

Meteorological Information Application Service in Green Energy

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Introduction





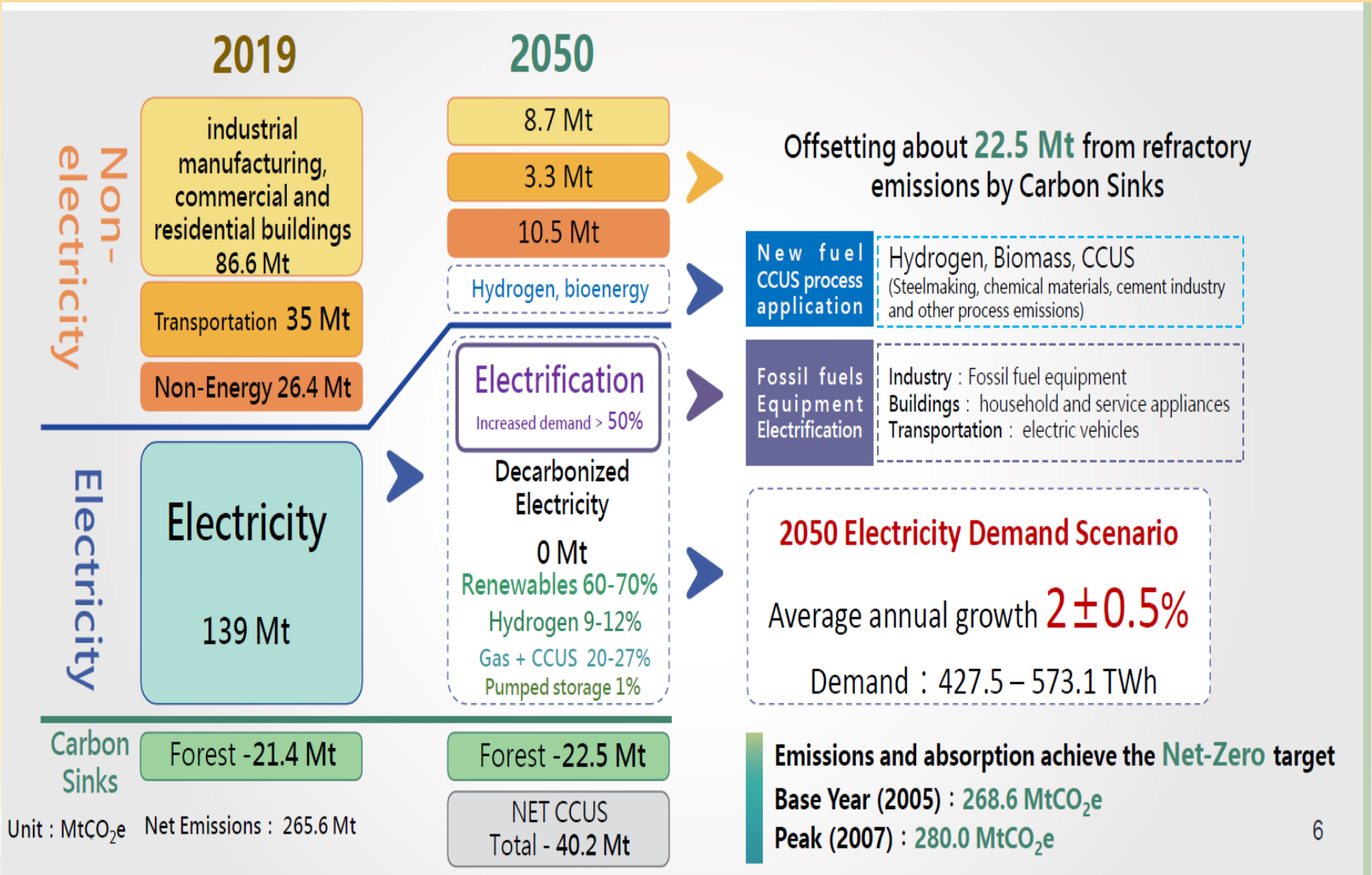
Sustainable Development Agenda of UN and SDGs

- UN launched the 2030 Agenda for Sustainable Development on 25-27 September 2015 and provided 17 Sustainable Development Goals (SDGs) under the Agenda. **Affordable and clean energy**, **Partnerships for the goals** is two of the SDGs.
- WMO, as a United Nations organization, is driven by the Global UN agenda.





2050 Net-Zero Emissions Plan in Taiwan





Taiwan's 2050 Net-Zero Transition – 12 Key Strategies





The future of energy is electric (power magazine, 2019)

The future market will deliver **lower costs for some**, but **higher prices and more power disruptions for others**. This transition is being driven by trends that industry experts call “**the Three Ds**,” that is, **decarbonization, digitalization, and decentralization**.



Microgrids – The next evolution of the grid

- ❑ Microgrids Will Impact the Energy
 - three Ds converging
 - isolate from the electrical grid
- ❑ Cost Increases for Some Customers
 - Fewer customers
 - More power outages
- ❑ Low-Carbon Energy and Transmission Costs
 - renewable energy with battery storage
 - intermittency of renewables

End-user costs and grid adaptation are still unanswered questions.



The consumer-driven 'Future of Energy'

New technologies and data are driving new services
tailored products and services
Delivering for all customers
Investing for the future



The next few years will see the launch of a host of **new products and services** for the benefit of all household and business consumers. This will range from **time-of-use tariffs** and **domestic storage**, to **low carbon heat** and **intelligent EV charging**.

https://www.energy-uk.org.uk/wp-content/uploads/2023/03/E-UK_FutureofEnergy_SummaryReport2019_23.04.19.pdf



The consumer-driven 'Future of Energy'

- ❑ **Competition, innovation and investment** deliver a retail market
 - The impact of data, innovation and new business models
 - **The importance of regulatory frameworks**
 - The need for equal and fair access to energy
- ❑ **Competition provides low-carbon power at low cost**
 - Securing low cost investment
 - Capacity Market and Contracts for Difference frameworks
 - Carbon pricing will continue to have a role
 - Intermittency and flexibility
 - Transporting energy to and from customers
- ❑ **Further decarbonization across sectors and reducing energy use**
 - Innovation driven by signals from government
 - The central importance of energy efficiency
 - Driving change through adopting electric vehicles



The renewable energy market is changing

5 technologies changing the future of RE

❑ Wind and solar

According to the IEA, RE is expected to make up **30%** of the world's energy by **2024**.

❑ Electrification

Experts agree that the advance of **electrification** in the coming decades will **super-charge the shift to renewables**.

❑ Power-to-X

Power-to-X is an umbrella term that covers different processes that turn electricity into heat, hydrogen or renewable synthetic fuels.

❑ Distributed Generation

Rapid growth in distributed generation in recent years, and this is expected to continue.

❑ Energy storage

Storage technologies will evolve within the energy system along with the **increased use of renewable** and the **skill is to combine them** in a system.

<https://www.wartsila.com/insights/article/5-technologies-changing-the-future-of-renewable-energy>

Meteorology Service Needs in Green Energy





GFCS: Climate Service Needs for The Energy Sector

Energy was Listed in The Priority Areas of GFCS in 2015

- ▶ Energy systems are the driving force of economic and social development.
- ▶ Under the trend of energy transformation and net-zero carbon, **the share of renewable energy is expected to increase dramatically.**
- ▶ Expanding energy systems are increasingly **exposed to the vagaries of weather and climate.**

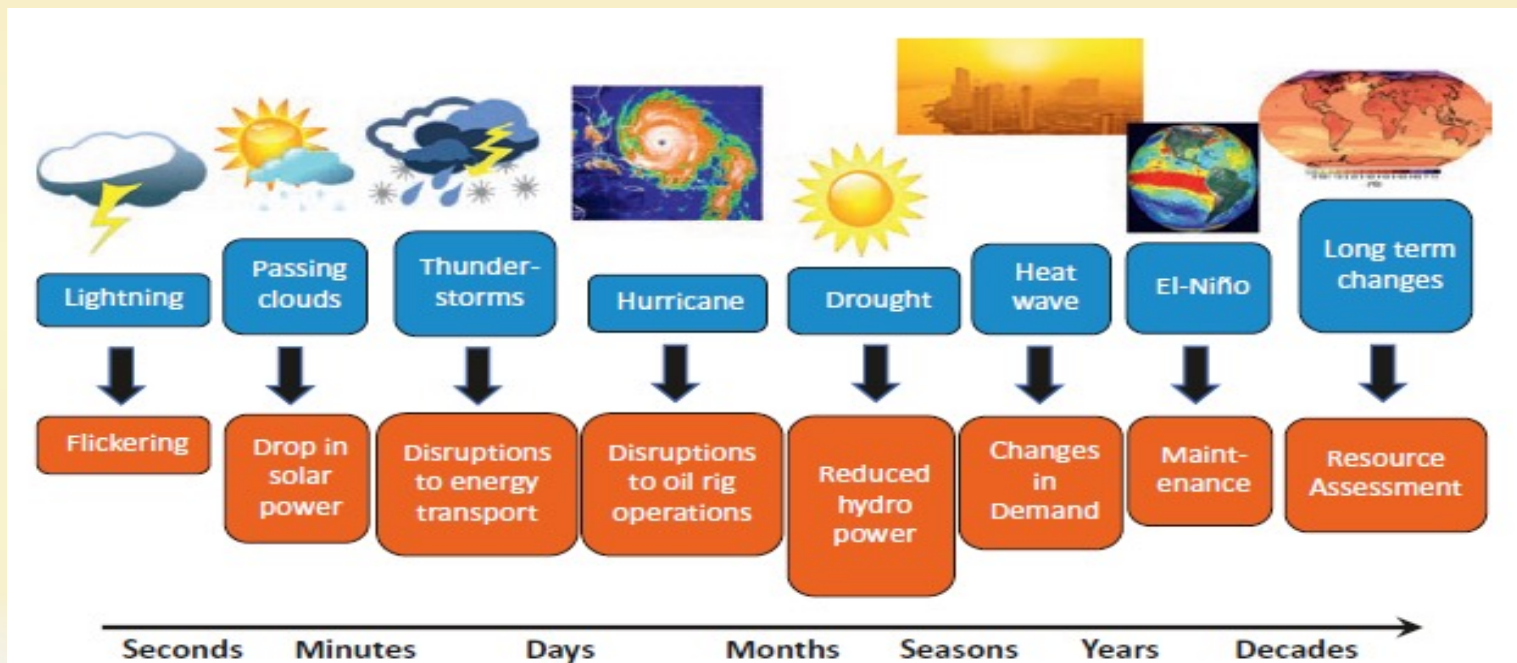


Fig. 4.3 Weather and climate impact the energy sector on all timescales (source: WEMC)



GFCS: Climate Service Needs for The Energy Sector



Energy Exemplar to the User Interface Platform of the Global Framework for Climate Services



- ▶ In order to assist with the development of climate services for the energy sector, a schematic framework that identifies key elements in the way the energy industry operates is provided below.

1. **Identification and Resource Assessment**
2. **Impact Assessment (including infrastructure and environment)**
3. Site Selection and Financing
4. Operation and Maintenance
5. Energy Integration and grid security

Source : GFCS (2017). Energy Exemplar to the User Interface Platform of the Global Framework for Climate Services, Geneva, WMO press. (https://library.wmo.int/doc_num.php?explnum_id=3581)



The application of meteorology in green energy

Resource Assessment

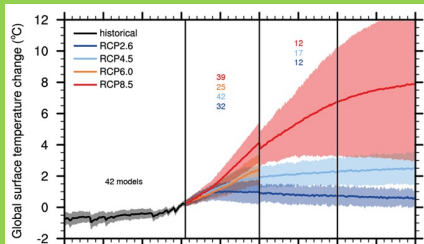
Purpose: Long-term planning

Application:

- ❑ power demand
- ❑ Renewable energy reserves

Service:

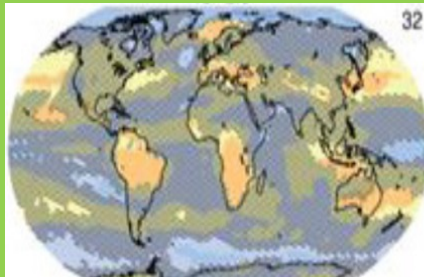
Regional meteorological information under different scenarios



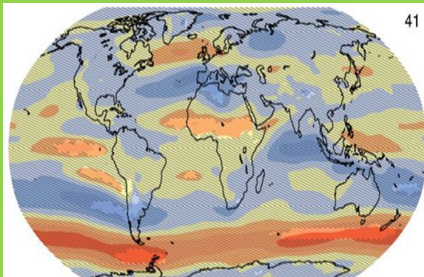
Average temperature anomalies under different scenarios



Under RCP2.6, annual average temperature changes at the end of the century.



Changes in annual average cloud fraction at the end of the century under RCP2.6



Changes in annual mean zonal wind from 2016 to 2035 under the RCP4.5 scenario

Impact Assessment

Purpose: climate change adaptation

Application: Based on the supply chain

- ❑ Resource acquisition
- ❑ Resource transportation
- ❑ Energy conversion
- ❑ Power transmission and distribution

Service:

Changes in gradual climate change and associated extreme weather events.

TABLE 1. IMPACTS OF GRADUAL CLIMATE CHANGE ON AND ADAPTATION OPTIONS FOR NUCLEAR ENERGY

Impact	Potential vulnerabilities	Examples of adaptation options
Higher mean temperatures	Decreasing thermal efficiency Decreasing cooling efficiency	Select sites in cooler local climates when possible Design different cooling systems
Lower mean precipitation	Less and warmer cooling water, leading to potential reductions in output or even short term shutdown	Reuse wastewater, recover evaporated water in recirculating systems Improve wet cooling; install dry cooling
Increased windiness near coasts and dry areas	Salt sprays from sea leading to long term corrosion and short circuit of exposed electrical equipment; dust and sand carried by wind, leading to equipment malfunction	Weather seal critical equipment
Sea level rise	Flooding of low lying coastal sites	Raise dykes and other protective embankments

Adaptation - the example of nuclear energy



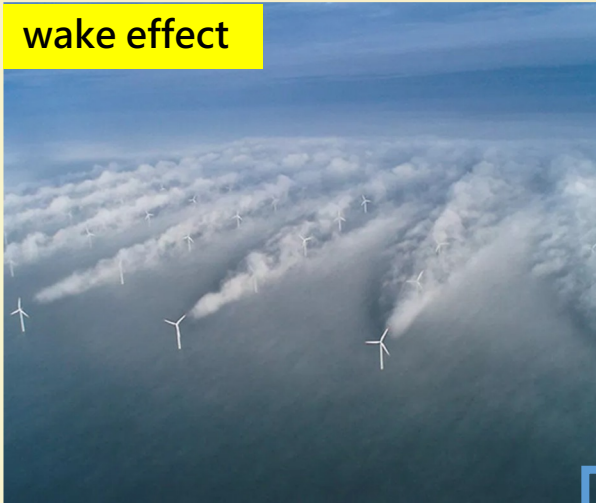
The application of meteorology in green energy

-Site Selection and Financing

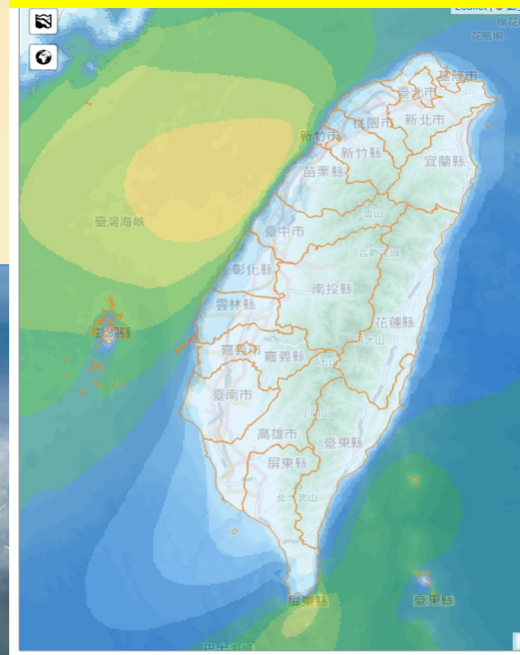
purpose : cost benefit assessment

- Site Selection
- Detailed planning
- design basis
- Benefit assessment
- Financing application

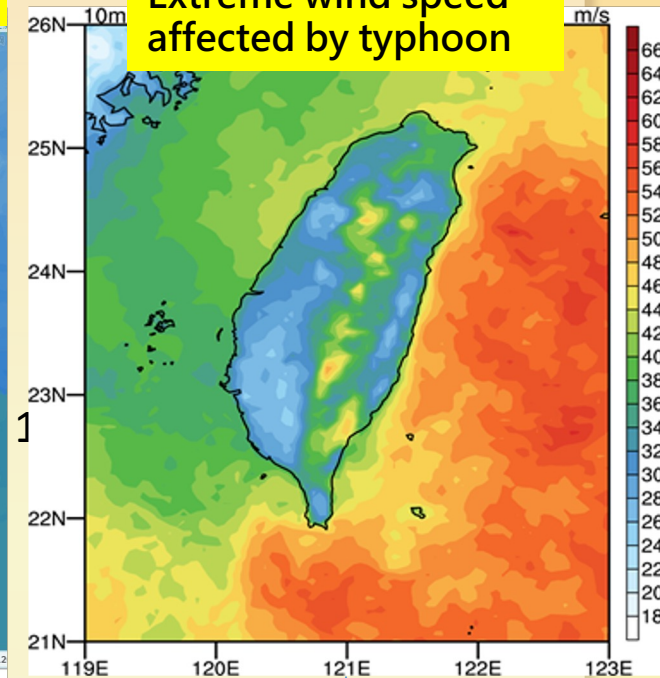
wake effect



100M wind energy density



Extreme wind speed affected by typhoon



Detailed planning: fan arrangement

Site Selection

design basis

Benefit assessment

Financing application

+

+



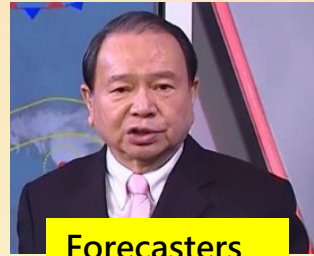


The application of meteorology in green energy

-Operation and Maintenance

Purpose: Maximize cost-benefit ratio

- construction risks
- monitoring and analysis
- Security Monitoring
- Optimization operation
- maintenance schedule



Forecasters forecast and watch

IST	CONF	Dir	WINDS				TOTAL SEA				WIND WAVES			SWELL		WEATHER		
			Ws10m	Wg10m	Ws50m	Wg50m	Hs	Hmax	Tz	Tp	Dir	H	T	Dir	H	T	T2m	Vis
WED																		
14/07 02	●	WSW	18	23	23	27	1.7	2.7	4.2	5.8	SW	1.2	4.3	S	1.2	7.8	27	3.1
14/07 03	●	WSW	18	23	22	27	1.7	2.7	4.3	6.0	SW	1.2	4.4	S	1.2	7.7	27	4.1
14/07 04	●	WSW	18	23	22	27	1.7	2.7	4.3	6.0	WSW	1.1	4.4	S	1.2	7.6	27	5.4
14/07 05	●	WSW	17	22	21	26	1.7	2.7	4.3	6.1	WSW	1.1	4.4	S	1.3	7.6	27	6.5

Weather window

schedule

Construction and maintenance

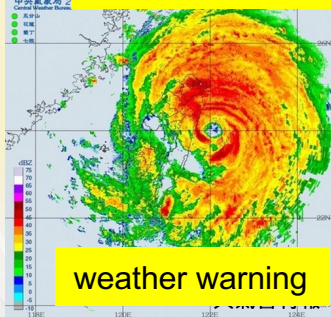


Wave monitoring



Wind monitoring

Safety monitoring and accident assessment information



Bird Radar Monitoring



generation/capable generation = generation efficiency analysis

Optimization operation

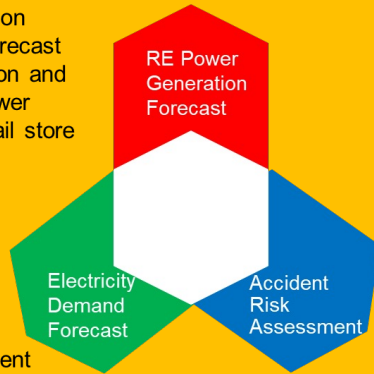


The application of meteorology in green energy

-Energy Integration and grid security

Application of meteorological information in power systems

- Power dispatch optimization
- Electricity trading price forecast
- Target: Power transmission and distribution operators, power generation operators, retail store operators

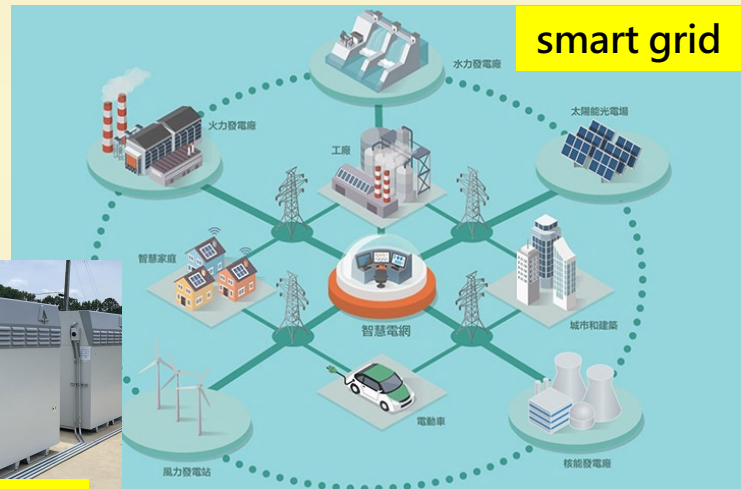


- Load trend forecast
- Demand reflection judgment and execution
- Target: Electric power companies, demand reflection aggregators, energy management service providers

- The impact of weather on the stability of the power system (storms, heavy rain, lightning, etc.)
- Target: Power transmission and distribution operators, power generation operators

Through **Electricity Trading Platform**

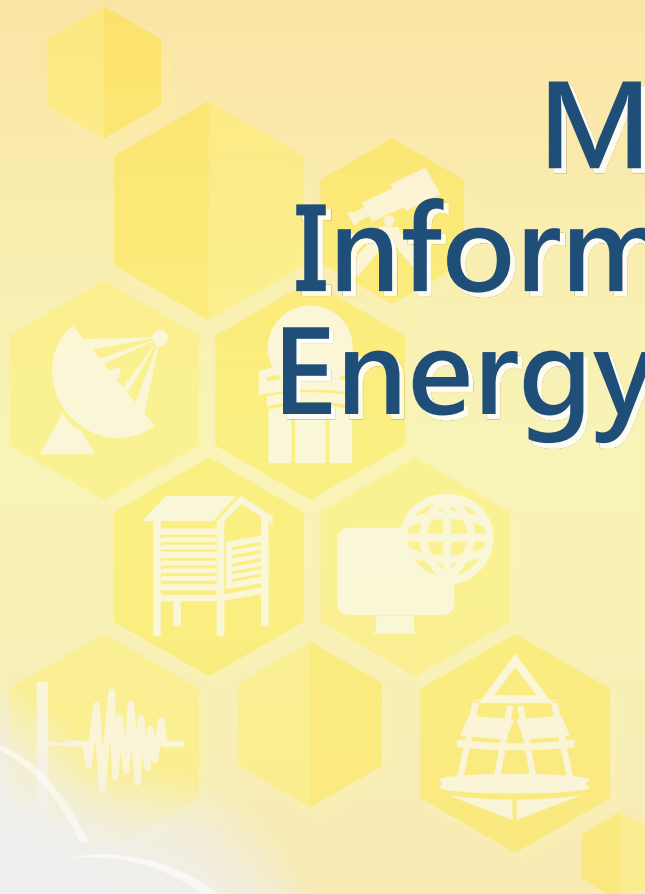
You can also sell electricity to Taipower



Purpose:
Ensure the safety of power systems



Power storage



Meteorological- Information Based Green Energy Operations Center



Meteorological-Information Based Green Energy Operations Center in CWB

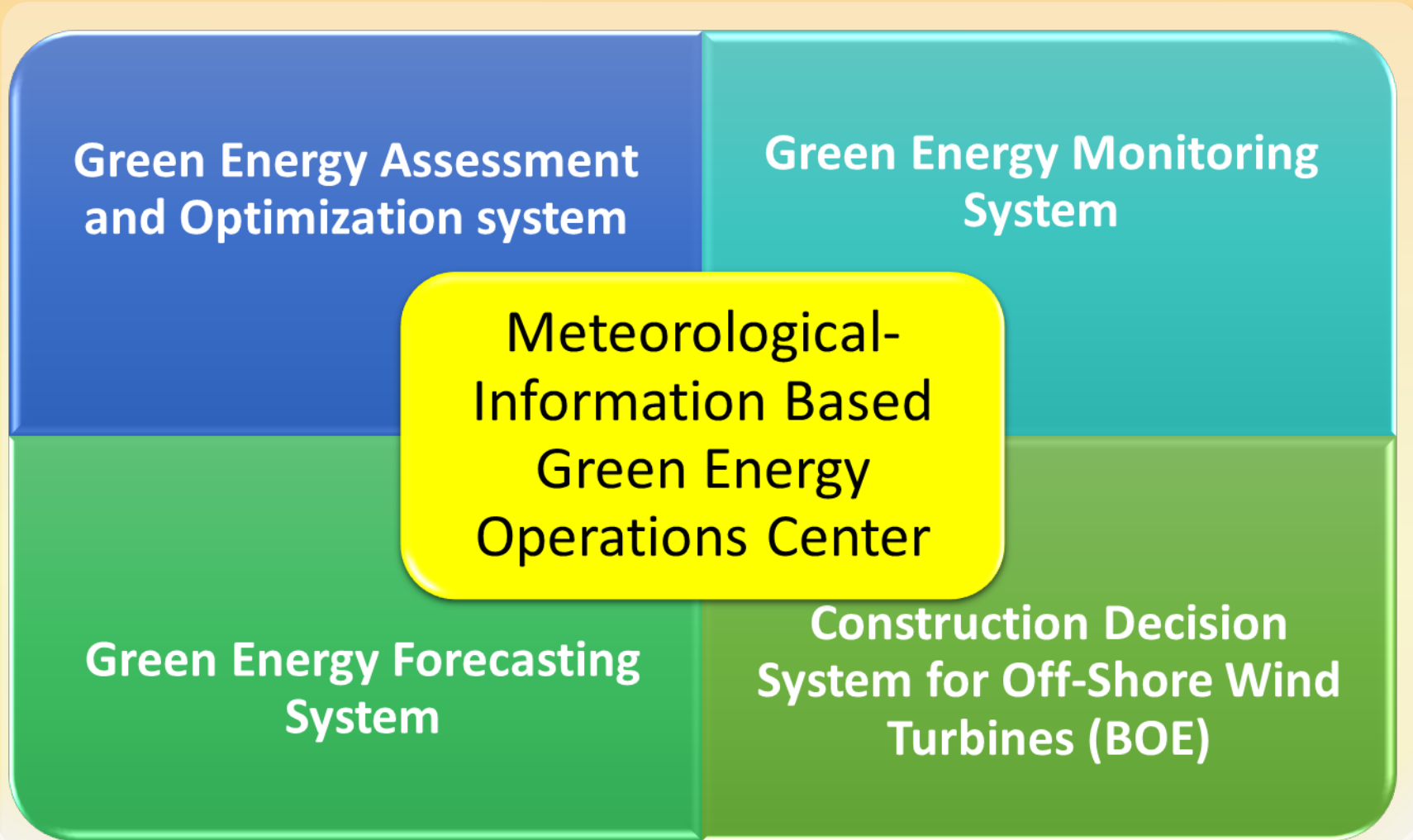


Figure 1: Framework of Meteorological-Information Based Green Energy Operations Center



Meteorological-Information Based Green Energy Operations Center in CWB

Green Energy Assessment and Optimization system

年 季 月

資料項目

- 100m風能發電量
- 100m風能密度
- 100m風速
- 太陽能發電量
- 地表日射量

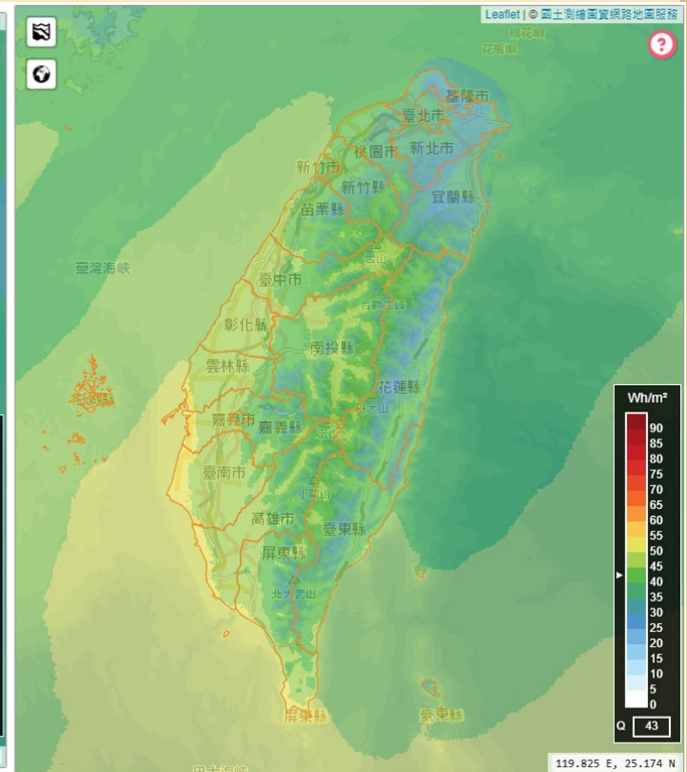
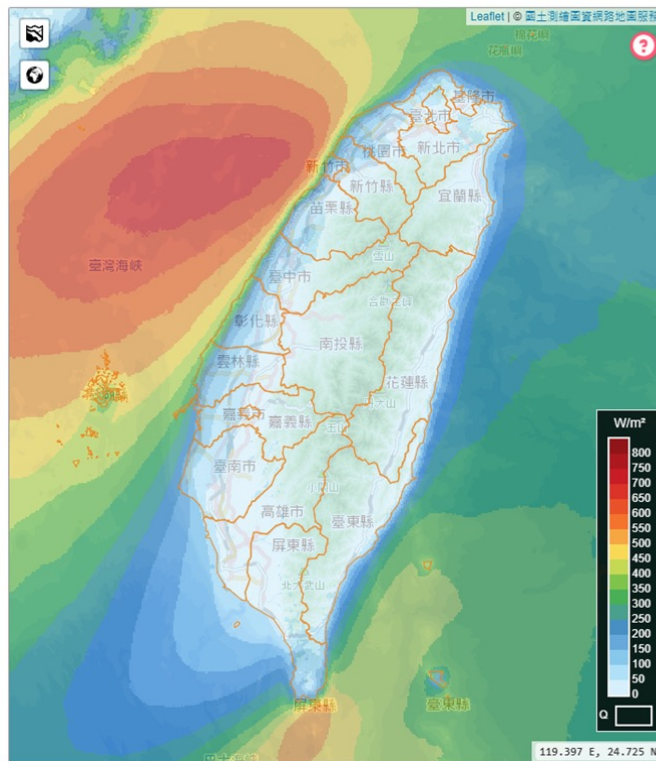
資料來源

區域模式

- CWB/WRF 1KM

降尺度系統

- MDAS CWB/WRF

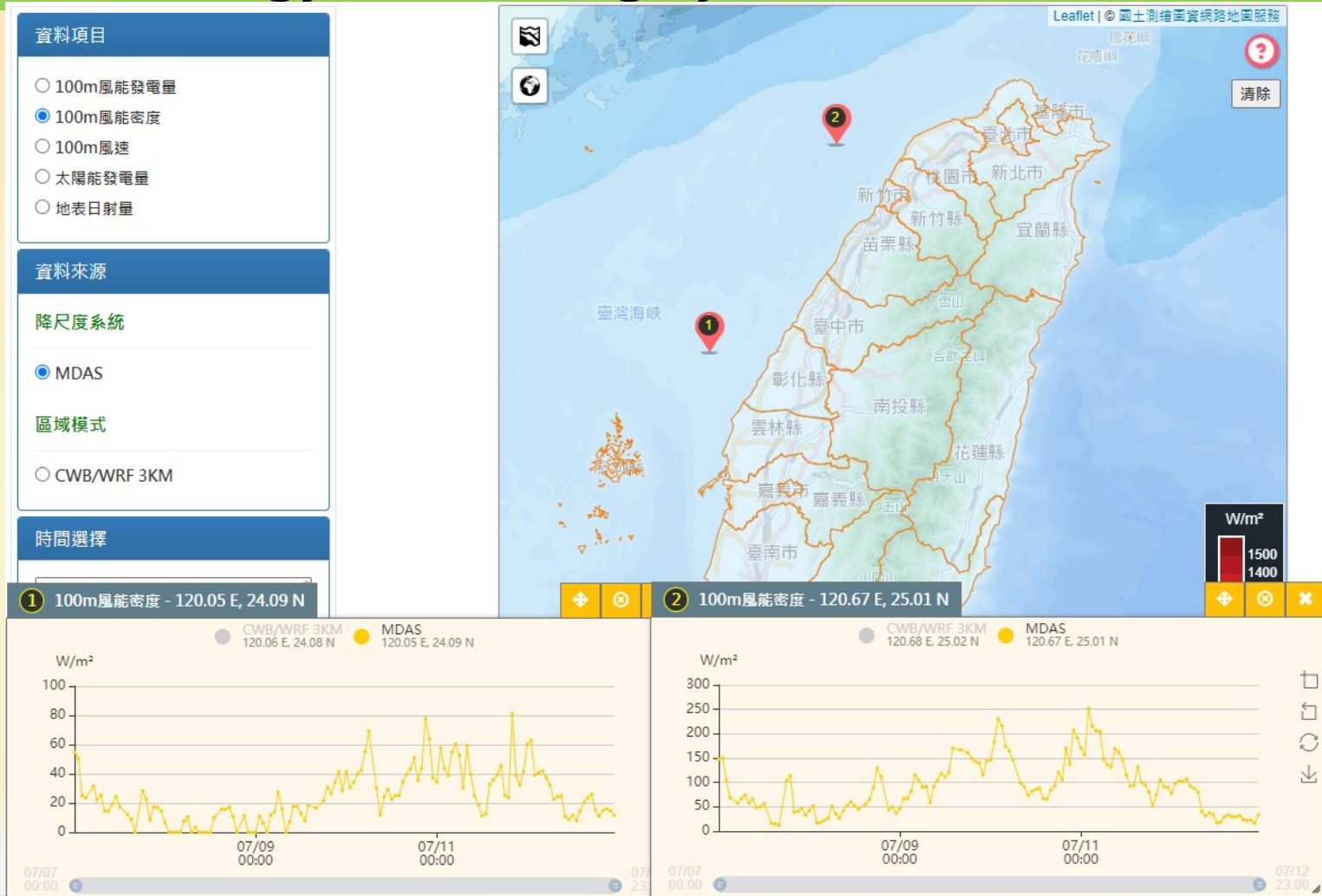


Provides gridded annual, quarterly and monthly average wind and solar energy density data with a resolution of 1 km



Meteorological-Information Based Green Energy Operations Center in CWB

Green Energy Monitoring System- wind

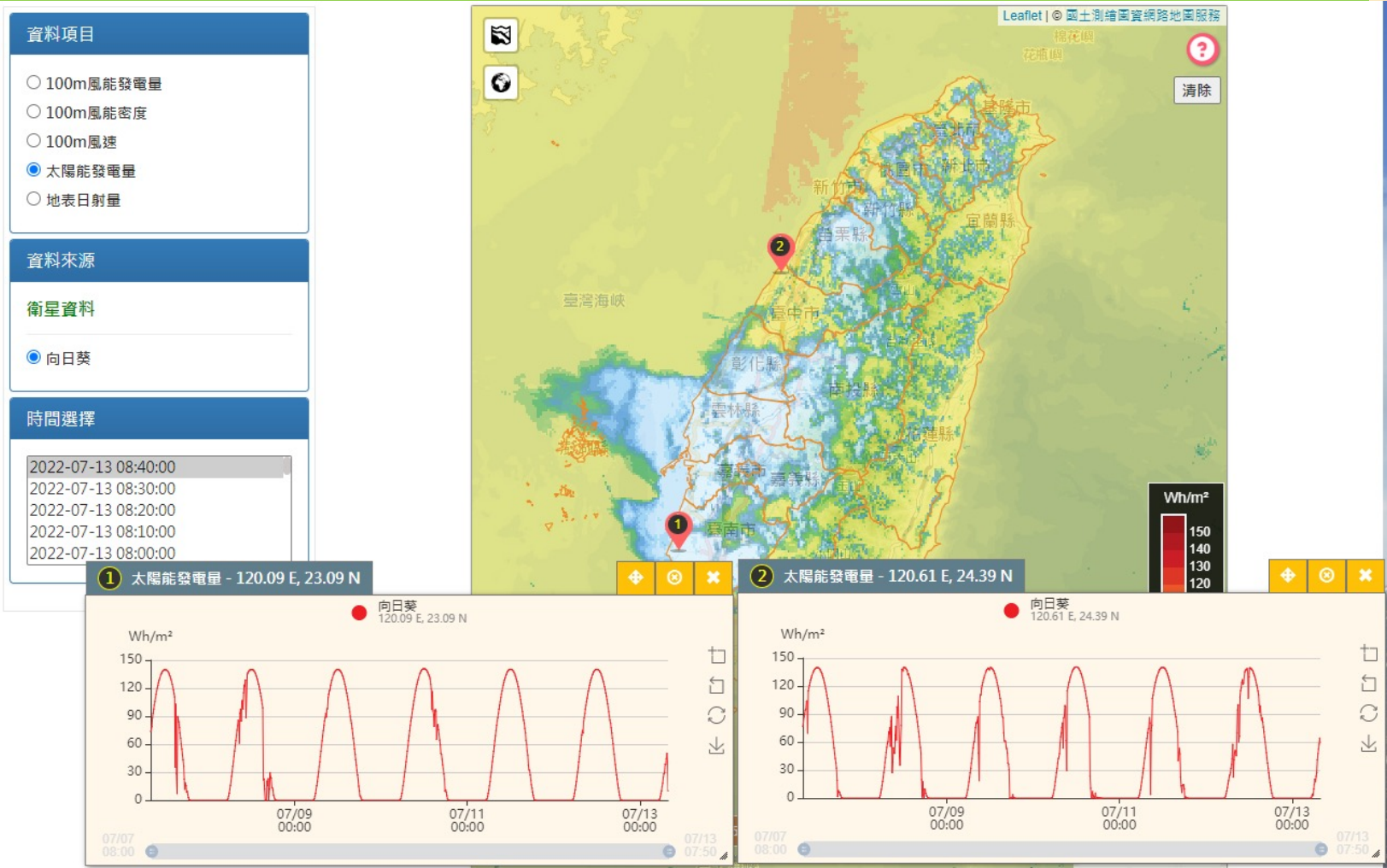


Provide WRF 3KM (6 hourly) and MDAS 1KM (hourly) wind and wind energy density information at a height of 100 meters



Meteorological-Information Based Green Energy Operations Center in CWB

Green Energy Monitoring System- solar

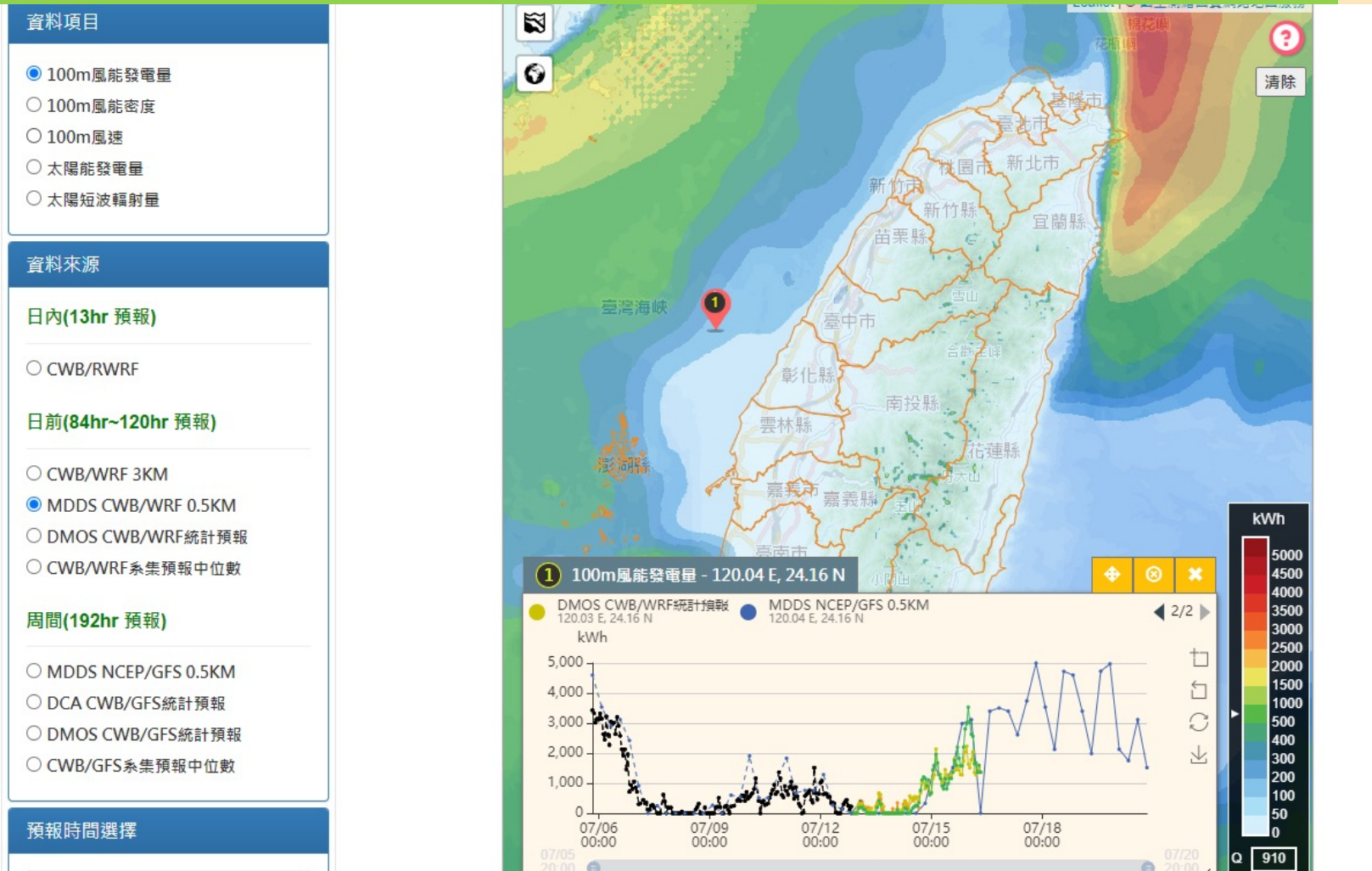


Provide Himawari satellite retrieval 1KM resolution surface insolation and solar density information (every 10 minutes)



Meteorological-Information Based Green Energy Operations Center in CWB

Green Energy Forecasting System - wind

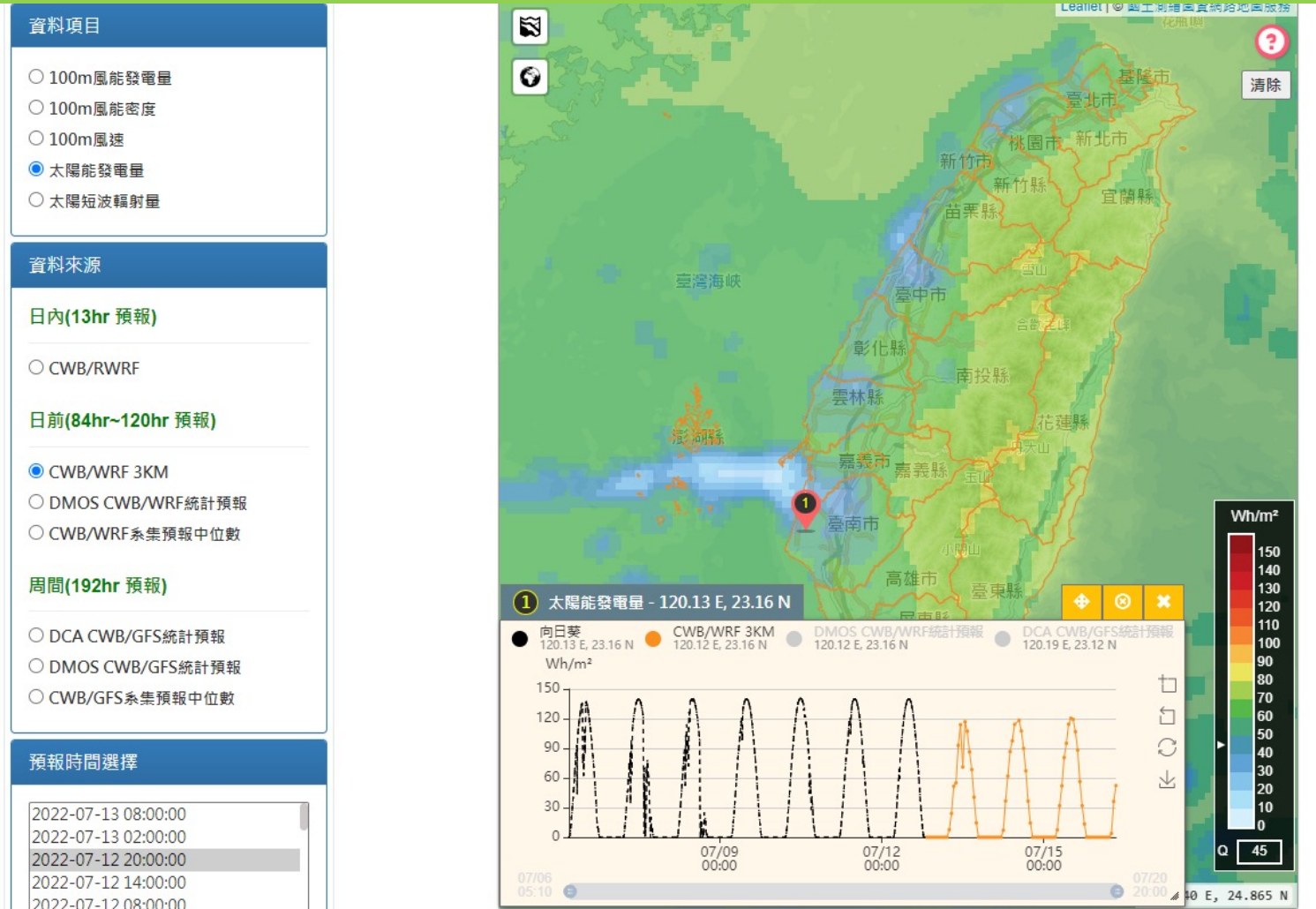


Provide intra-day and day-ahead (7 days) physical (including ensemble) and model statistical forecast information of wind



Meteorological-Information Based Green Energy Operations Center in CWB

Green Energy Forecasting System - solar



Provide intra-day and day-ahead (7 days) physical (including ensemble) and model statistical forecast information of solar



Meteorological-Information Based Green Energy Operations Center in CWB

Offshore Construction Marine Weather Risk System

船舶派遣與追蹤決策系統

離岸風機發電量評估展示系統

離岸風場區海氣象監測與預報系統

- 警特報
- 雷達整合回波
- 潛力區預報
- 浪預報
- 潮預報



逐 3 小時天氣



預報 3 天預報(逐 3 小時) 7 天預報(逐 12 小時)

日期	05/29 星期三				05/30 星期四				05/31 星期五				06/01 星期六											
時間	12:00	15:00	18:00	21:00	00:00	03:00	06:00	09:00	12:00	15:00	18:00	21:00	00:00	03:00	06:00	09:00								
天氣狀況	☁	☁	☁	☁	☁	☁	☁	☁	☁	☁	☁	☁	☁	☁	☁	☁								
溫度(°C)	26	26	25	24	23	23	23	25	26	26	25	24	24	23	23	26	28	28	27	26	26	26	25	28
體感溫度(°C)	22	21	20	20	20	20	21	24	25	24	25	25	25	25	25	29	30	29	29	28	28	27	28	31
風速(m/s)	12.9	12.3	11.3	9.8	9.3	8.2	6.7	6.2	7.7	5.1	3.6	2.6	2.1	1.5	1.5	2.6	3.6	3.6	3.1	3.6	3.6	3.1	3.1	4.1
風向	東北風	東北風	東北風	東北風	東北風	東北風	東北風	偏北風	偏北風	東北風	偏北風	偏北風	西北風	西北風	西北風	偏西風	偏西風	西南風	西南風	西南風	西南風	西南風	偏南風	西南風
相對溼度(%)	75	74	79	83	86	87	85	78	73	74	79	85	87	89	88	82	78	79	84	88	90	88	89	88
降雨機率(%)	20		20		10		20		0		10		10		0		0		0		30			
舒適度	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.5	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.7
浪高(m)	2.5	2.4	2.3	2.0	1.6	1.4	1.1	1.0	0.8	0.6	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
浪向	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	東北風	西北風
浪周期(s)	6.3	6.2	6.0	5.8	5.6	5.3	5.1	5.0	4.7	4.6	4.7	4.9	5.0	5.0	5.1	5.1	5.2	5.3	5.4	5.5	5.6	5.6	5.6	5.5



Meteorological-Information Based Green Energy Operations Center in CWB

Offshore Construction Marine Weather Risk System

船舶派遣與追蹤決策系統

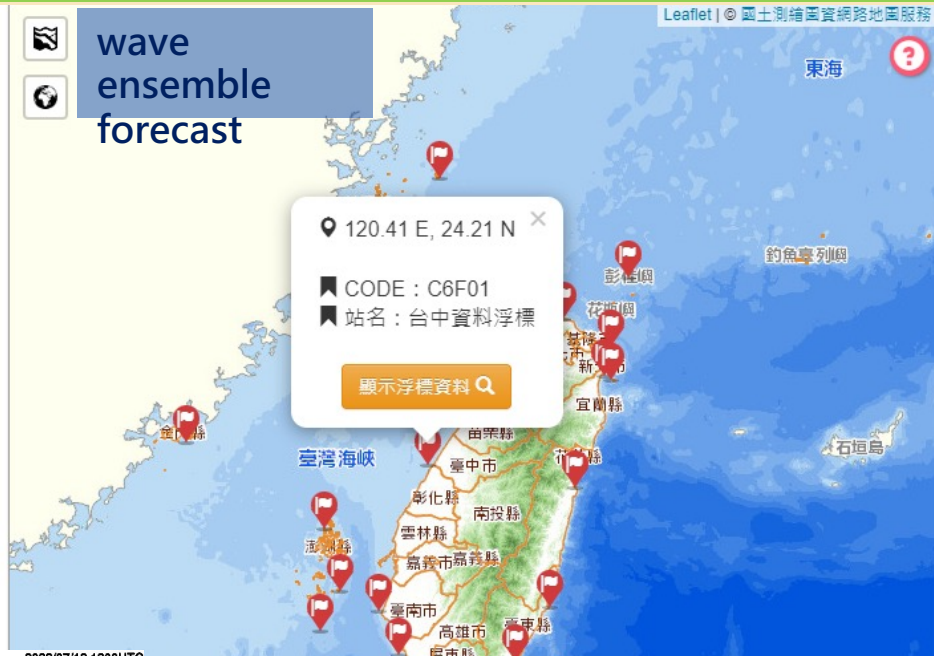
離岸風機發電量評估展示系統

離岸風場區海氣象監測與預報系統

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- 潮預報

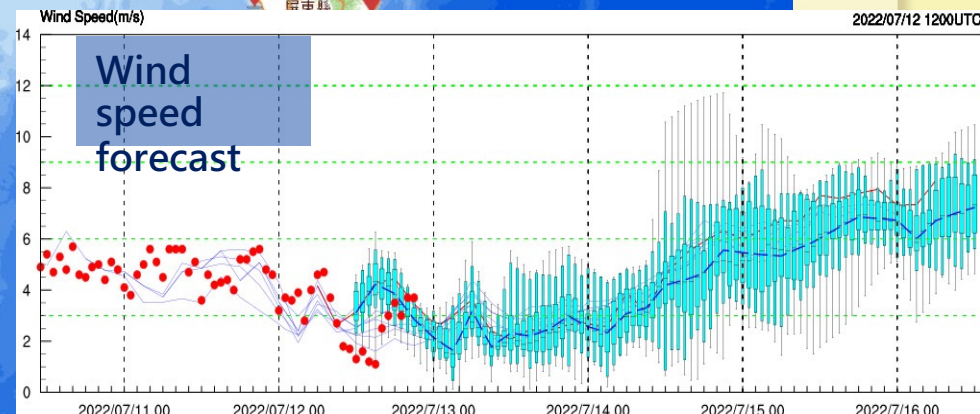
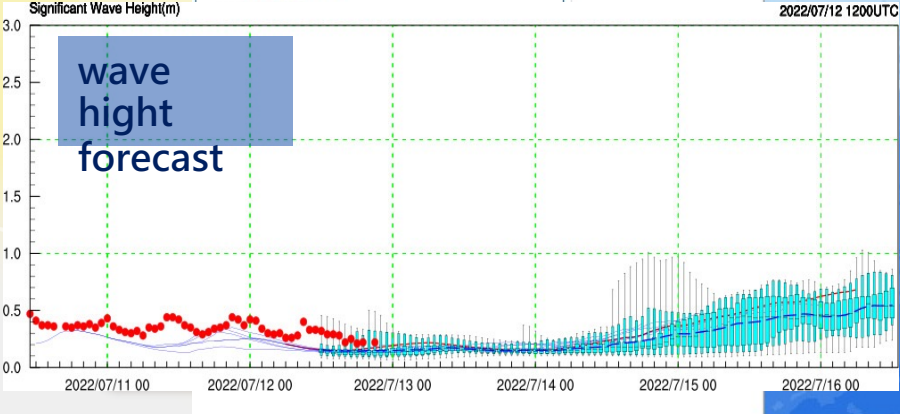
波浪系集預報

- 單點圖
- 24張系集團
- 系集平均圖



2022/07/12 1200UTC

2022/07/12 1200UTC



The Practice of Public-Private Engagement





Public-private partnership (PPP) and Public-private Engagement (PPE)

Public-private partnership

- WMO Congress defined 'partnership' as working with international agencies, other organizations, academia, the media and the private sector to improve the range, quality and delivery of critical environmental information and services.
- PPP are voluntary and collaborative relationships among various actors in both public (State) and private (non-State) sectors, in which all participants agree to work together to achieve a common goal or undertake specific tasks.

Public-private Engagement

- The purpose of PPE is to guide global, regional and national action by the WMO and its Members to successfully manage and participate in the Global Weather Enterprise.

2015

- WMO proposed an engagement to assist the cooperation between private sectors and NMHS.

2017

- WMO launched the development roadmap of PPE.

2018

- WMO published Policy Framework for Public-Private Engagement

2021

- WMO proposed the Guidelines for Public-Private Engagement.



Principles of Engagement

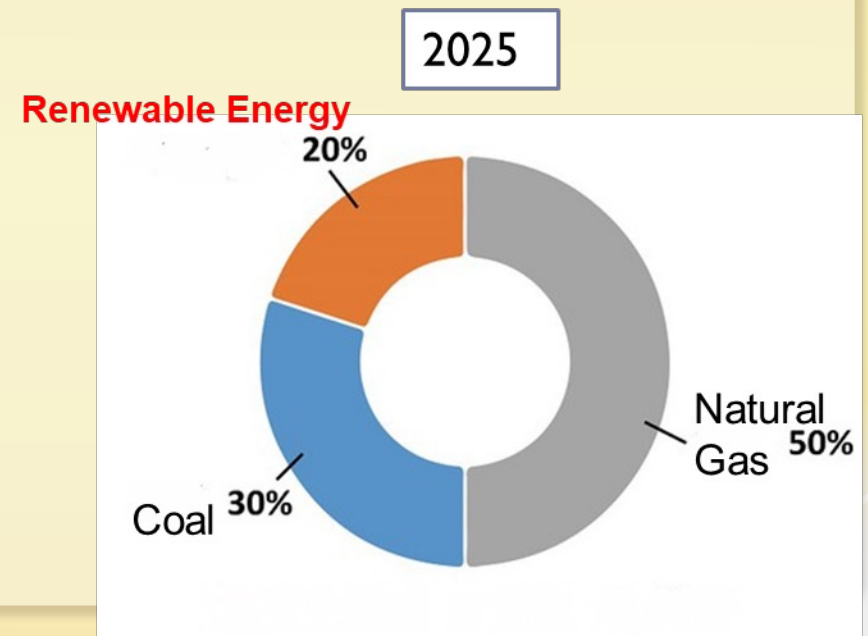
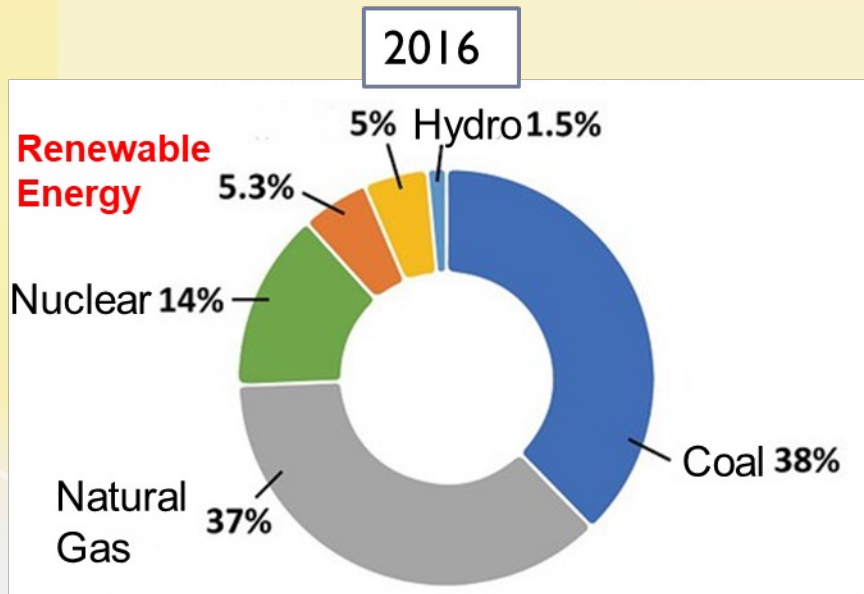
- ▶ The PPE policy framework steps on the core values and goals of the WMO and serves two main tasks:
 - ✓ To guide an effective engagement of the public, private and academic sectors in the GWE.
 - ✓ To guide Members' intentions and efforts in expanding the public-private-academic partnerships for ensuring better service to their governments, business and citizens.
- ▶ The principles of PPE contained:
 1. 'People First'
 2. WMO Guidelines on commercial relations
 3. Mutual benefit
 4. Shared value
 5. Sustainability
 6. Advancing together
 7. Level playing field
 8. Integrity and Transparency
 9. Sovereignty





The Green Energy and Policy of Taiwan

- ▶ According to the “Renewable Energy Development Act”, the amount of renewable energy for power supply, which 2016 stands at around 5.3 %, has to be increased to 20 % by 2025.
- ▶ Main renewable energy in Taiwan is Wind and Solar energy, all are strong influenced by weather. In order reach the targets, we start a program to meet green energy industry application requirements.





How do we build up partnership with private sector in Taiwan?

- ▶ We follow the principle of PPE and propose the following steps:
 - ✓ Step 1: Define the climate services value chain in renewable energy
 - ✓ Step 2: Survey and discuss with stakeholders
 - ✓ Step 3: Sign MOU with renewable energy units
 - ✓ Step 4: Holding workshop every year

Define Value
Chain

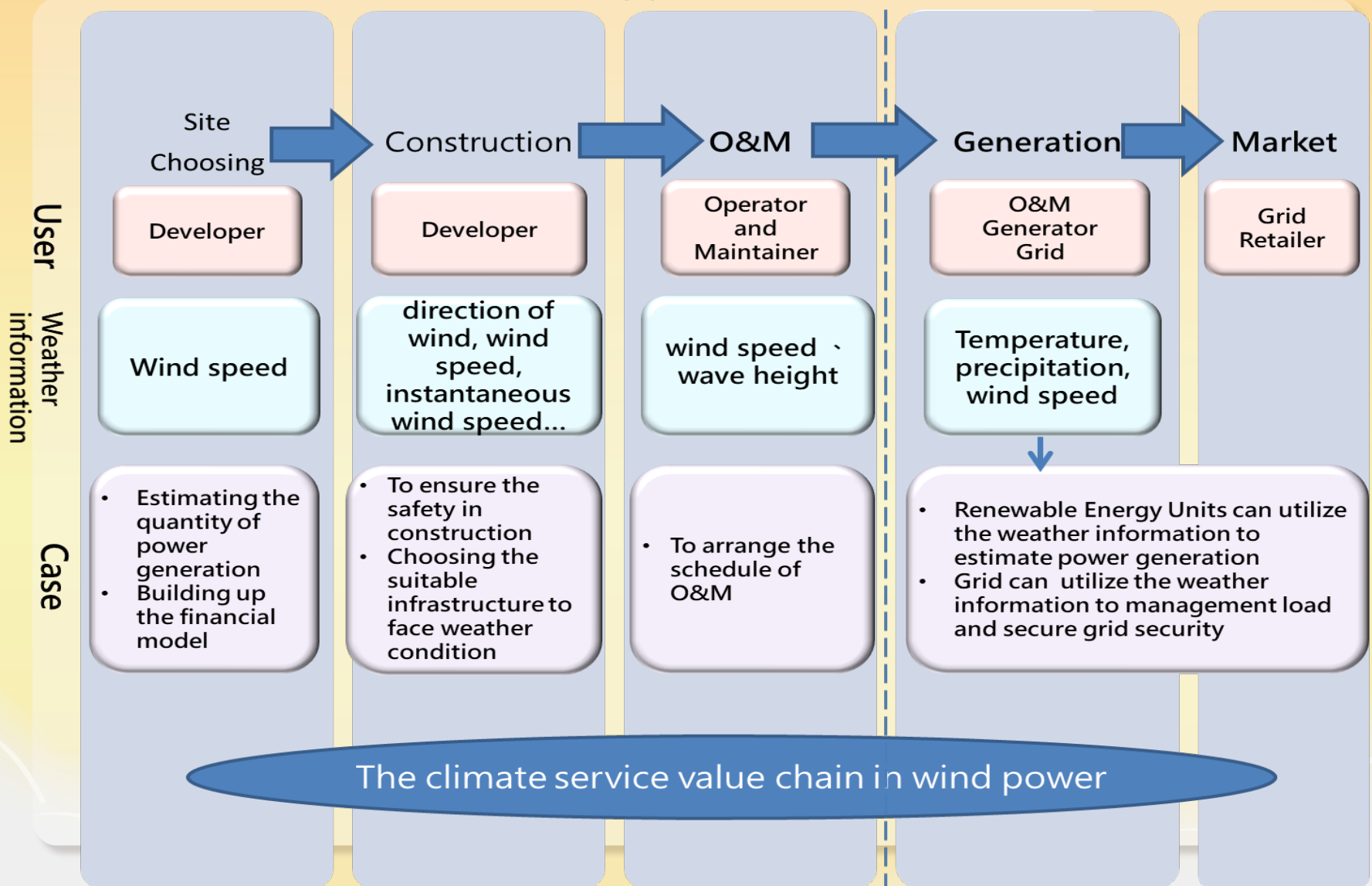
Talk to
stakeholders

Sign MOU

Holding
workshop

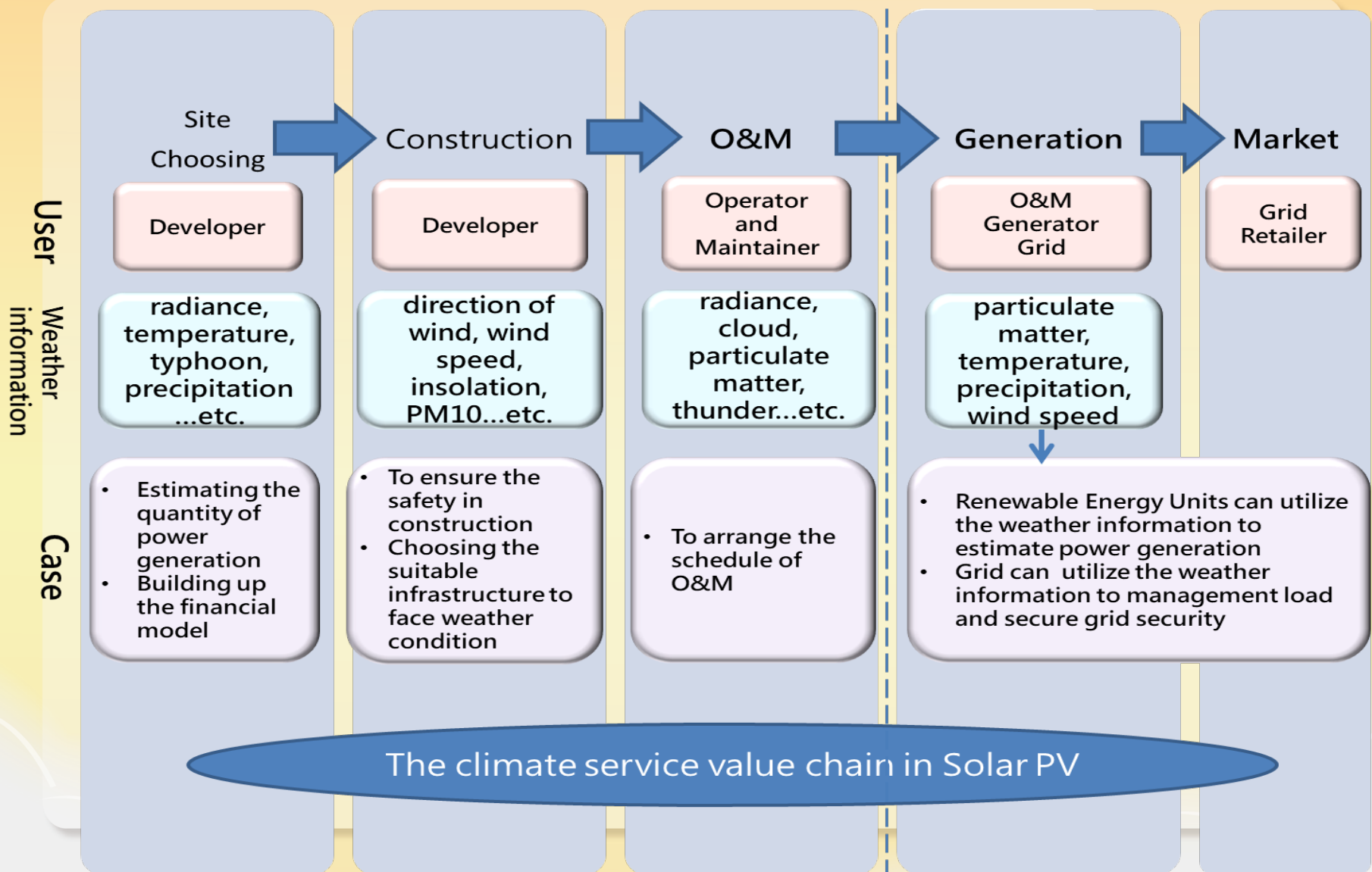


Step 1: Define the climate services value chain in renewable energy(1/2)





Step 1: Define the climate services value chain in renewable energy(2/2)





Step 2: Having a Dialogue with Private Sectors

- ▶ After studying the potential opportunity of climate services in green energy, **we held the meetings between private sectors**, such as Taiwan Power Company, Renewable-Energy-Based Electricity Retailing and other renewable energy units.





Step 3: Finding the Cooperation Opportunity between public and private sector



- ▶ After **discussing with private sectors**, we dig out the business will bring benefit to both of public and private sector.
- ▶ These collaborations are not just unilateral provision of data by the CWB, but also create the new systems with private sector.

Source : iStock, MOU, retrieved from <https://www.istockphoto.com/illustrations/mou>.



Step 4: Holding the Workshop(1/2)

- ▶ In order to expand and deepen the climate services in energy sector, we held the “Workshop on the Application of Climate Services in Green Energy”



Keynote
speech



Round
table



General
session



Step 3: Holding the Workshop(2/2)





Summary and Conclusion

- We continue to improve the meteorological monitoring and forecasting capabilities related to green energy forecasting, carry out interdisciplinary cooperation with green energy teams.
- We build up and progressively revise the public-private cooperation mechanism, and research to promote the value-added application of meteorological information.
- Strengthen the cooperation between agencies and the public and private, and jointly create a favorable environment for the industrialization of meteorological information in green energy applications

A decorative graphic on the left side of the slide consists of a cluster of yellow hexagons of varying sizes and orientations. Some hexagons contain white icons: a satellite dish, a telescope, a classical building with columns, a globe, a computer monitor, a waveform, and a structure resembling a space station or a large antenna. The background is a gradient of light yellow to white, with faint white curved lines at the bottom.

Thank you for your attention!