41st APEC EGNRET Meeting

The Implementation, Achievement and Challenges of Renewable Energy Promotion and Low Carbon Technology in Chinese Taipei

Bureau of Energy
Ministry of Economic Affairs
Chinese Taipei

16~17 October, 2013

Outline

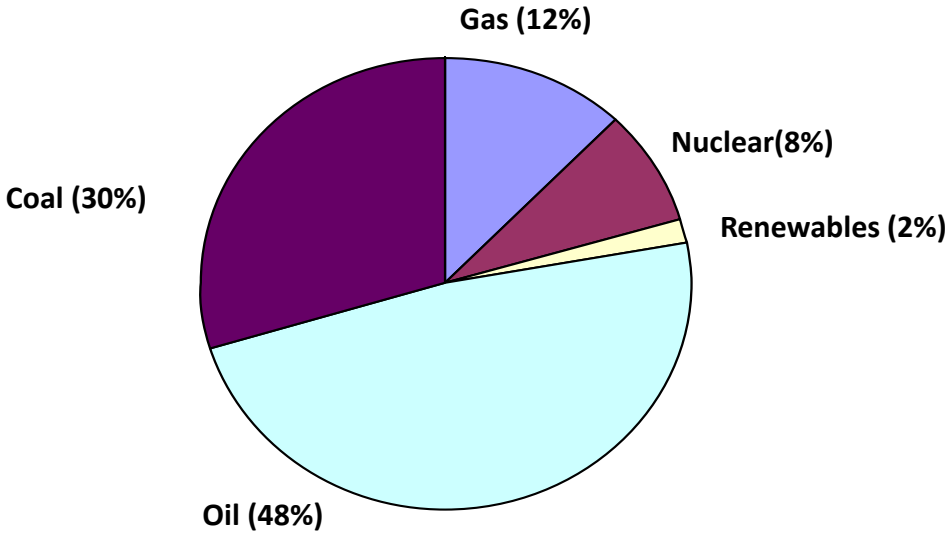
- Energy Situation in Chinese Taipei
- RE Development in Chinese Taipei
- Low Carbon Technology Application
- Concluding Remarks

Energy Supply in Chinese Taipei

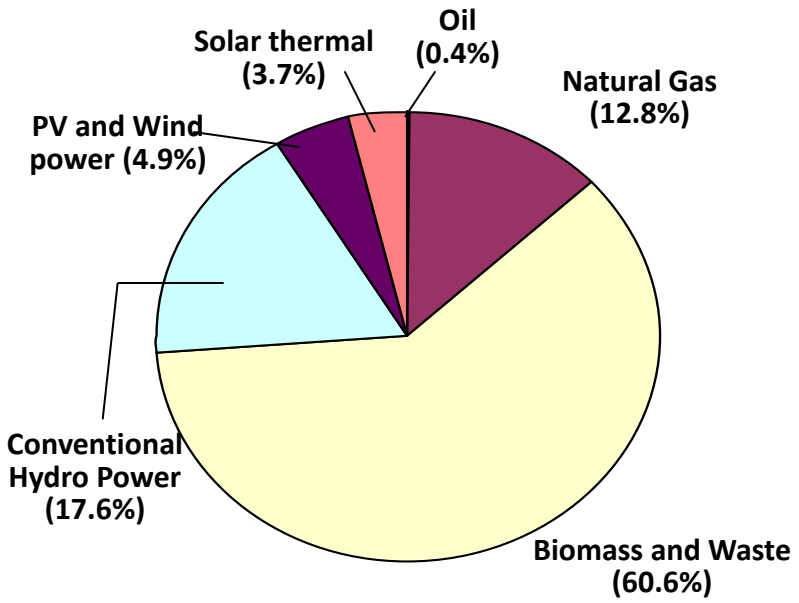
High Dependence on Imported Energy

- 98% energy supply rely on imports of which fossil fuel accounts for the major part
- 87% of total indigenous energy supply is renewable energy

Total Primary Energy Supply (2012)
140 Million KLOE



Indigenous Energy Supply (2012)
3 Million KLOE

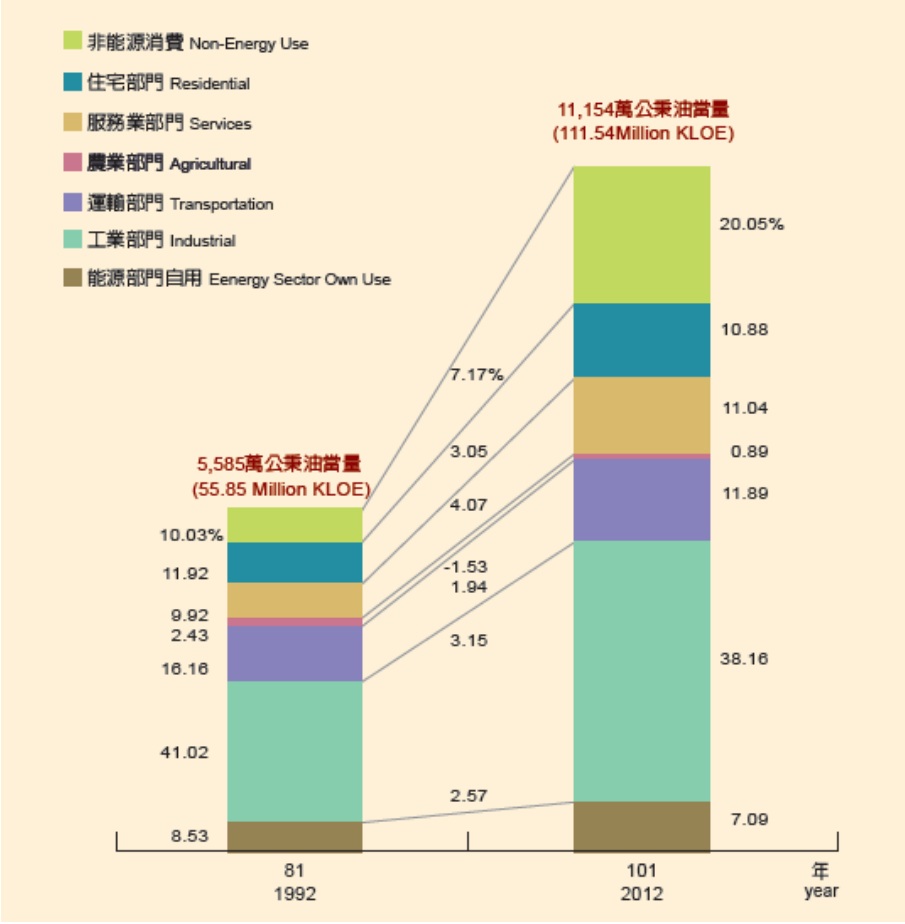


Source: 2012 Energy Statistics handbook, BOE

Energy Consumption in Chinese Taipei

- The energy consumption of 2012 totaled 111.54 million KLOE (kiloliter oil equivalent), of which 38% is for industrial sector, 12% for transportation sector
- Both service and residential sectors energy consumption are growing annually and represent 11% share, respectively

Energy Consumption by Sector (2012)

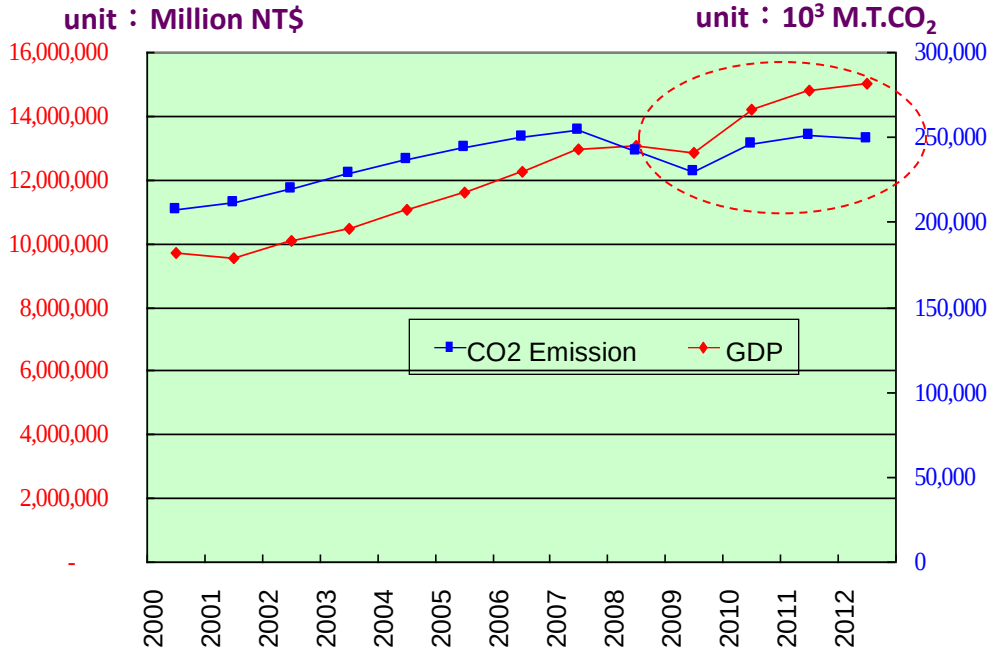


Source: 2012 Energy Statistics handbook, BOE

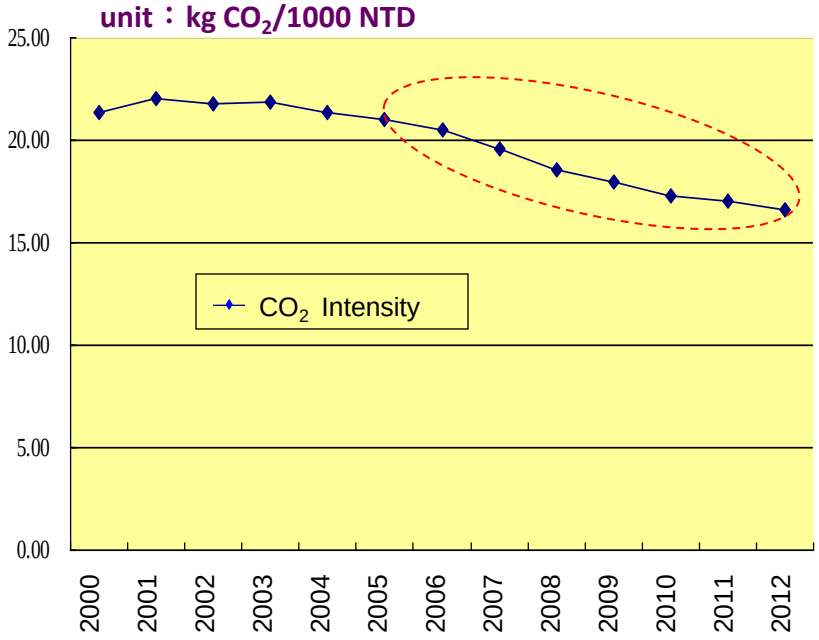
CO_2 Emissions in Chinese Taipei

- The carbon emissions of year 2008 and 2009 for the first time in 20 years had negative growth for two consecutive years. However, compared to 2009, the CO_2 emission has grown by 6.2% because of the economic recover in 2010
- CO_2 emission for producing one unit of GDP continues to decline (CO_2 emission intensity) which is an indication of gradual year-by-year improvement on the low-carbon energy structure and energy efficiency

CO_2 Emission and GDP of CT (2012)



CO_2 Intensity in CT (2012)



Source：Bureau of Energy, Monthly Energy Statistic

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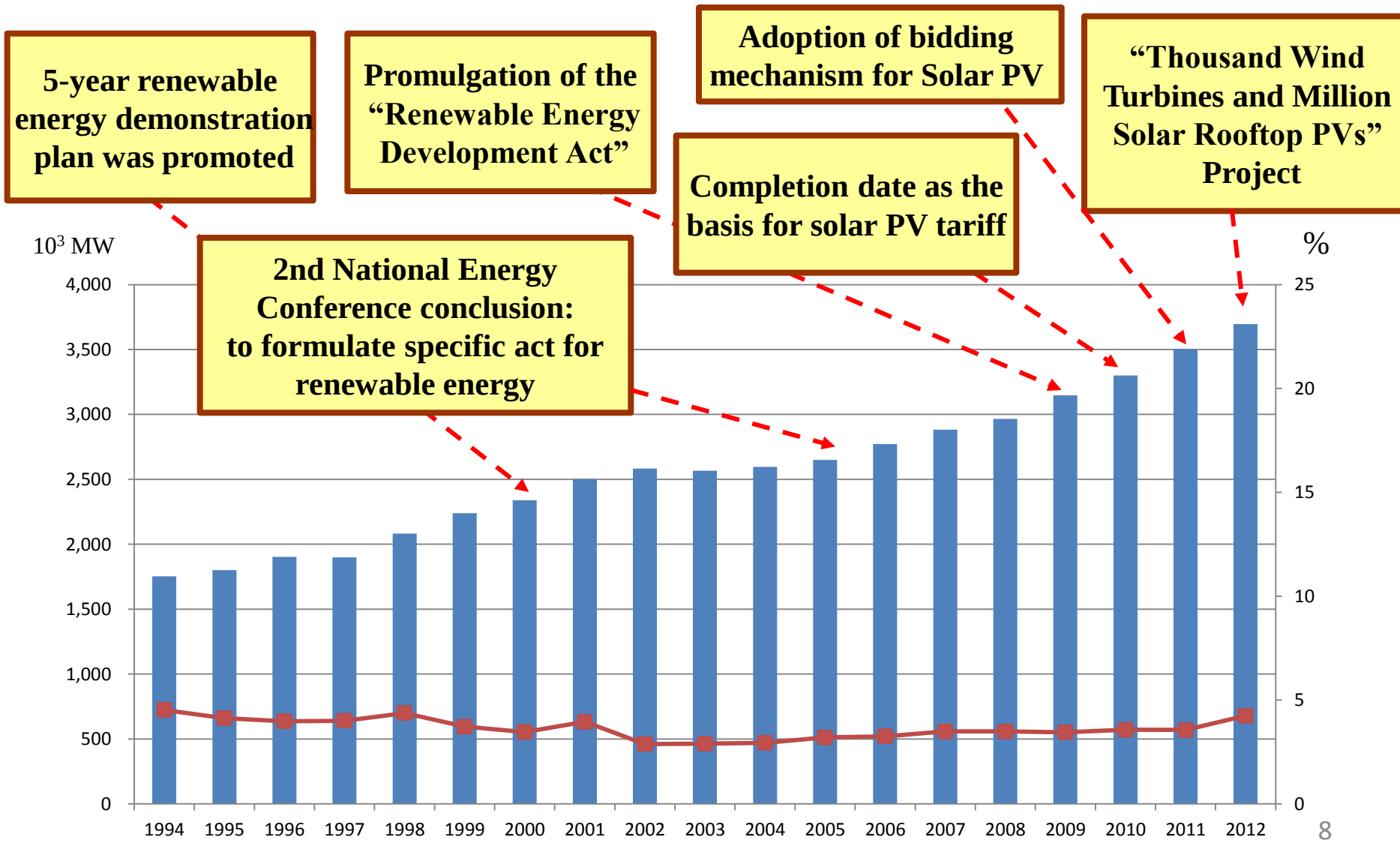
Installation of Renewable Energy

- The installed capacity of renewable energy was 3,697 MW in Dec 2012.
- Targeted renewable power generation capacity is 12.5 GW by 2030.

Energy Source	2012	2015	2020	2025	2030
On-shore Wind	571	866	1,200	1,200	1,200
Off-shore Wind	0	15	600	1,800	3,000
Hydro Power	2,081	2,052	2,112	2,502	2,502
Solar PV	222	420	1,020	2,500	3,100
Geothermal	0	4	66	150	200
Biogas	19	29	29	31	31
Waste to Energy	803	848	925	1,369	1,369
Ocean Energy	0	1	30	200	600
H2&Fuel Cells	0	7	60	200	500
Total	3,697	4,242	6,042	9,952	12,502
Percentage of installed capacity	6.8% 3.44%	9.7% 4.56%	11.9% 5.75%	18.4% 9.16%	20.8% 10.67%

Source: Bureau of Energy, Ministry of Economic Affairs, Chinese Taipei

Status of Renewable Energy Development



The Installed capacity of Renewable Energy

The percentage of Renewable Energy of power supplying

Status of Renewable Energy Development

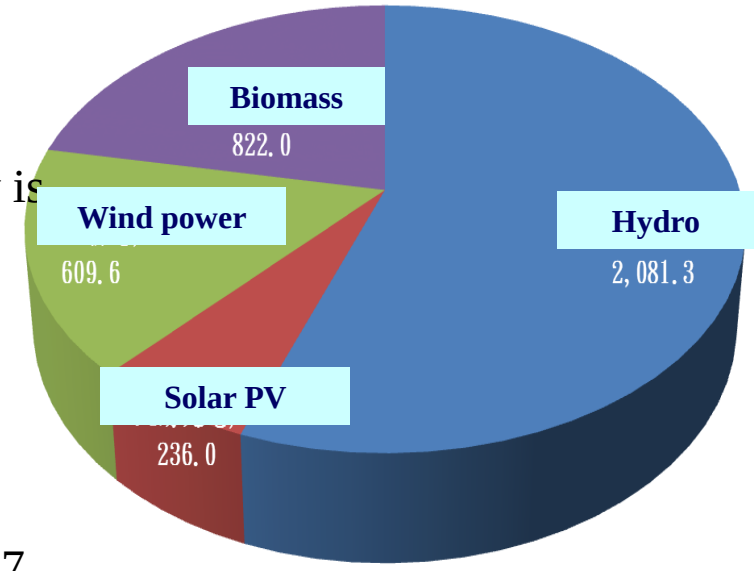
1. As of the end of May 2013, cumulative installed capacity of renewable energy is approximately 3,748.9 MW, 7.7% as of total power system.

2. Total installed area of solar water heating system is 2.27 million m^2 (estimated 500,000 household installed, penetration rate 3.63%), installation density is 5th in the world (2008).

3. Comprehensive supply of biodiesel B2, with annual usage of 100,000 kiloliters.

4. Promotion Achievement

- 1998~2009: average annual increase of installed capacity of renewable energy power generation is 88.7 MW.
- 2010~2012: average annual increase of installed capacity of renewable energy power generation is 132.0 MW.
- Installed capacity of solar PV has grown 23 times after Renewable Energy Development Act passed in 2009.



Cumulative installed capacity of renewable energy (2013.05)

Mechanism of Feed-in Tariffs

- Tariffs and formula should be reviewed annually by referring to technical advancement, cost variation, goal achievement status, etc. ➔ no depression system in place
- Tariffs shall not be lower than the average cost for fossil-fired power of domestic power utilities.
- Current, only Solar PV tariff rates are set on date when generating equipment installations are completed. Other technologies have tariff rates set on the Power Purchasing Agreement (PPA) signing date. ➔ applied for 20 years
- BOE announces PV capacity quota every year. PV systems > 30 kW are subject to a bidding procedure to decide tariffs. Developers proposing higher discount rates get the priority to get the quota.

FIT for Renewables (2013)

- Applied for 20 years to electricity from renewables (except PV) whose owner signs PPA with power utility from **1 Jan. 2013 to 31 Dec. 2013**

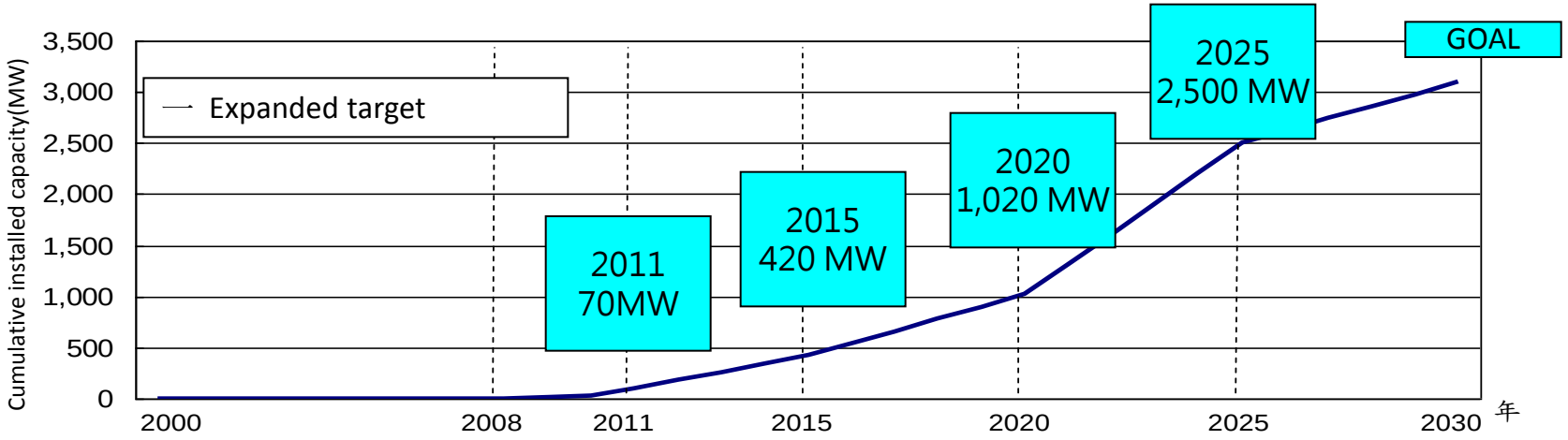
Item	Type	Capacity (kW)	2013 Tariff Rates (US¢/kWh)		2012 Tariff Rates (US¢/kWh)		Variation	
			period 1	period 2	period 1	period 2	period 1	period 2
PV	Roof type	≧1 ~ <10	28.9555	28.2193	32.6362	31.9000	-11.28%	-11.54%
		≧ 10 ~ < 100	26.0110	25.2748	29.4462	28.7100	-11.67%	-11.97%
		≧ 100 ~ < 500	24.5386	23.8024	28.2193	27.4831	-13.04%	-13.39%
		≧ 500	21.8393	20.6124	25.2748	24.7838	-13.59%	-16.83%
	Ground type	≧1	20.6124	19.3855	23.8024	23.3117	-13.40%	-16.84%
Wind Power	Onshore	≧ 1 ~ < 10	25.3662		25.3662		0.00%	
		≧ 10	9.0545 (with LVRT)		9.1128 (with LVRT)		-0.64%	
	Offshore	--	19.1814		19.1814		0.00%	
Hydropower	Stream-Type	--	8.5007		8.0352		5.79%	
Geothermal	--	--	16.5652		16.5652		0.00%	
Biomass	No biogas eqip.	--	8.5007		8.0352		5.79%	
	With biogas eqip.	--	9.6600		9.3086		3.77%	
RDF	--	--	9.7379		9.7379		0.00%	
Others	--	--	8.5007		8.0352		5.79%	

* Exchange rate: USD 1 = NTD 29

「Million Solar Roofs」Program

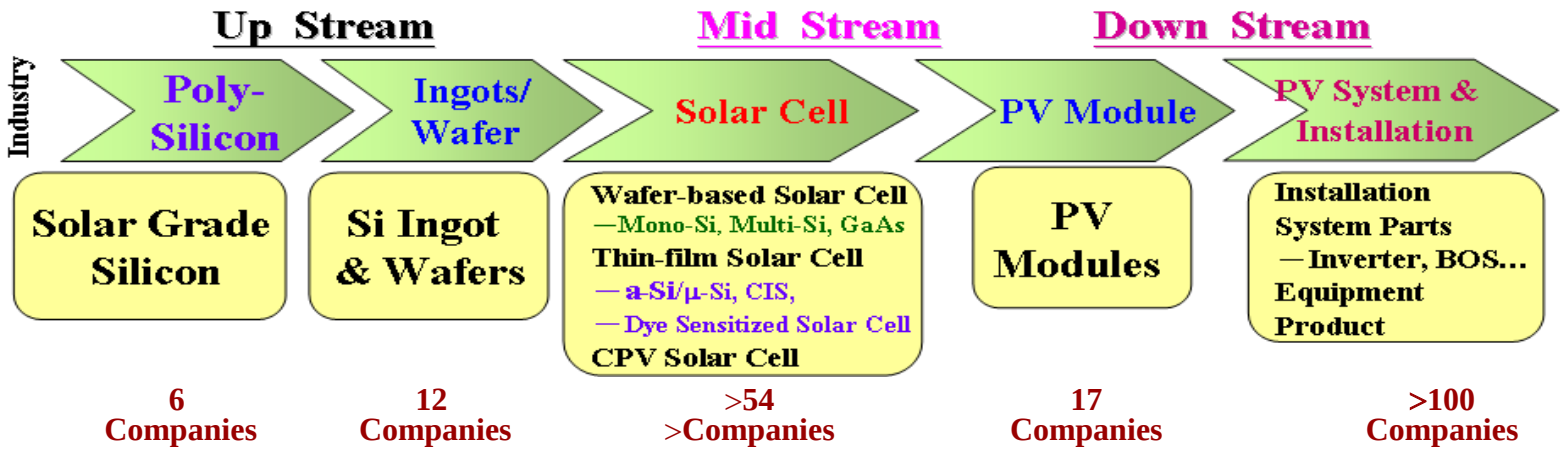
- Target - The solar roofs installed capacity achieve 3,100 MW before 2030
  - **Roof type(3,000 MW)**：Million unit solar roof (per 3 kW)；1 million ×3 kW = 3,000 MW.
  - **Ground type(100 MW)**：Installing the capacity of about 100MW.
- Strategies - slow to fast / ground after roof
  - **Promote by the Feed-in Tariffs**

Tainan Tzu primary and secondary solar roof



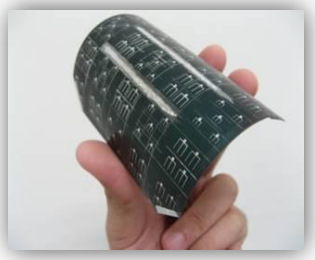
Developing Chinese Taipei's PV Industry

- Technology R&D: Si Base, DSSC, CIGS, CZTS /BOE, MOEA Programs
- Establish Solar Cell Calibration and Characterization Laboratory, SCCL
- Industry Incubator: Open-lab, Technology Training/Transfer, Spin-off/Spin-in
- 1/3 CEO/Top Manager/ Chief Engineer are from ITRI.



Worldwide Rank #2 with 4.3GW in 2012

- Developing high-efficiency with low-cost technology is the key strategy to Increase our competitiveness



「Thousand Wind Turbines」 Program

- Target –The wind power installed capacity achieves 4,200 MW before 2030
  - Onshore: Develop excellent wind farms first, and then develop secondary wind farms before 2015
    - Install 800 MW before 2015, develop 400 MW secondary wind farms after 2015, there will be total 1,200 MW in 2020 (about 450 wind turbines).
  - Offshore: Develop shallow-water area first, and then develop deep-water area before 2020
    - **Complete the first demonstration offshore wind farm of Taiwan before 2015**; develop 600 MW shallow-water wind farms in 2020 (120 wind turbines).
    - Develop wind farm in business scale during 2021-2030 (total 2,400 MW, about 480 wind turbines in 10 years).
- Strategies
  - Demonstration Incentives for offshore wind power systems.
  - To establish inter-ministerial coordination mechanism.

Dayuan Guanyin wind farm

Simulated image of an offshore wind farm

Promoting Chinese Taipei's Off-shore Wind Power Industry

- Execute BOE R&D and Demo Program
- Seek ICP international Cooperation
- Promote Alliance Industry

Short-term
(Pilot/Demonstration)
Technology Transfer

→

Mid-term
Co-development and co-construction

→

Long-term
Taiwan industry

Offshore Wind Power

International Collaboration

ex. MECAL and DWD
- Off-shore wind turbine design
- Key components
- Integrated system and control

ex. ECN (Holland)
-Typhoon-resisted design turbine
-Cost analysis

ITRI's Development :
- Wind turbine system development
- Wind farm evaluation
- Grid/Storage

Industry Alliance

- TECO(System)
- CSC(Steel Plate)
- CSMC(Tower)
- TECO(Generator)
- FHI(Gear Box)

→ Tai-Power Grid

Bio-Power

Current status

- Total installed capacity of bio-power in 2010 is 814.5 MW fueled by MSW, biogas and RDF (Refuse Derived Fuel)

Prospect

- Annual supply of agriculture and biomass wastes in Taiwan is 8.84 MT/yr, equivalent to 2.39 billion LOE or 1.2 GW (2.4%-2010)。
- Future increase in bio-power focuses on the co-firing of bio-coal in coal-fired units with the ratio <10%

Scheme combining distributed pretreatments and centralized generation

Rice Straw

Transportable Pellitizer

Pellets

Pyrolysis System (ITRI)

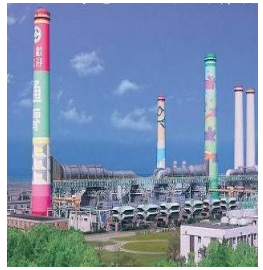
Bio-oil

Torrefaction System (ITRI)

Bio-coal

Boiler

Engine

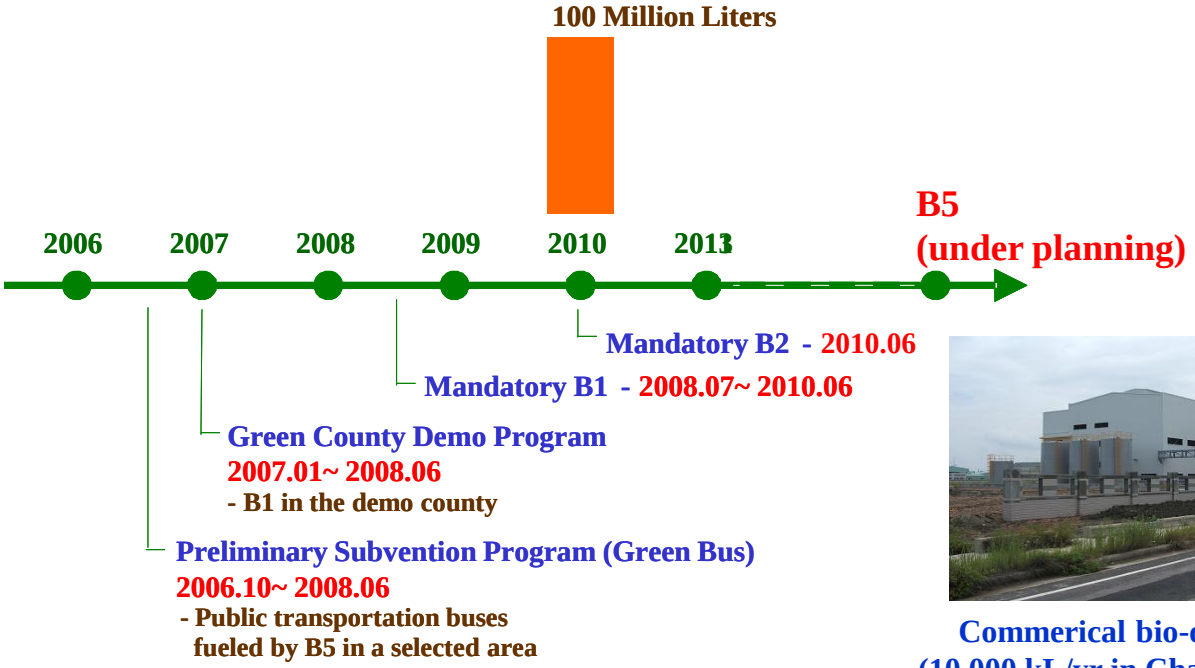


Oil-fired Power Plant

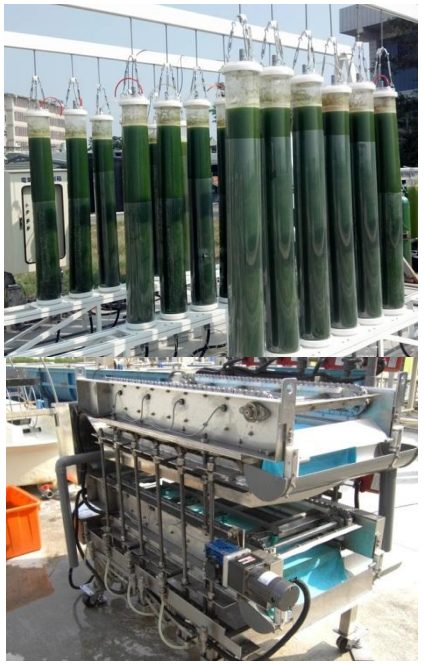
Coal-fired Power Plant

Biodiesel

- Mandatory B2 diesel starting from June 2010, which could reduce 0.26 million ton CO_2 emission annually.
- Spent cooking oil is the main feedstock for domestic production, and looking for oversea plantation and microalgae as future feedstocks.
- Higher blend ratio in the future depends on the supply of feedstock.
- Non-food, environmentally and ecologically friendly, cost competitive, positive energy balance



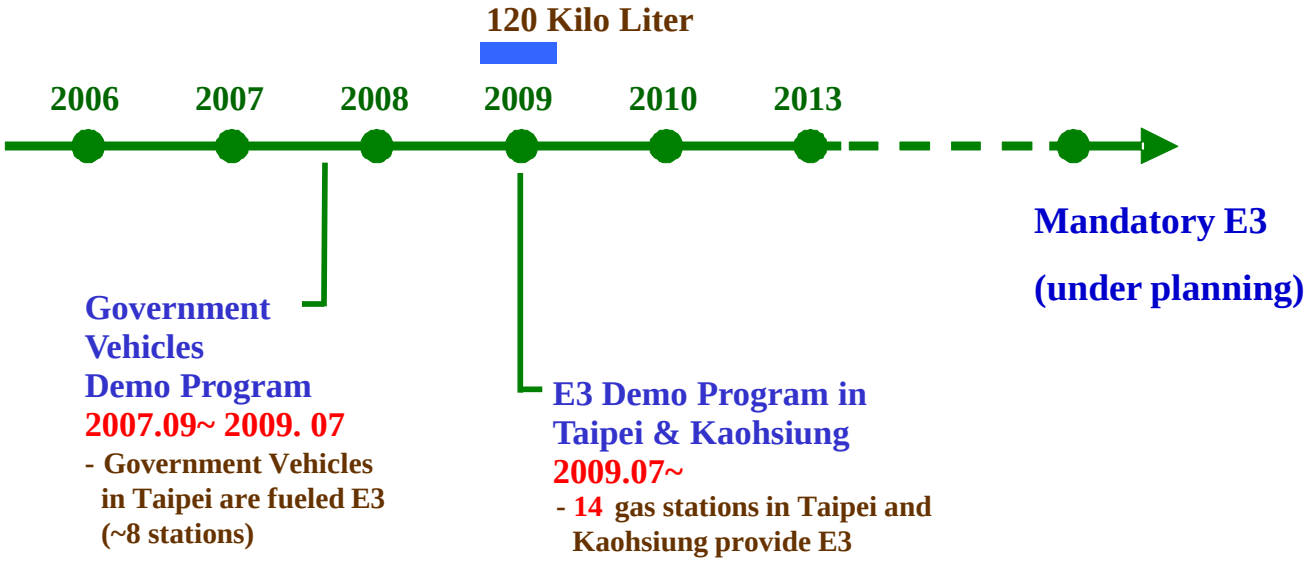
Commerical bio-diesel plant
(10,000 kL/yr in Changhua , 2007)



Microalgae
Cultivation/Harvest/Dewater

Bioethanol

- Promote E3 gasoline in Taipei and Kaohsiung cities since July 2009. There are 14 gas stations in Taipei and Kaohsiung supply E3 with an incentive price 2NT$/L cheaper than gasoline.
- Compatibility of old model vehicles and scooters is the major concern for mandatory E3 gasoline
- No fuel ethanol plant in Chinese Taipei now; cellulosic ethanol technology is under development.
- Cellulosic alcohol (ethanol & butanol) technologies are under development via enzyme/chemical hydrolysis of lignocellulose.



Typical gas station

Rice straw bale

Enzyme / Chemical Cellulosic Hydrolysis

Developing Ocean Energy Technology

High potential

Type	Potential
OTEC	52GW
Wave	80GW
Ocean Current	30GW

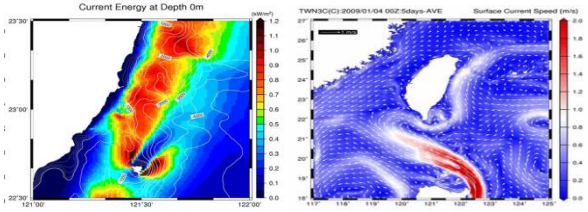
Challenges

- Technology, Reliability, Maintenance, Transmission, Cost, Ecologic issue, Ocean Engineering Capability, Extreme Conditions

Developments

- kW WEC Point Absorber test at Keelung

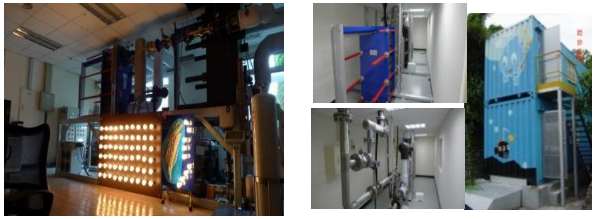
- Ocean Current Energy- Generation Potential Survey of Green Island



Potential Sites

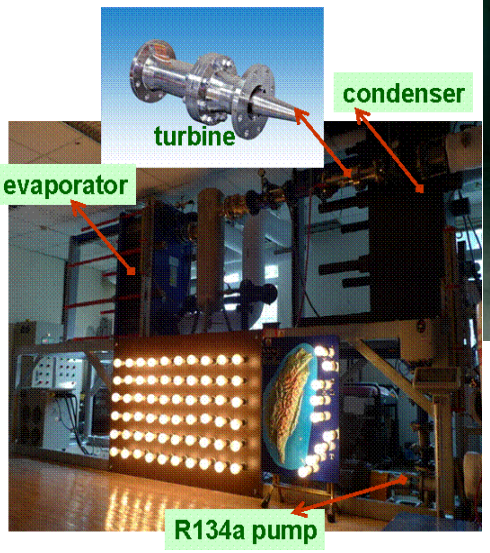
- Wave：Northeast Offshore, Penghu
- Current：Cape Fukuei, Eastern Offshore, Penghu Channel
- OTEC：Hualien and Taitung Offshore

- OTEC-Establish first ORC system and OTEC system in Chinese Taipei



Ocean Thermal Energy Conversion (OTEC)

- **Chinese Taipei has good sites for both offshore and onshore OTEC systems.**
  - The Kuroshio current flows off the east coast, the surface seawater temp. is 24~30°C around the year.
  - The seabed bathymetry in eastern Taiwan Island has a natural advantage, where the water depth can reach 1000m just several kilometers offshore, T ~ 4°C.
- **Current Status & future Plan**
  - Establish first 5kW ORC system in Chinese Taipei
  - Develop the first running OTEC system in Asia (at Hualien Facility, Taiwan Fertilizer Co., Ltd.)
  - R & D 50kW and 200kW OTEC system
  - Expand the technology to waste-heat and geothermal fields



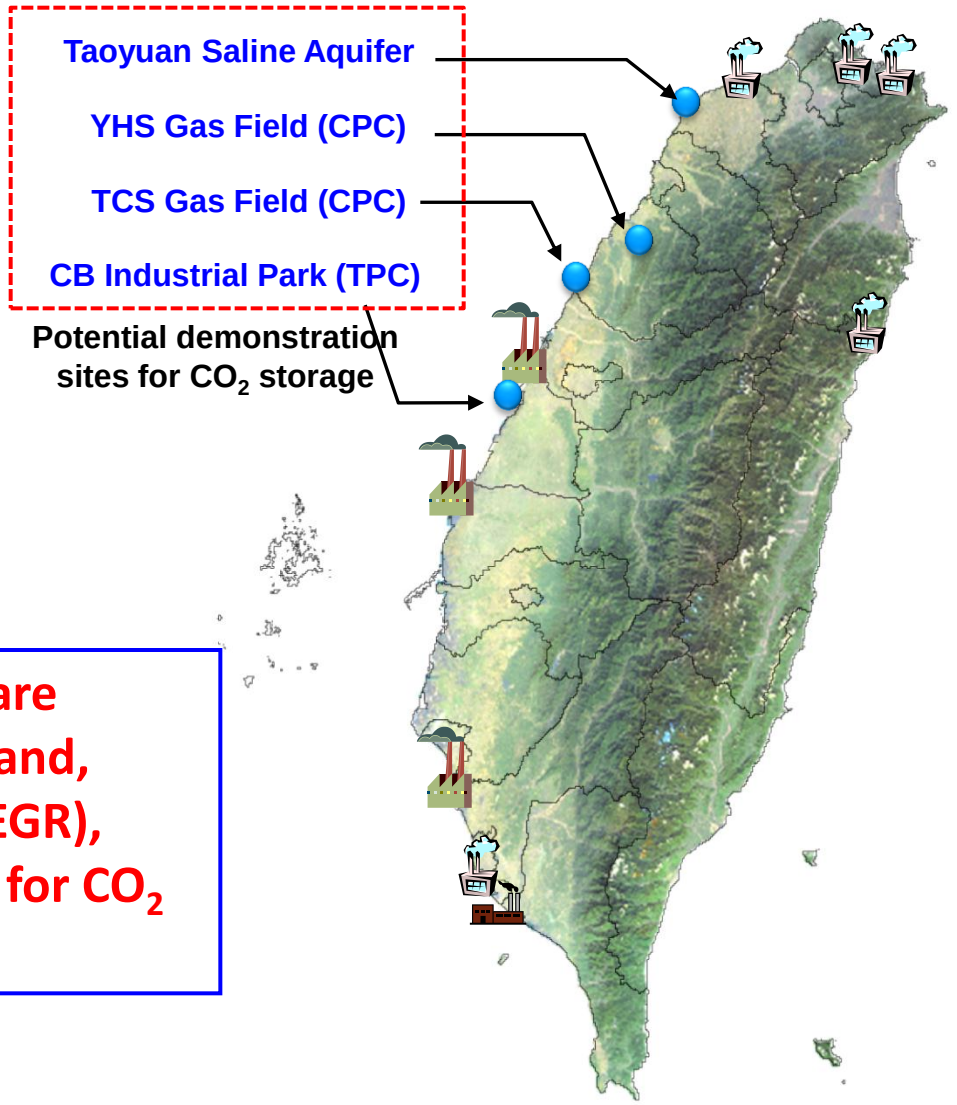
OTEC Lab Unit in ITRI

Organic Rankine Cycle, ORC

Carbon Storage Potential in Chinese Taipei

Estimated CO_2 storage capacity in the western part of Chinese Taipei

- Onshore oil and gas structures: 2,800 Mtons
- Coastal and offshore deep saline aquifers: 9,000 ~ 68,000 Mtons



Most power plants and industrial parks are located in the western part of Taiwan Island, where suitable enhanced gas recovery (EGR), sedimentary basins and rock formations for CO_2 storage are abundant.

Carbon Capture Business Model

- Calcium looping by Cement Industry -

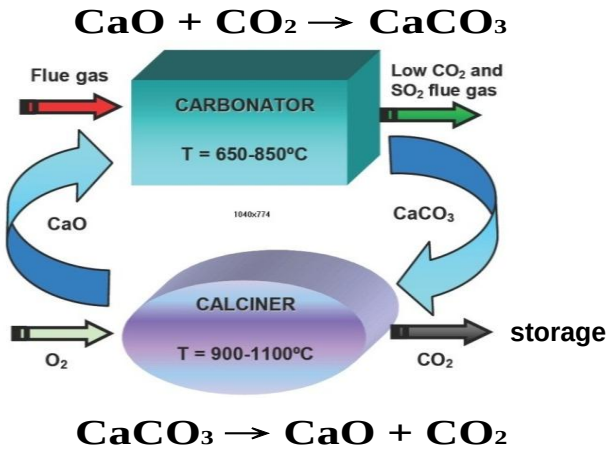
Leading business model for scale-up and commercialization

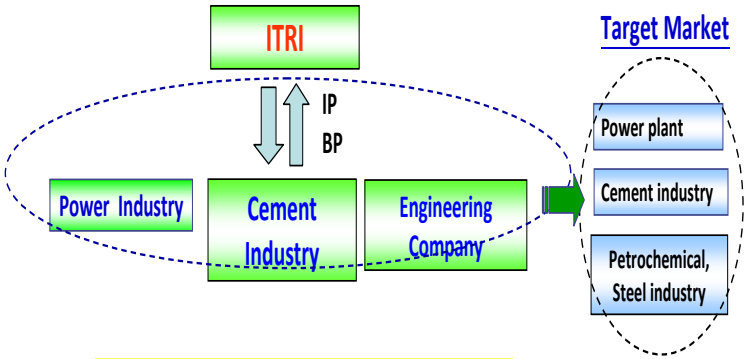
Innovative business model and benefit

- Engaging cement industry **(1.9 MW pilot)** for synergy
- Zero adsorbent cost and low energy consumption in carbon capture reduce the capture cost **from US$ 45 to US$ 26 /t CO_2**
- 28 Mts CO_2 reduction potential in 2025

Core technology

- Patented technology of low-energy calcium looping cycle for post-combustion carbon capture
- Advanced oxy-fuel calcination technology





CCS Business Model

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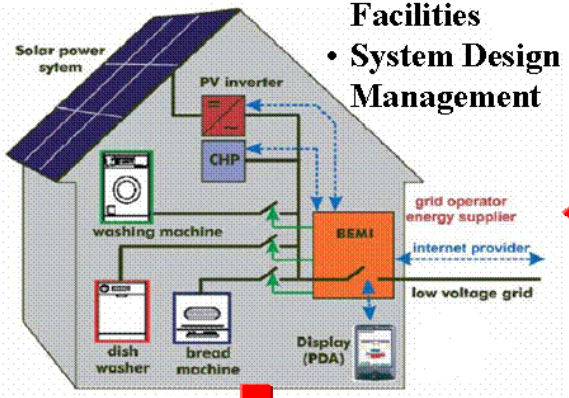
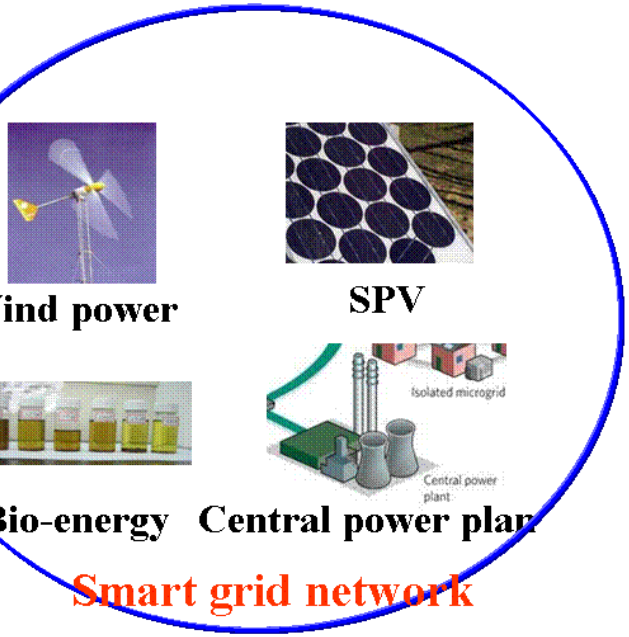
Integration of Low Carbon Technology

ZEB requirements
- **Building Design & Materials**
- **Living Environment & Facilities**
- **System Design & Management**

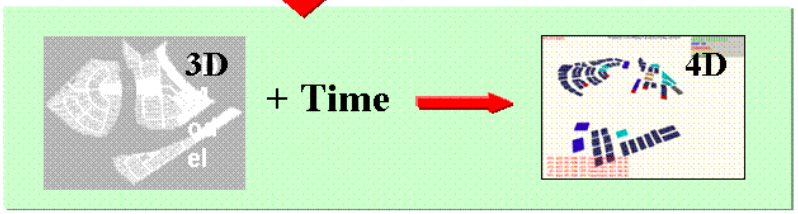


Power supply

Storage Device



Load simulation



4D Dynamic simulation

Transient load variation

Output/input

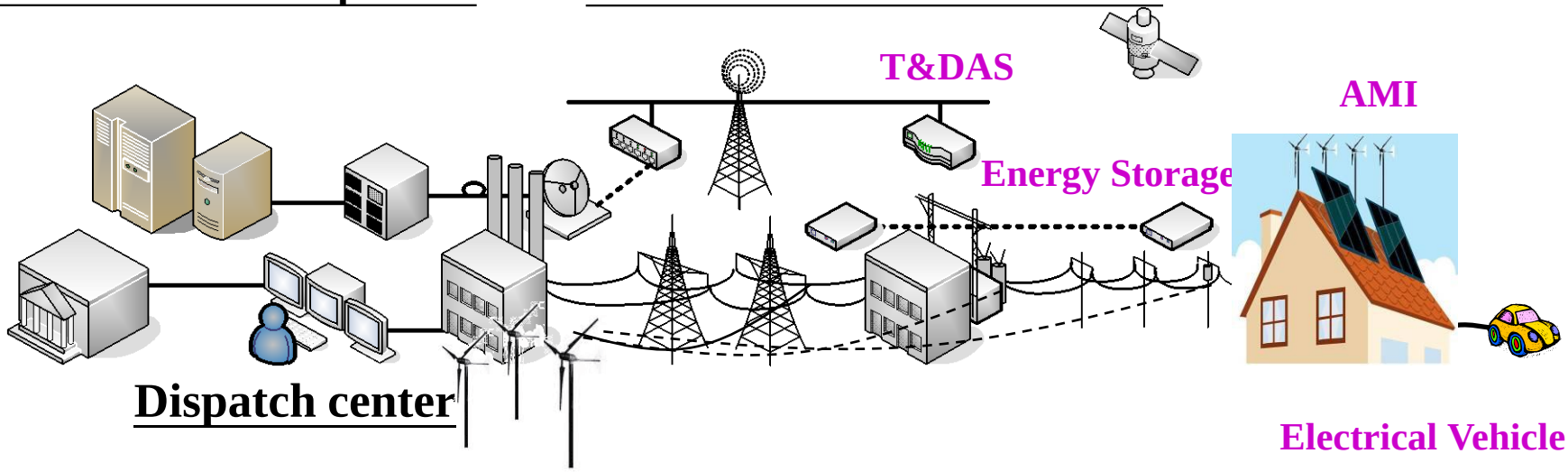
Supply-side management
(Dynamic peak load adjustment)

Building Energy Management System (BEMS)

Scope of Smart Grids

Supply-side **Demand-side**

Generation & Dispatch **Transmission & Distribution**



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Concluding Remarks

- **Actively promote the development of renewable energy, serve to enhance energy independence, reduce carbon emissions and strengthen energy supply sustainability. The promotion of “Thousand Wind Turbines", “Million Solar Roofs" and other specific measures can reach the installed capacity of 12,502 MW by 2030, accounting for Chinese Taipei's total installed capacity of the power system 20.80%.**
- **Review the domestic nuclear safety and energy policy due to Fukushima nuclear disaster in 2011 to increase the amount of renewable energy. It is expected to contribute Chinese Taipei's total electricity consumption from 2.51% in 2010 of to 10.67% in 2030.**
- **Low carbon technology covers both supply side and demand side.**


Thank You