

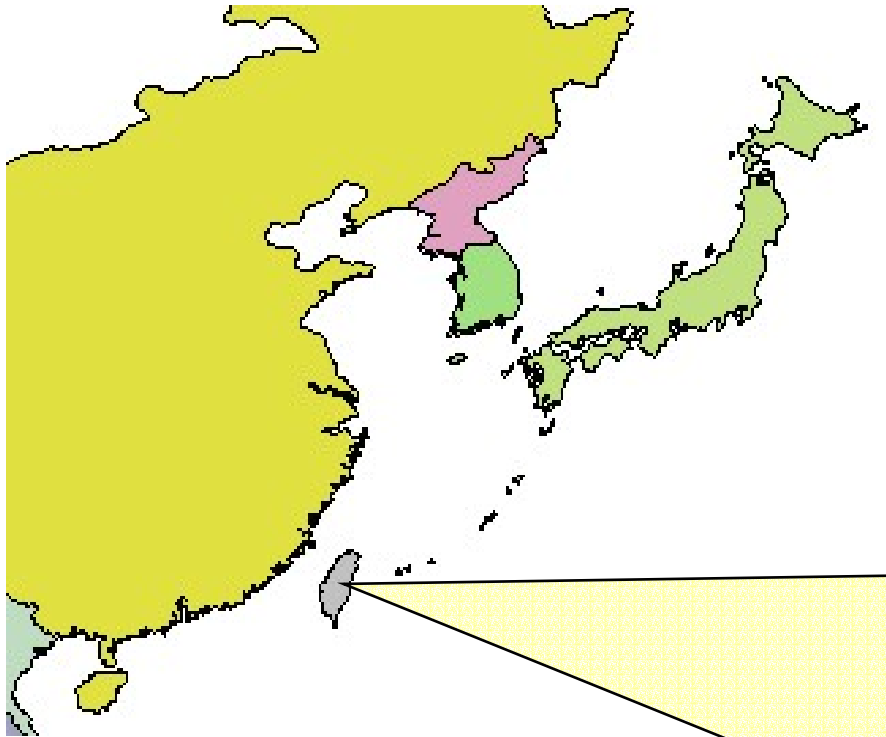
The Recent Development of Clean Energy Applications in Chinese Taipei

Dr. Hwai-Derg Chiang

**Director, Clean Energy Technology Division
Energy & Resources Laboratories
Industrial Technology Research Institute**

16 May 2005

Rapid Economic Development



Taiwan, Republic of China

Land area: 36,190 km²

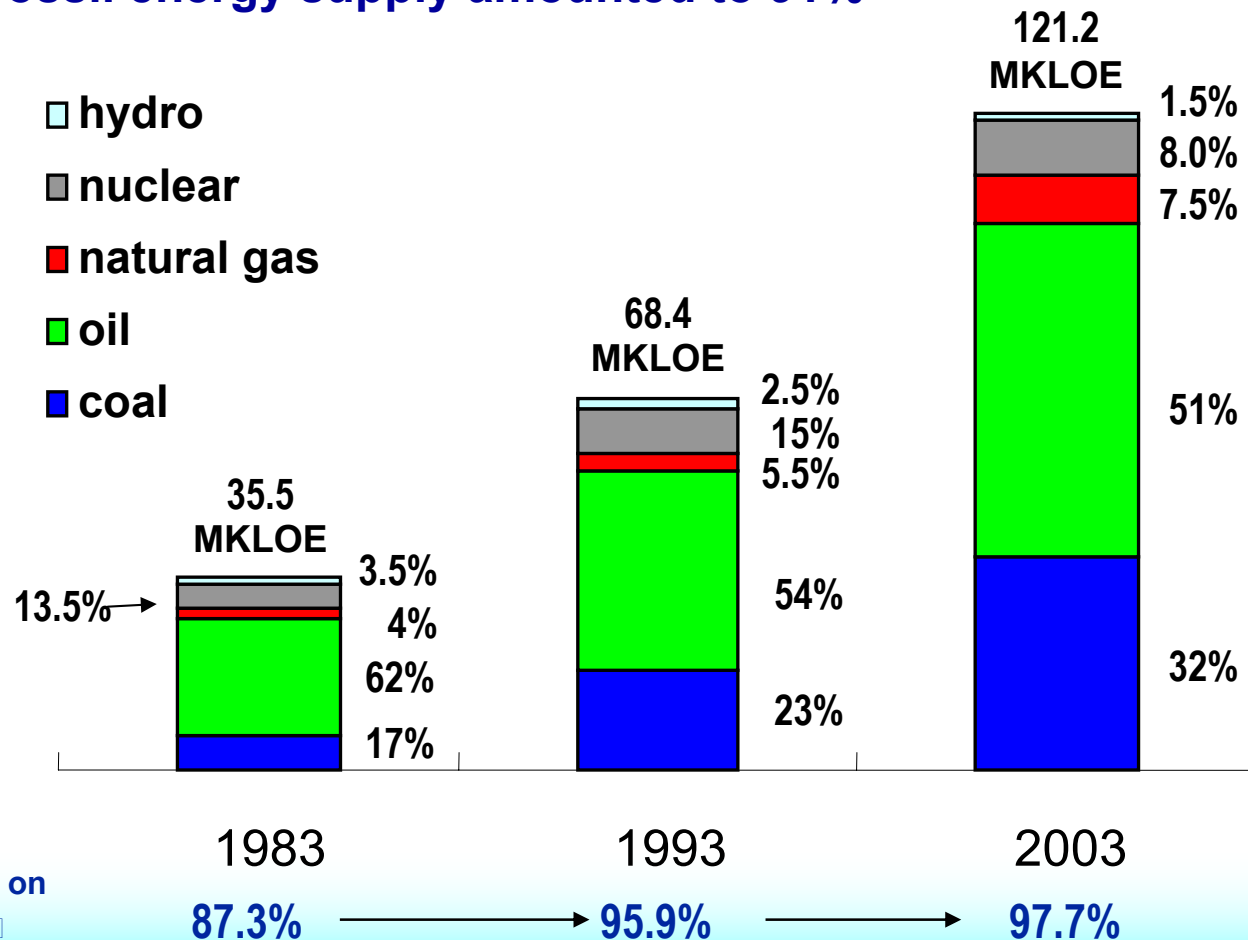
Population: 22.6 millions

(Population density = 625 per km², world 2nd highest)

- Over the last two decades (1983-2003), the rapid economic growth has created substantial changes in the economic structure:
- GDP rose from US\$52.4 billion to US\$295.9 billion, and per capita GNP increased from US\$2,832 to US\$13,157, with average annual growth rate of 6%.
- Now 67% of GDP is from service sectors vs. 48% in 1983.

Energy Supply Structure in Taiwan

- Annual increased by 6.3% during last two decades
- Limited indigenous supply, 97.7% importation
- Fossil energy supply amounted to 91%



Background & Strategies for Development of REs

- Major conclusions from a number of notable energy conferences since 1998 that advise the Government energy policies committing to the promotion of REs and regarded as Non-Regret policy :
 - National Energy Conference (May 1998)
 - National Economic Development Conference (January 2001)
 - Sixth National Science and Technology Conference (January 2001)
 - National Nuclear-free Homeland Conference (September 2003)
- Highlights of Promotion Strategies
 - Renewable Energy Promotion Plan (since 2002)
 - Establishment of inter-ministerial co-ordination mechanism
 - Providing financial incentives, subsidies, and conduct R&D programs
 - Legislating Renewable Energy Development Act (Draft)
 - Fixed feed-in tariff for RE electricity, ensuring reasonable profit.
 - Taipower company's Interim Power Purchase Measure (since 2003)
 - Nuclear-Free Homeland Action Plan (since 2003)
 - Government shall allocate an annual NT\$3 Billion (US\$90 million) budget for promoting the development of clean energy and energy conservation industries.
- Renewable energy applications have increased rapidly in recent years.
REs increased 13.9% from 2,233MW (in 1999) up to 2,438MW (in 2003).

2010 Target for RE Promotion

- **2010 Goal : Installation capacity of 5,139 MW, or 10% of Electrical Network Capacity.**

Schedule Item		2003		2008		2010	
		Status		Promotion Goal		Promotion Goal	
		Cumulative Installation ; MW; ^	Ratio(%)	Cumulative Installation ; MW; ^	Ratio(%)	Cumulative Installation ; MW; ^	Ratio(%)
1. Hydro Power		1,908	4.27	2,085	4.31	2,168	4.20
2. Wind Power		9	0.02	761	1.62	2,159	4.22
3. Photovoltaics		0.3	0.00	11	0.02	21	0.04
4. Geothermal		; Đ	; Đ	5	0.01	50	0.10
Biomass Power	5. MSW	435	0.97	545	1.13	553	1.07
	6. Biogas	23	0.05	27	0.06	29	0.06
	7. Agricultural and Industrial Waste	63	0.14	74	0.15	159	0.31
Total		2,438	5.45	3,508	7.3	5,139	10.0
Percentage of Renewable Energy in Total Installation of Power Capacity			5.45%	7.3%		10.0%	

NOTE: 1. Agricultural and industrial wastes include bagasse, rice husk, paper industry waste, black liquid,, waste tire, waste plastics and rubber and refuse derived fuels, etc., which may be applied for power generation.
2. After the occurrence of typhoons in 2004, several hydro power plants were damaged. The out-of-operation capacity was estimated at about 1,000 MW. Emergency repairs are still underway.

Solar

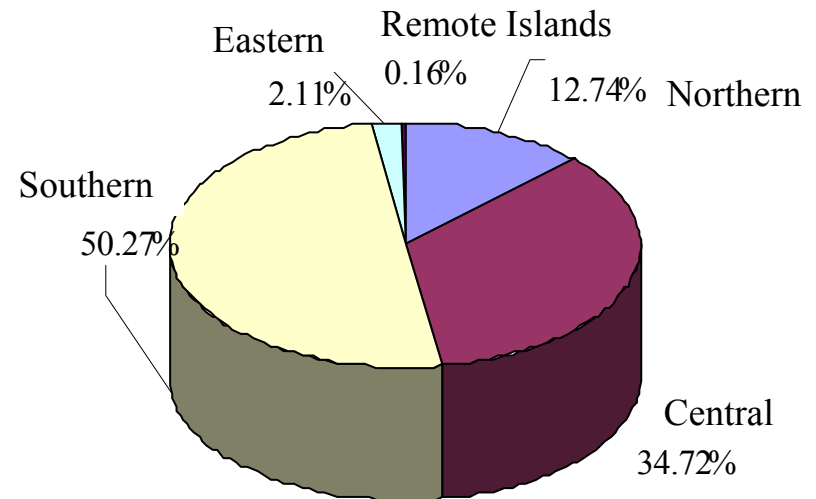
Promotion of SWH (Solar water heater)

Subsidy for SWH

Subsidy means are based upon collector area
(NT Dollars per square meter)

	Main Island	Remote Island
Flat Plate and Glazed Collector	1,500	3,000
Evacuated Flat Plate Collector	1,500	3,000
Flat Plate & Non-Glazed Collector	1,000	2,500
Collectors of other types	Authorized on Needed	Authorized on Needed

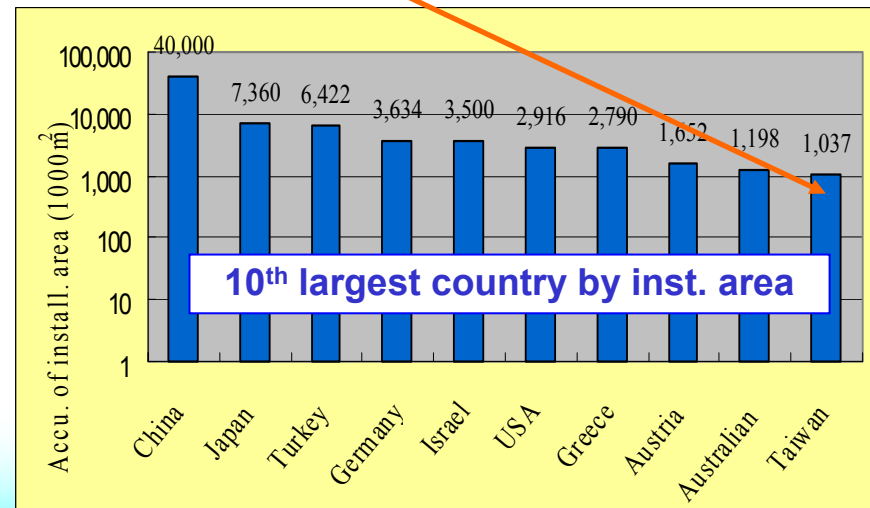
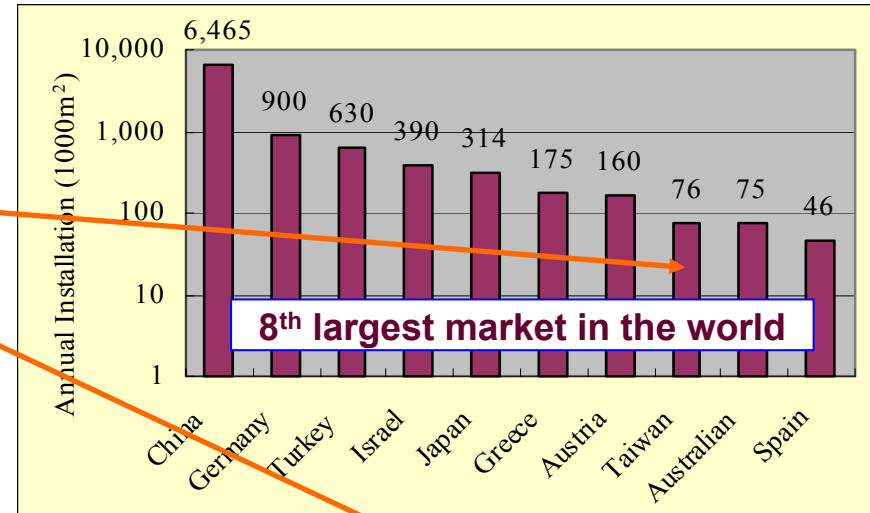
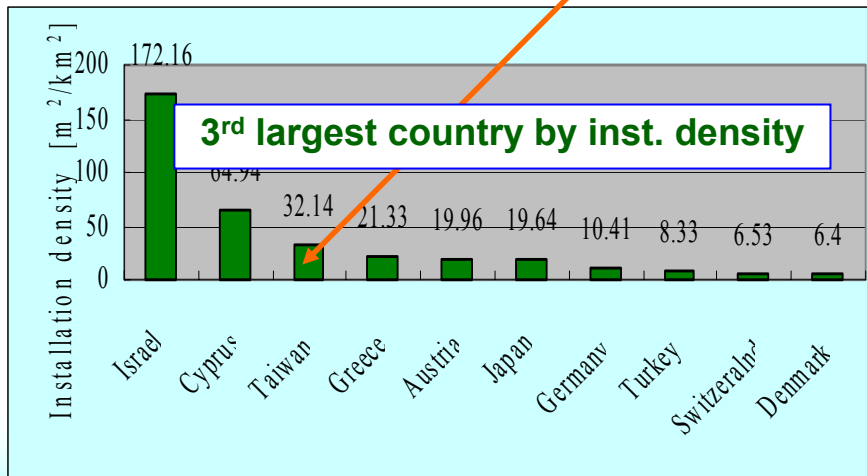
Data Period: Jun 2000 to Sep 2004



Achievement of Promotion

2001	Installation	Ranking
Annual installation area [m ²]	80,000	8
Accumulation of installation area [m ²]	1,037,000	10
Installation density [m ² /km ²]	32.14	3

Source: Sun in Action II – A Solar Thermal Strategy for Europe, ESTIF, 2003.



Solar

Application of Solar PV systems (before 2000)

- There were about 100 kW of PV systems installed prior to year 2000, mainly for R&Ds and remote weather stations.



高雄玉山氣象站 (二)

A 10kWp Solar PV system on a weather station at the top of Jade Mountain (installed 1990)



1998 年裝置 10kW 太陽能發電系統，以解決儀器用電問題。

Another 10kWp Solar PV system on an offshore island (1998)

Solar

Promotions of Solar PV Systems

By 2004, Total installed capacity: 419 kW (55 Demonstration Systems)



Presidential Hall: 10.5kW



Taipin Island, NanSha



Elementary School in Taichung



Legislative Yuan



Taipei Water Park



A household: 4.2 kW

Solar

Solar City

Actively Promoting a Demonstration of Innovative Solar PV Applications

Expected timeline: August 2004

June 2005

June 2005 ~ Dec. 2007

Request for Proposals (3 finalists selected)

Choice of Final Site

Construction

- (1) Residential: A concentrated housing estates properly planned as a living demonstration of sustainable energy
- (2) School: Integrate Solar application with education
- (3) Usage on Parking lot, Sound barriers & Traffic signs
- (4) City Square & Park: to promote sustainable and green energy usage
- (5) City Landmark: Community Center, Railway station and others



(3) Usage on Parking lot, Sound barriers & Traffic signs



Wind

R&D of Wind Turbines in Taiwan



- **1960: Taipower Co. installed a 50 MW wind turbine in Pen Hu**
- **1980~1990: Supported by BOE, ERL/ITRI successively completed construction of three wind turbines (4 kW, 40 kW, 150 kW) and feasibility assessment of wind energy potential in Taiwan. The project was closed due to the big drop in oil price in the early 90's.**
- **1991: Taipower Co. installed two commercial wind turbines (100 kW) connected to diesel generators (a hybrid system).**
- **1996: Central Weather Bureau installed a 10 kW wind turbine combined with a PV system to supply power for a meteorological observation station.**

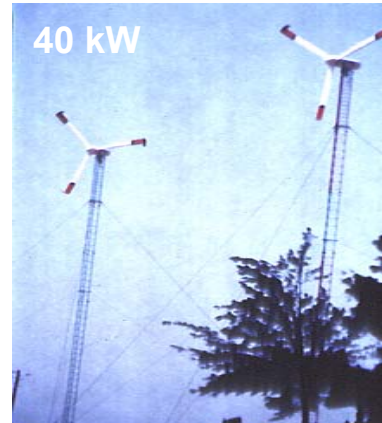
ITRI's wind turbines

Wind

Wind Energy Application in Taiwan



Wind Turbine built by Taipower Co. in Paisha (1960)



Wind turbine in Kinmen built by ERL, ITRI (1980's)



Wind turbine-PV hybrid by Central Weather Bureau (1996)



Mailiao Demo System (2000)



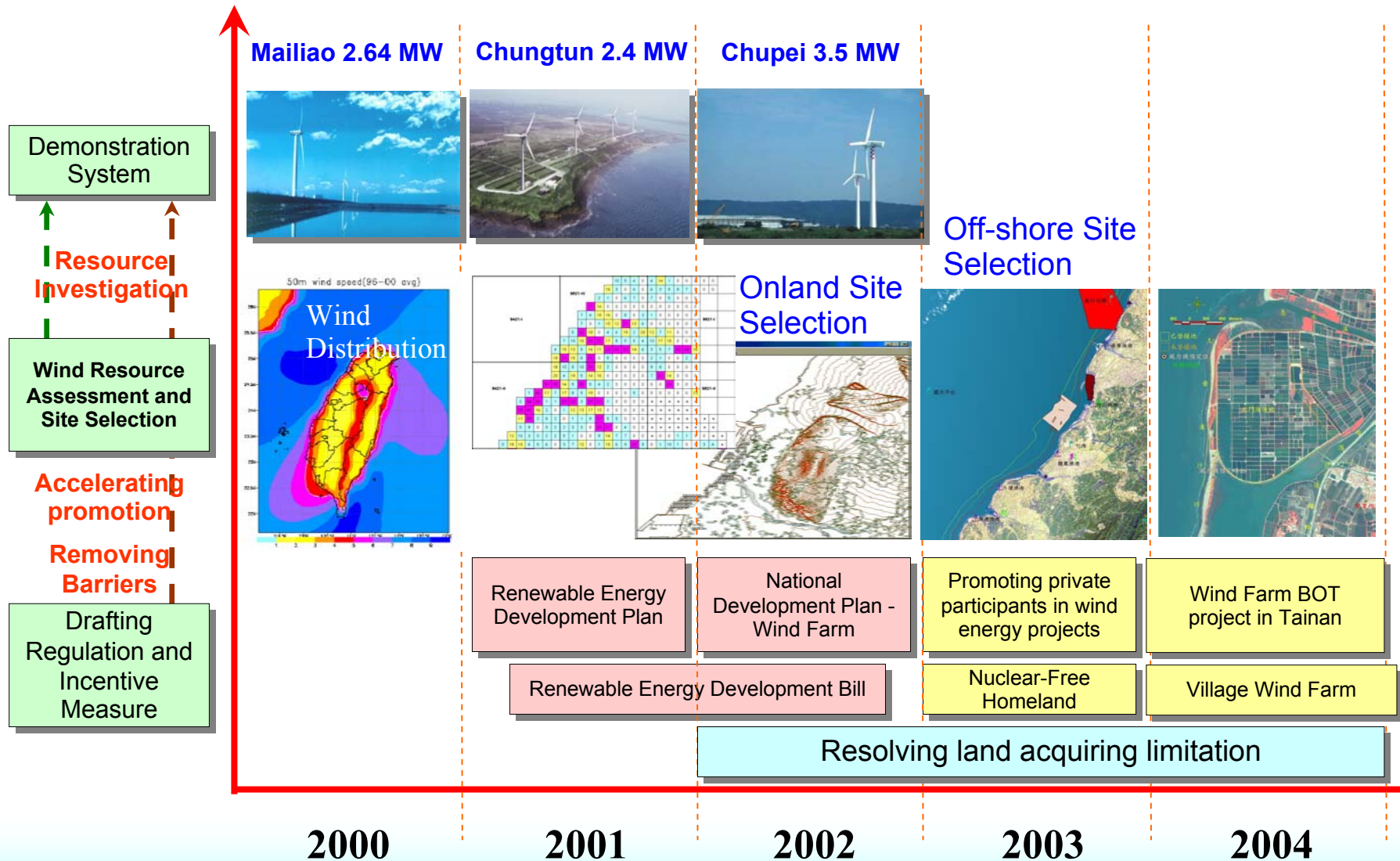
Chungtun Demo System (2001)



Chupei Demo System (2002)

Wind

Achievement of Wind Energy Promotion

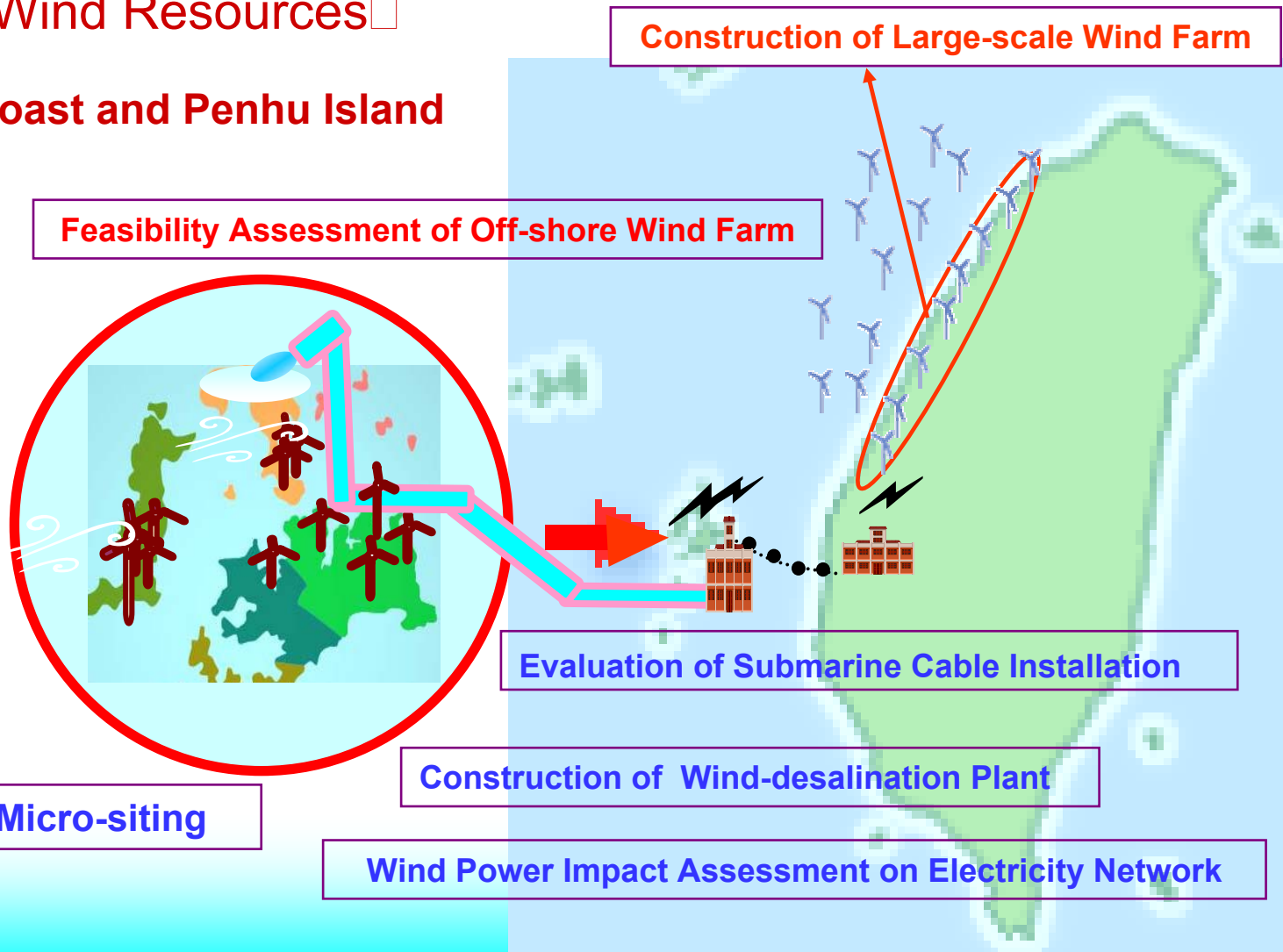


Wind

Challenge 2008 - Wind Farm Demo Plan

➤ Excellent Wind Resources

Western coast and Penhu Island



Biomass

Biomass Energy Application



Biogas
utilization



Bio-diesel



d-RDF



Liquefaction

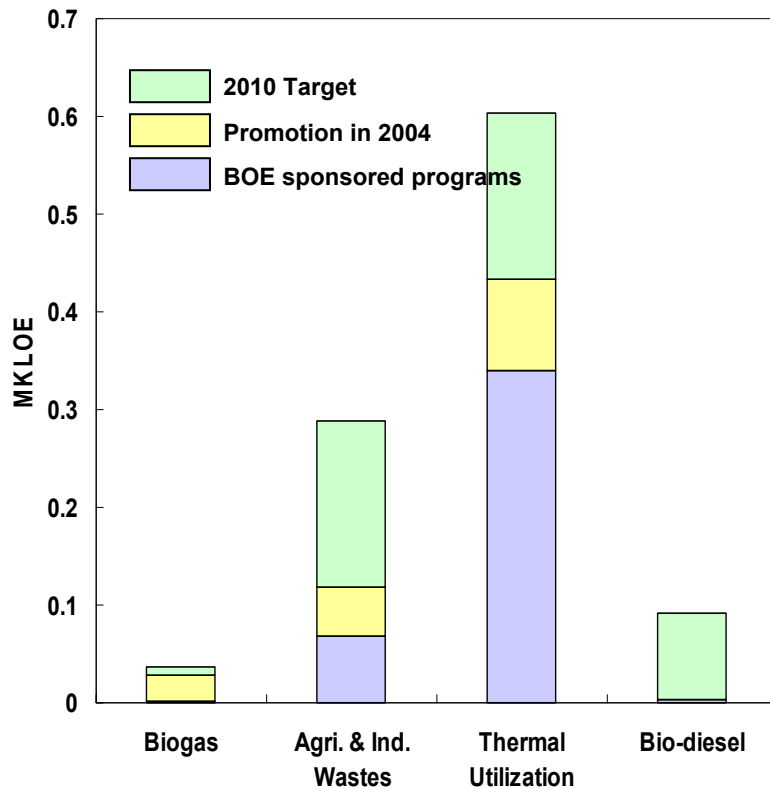


Gasification



High temp
gas
cleaning

Biomass Energy in 2004: 545 MW



Achievements of biomass energy R&D and promotion, 2000-2004

- Biogas power generation demonstration
- RDF demonstration plant for MSW
- Co-utilization of RDF in industrial boilers and cement kilns
- Demonstration plant for fast pyrolysis of mixed plastic wastes
- Combustion of synthetic liquid fuel and pollution control
- Feasibility assessment of co-firing and re-burning of syngas in industrial boilers
- Waste gasification demonstration plant
- Feasibility assessment of gasification of RDF from paper reject
- Moving granular bed filter (MGBF) demonstration system for high temperature gas-cleaning
- Bio-diesel demonstration plant

Biomass

Bio-diesel Technology



經濟部能源局 | 工業技術研究院



3,000 kl/yr Bio-diesel demo plant in Chiayi
BOE Project Tech. developed by ITRI

Advantages of Bio-diesel

- Renewable energy
- Safe to handle and transport
- Biodegradable
- Can be used alone or mixed in any ratio with petroleum diesel fuel
- More eco-friendly and lower pollution
- Improving the image of Diesel cars



Road-test of bio-diesel truck in Taipei city



Bio-diesel van

Potential for Bio-diesel Utilization in Taiwan

Demand for Diesel fuel in public and cargo transportation is around 1.6 m kiloliter. It is estimated that potential for bio-diesel utilization in Taiwan could be 0.32 m kiloliter per annum.

Biomass

Densified Refuse Derived Fuel

■ First d-RDF Demo Plant for MSW in Taiwan (Fengbin, Hualien)



Treatment capacity: 1,000 kg/hr MSW



經濟部能源局

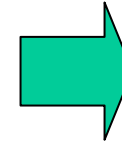


研 發 所



hualien

花蓮教育大學



Waste

RDF

● Potential for RDF utilization in Taiwan

- If 15% of MSW can be converted into RDF would substitute for 350,000 tonnes of coal approximately.
- The total electricity generation can reach about 145 MW with an amount of carbon dioxide reduction of 980 thousand tonnes.

FUEL CELL

ERL/ITRI PEMFC Development Program

2001-2004 Stationary PEMFC Project Goal

3 kW CHP System

□ FC CHP System

- Stack
- Power and control
- Reformer
- H₂ storage
- Standards

□ FC Testing Center

- Stack
- Reformer
- System
- Codes &

System Design
300W Stack
300W Reformer

1 kW PEMFC CHP System (Alpha)
Stack □ Reformer
□ H₂ storage □
Power & Control

3 kW PEMFC CHP System (Alpha)
1 kW PEMFC CHP System (Beta)
Reformat Stack
□ Reformer □
Life Test

3 kW PEMFC CHP System (Beta)
Performance Improvement □
Life Test □
Demo

FUTURE R&D

5~10 kW DG PEMFC System

Portable PEMFC Systems

Performance Improvement

Cost Reduction

H₂ Production, Storage, Delivery
Economic Models

PEMFC & Renewable Energy Hybrid Power

2001

2002

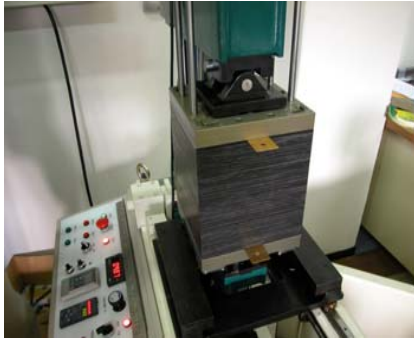
2003

2004

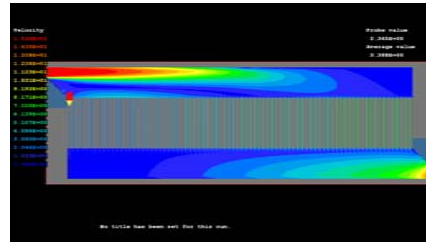
2006

2008

Stack Design & Assembly Technology



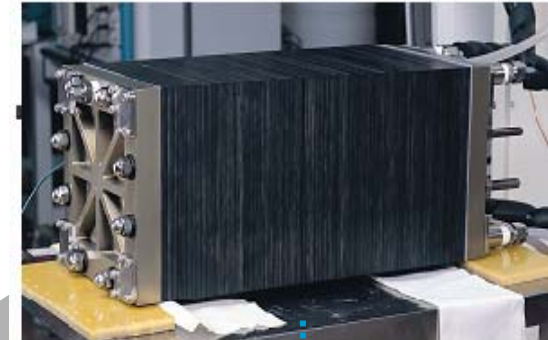
Stack Assembly



Stack Flow Simulation

Volume Reduction : 27.4%

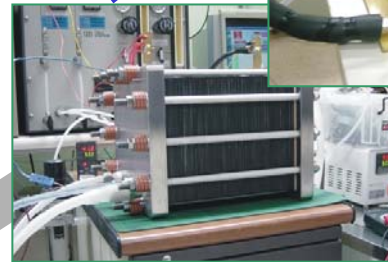
3 ~5 kW (with Air)



Power Module Specifications:

- Hydrogen Consumption: 3.6 slpm
- Electricity Output: 300W
- DC 12V 25A
- Electrical Efficiency: 40%
- Air Cooled

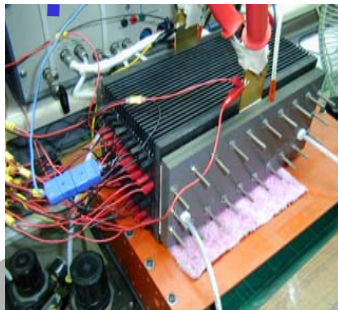
1.5 kW



Power Module Specifications:

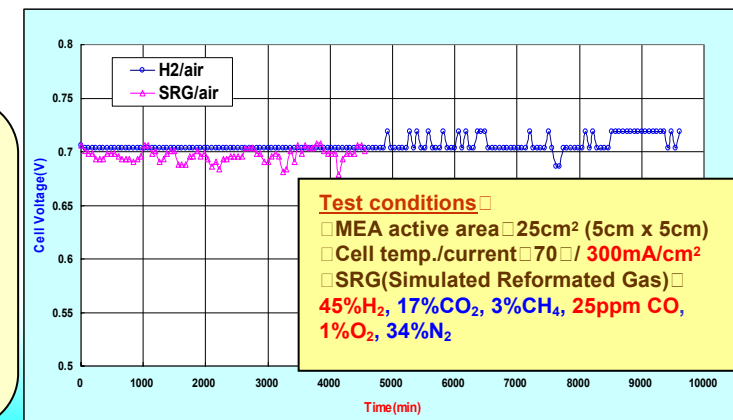
- Hydrogen Consumption: 36 slpm
- Electricity Output (Nominal): 3 kW
- DC 47V 65A
- Water Cooled

300W



Power Module Specifications:

- Hydrogen Consumption: 12.0 slpm
- Electricity Output (Nominal) : 1kW
- DC 24V 50A
- Water Cooled



Power Conditioning & Control

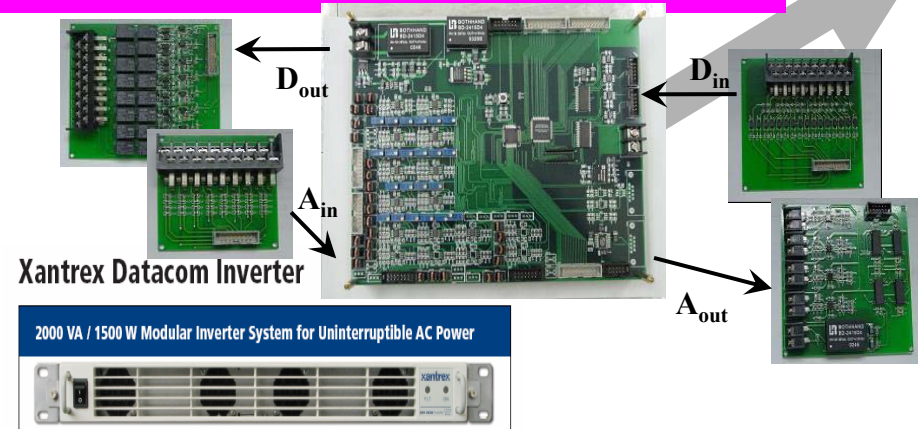
Power electronics is essential for ease of operation in back-up & residential/commercial applications

Parallel Bus Control Architecture



Inverter: 22-30 VDC to 110/220 VAC/Single Phase @ 85%
Harmonic Distortion < 3% (linear)
Converter: 18-36 VDC to 24 VDC @ 90%

Serial/Dual Bus Control Architecture



Inverter: 40-60 VDC to 110-120 VAC/Single Phase @ 85%
Harmonic Distortion < 3% (total)
Converter: 40-60 VDC to 24 VDC @ 90%

Control architecture should be adequate for stationary power applications in its simplicity, adaptability, ease of expansion and low cost

Hydrogen Technology and Applications Map

