

Innovative Low-carbon Technology to Achieve Green Transition

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Outline

- **Who we are?**
- **Taiwan's Energy Transition**
- **Innovative Green Technologies in ITRI**
- **Concluding Remarks**

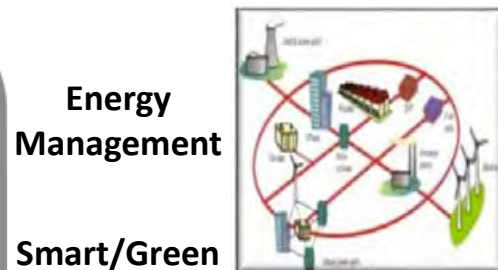
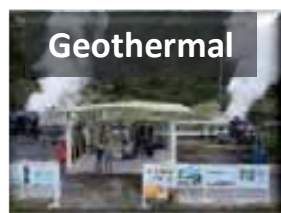
Industrial Technology Research Institute (ITRI)

- Non-profit research organization with ~6,000 employees
- Over 1,000 patents granted a year in energy, materials, electronics, communication, biomedical and mechanical
- Global leading institute in developing industrial technologies and incubating new businesses



Source: Philip E. Coyle, The Missing Middle, National Security and International Affairs, Office of Science and Technology Policy, USA (May, 2011)

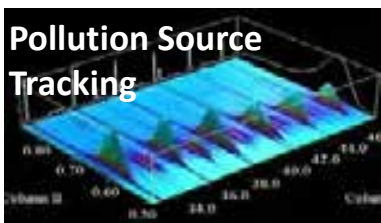
Research Fields in Energy and Environment



Smart/Green Building



Policy
Think Tank



Circular Economy



Air pollution control



Carbon Capture & Storage



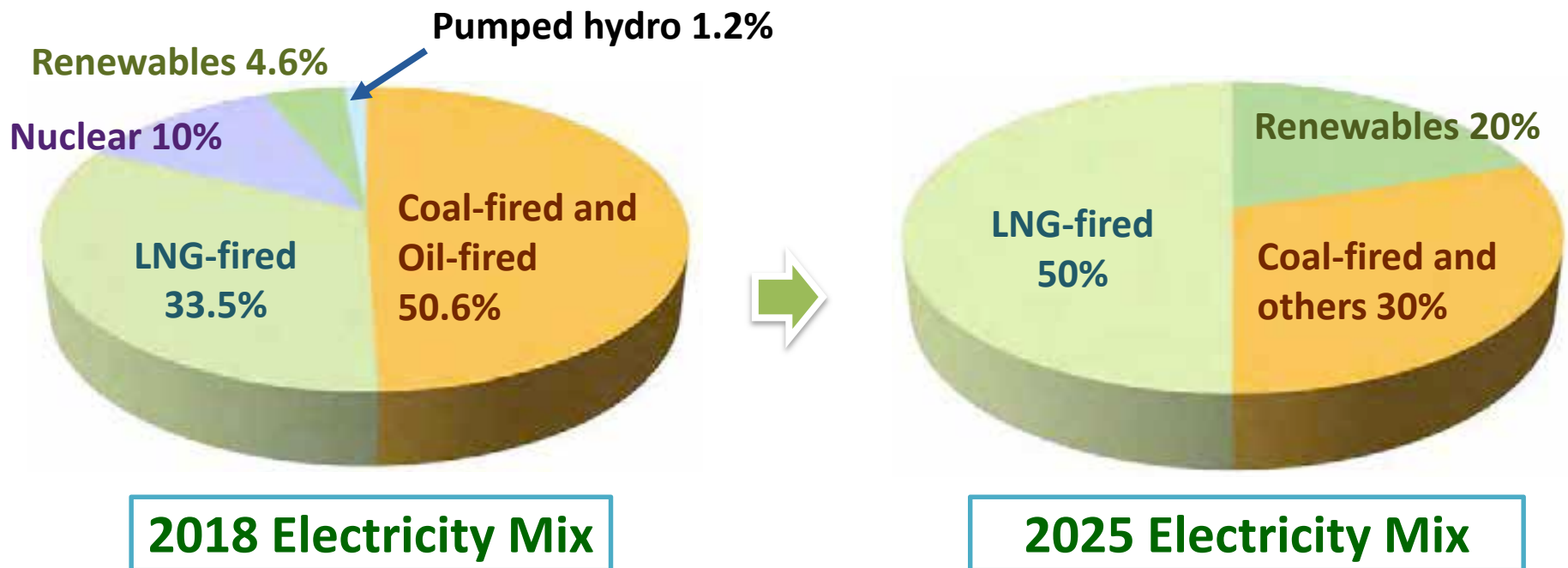
Biomass



TAIWAN'S ENERGY TRANSITION

Taiwan's Energy Transition

- 2025 Target: 20-30-50 power mix & nuclear-free homeland
- Raising energy security, building sustainable environment and green economy, including promoting jobs opportunities and industrial upgrading



Source: Energy Statistics Handbook, Bureau of Energy, 2019

Renewable Energy Target in Taiwan

- PV and offshore wind power are two major promotion items.
- The first time annual PV installation > 1GW in 2018
- The first offshore wind farm of 128 MW is in operation in 2019.

Target of Install. Capacity (MW)	PV	Onshore Wind	Offshore Wind	Geo-thermal	Bio-energy	Hydro	Fuel Cell	Total
2019 installed	3,783	708	128	0.33	713	2,092	0	7,424
2020	6,500	814	976	150	768	2,100	22.5	11,331
2025	20,000	1,200	5,738	200	813	2,150	60	30,161

Source: Bureau of Energy (September, 2019)

Ground Type PV in Taiwan

■ Integrating with existing land use

- Including farm land, reservoir or fishery pond
- Minimizing the environment impacts

■ Waste lands utilizations

- Adding value through PV deployment



Fudekeng Restoration Park, Taipei (2MW)



Changbin Industrial Zone, Changhua
(100MW)

Source: Bureau of Energy



Agongdian Reservoir, Kaohsiung
(2.3 MW)

First Offshore Windfarm in Taiwan

- Executing R&D and Demo Program
- International Cooperation
 - Formosa I: Orsted + Jera + Macquarie Capital + Swancor

Formosa I: Taiwan's first offshore wind power plant (128MW)

- Phase I: two 4MW offshore wind turbines (2017)
- Phase II: twenty 6MW offshore wind turbines (2019)

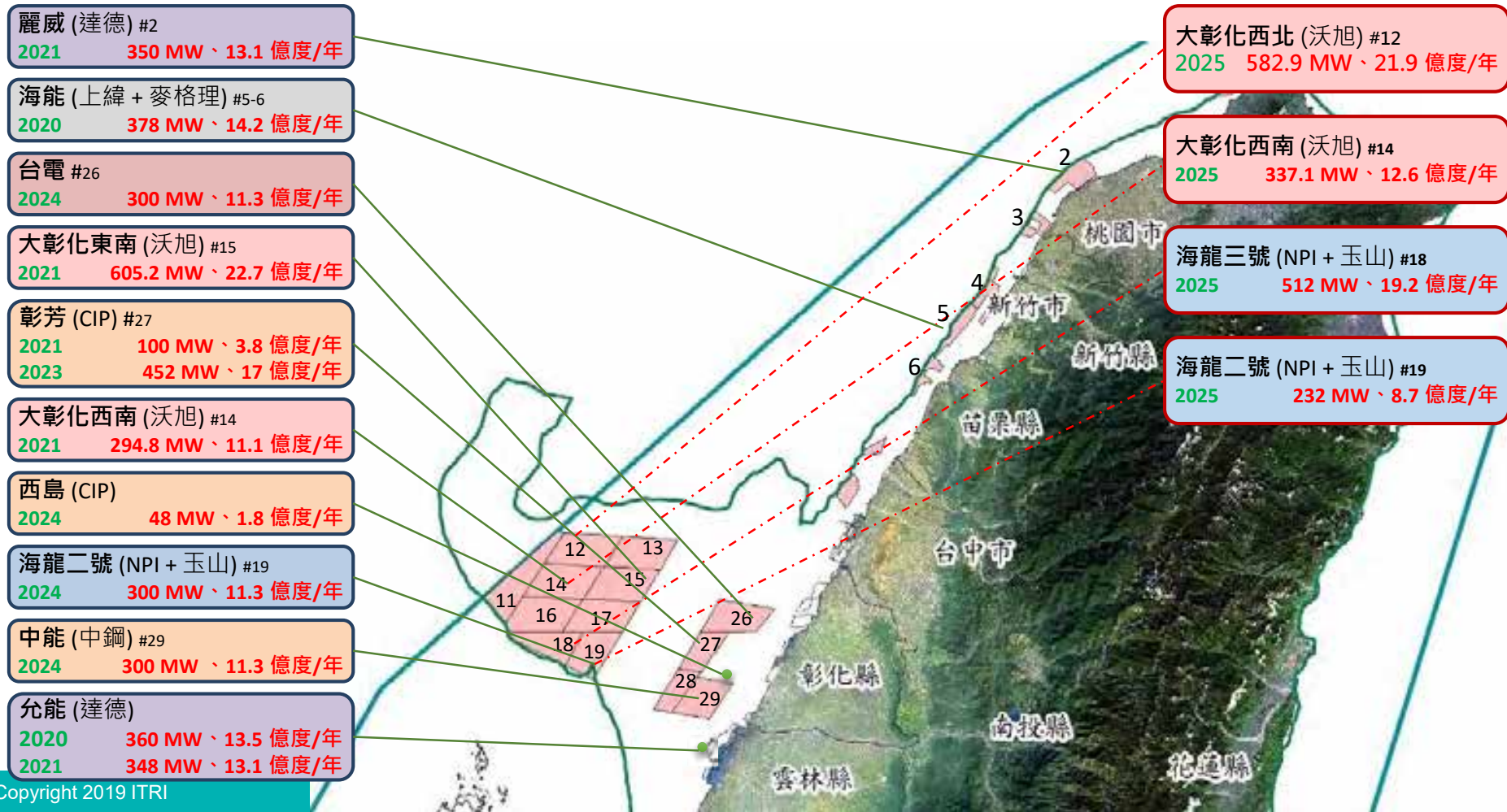
Source: Bureau of Energy



Source: Orsted

Offshore Windfarm Program in Taiwan

- 5.5 GW wind farms will generate 21.6 TWh of electricity.
- 14 wind farms invested by 9 companies



INNOVATIVE GREEN TECHNOLOGIES IN ITRI

Lignocellulose Hydrolysis Technology

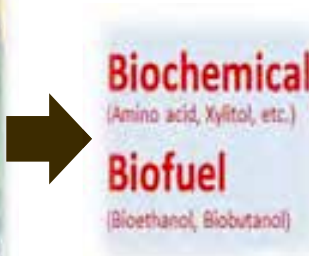
- **Lignocellulose hydrolysis technology: convert wastes into high-value products**
 - Agricultural waste as raw material ~ not compete with food
 - Reduced 50% CO₂ emissions ~ compared to enzymatic hydrolysis process
- **Collaborated with a Malaysia's company to promote sustainable technology to ASEAN**
- **A green economic output value of NT\$3.38 billion will be produced by 2023. About 180,000 tons (dry base) agricultural waste will be reduced**



Oil Palm Empty Fruit
Bunches



Lignocellulose Hydrolysis
System



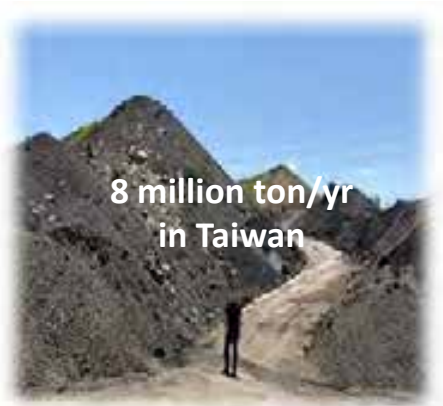
High-value
Products



ASEAN Countries

Reclaimed Asphalt Pavement Regeneration

- **Bio-based Asphalt Rejuvenating Agent (ARA):**
 - Solve the problems relating to the stacking and reuse of asphalt waste-materials
- **The Reclaimed Asphalt Pavement (RAP) can comply with the Hamburg Wheel Tracking (HWT) Test standard and be fully recycled and reused**
- **In a case of 8 million tons/yr asphalt waste-materials, 30% asphalt waste-materials were reused**
 - The consumption of aggregates and asphalt will be reduced respectively by 2.3 million tons and 96,000 tons every year



Stockpiling of Asphalt Waste-materials



RAP Regeneration Technologies



Pilot Plant
(1,500 tons/yr)



Road Proven
(> 690 Hectares)

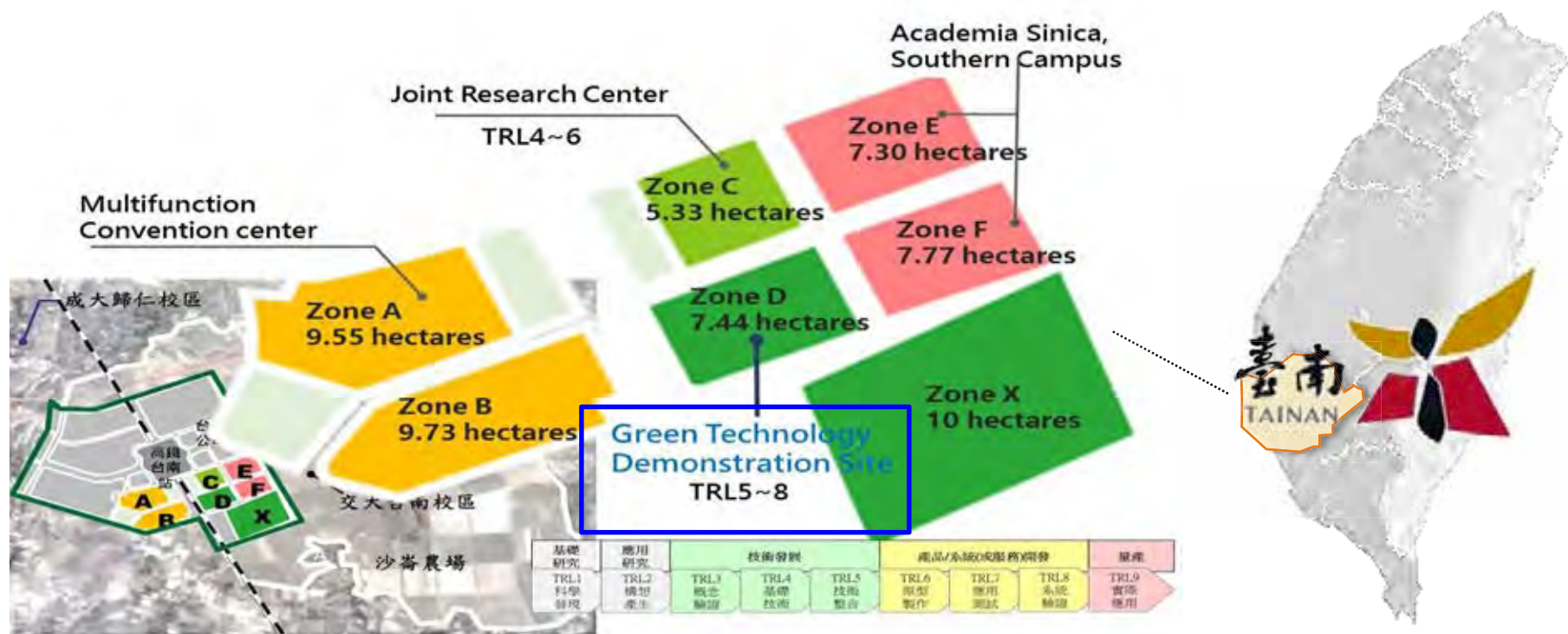
Energy Management and Control

- **Tailored-made energy management and control system**
 - Based on wireless Internet of Things (IoT), easy to install, applicable to both new stores and existing stores
 - AI algorithm to control the A/C and refrigeration for energy saving
- **Installed in more than 3,100 convenient stores and supermarkets**
 - 5~10% overall electricity saving, 1.5~2 yrs ROI based on Taiwan's electricity price
 - International promotion in Thailand, Philippine, and Shanghai is underway

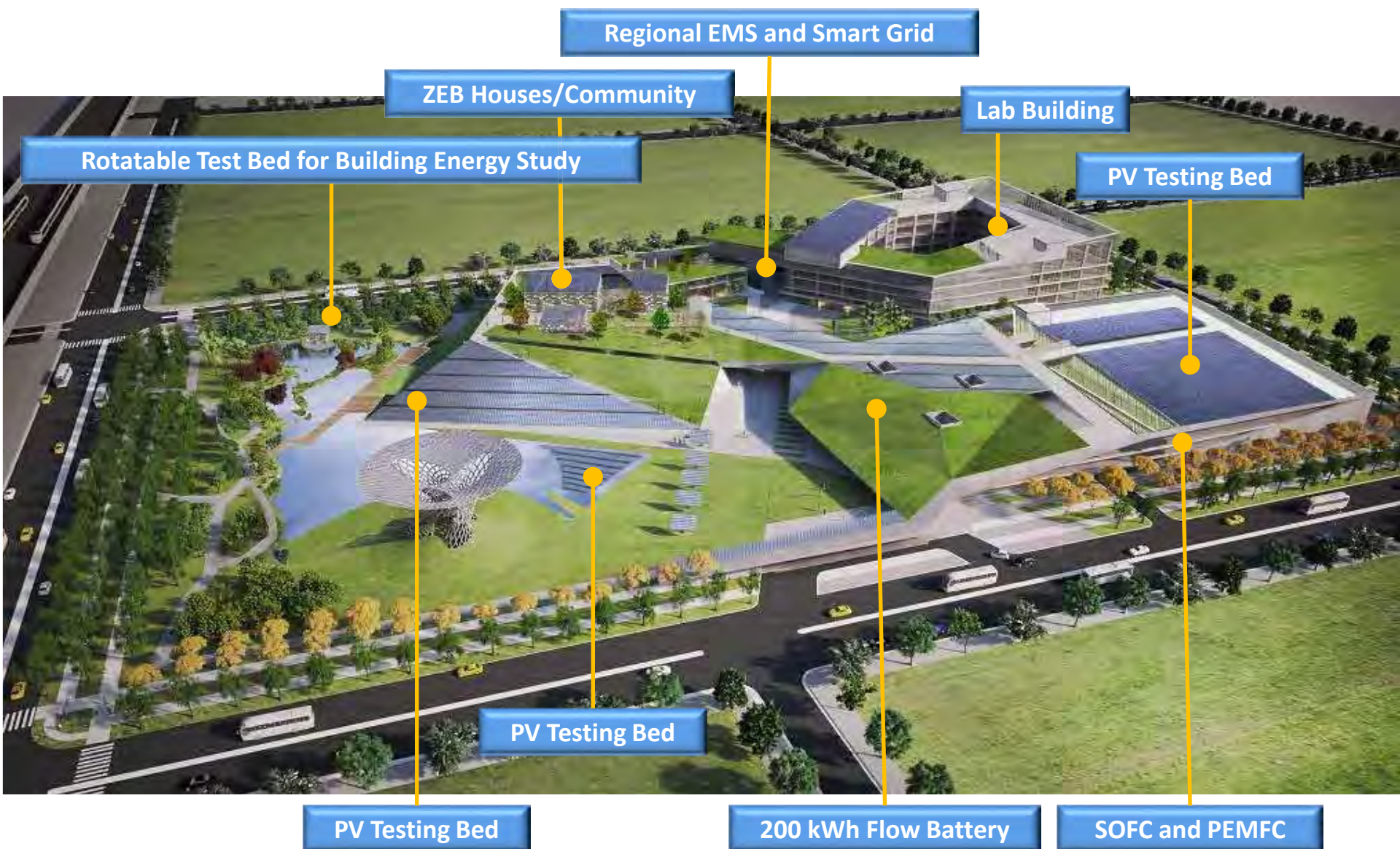


Shalun Smart Green Energy Science City (SGESC)

- Energy generation, energy storage, energy efficiency and conservation, energy system integration
- Modular plug & play testing and demo system for various products and technologies
- An open Innovation-and-Integration platform for green energy technologies



Green Energy Technology Demonstration Site



Energy-Saving Building Technology Testbed

- Unique platform to validate efficient building technologies ranging from building exterior envelope and devices to all interior components, and energy management systems

Cross-Disciplinary Cooperation

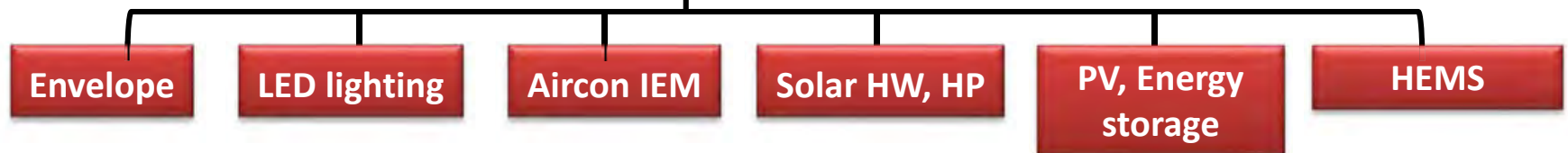
- **TEPCO(東京電力):** Electrical Meter, Gateway
- **RECHI (瑞智):** Heatpump
- **Panasonic (台灣松下):** Smart appliance
- **HITACHI (台灣日立):** Smart aircon 、 DC powered aircon
- **HiSS (清展企業):** Heat bearer window design 、 sun shade
-



**Energy-saving building
technology demonstration
platform and testbed**

7 units of Energy-saving buildings for different scenarios

- **Stand-alone Net-Zero Energy House:** energy saving up to 50% more than traditional single home
- **Smart Home Scenario:** energy saving up to 40% more than traditional home with smart control
- **First-tier Energy Efficiency Performance Equipment:** energy saving up to 30% more than traditional home



Global Cooperation and Promotion

PV Mini-grid ~ Myanmar

- Develop replicable business models for rural lighting
- Establish Village Power Operation and Management Committee to verify and modify operation model by using actual charging
- Monthly charge is estimated as 1.75 USD ~ 8.5 USD (current charge for candles as 4.13 USD ~ 12.14 USD)



PV System Training ~ Indonesia

- Developed a PV system installation course
- Installed two sets of Solar PV system for capacity training
- Trained seed instructors on system installation



Technical Evaluation ~ Philippine

- Identified electrification challenges
- Provided technical evaluation and solutions: a hybrid mini-grid composed of diesel, solar, wind and storage system



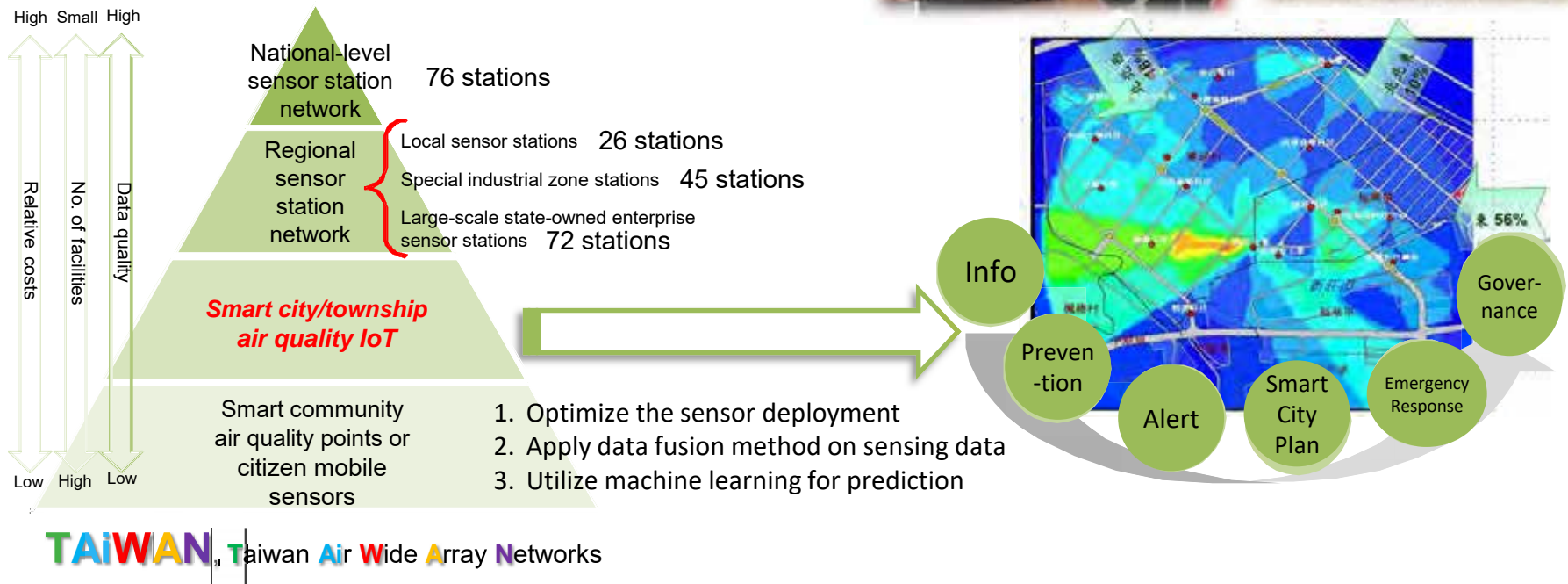
LED Consulting ~ Republic of Georgia

- Identified the gap for retrofitting the system
- Proposed potential street lighting retrofitting strategy
- Performed detailed financial analysis for the banks



Air Quality Monitoring System

- A smart air monitoring network that monitors the environment on a minute-by-minute basis. When pollution is once discharged, the precise measures will be introduced to solve problems effectively
- **ITRI-CSIR cooperate phase I and II verification** (in Jaipur, 500 sensors) and will initiate new EIOT and sensor projects to apply to smart city projects in other cities or countries



Concluding Remarks

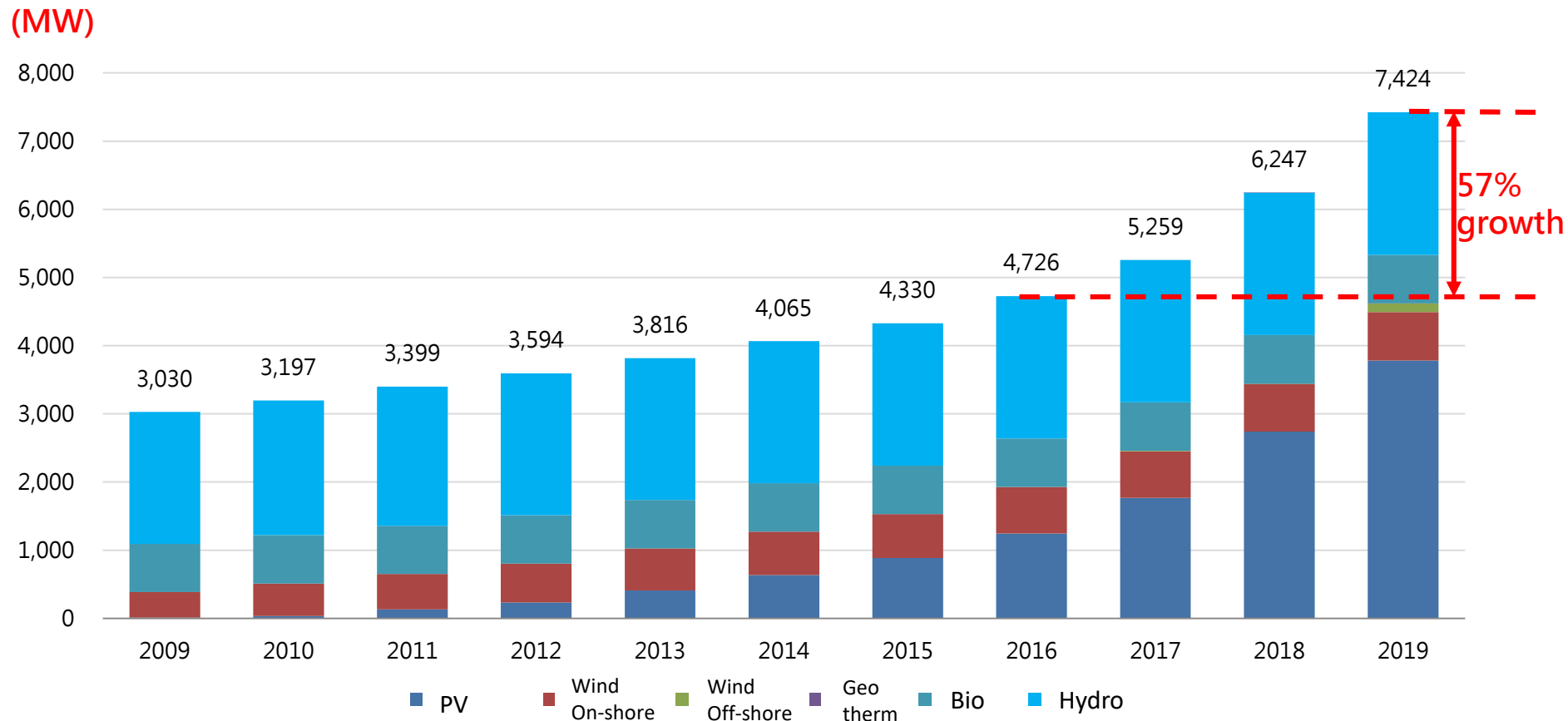
- Taiwan actively devotes to the energy transformation program. By 2025 Taiwan will achieve 20% renewable energy power generation structure, expecting to achieve low-carbon and industry-driven win-win results..
- ITRI strategically focuses on technology innovation and system integration to accelerate the commercialization of green technologies.
- International cooperation is the key for synergizing the worldwide effort to reduce carbon emission. ITRI is willing to provide technical insight and experience to assist the development of greener growth globally.



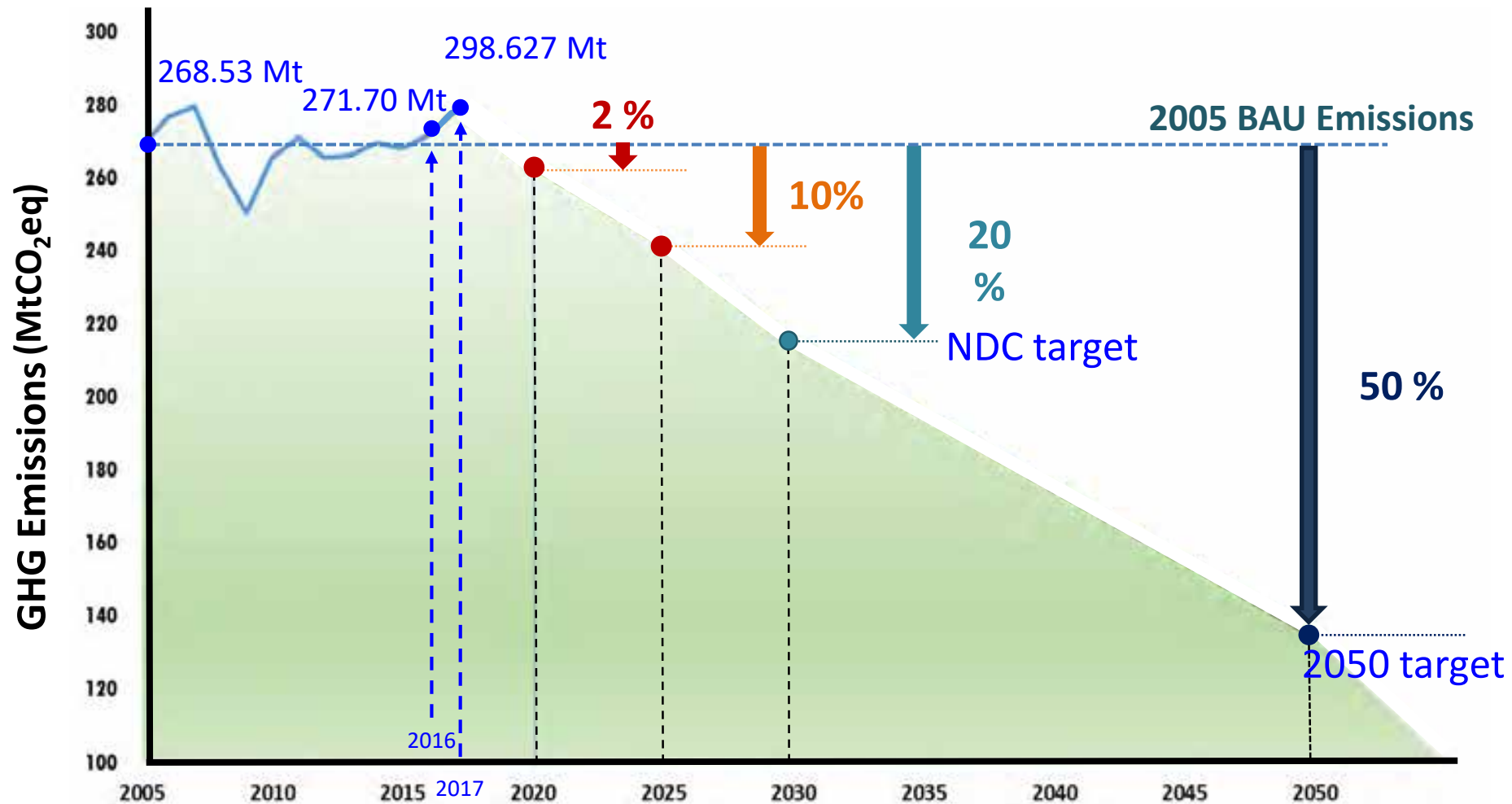
*Thank you for
your attention!*

Recent Progress of RE Installation

- The accumulated installation of RE reached 7,424MW in September 2019
- In 2018, RE contributes 11.9% and 4.6% in terms of power generation capacity and electricity generation, respectively



Taiwan's GHGs Emissions Reduction Target



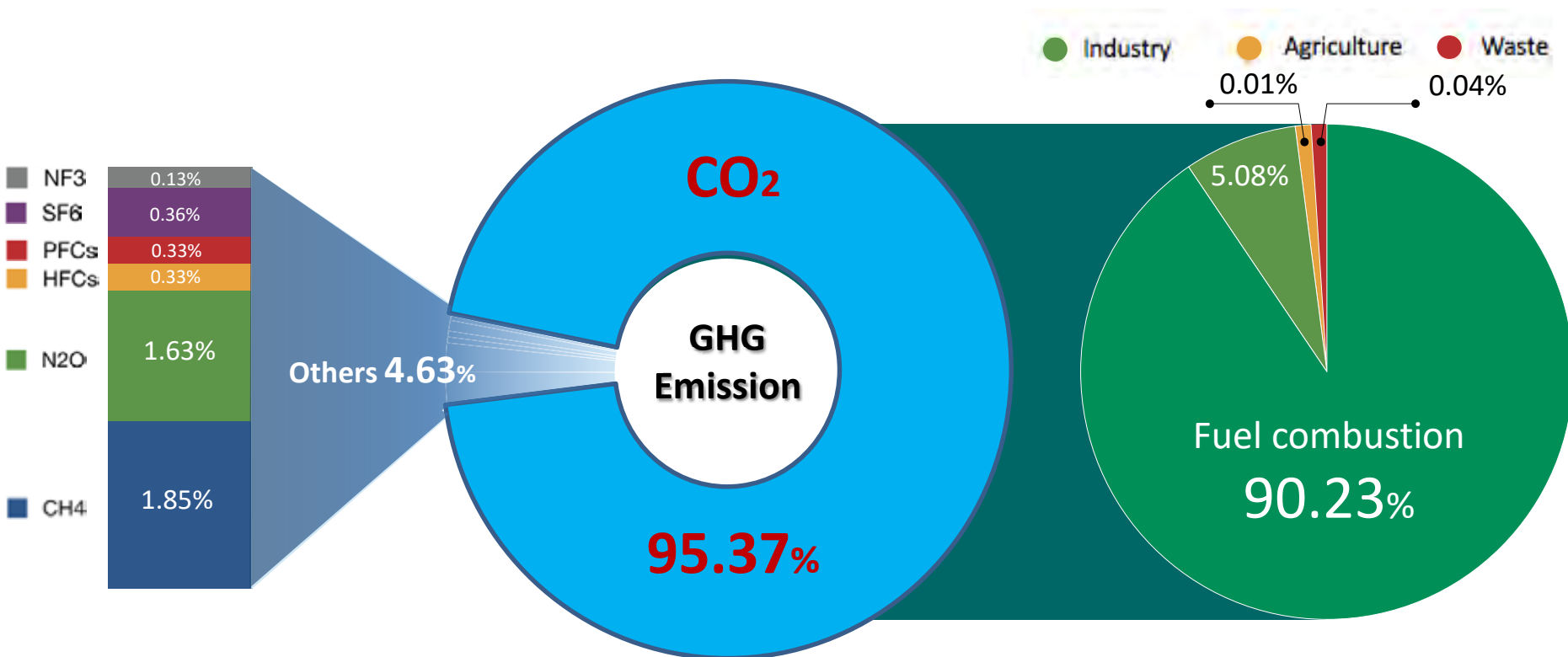
Ref. Taiwan EPA

* GHG: greenhouse gas

* INDC: Intended Nationally Determined Contributions

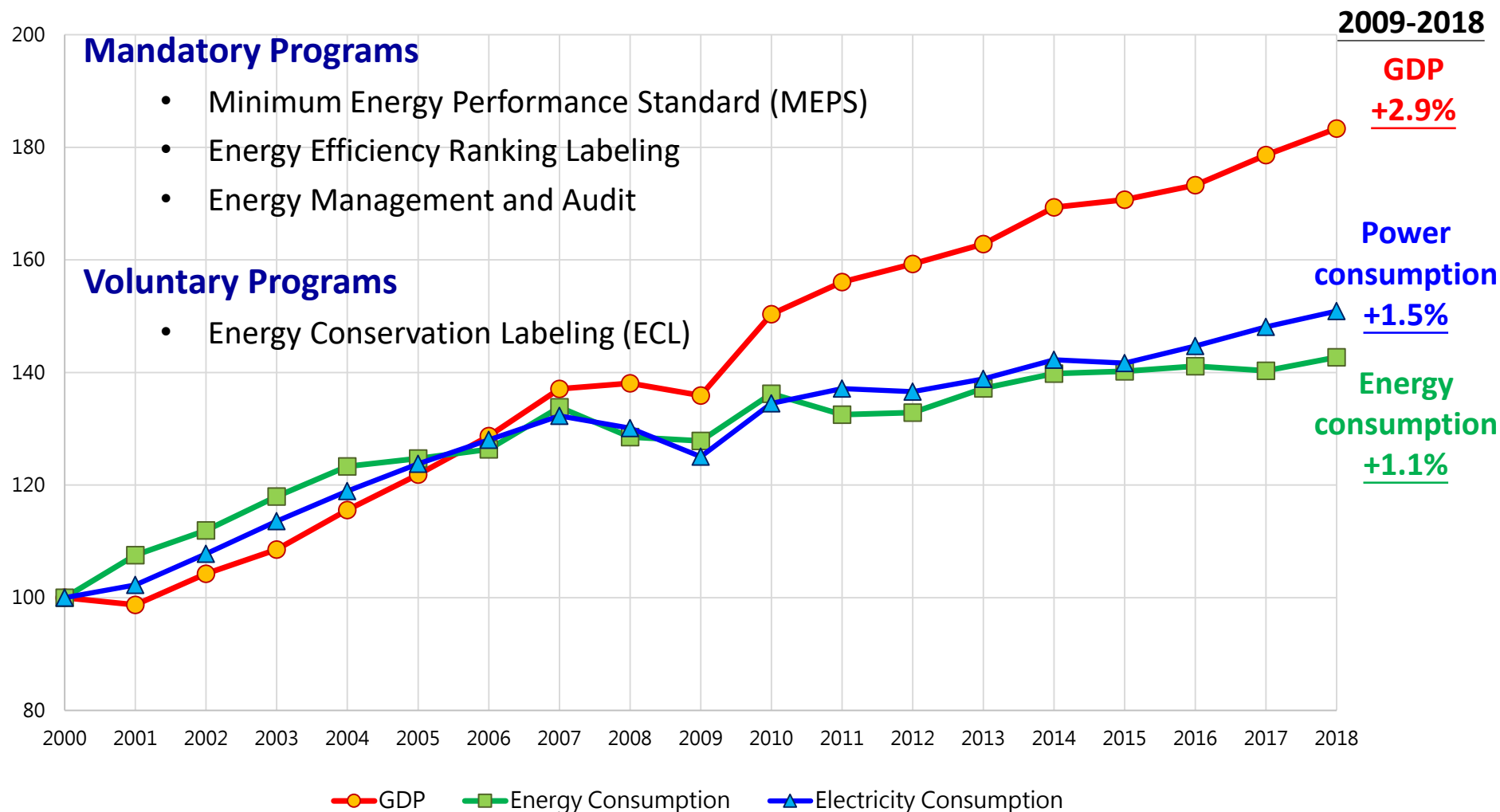
Greenhouse Gases Emissions in Taiwan

- Total emission: **298.627** MtCO₂e (CO₂: **95.37%**) in 2017
- Taiwan shares **0.55%** of global emission



Ref : Taiwan EPA (2019)

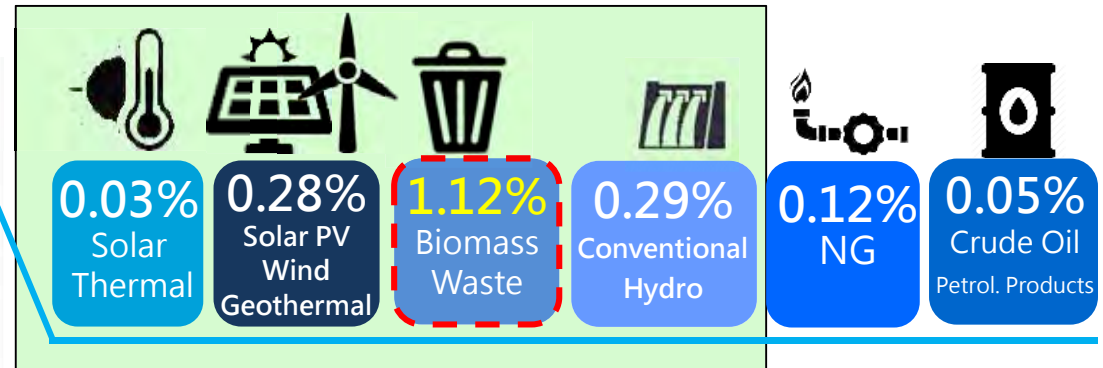
Decoupling of GDP and Energy Consumption



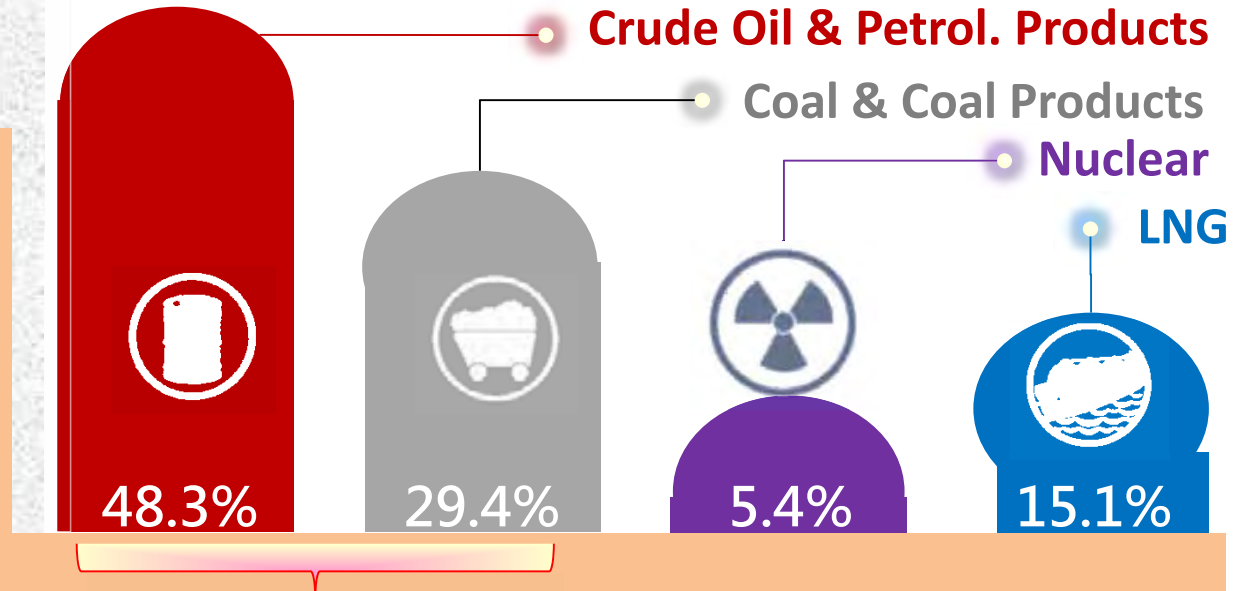
Source: Energy Bureau Monthly Report of the Energy Bureau of the Ministry of Economic Affairs (2018.07), Executive Office of the Executive Yuan (2018)
Energy intensity refers to the energy used to produce each unit of GDP in a certain period of time (i.e. energy consumption / real GDP, unit: liters of oil equivalent / thousand NTD)

Energy Mix in Total Energy Supply (2018)

2% Indigenous



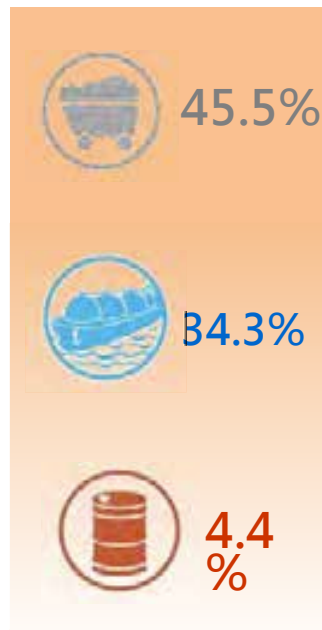
RE 1.72%



Fossil Fuel 78%

Fuel Mix in Total Electricity Generation (2018)

84.2%

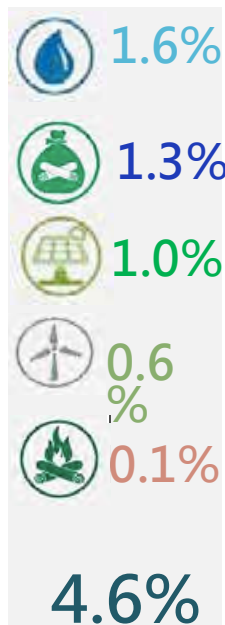


Thermal power

10.0%



Nuclear



Renewable energy

1.2%



Pumped hydro

Total Power Generation

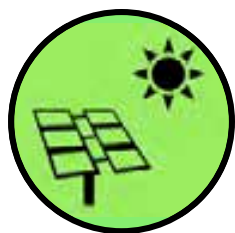
275 TWh

Of which fossil fuels

84.2 Percent

Taiwan's Energy Transition Policy

2025 Energy Policy : 20-30-50 power mix & nuclear-free homeland



Renewable energy

5% → 20%



LNG-fired

34% → 50%



Coal-fired & others

46% → 27%+3%



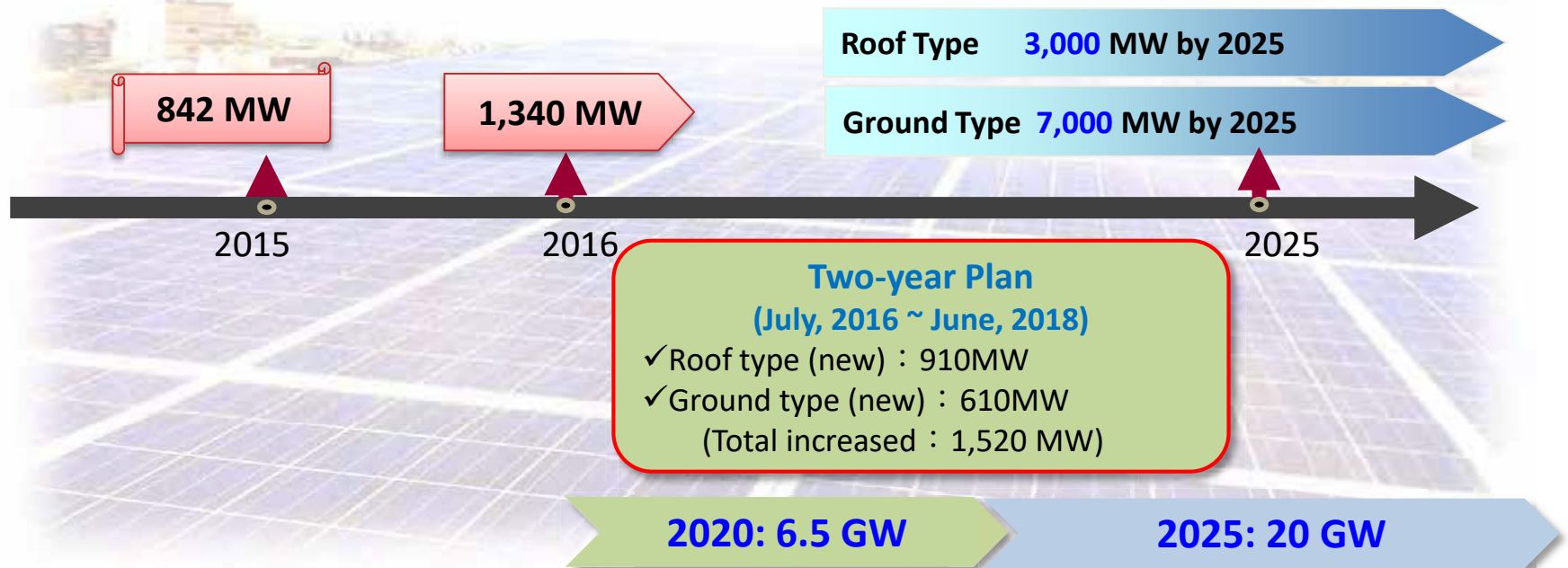
NPP #1-3 **no extension**

NPP #4 **mothballed**

Solar PV Industry Promotion

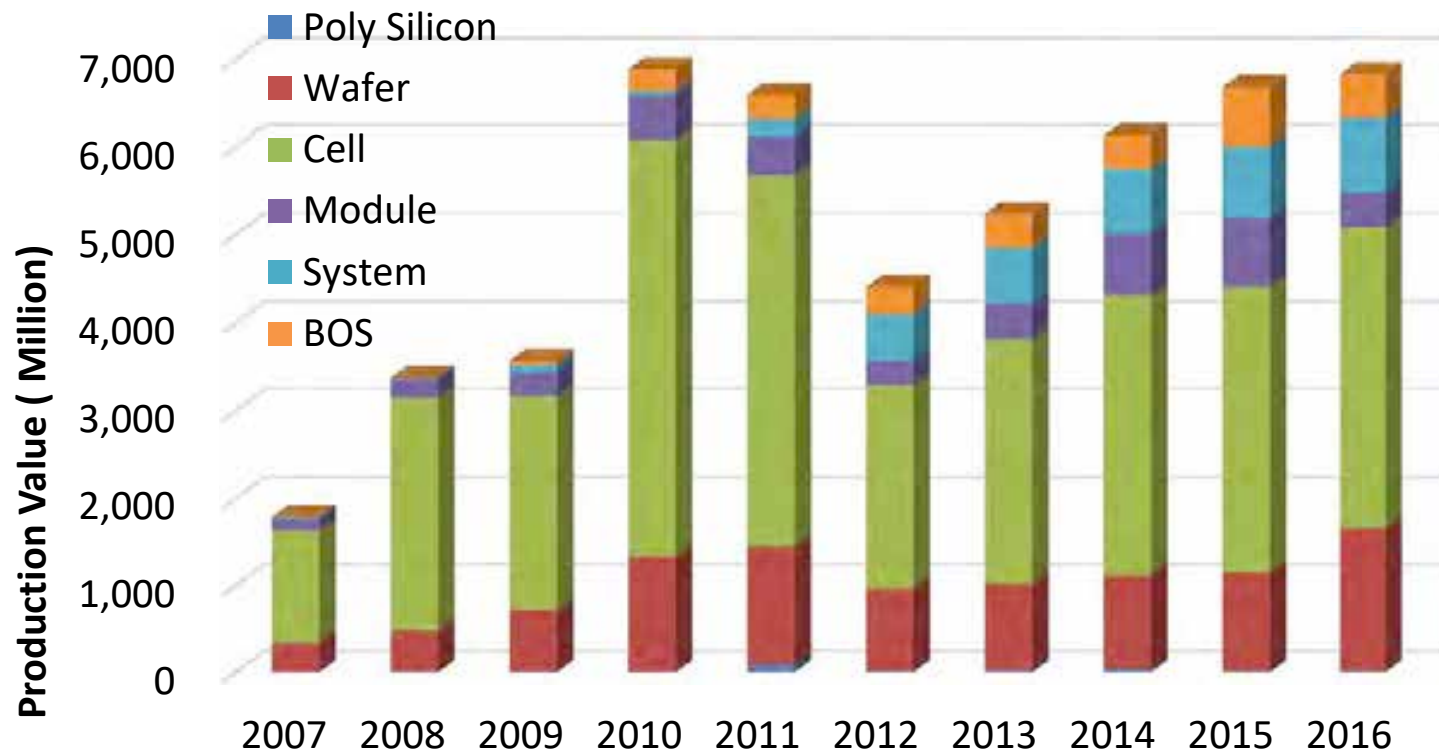
■ Development strategy

- Preliminary period: launching initial projects to stimulate roof solar PV installation; thereafter, we introduce ground type projects
- Short term: completion of the two-year solar PV demonstration plan to construct response measures
- Mid & long term: expanding application and establishing an enabling environment; enlarging the solar PV market from domestic to international



Photovoltaic Industry Status in Taiwan

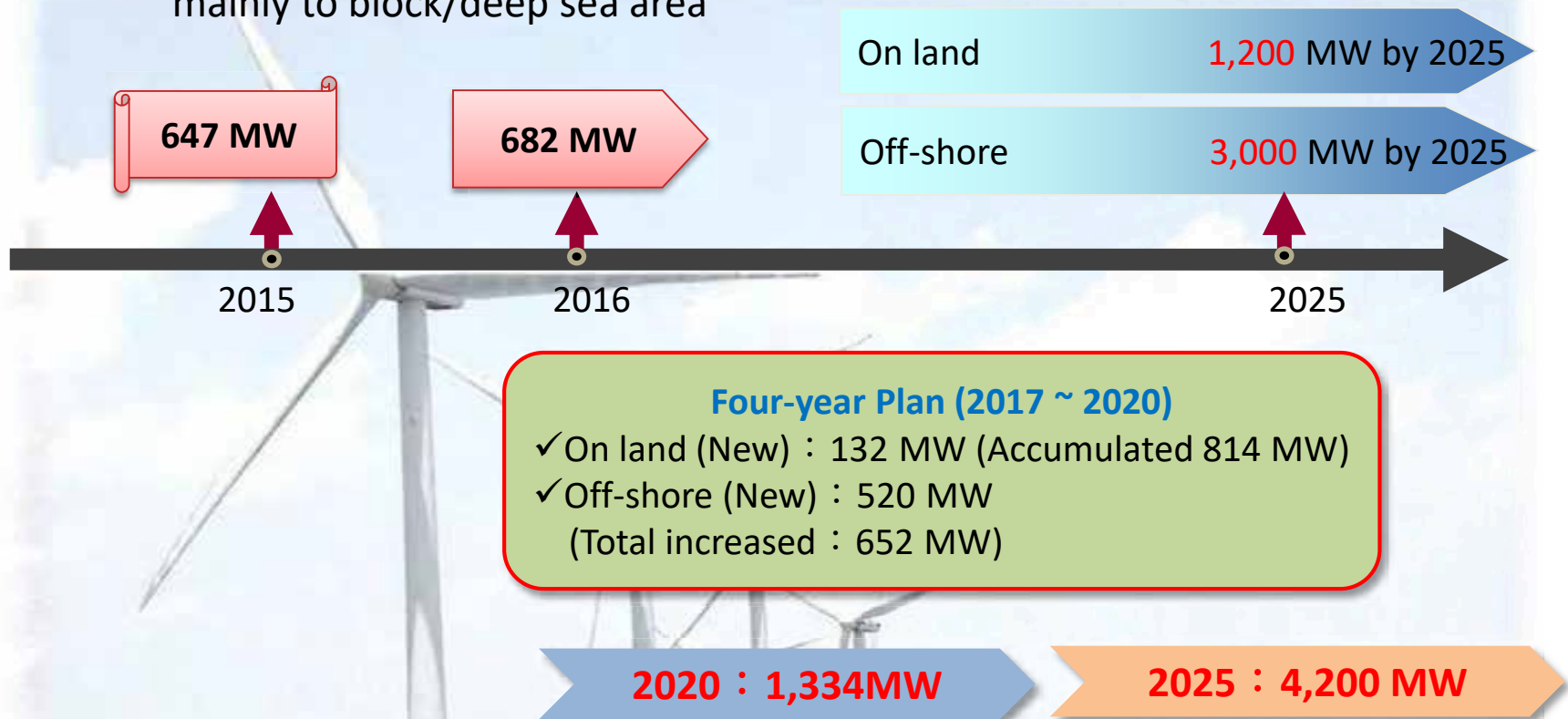
- Taiwan annual PV production value was **6.8 billion USD in 2016**.
- Annual solar cell production reached 12.08GW, which was the second place worldwide.(2016)
- The Taiwan PV module capacity reached 2,653 MW in 2015 and slightly dropped to 2,140 MW in 2016



Wind Power Industry Promotion

■ Development strategy

- Short-term : On-land area first developing excellent wind farm; offshore area mainly to demonstration/shallow area
- Long-term : On-land area developing secondary wind farm; offshore area mainly to block/deep sea area



Advanced Recycling Asphalt Pavement (RAP)

■ ITRI's Bio-based Recycled Asphalt Regenerant

- Lowering the asphalt viscosity under regulations
- Reduce 60% regenerant needed in regular constructions
- Excellent physical properties and pavement performance

■ Co-construct Bio-based Asphalt Regenerant pilot lines with industry.

- The pilot production is about 5 tons per day
- The advanced RAP has been applied to many road pavement construction in Taiwan.

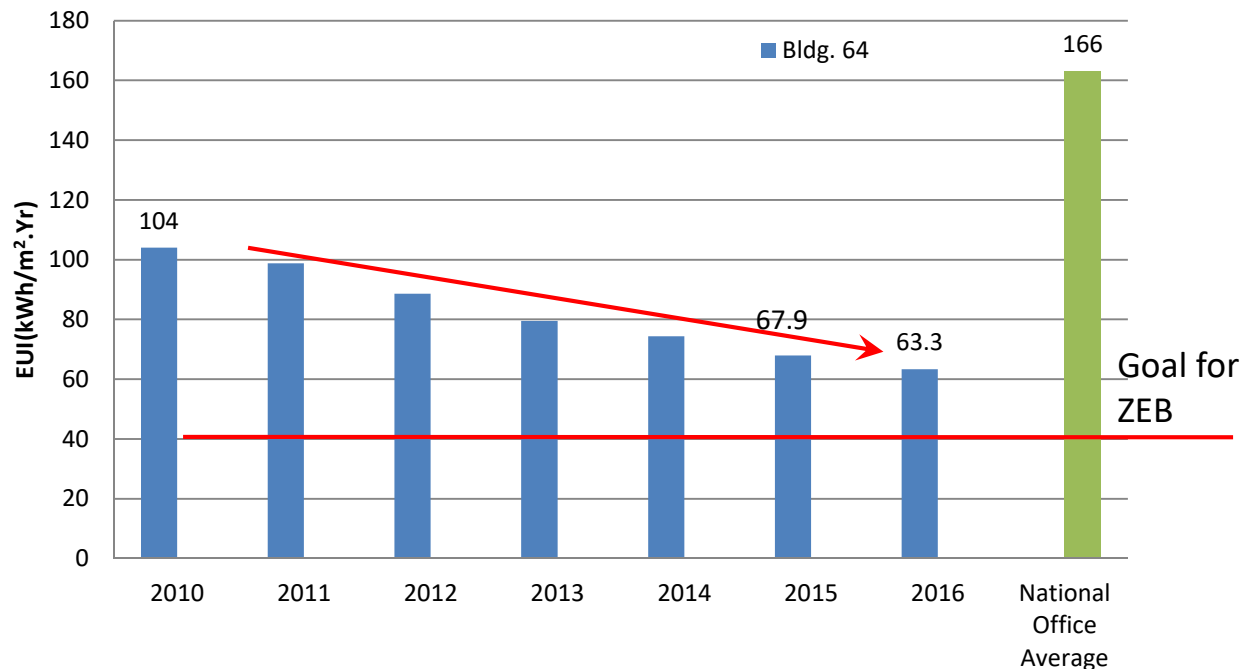


ITRI's Recycled Asphalt Regenerant



Retrofitting Old Building toward Low Carbon

- Bldg.#64 in ITRI to demonstrate the **technological feasibility of renovating an existing building to net-zero**.
 - 40% energy reduction in 6 years to reach $\text{EUI}=63 \text{ kW/m}^2\cdot\text{yr}$, less than half the national average
 - Further improvement to **$\text{EUI}\sim 45 \text{ kW/m}^2\cdot\text{yr}$ will ensure net-zero by roof-top PV**.
 - Some technologies developed were later **transferred to the industry and commercialized**: HVAC water-side optimization, AMB chiller, BEMS, etc.



History of Bldg. 64 in ITRI Campus

Item		Annual Consumption in 2011 (kWh)	Annual Consumption in 2015 (kWh)	Remarks
Lighting		124,922	83,111	T8 replaced by T5(2011) Smart lighting control(2013)
A/C	Chiller+Tower	122,897	77,903	Water Side Optimization(2012) AMB chiller(2014)
	AHU/FCU	57,800	36,225	AC FCU(2011)
	Pumps and Others	51,150	38,896	Water Side Optimization(2014)
Plug		204,117	136,218	iSleep(computer)(2013) BEMS and monitoring(2013-2015)
Bathroom Exhaust		13,280	7,915	BEMS and Smart control(2013)
Elevator		5,490	3,222	High efficiency Motor(2015)
Others		165,833	129,312	BEMS (schedule control)and monitoring(2012-2015)
Total (EUI)		745,486 (EUI=98.8)	512,802 (EUI=67.9)	

Solar PV Mini-Grid System in Myanmar

■ Establish solar PV mini-grid and develop solar lighting kit

- Develop solar lighting kit through cooperation with Myanmar's Asia World Group
- Install solar powered mini-grids and Implement into 556 households
- Provide training for system management and maintenance

■ Develop replicable business models for rural lighting

- Establish Village Power Operation and Management Committee to verify and modify operation model by using actual charging
- Monthly charge is estimated as 1.75 USD ~ 8.5 USD (current charge for candles as 4.13 USD ~ 12.14 USD)

■ Estimated results

- 3,000-4,500 houses will access to lighting system in three years
- USD 2.4-3.6 million will be created in demand.



PV mini-grid system



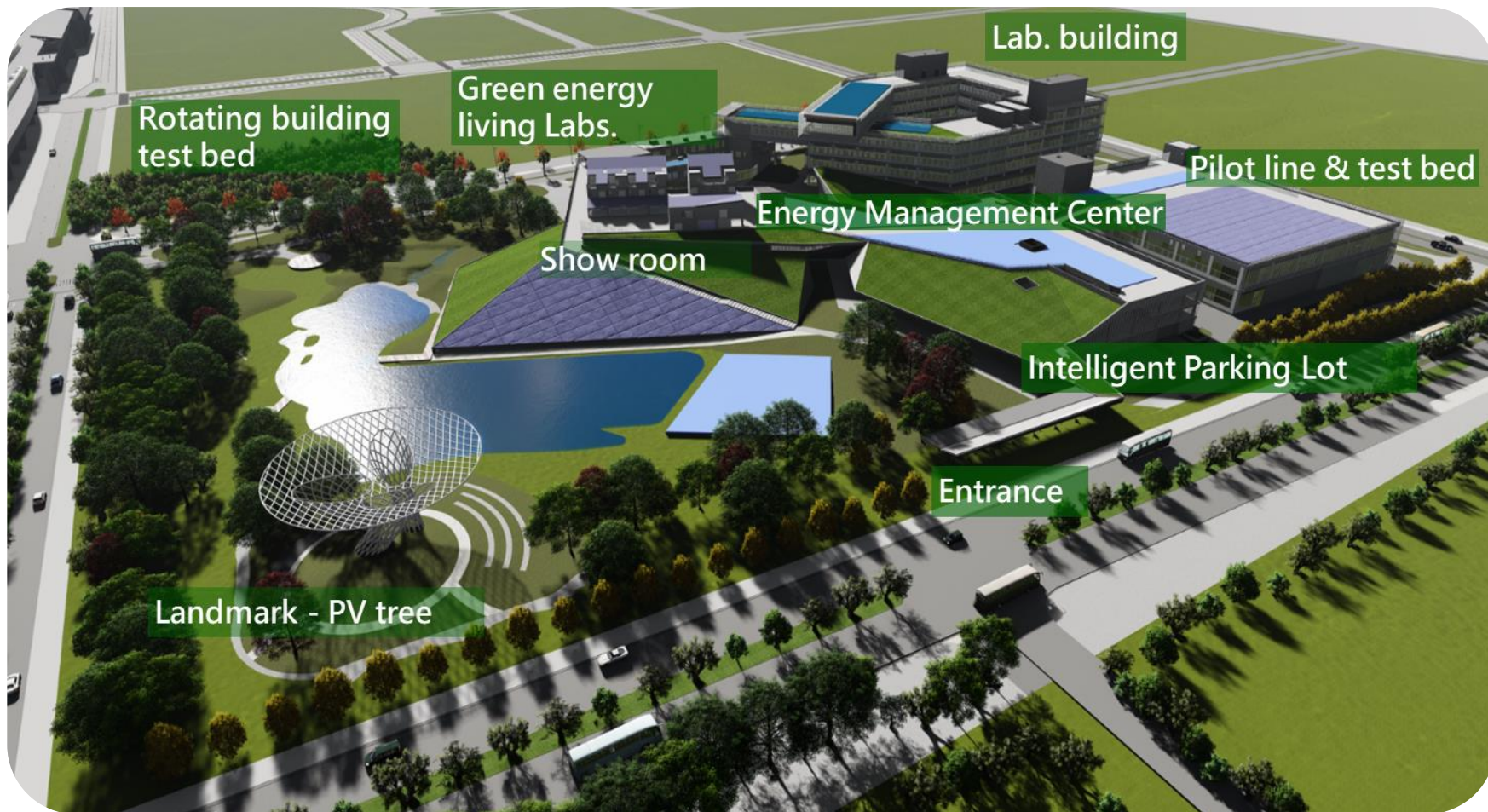
Solar lighting



Training class

Green Energy Technology Demonstration Site

- A integrity linkage of research, demonstrative verification, and industrial promotion to complete green energy industry



ITRI Technology Focus

- Market-oriented R&D, bridging research and commercialization, power house of the industry



Organic Rankine Cycle (ORC)-Waste Heat Utilization

- The ORC can convert low grade thermal energy, such as geothermal energy, and recovered waste heat, into electricity
- ITRI ORC system
 - Customization service, high power generation efficiency, stability and long lifetime, cost-effective.
 - Integration with Geothermal: Chinshui, I-lan county.
 - Waste heat recovery: FCFC Chemical



FCFC, Waste heat recovery (2014)

- 200kW system and saved 1,700,000 kWh electricity in 2015



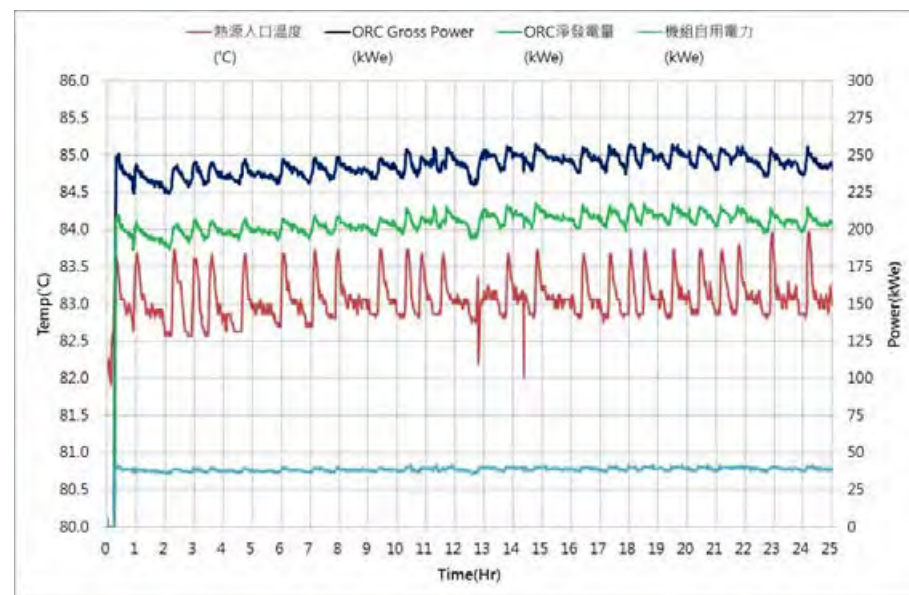
Chingshui , Geothermal Demonstration Power (2019)

- Turbo-expander design and 300 kW binary cycle, 24 hours operation
- Conversion eff. 10.5% @ 93°C (ΔT)

低溫工業餘熱發電系統建置 (2014)

■ 台化公司製程餘熱回收ORC系統

- 國內最大低溫型自行研發機組(200kW_e)
- 結合ORC與多項節能技術，獲得經濟部能源局103年-企業節約能源績優獎項第一名殊榮。
- 機組24Hr全時運轉，平均淨發電量為195kW_e，每日發電度數為4,680kWh，廠區節電達2.1%。



Air Quality Monitoring for Smart Cities

Industrial

high density of
factories

High-density
deployment

Community

Large-scale
community

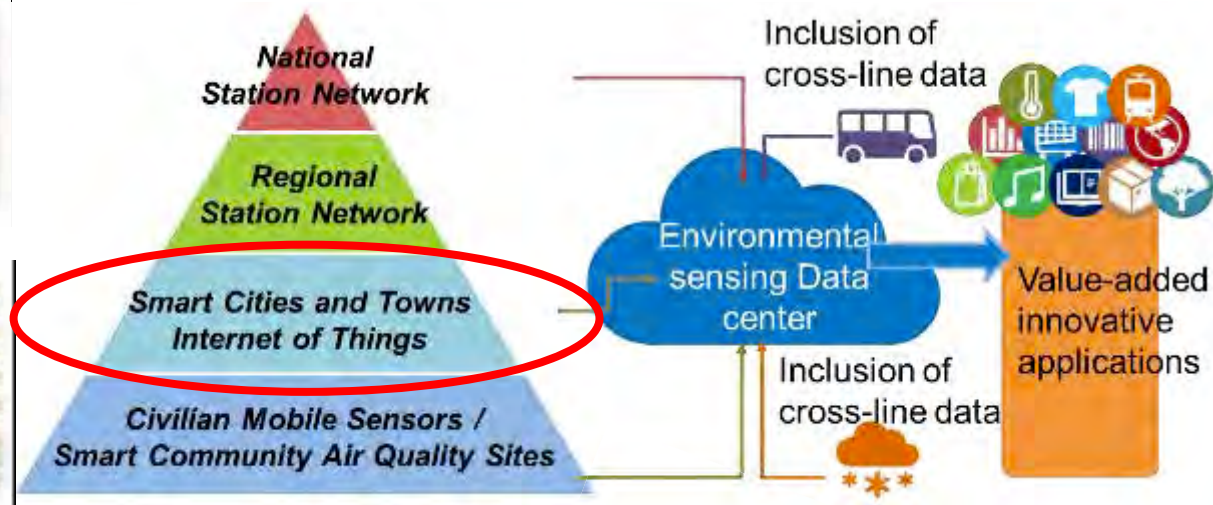
Transportation

Areas with
busy traffic

Auxiliary

Rural areas
without
stations

Low-density
deployment

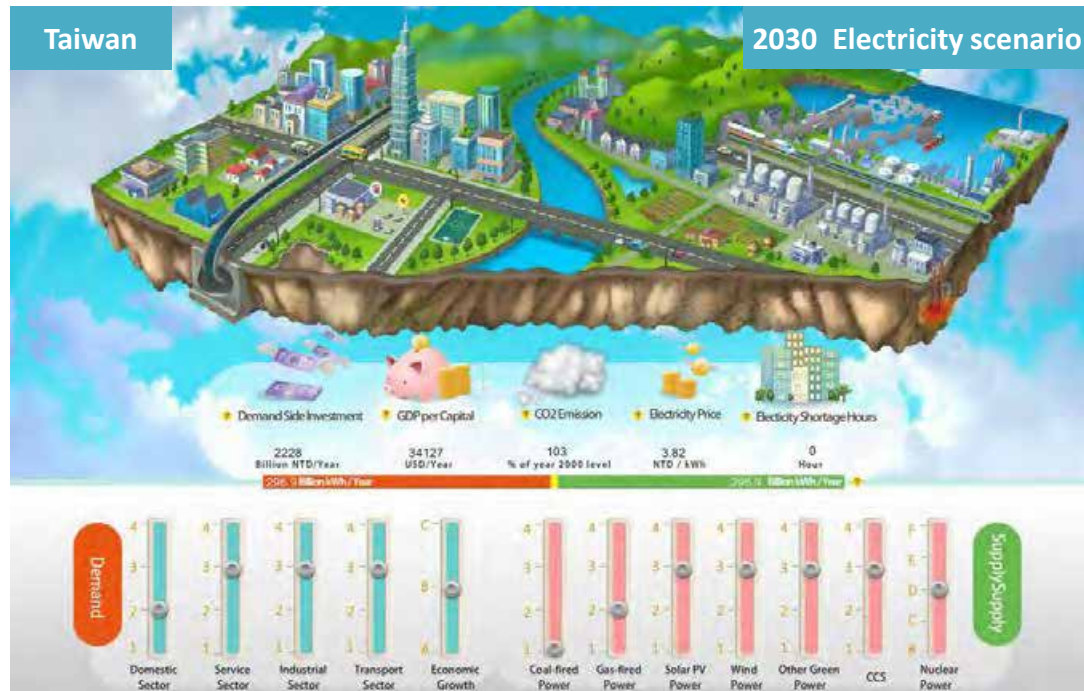


Dashboard for each
sensor status



Taiwan 2050 Calculator

- Taiwan launched the “2050 Calculator” in 2013
- A platform for public energy education, policy communication, public energy issue debate, future energy mix discussion, energy resource research, and energy development strategy-making
- Developed energy models for **7 countries of South East Europe**



To build 2050 Energy Models for seven countries in South East Europe



2050 Energy Model for South East Europe (Albania, Bosnia and Herzegovina, Croatia, Macedonia, Kosovo, Montenegro, Serbia)



2050 Energy Model for South East Europe was Presented in EU Sustainable Energy Week 2015.

Life Cycle Assessment (LCA)



LCA : Assess environmental impact of product life cycle



**Taiwan 1st
LCA Database**

&



Carbon Label



**Introduce CFP into
LCA database**

➤ Introduce other countries' carbon emission factor into LCA database

- JEMAI(Japan)
- KEITI(Korea)
- MTEC(Thailand)



Carbon Label-mutual recognition

- **Thailand , Korea , Taiwan(Under UNEP ACFN network)**
 - Carbon Label-mutual recognition
 - CFP Product Category rule harmonization
 - 3 products(shampoo,drink,oil)
- **Carbon trust(UK)**
 - Pilot study-Carbon Label mutual recognition
 - O'right Tea Tree Shampoo

2050 Calculator 補充資料

2013年從英國DECC*(Department of Energy & Climate Change)引進2050能源供需模擬器

■ 2015年辦理首屆2050能源供需模擬器國際研討會

- 本所在2050模擬器的開發應用皆處於國際領先地位
- 與英國DECC、日本地球環境戰略研究機關共同舉辦
- 23國、3組織總計72位國際專家出席交流
- 重要與會者：行政院長毛治國、英國代表Mr. Chris Woods、英國DECC前首席科學家Prof. David MacKay、英國DECC副主任Dr. Thomas Counsell
- 包括英國、美國、愛爾蘭、歐盟委員會(組織)、孟加拉、哥倫比亞、印度、印尼、墨西哥、奈及利亞、南非、泰國、越南、英國駐中國大陸大使館人員、厄瓜多、比利時、Climact(組織)、日本、新加坡、東南歐(組織)、紐西蘭、模里西斯、澳洲、韓國等。



毛院長與國際專家出席合影



東南歐專家於歐盟永續能源周展示系統

■ 2015-2016年協助東南歐7國建立2050能源供需模擬器

- 協助東南歐改變網絡基金會建構**東南歐2050模擬器**
- 7國包括：阿爾巴尼亞、波士尼亞與赫塞哥維納、克羅埃西亞、馬其頓共和國、科索夫、蒙特內哥羅、塞爾維亞
- 協助**東南歐7國低碳能源轉型**，逐步達成加入歐盟的終極目標。



東南歐庶民版系統

說明：*2016年更名Department for Business, Energy & Industrial Strategy