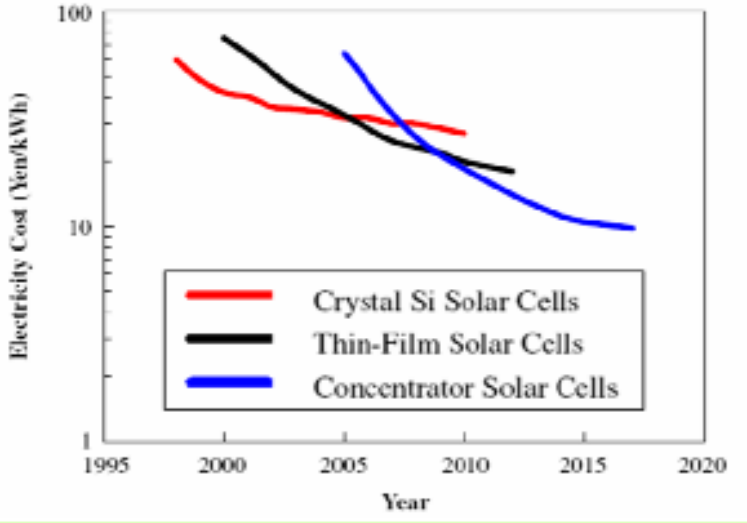
太陽光電（Photovoltaic，PV）主要技術：

- **矽晶型太陽電池**：市場佔有率為大宗，未來成長趨緩。
- **薄膜型太陽電池**：具可撓性、與建材結合，將具有可觀的成長。
- **Ⅲ-Ⅴ族聚光型太陽電池**：高效率與低成本潛力，亦將佔有一席之地。
- 其他技術如有機太陽電池等，現今尚未成熟，但未來發展可期。



ref : Takashi Tomita, PHOTOVOLTAICS as a NEW ENERGY SOURCE, GLOBAL SCIENCE FORUM, 18 May 2006, Paris.

Scenario of electricity cost reduction

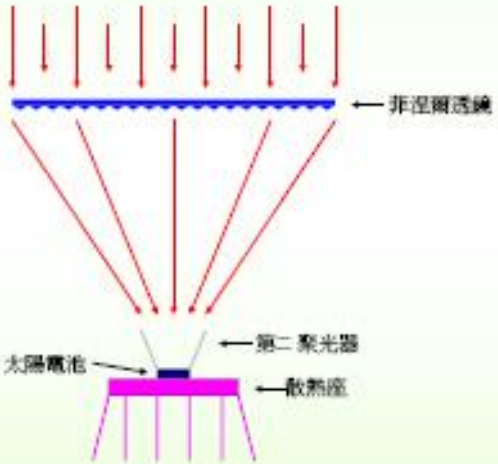


ref : M. Yamaguchia, T. Takamotob, K. Araki, Solar Energy Materials & Solar Cells 90 (2006) 3068–3077

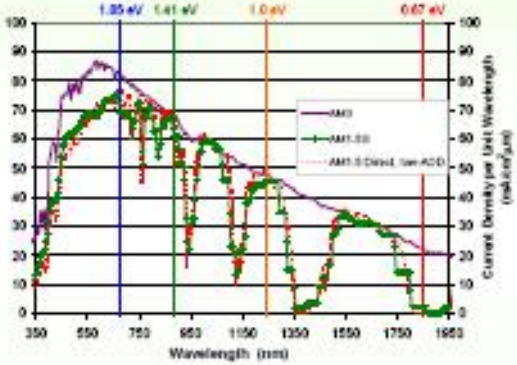
高雄世運主場館

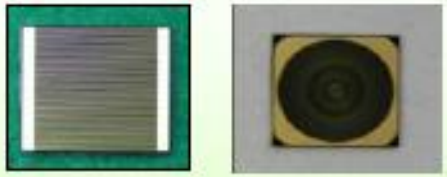
三、太陽光電發展-高聚光PV系統

High Concentration PhotoVoltaic(HCPV)系統主要係結合
聚光裝置、高效率太陽電池、太陽光追蹤器等製作而成



聚光模組單元架構
(應用 低價位的Fresnel透鏡聚光，減少太陽電池使用量)





高效率太陽電池
(應用 多接面太陽電池提昇能量轉換效率)

聚光模組與太陽光追蹤器
(應用 太陽光追蹤器提昇太陽光之接收效能)

路竹聚光型太陽光電池發電廠

三、全球太陽光電發展補助概況

國家	建置目標	建置補助	躉售補助
德	2GW$_P$ (2010)	低利貸款	・Ground：$0.35EUD/kWh ・Building： <30kW$_P$，$0.47 EUD/kWh； 30-100kW$_P$，$0.44EUD/kWh； >100kW$_P$，$0.44EUD/kWh； BIPV，+$0.05EUD/kWh
美	依各州規定，如NJ為1.5GW$_P$ (2020)	以加州為例 ・$4USD/W$_P$，100%無息貸款 ・未獲補助部分的15%可抵扣所得稅	$0.15USD/kWh
日	4.8GW$_P$ (2010)	・住宅：$90Yen/W$_P$ ・產業：上限50%設置費用	與市電同，電力公司可自行調高補助金額
西	135MW$_P$ (2010)		・<100kW$_P$，$0.44EUD/kWh； ・100k-10MW$_P$，$0.42EUD/kWh； ・10-52MW$_P$，$0.23EUD/kWh
荷	250MW$_P$ (2010)	$3.5EUD/W$_P$，補助上限6kW$_P$	
英	再生能源發電比例於2010年達10%	・<5kW，上限50%設置費用 ・5-100kW，上限65%設置費用	要求電力公司對於綠色電力之購買義務
中國大陸	300MW$_P$ (2010)		>5kW$_P$，當地市電年均價之四倍價格購回
台灣	31MW$_P$ (2010)	・一般申請：$150NTD/W$_P$，上限50%設置費用 ・政府單位、公立學校、偏遠離島、特定建物：獨立型$350NTD/W$_P$，緊急防災$400NTD/W$_P$	立法中

四、纖維酒精發展－國際使用酒精汽油現況

酒精汽油規格	國家	2006酒精年產量(萬公秉)	2006車用酒精需求量(萬公秉)
E22-25 , E100	巴西	1700	1340
E10, E85	美國	1997	2315
	加拿大	58	-
E5, E85	瑞典	11.5	(2020年起不用汽油)
E10	中國	385	-
	澳洲	15	-
	哥倫比亞	28	-
	泰國	35	-
E5	印度	190	-
	歐盟	340	-
	阿根廷	17	-
E3	日本	11.3	-

參考資料: UNICA, Prospects for the Sugar & Ethanol Industry & Climate Changes Reduction of the Greenhouse Effect (2005)
Szwarc, A., Fuel Ethanol Production & Use (2005)
Australian Government Biofuels Taskforce, Report of the Biofuels Taskforce to the Prime Minister (2005)
RFA, "Ethanol Industry Outlook 2007 " （2007）

四、纖維酒精發展–國內燃料酒精之發展現況

➢政府推廣酒精汽油之時程

- ◆2007年9月於台北市推動E3酒精汽油，預估年使用酒精約770公秉。
- ◆2009~2010年北高兩市全面供應E3，預估年使用酒精約1.2萬公秉。
- ◆2011年全面供應E3，預估年使用酒精約10萬公秉。

2007年9月國內推動酒精汽油之油價

四、生質酒精國際發展趨勢-以纖維原料為主軸

第一代生質酒精以糖質/澱粉為生產原料

玉米
Sweet potato

酵素水解

甘蔗

糖化

發酵

2007年燃料酒精產量
500 億公升
(RFA, 2007)

燃料酒精
(未來700億公升將主要來自纖維酒精)

纖維原料

前處理

纖維素

酵素水解

燃料酒精需求量
1200億公升
(IEA, 2020)

第二代生質酒精(纖維酒精)以木質纖維素為生產原料

農業廢棄物

能源作物

生質酒精之能量產出>投入

參考資料： Alexander E. Farrell et. al, " Ethanol Can Contribute to Energy and Environmental Goals", 27 January 2006 Vol. 311, Science.

四、纖維酒精發展－生質能源作物

生質酒精作物:

甘蔗　甘藷　芒草

玉米、甜高粱、甜菜、木薯、小麥、稻米、乾草、玉米桿、麥桿、木材、風傾草、銀合歡

生質柴油作物:

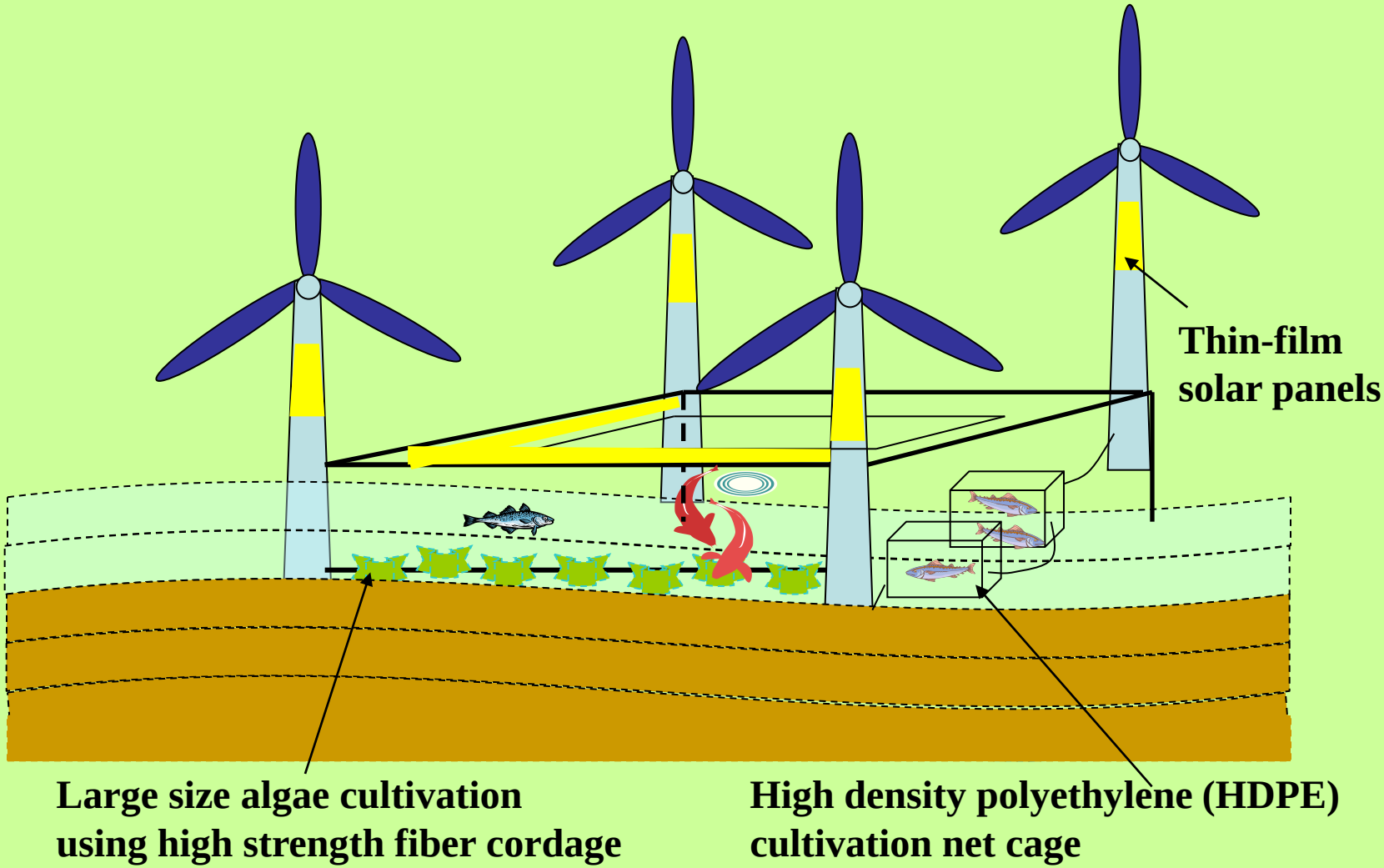
油菜籽　大豆　向日葵

椰子、棕櫚

果實：
生質柴油

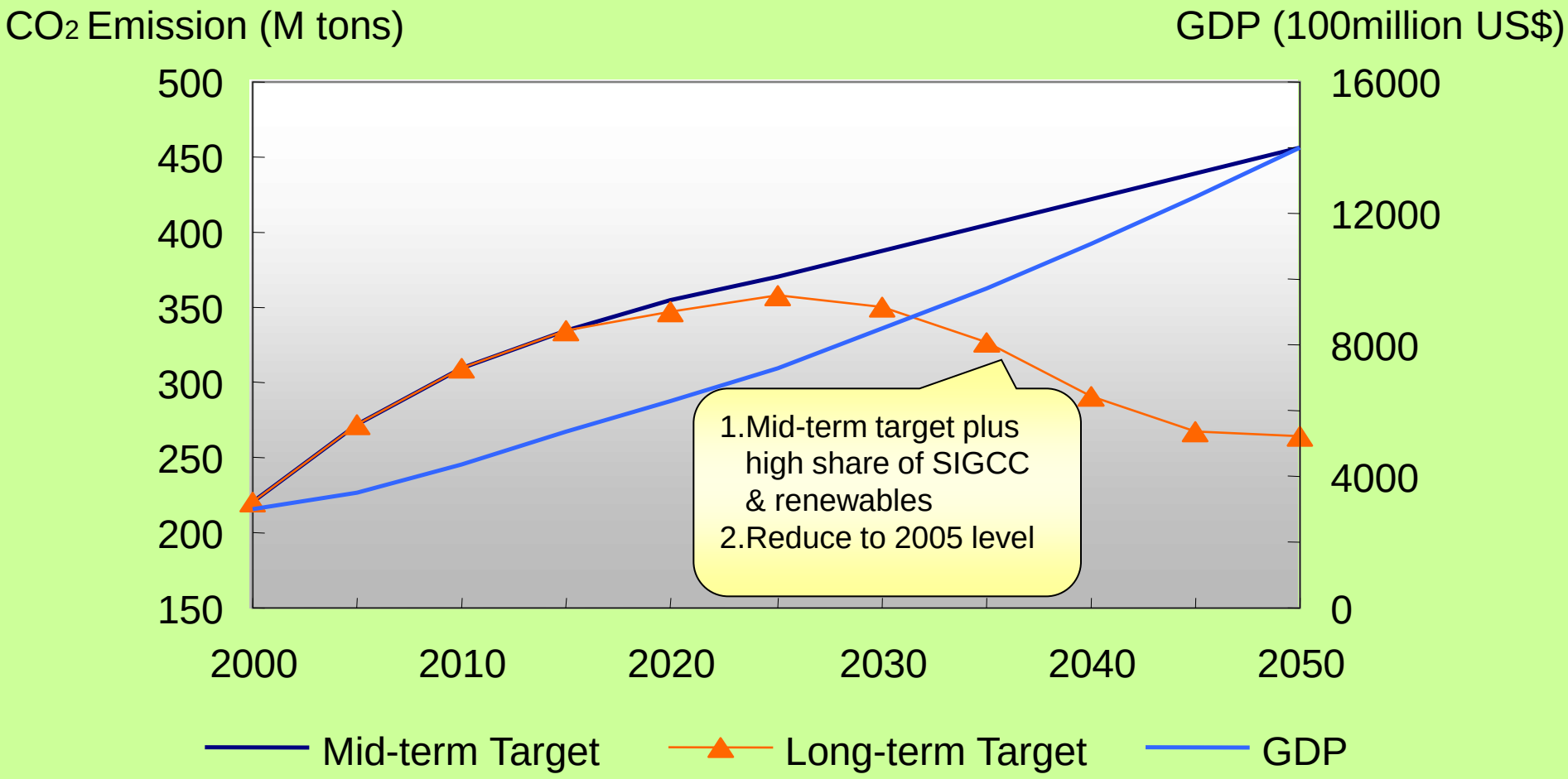
其餘根莖葉:
生質酒精（纖維素）
生質電力原料

A Conceptual Underwater Pasture Combined with Wind and Solar Power Applications



Long-term Target of CO_2 Reduction

-Reduce to 2005 Level



Smart Grid in Taiwan

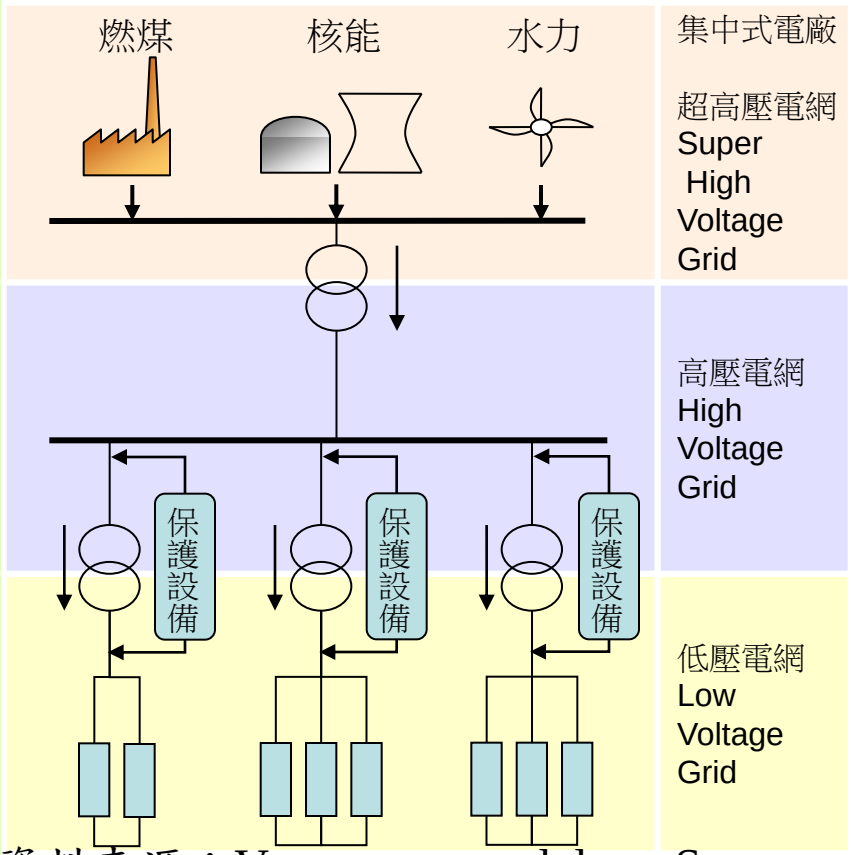
Taiwan Smart Grid Industry Association

Gou-Chung Chi

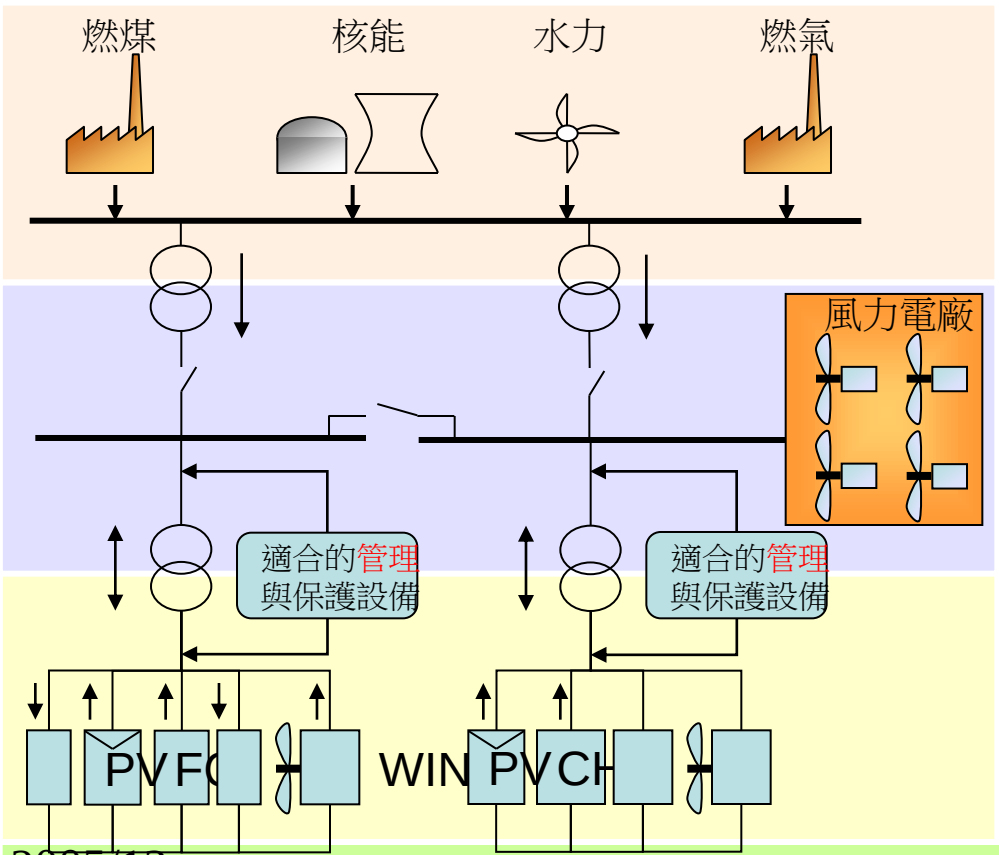
未來永續電力供應結構

	汽電共生(< 50 MW)	再生能源 (< MW)
分散式發電	中型工廠汽電共生、商用汽電共生、微型汽電共生	中小型水力、風力、生質燃料、廢棄物焚化、太陽光電、海洋溫差

傳統電力結構



未來電網連結分散式發電設備



資料來源：Vernetzung modularer Systeme, 2005/12

NSC Intelligent Grid and Advanced Metering Infrastructure General Project

Improve of building energy efficiency and public energy saving conscious

Source：Lin, Faa-Jeng，EPA-Intelligent Grid and Advanced Metering Infrastructure General Project ,NSC

Smart Grid: What is it?

DOE has defined seven core Smart Grid Characteristics :

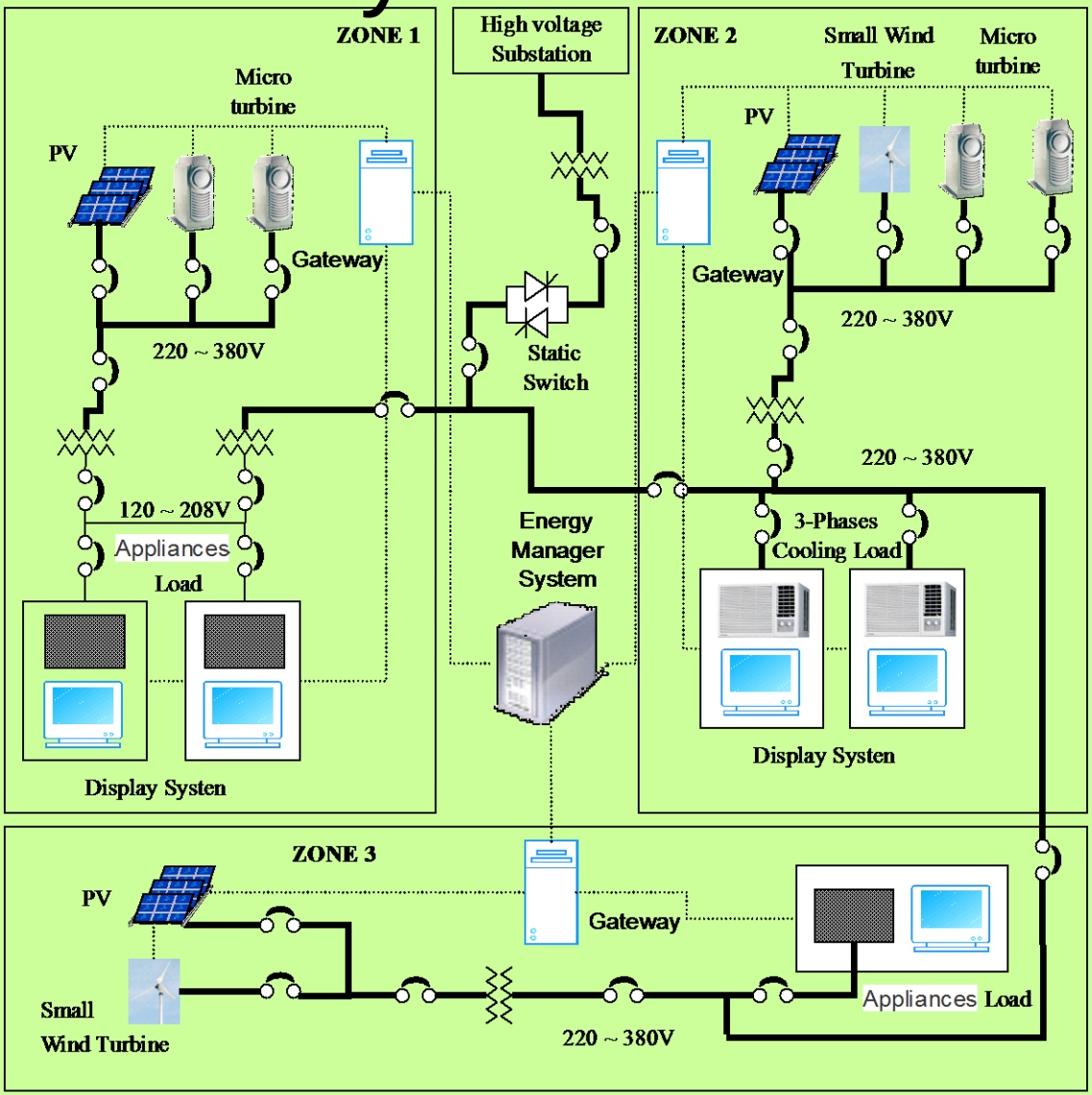
1. Customer Participation
2. Integrates All Generation and Storage Options
3. New Markets and Operations
4. Power Quality for 21st Century
5. Asset Optimization and Operational Efficiency
6. Self-healing
7. Resilient Against Attacks and Disasters

Smart Grid Applications: Operational Strategies that Utilize Smart Grid Assets to Create Values

- Transmission Automation
- Distribution Automation
- Renewables Integration
- Demand Participation Signals & Options
- Smart Appliances, PHEVs & Storage
- System Coordination, Situation Assessment
- System Operations
- Energy Efficiency
- Distributed Generation & Storage

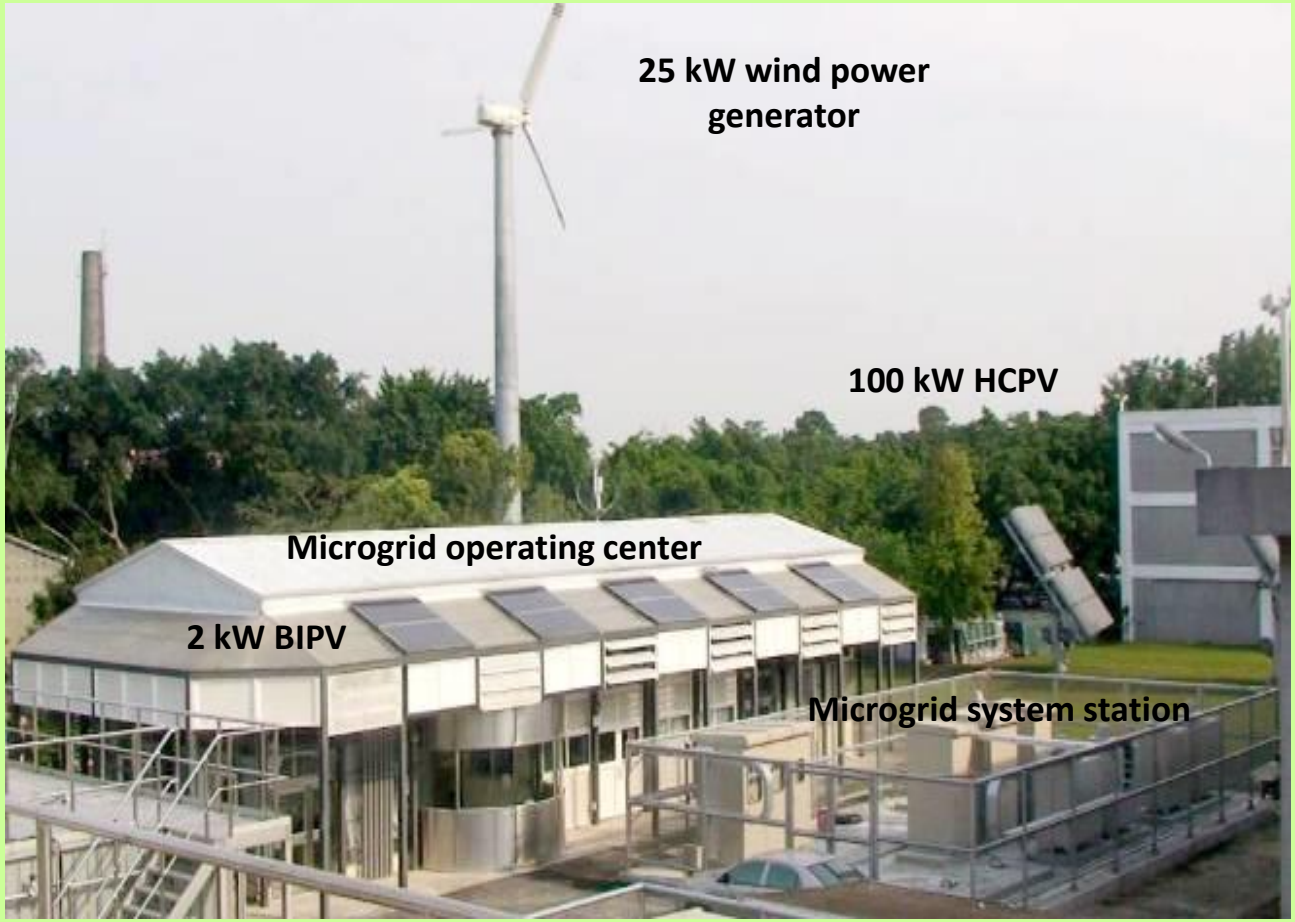
Micro Grid System

- The general idea of Micro Grid is to integrate a series of power loads with micro sources. The integrated system so called Micro Grid is controllable and would provide users with electric power and thermal energy.
- The Concept of Multi-Micro Grid is that arbitrary Micro Grid could be integrated or separated and become a new grid. This concept could support the development of Cellular Smart Gird.



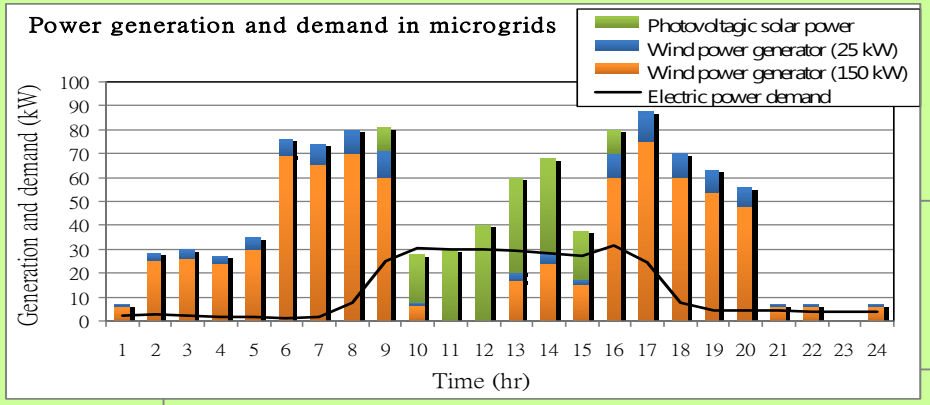
資料來源：紀國鐘，國科會產學合作計畫－微電網技術規範及產業發展研究計畫(1/2) NSC 100-3113-E-009 -003 -CC2

The INER Microgrid in Taiwan



Reference : Ming-Che Hu, Yen-Haw Chen, Yen-Hong Chen, Yung-Ruei Chang, Optimal Operating Strategies and Management for Smart Microgrid Systems, Journal of Energy Engineering, Published: 15 February 2013 (SCI, IF= 0.5)

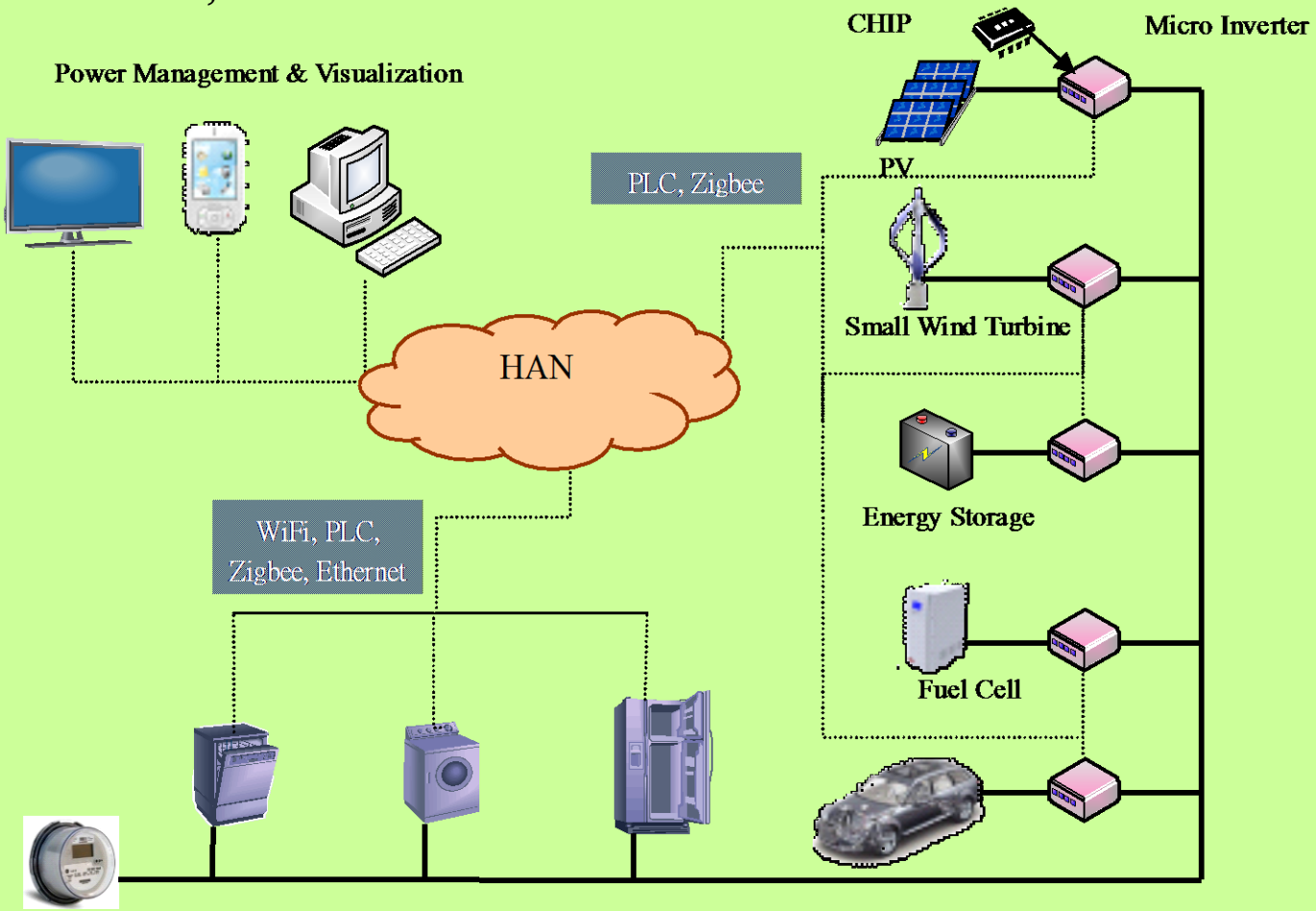
Electric Power Generation and Demand in the INER Microgrid System



Reference : Ming-Che Hu, Yen-Haw Chen, Yen-Hong Chen, Yung-Ruei Chang, Optimal Operating Strategies and Management for Smart Microgrid Systems, Journal of Energy Engineering, Published: 15 February 2013 (SCI, IF= 0.5)

Smart Home and Building System

Equipment associated with smart home energy system including intelligent home appliances, slow chargers for electric vehicles, power management chips, energy management system, home gateway, human-machine interface control, load type of control interface, wireless sensors, wired sensors, and communications module.



資料來源：能源國家型科技計畫－智慧電網與先進讀表主軸專案計畫總計畫 NSC 100-3113-P-008 -001 -PO

Development of Smart Appliance in Taiwan

Traditional Appliance

First Generation Smart Appliance

Real time display electricity expenditure, automatically energy saving control，ex inverter Appliance。

0 Standby power and auto regulate water consumption

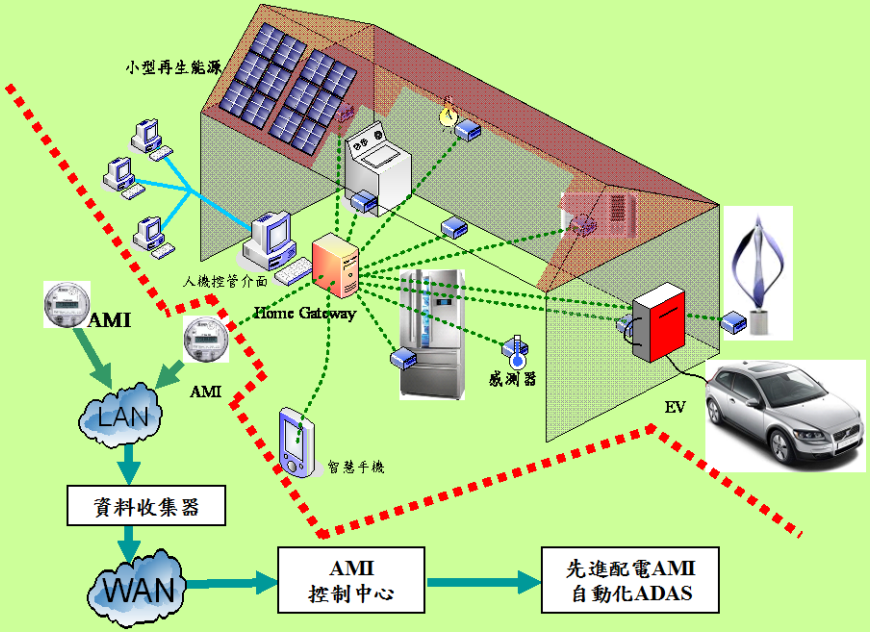
Multi-sensing and adjust temperature of refrigerator

Visible of power consumption and expenditure

Automatically adjust suction power by waste amount

Second Generation Smart Appliance

Using ICT technology to integrate Smart Appliance and Smart Grid, enhance the costume to joint.



The condition and timing of integration smart appliance and smart Grid: (1) Interoperability standards between Appliance and grid mature. (2) Time price system of electricity.

1949 **2000** **2014 ~ 2016**

資料來源：能源國家型科技計畫－智慧電網與先進讀表主軸專案計畫總計畫 NSC 100-3113-P-008 -001 -PO

Structure of TSGIA

Assembly
(chairman)

Secretariat
TIER

智慧型電表組
AMI
TATUNG (Director)
DELTA (Co-Director)

智慧輸配電組
intelligent transmission and distribution
AEC (Director)
MOXA (Co-Director)

智慧家庭組
Smart Home (Buildung)
TATUNG (Director)
CHT (Co-Director)

微電網組
Micro Grid
CHEM (Director)
INER (Co-Director)
CSIST (Co-Director)

標準與規範組
Standard
III (Director)

能源產業組
Energy Industry
TIER (Director)

資通訊組
Energy ICT
ITRI (Director)
CHT (Co-Director)
MOXA (Co-Director)

ALLIS ELECTRIC CO (AEC), Chung-Hsin Electric and Machinery Manufacturing Corp. (CHEM), Institute for Information industry (III), Industrial Technology Research Institute (ITRI), Institute of Nuclear Energy Research (INER) , CHUNG-SHAN INSTITUTE OF SCIENCE &TECHNOLOGY (CSIST), Chunghwa Telecom(CHT)

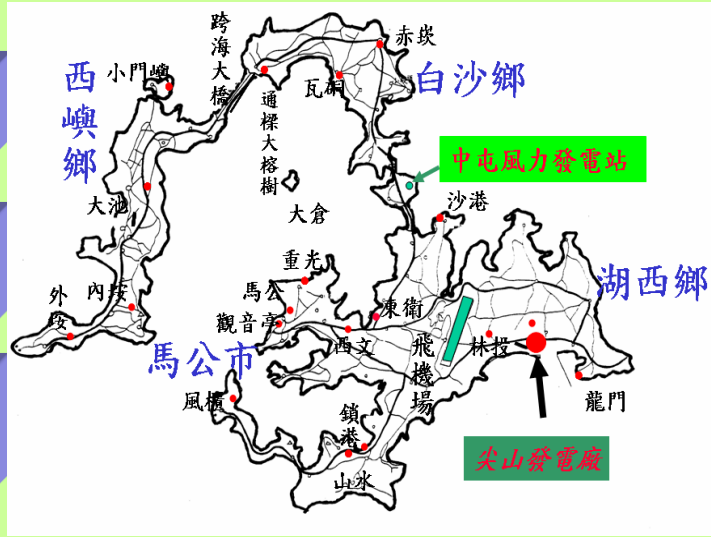
Overall Demonstration to Promote the Idea of Smart Grid and AMI

Using results from the 1st phase of this project, cooperating with the Executive Yuan to implement Low Carbon Island Project in Penghu archipelago (50Km from Taiwan, inhabitants 89000, average load 45MW, peak load 83MW), as well as with the Bureau of Energy, Ministry of Economic Affairs and TPC to promote AMI, micro grid, advanced power distribution, smart home and building energy management, and electric vehicle energy supply management.

Smart Meters

Substation Intelligentize

Power management system



Solar thermal energy ➔ Alternative gas

Photovoltaic system

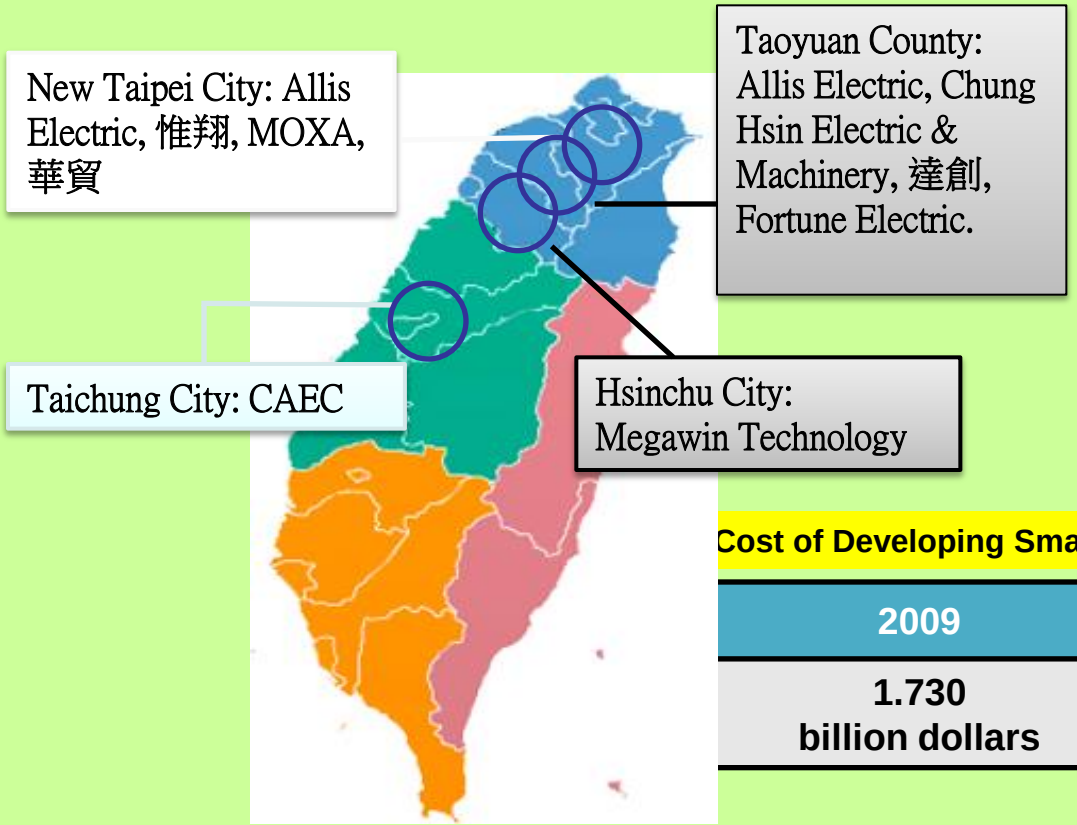
Large-scale wind turbine

Small-scale wind turbine

Motor vehicle subsidies Charging stations

Taiwan Smart Grid Industry III

Classify by region, in 2009-2010, the major markets of Taiwanese smart grid related products are as follow：China, Japan, South Korea, India, Australia, Germany, United Kingdom, USA, Canada, Mexico, Brazil, South Africa. Factories are expecting to develop Japan, China, Southeast Asia, India, Europe, Middle Asia, USA, South America.



Most of domestic factories which produce smart grid related products are located in New Taipei City, Taoyuan County, Hsinchu City and Taichung City. Otherwise, most of foreign locations are in Qingdao, Shanghai, Jiangsu, Shenzhen, Guangzhou, Dongguan, Berlin (Germany).

Cost of Developing Smart Grid Related Products in Taiwan from 2009 to 2010

2009	2010	Growth Rate
1.730 billion dollars	2.057 billion dollars	18.9%

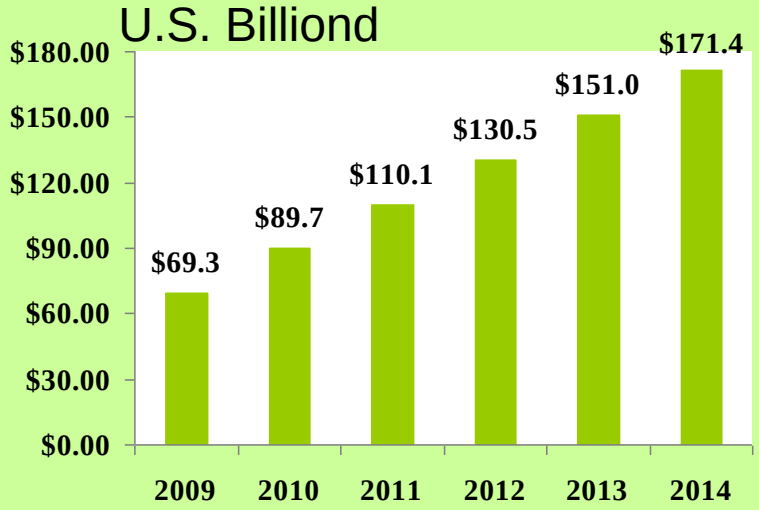
unit：NTD

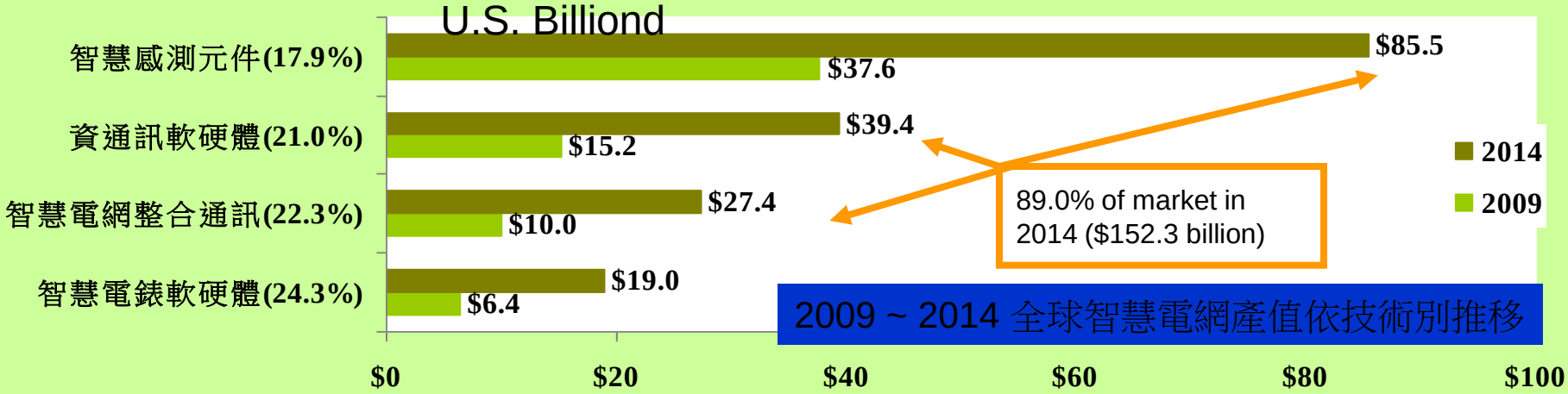
Location of Producing Taiwanese Smart Grid Related Products

全球智慧電網市場規模推移

- 各國多將智慧電網視為未來發展的重要政策項目，甚至 2010 年即計劃大規模投資，中國預計投入逾 73 億美元，其次為美國預計投入 71 億美元
- 智慧電網發展主要機會不僅僅是公用事業，電力營銷，能源生產者，投資者和風險資本家。在2014年，89%或1523億美元的全球智能電網市場預計將包括元件、設備、硬體、軟體和通信設備。這些產品將建造、鏈接、監控、管理和確保智慧電網成為關鍵的基礎設施和通信系統。

2009 ~ 2014 全球智慧電網產值推移





2009 ~ 2014 全球智慧電網產值依技術別推移

Source:Zpryme Resarch &

智慧電網願景

資料來源：Europe SmarlGrids Technology Platform, EUROPEAN COMMISSION, 2006