



經濟部能源局

BUREAU OF ENERGY, MINISTRY OF ECONOMIC
AFFAIRS



12 Key Strategies for Taiwan' s 2050 Net-Zero Transition (Draft)

Key Strategy 3 - Innovative Energy

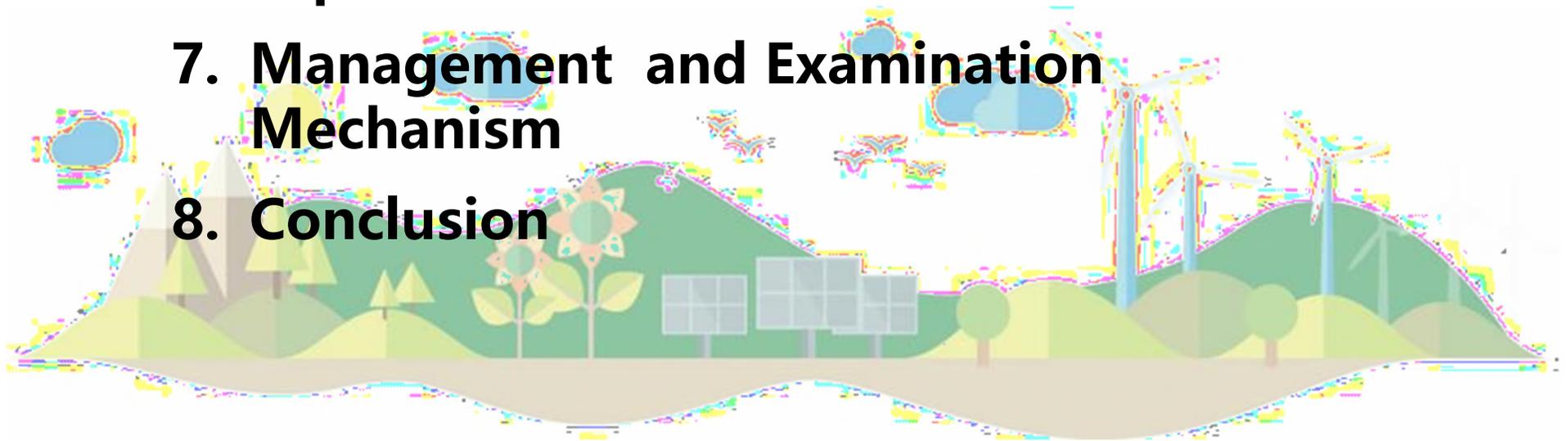
(Geothermal Power Generation/Bioenergy/Ocean Energy)

Bureau of Energy, MOEA



Outline

- 1. Analysis of Current Status**
- 2. Project Goal and Pathway**
- 3. Promote Schedule**
- 4. Unit Assignments**
- 5. Strategies and Methods**
- 6. Expected Benefits**
- 7. Management and Examination Mechanism**
- 8. Conclusion**





1. Analysis of Current Status - Current Situation of Global Geothermal Power Generation (1/2)

Global Geothermal Power Generation Cumulative Installation Capacity and Top Ten Countries

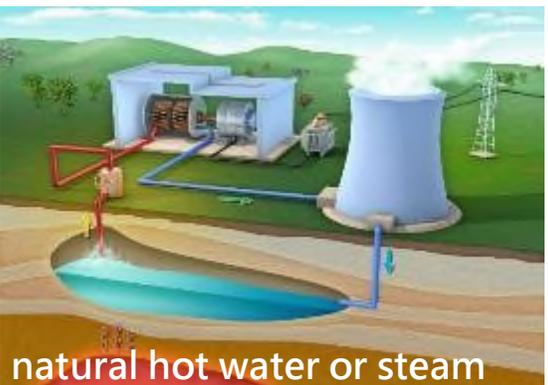
- In 2021, global cumulative installation capacity **amounted to 15.9GW**, with an average growth rate of **4.6%** in the past ten years.
- The top ten countries accounted for **91%** of global installed capacity, and six of them had exceeded **1GW**.





1. Analysis of Current Status - Current Situation of Global Geothermal Power Generation (2/2)

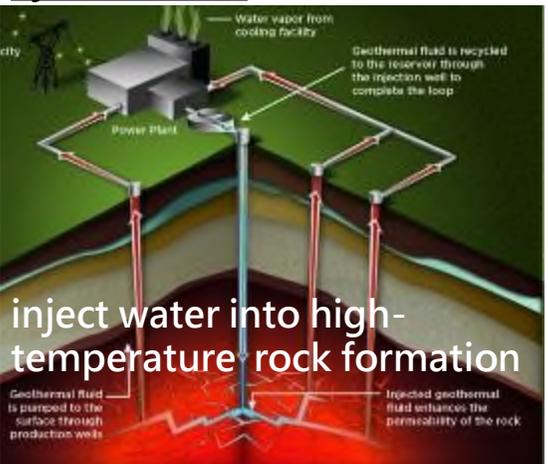
Current Status of Geothermal Technology Development



natural hot water or steam
Conventional Geothermal System (CGS)

Conventional Geothermal System

- ❑ Utilize natural **hot water** and **steam**
- ❑ Depth of wells mostly between 500 and 3,000 m
- ❑ Mature commercial technology



inject water into high-temperature rock formation

Enhanced Geothermal System (EGS)

Technologies Under Development

- ❑ **Inject water** into high-temperature rock formation to **extract heat**: **Enhanced Geothermal System (EGS) & Advanced Geothermal System (AGS)**
 - **Enhanced Geothermal System, EGS**
In high-temperature but dry formation, inject water to create fractures and extract heat. (US DOE expects to be **commercialized** in 2035)
 - **Advanced Geothermal System, AGS**
In high-temperature and dry formation, create closed channels and inject water to extract heat without artificial cracks. (**Validated** at German **test site**)
- ❑ **Supercritical Geothermal System (SGS)**
 - Extraction of **supercritical fluid** from mantle and magma in **volcanic areas** to generate power. (**Drilling research** phase; still in proof-of-concept phase)



1. Analysis of Current Status - Current Situation of Global Bioenergy Development

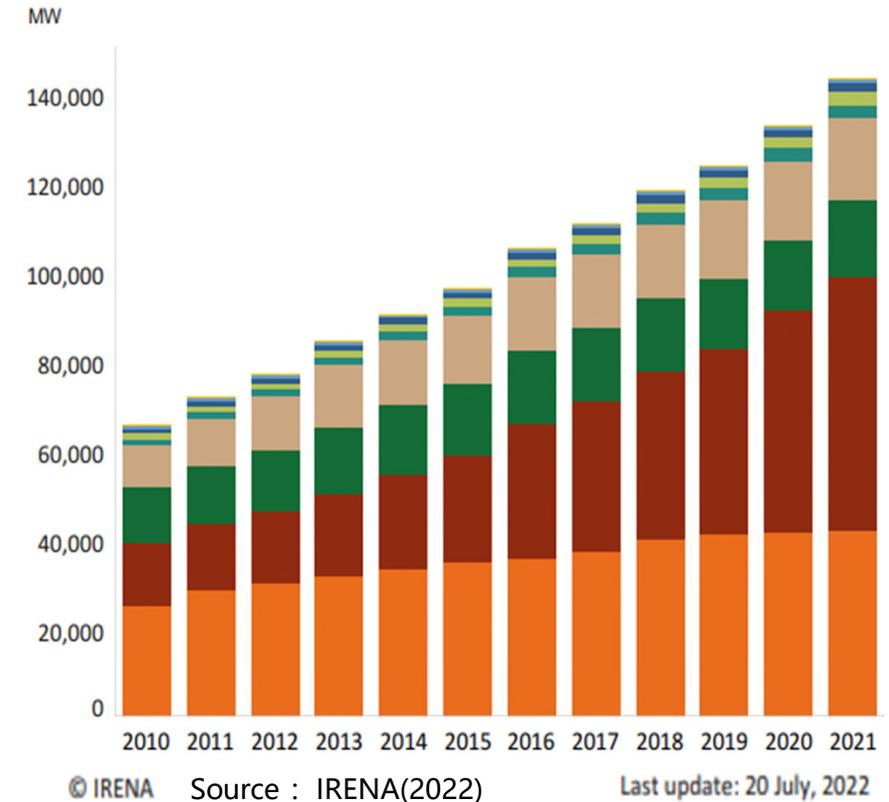
Global Bioenergy Capacity

□ Key Features of Global Bioenergy

- **Bioenergy** is **considered** carbon-neutral and can be applied to **power and heat generation, and transportation**.
- **Bioenergy** can replace **fossil fuels** on base-load power system.

□ Bioenergy Capacity Continues Incrementing

- Under the vision of net zero energy transition, the capacity of global bioenergy were accounted for **143 GW** in 2021. (growth rate: 7.5%)
- Biomass source: Forestry residues or agriculture waste were 82%; urban waste were 12%



1. Analysis of Current Status - Current Situation of Global Bioenergy Development

Future Trends of Bioenergy

Demands are growing steadily

- IEA estimates modern bioenergy will account for **18%** of total final consumption by 2050. (**4.5% @ 2015**) Ref: IEA Bioenergy

Trends in technology development

- Bioenergy and Waste-to-Energy technology have been well developed, and further development of high-efficiency biomass-energy conversion systems with **multi-biomass** and carbon capture and storage system (**CCS**) can accelerate the achievement of net zero emission goals.
- Converting coal-fired power system to **biomass power system**. (Coal-to-biomass)
- Multi-biomass treatment system
 - ✓ Thermochemical gasification system: High-efficiency, low-pollution fuel conversion technology
 - ✓ Biogas power generation system: Biogas production technology (anaerobic fermentation to produce biogas)

Coal-to-biomass Conversion System



Drax-2,595MW



Suzukawa-85MW



Amer-631MW



Yeongdong-125MW

Biogas



Linkogas-2MW

BECCS



KVV8-285MW_{th}+130 MWe
Linked to CCS in 2023

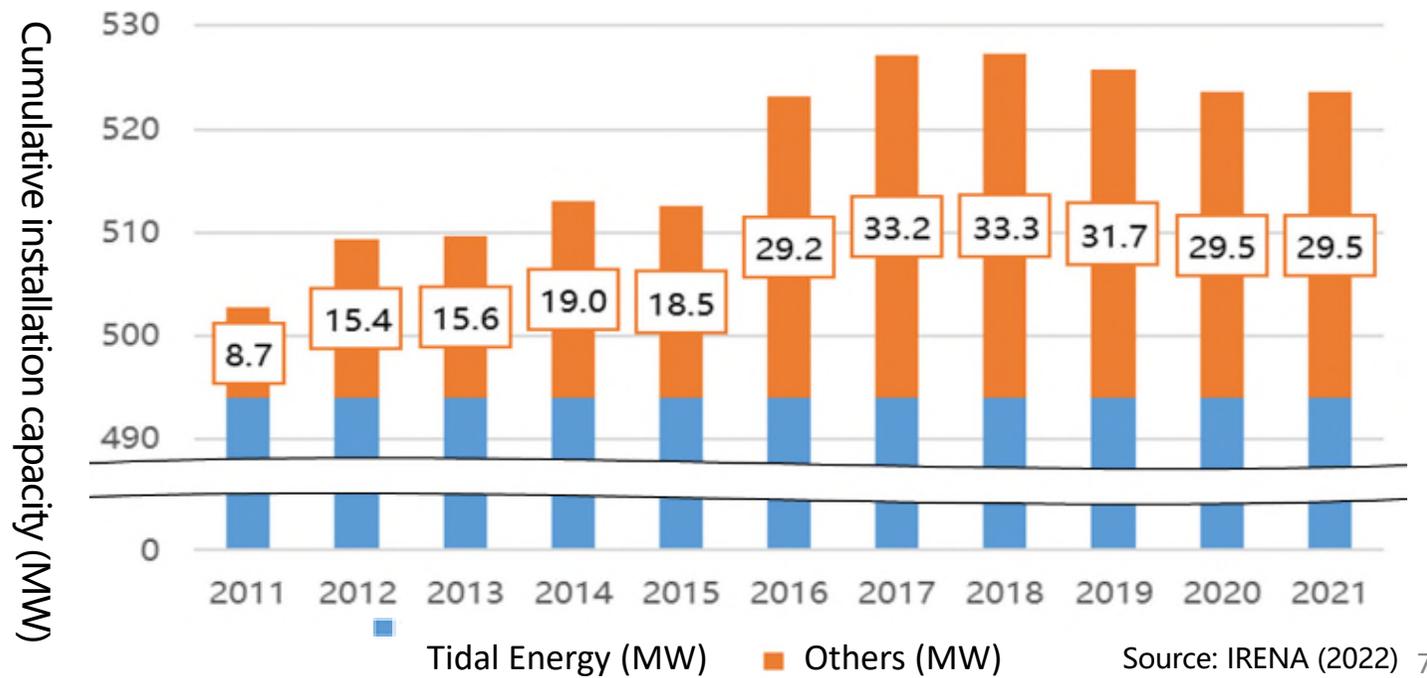


1. Analysis of Current Status - Global Ocean Energy Development

Status Quo (1/2)

Global Ocean Energy Installation Capacity

- Ocean energy refers to tidal range, tidal stream, ocean current, wave energy, ocean thermal energy conversion (OTEC), and salinity gradient energy, etc.
- As of 2021, the total global installed capacity was **524 MW**, in which **tidal energy** had relatively matured, accounting for 494 MW (about **94%** of the total installed capacity).
- Exclusive of tidal range energy, the primary installed marine energy in the last decade (2011-2021) was **ocean currents** and **waves** in an average growth rate of **5.8%**.





1. Analysis of Current Status - Global Ocean Energy Development Status Quo (2/2)

Global Ocean Energy Installation Capacity

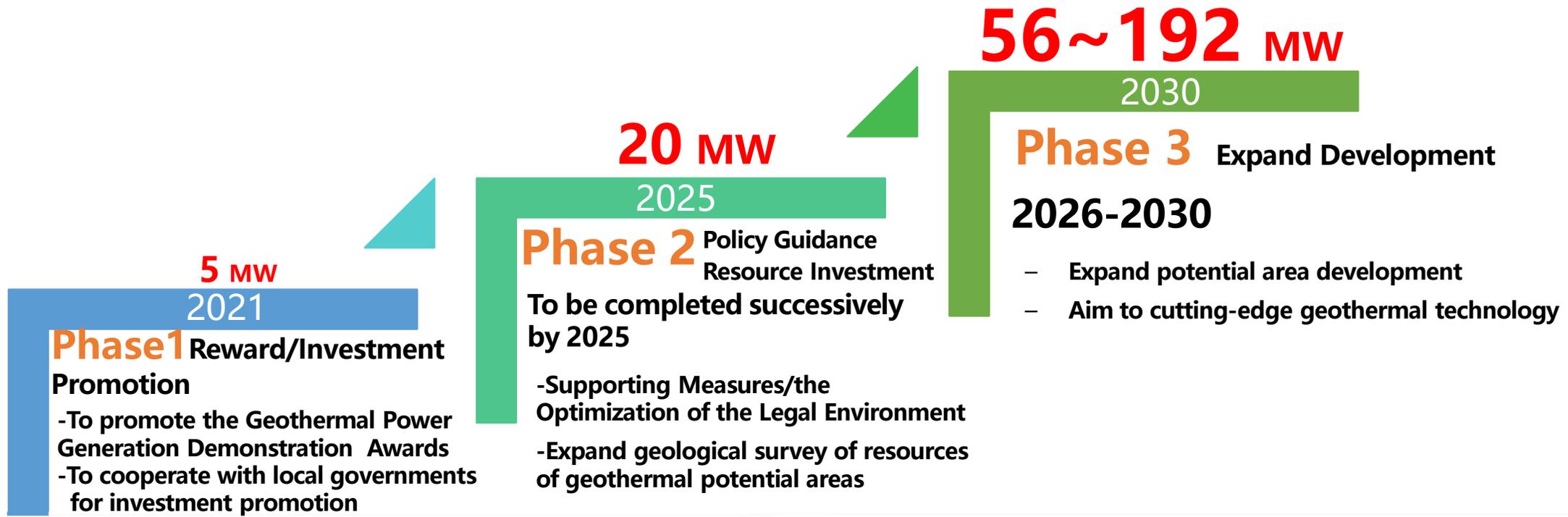
- **Tidal range energy** has nearly been in commercial power plant level (TRL 8-9). France and South Korea, among other countries, had constructed tidal range power plants of capacities over 200 MW.
- **Other types of ocean energy are still under development.** (TRL 3-7)

Energy type	Commercial (TRL 8-9)		Research and Demonstration (TRL 3-7)			
	1. Tidal Range	2. Tidal Stream	3. Wave	4. Ocean Current	5. OTEC	6. Salinity Gradient
Cumulative Installation Capacity	494 MW	25.2 MW	4.2 MW	NA	0.23 MW	0.05 MW
1966~ France - La Rance - 240 MW		Scotland - MeyGen - 6MW	Spanish - Mutriku - 296 kW	Hawaii Makai - 100 kW	Netherlands - REDstack - 50 kW	
2011~ South Korea - Sihwa Lake - 254 MW		 2017~	 2011~	 2015~	 2014~	

Source: IRENA (2022) · IEA-OES (Ocean Energy Systems, 2021)



2. Project Goal and Pathway - Geothermal Power Generation Pathway



20MW by 2025

56~192 MW by 2030



2. Project Goal and Pathway - Bioenergy Pathway

724 MW

- Wastes (MSW, industrial Wastes, agricultural wastes) : 632MW
- Biomass energy(solid fuels) : 71 MW
- Biomass energy(biogas) : 21MW

MSW: Municipal solid waste

2021

Phase1 Construction of The Infrastructure

- Agricultural Waste was added in FIT
- Subsidy Demonstration: Bioenergy-biogas power plants

778 MW(target)

2025

Phase2 Distributed Bioenergy Generation Systems

Building new bio-power plants before 2025

- Wastes (MSW, Industrial Wastes) ≥ 80 MW
- Wastes (agricultural waste) ≥ 1 MW
- Biomass energy (biogas) ≥ 3 MW

805~1,329 MW

2030~

Phase3 Coal-fired Power Plant Transition

2026-2030

- Coal-to-biomass conversion power system: 500 MW (bioenergy)
- Bioenergy (biogas) : 1 MW
- Wastes (MSW, and Industrial Wastes: 30MW

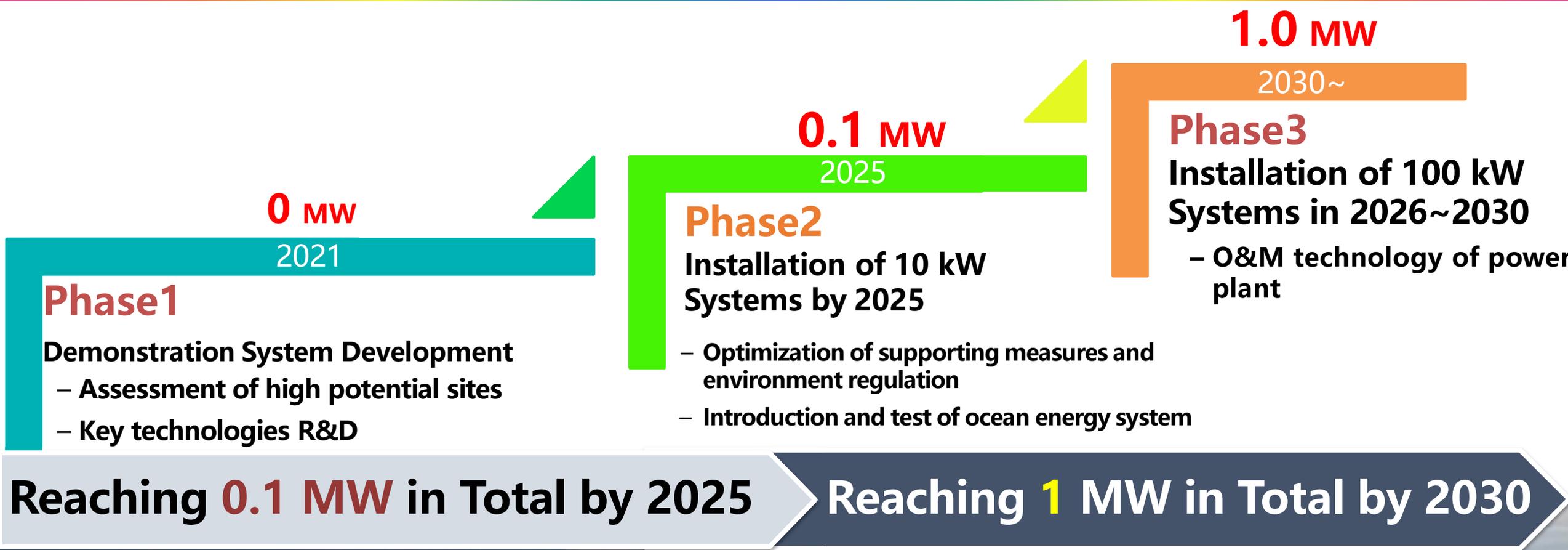
778 MW in 2025

805~1,329 MW in 2030





2. Project Goal and Pathway - Ocean Energy Pathway





3. Promote Schedule - Geothermal Power Generation Short-Term Promotion

Economics

- 1-1 **Feed-in-tariff** Reinforce Incentives.
- 1-2 Formulate **the Geothermal Power Generation Demonstration Awards** to share exploration risks among developers.

Regulation

- 1-3 Revise **the Renewable Energy Development Act Amendments** to the Renewable Energy Development Act.

Resource

- 1-4 **The public sector** is actively exploring.
- 1-5 **Geothermal Exploration System website** to Disclose the Geothermal Exploration Information.

Technology

- 1-6 **CPC Promotes Drilling Ability** to Accelerate the Construction of Geothermal Sites.
- 1-7 Aim to **Cutting-Edge Geothermal Technology**.

3. Promote Schedule - Bioenergy Short-Term Promotion



Construction of the Infrastructure

- 2-1 Driving the biomass/waste-to-power market by **FIT** and **subsidy incentives**.
- 2-2 Promoting the construction of infrastructure for SRF (Solid Recovered Fuel) and biogas/agricultural waste power plants.



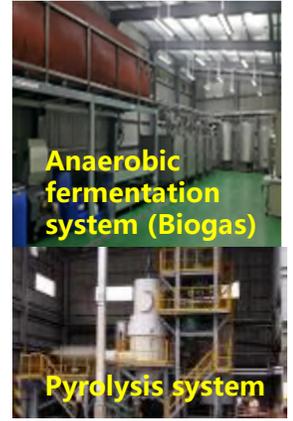
Establish Large-scale Biomass Power System

- 2-3 Establish and introduce biomass power system.
- 2-4 Develop overseas biomass feedstock market.



Optimize Technology to Expand Capacity

- 2-5 Develop high efficiency biomass conversion technology. (Thermochemical gasification and anaerobic fermentation)
- 2-6 Effective utilization of the by-products (e.g. ash or biogas residues)



3. Promote Schedule - Ocean Energy Short-Term Promotion

Ocean Energy Policy

- 1 Rolling revision of marine energy **FIT**.
- 2 Clarifying the **application and installation procedures** for ocean energy system.

Ocean Energy Technology Development

- 3 Identifying proper ocean energy **development sites**.
- 4 Assessing the feasibility of **hybrid ocean energy systems** and optimizing the utilization of marine space.
- 5 Improving key technologies, such as typhoon weather-tolerant technologies, high reliability or efficiency of **ocean energy systems**.



3. Promote Schedule - Foresight Energy Medium and Long-Term Promotion Concept

Perspectives	Promotion Concept from 2031 to 2050
Geothermal Power Generation	<ol style="list-style-type: none">1. Explore and verify high heat flow potential areas.2. Clarify Geothermal resource, mature advanced geothermal technology, and gradually develop geothermal energy in metamorphic rock areas and igneous rock areas.
Bio-energy	<ol style="list-style-type: none">1. Continue to investigate domestic or overseas feedstock with application potential, and integrate the biomass feedstock system.2. Promote high-efficiency power generation technology and its by-product reuse, and adjust relevant laws and regulations timely with technological development, such as incentives for waste reuse routes and FIT...etc.
Ocean Energy	<ol style="list-style-type: none">1. Inventory infrastructure, such as marine ports and engineering construction ships.2. Enlarge the capacity of ocean energy installations by sharing platforms, fields, and related equipment (substations and grid connections), and optimizing utilization of marine space.

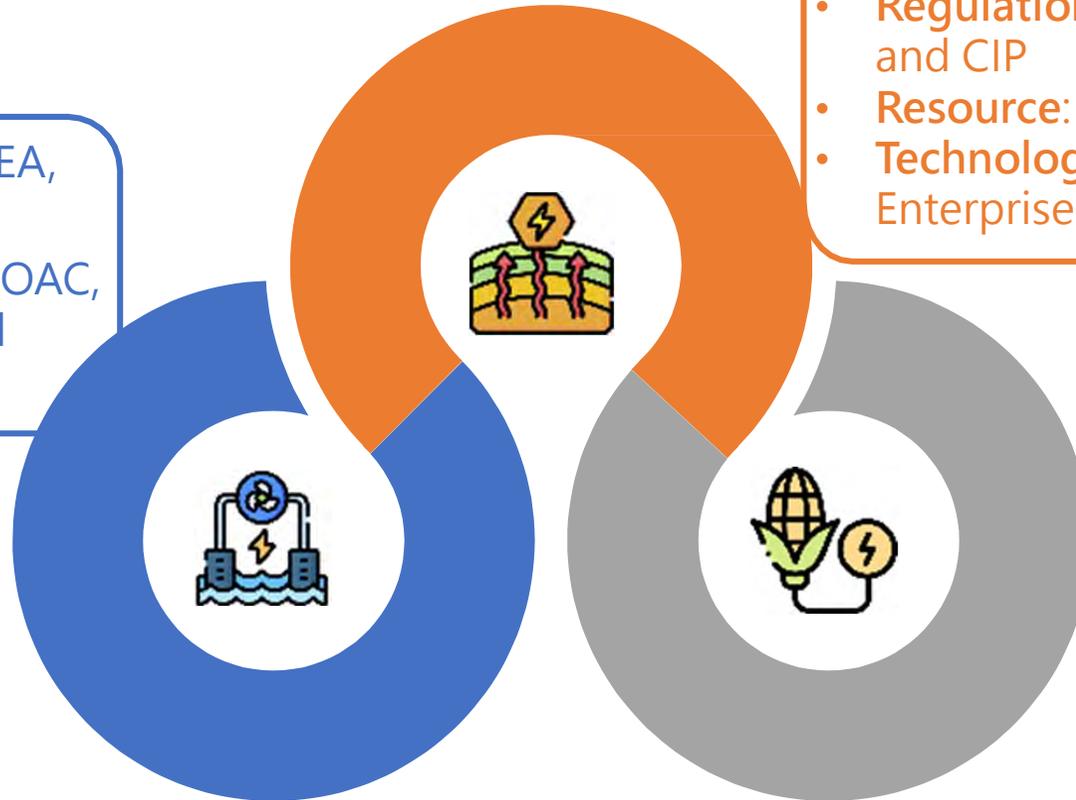


4. Unit Assignments - Central Government Authorities

Ocean Energy

Host: NSTC

- Supporting Measures: MOEA, OAC, and NSTC
- Technology Development: OAC, NSTC, Academia Sinica, and MOEA



Geothermal Power Generation

Host : MOEA

- Economics: MOEA
- Regulation: MOEA, State-Owned Enterprises, and CIP
- Resource: MOEA and State-Owned Enterprises
- Technology: MOEA and State-Owned Enterprises

Bioenergy

Host : MOEA 、 EPA 、 COA 、 MOE

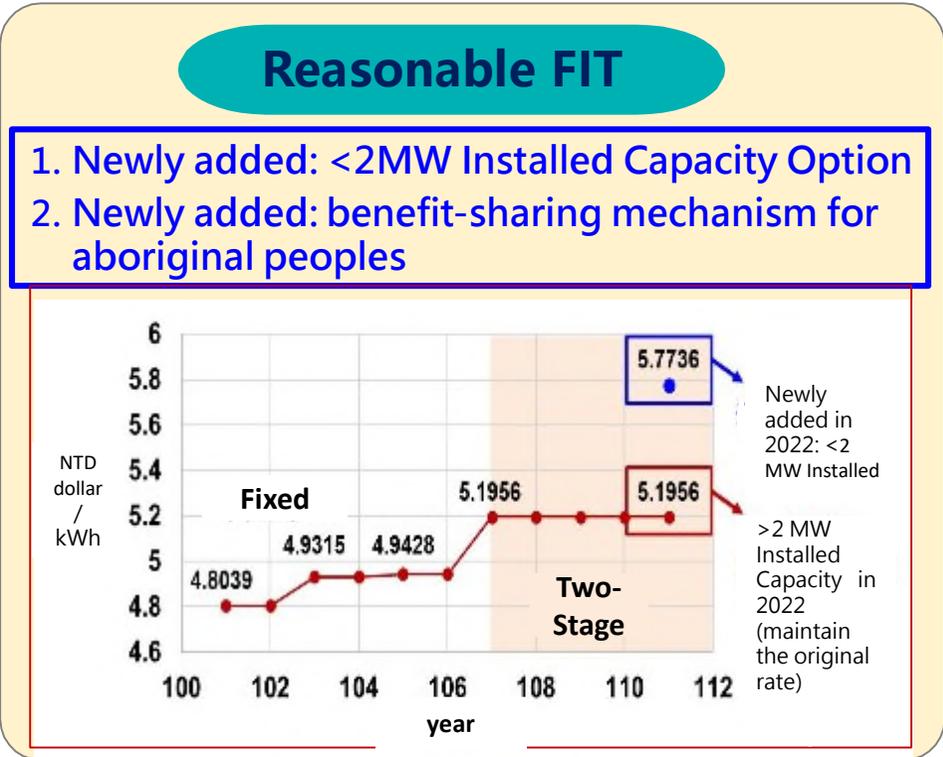
- Construction of The Infrastructure: MOEA, EPA, and COA
- Establish Large-Scale Biomass Power System: MOEA, EPA, and COA
- Optimize Technology to Expand Capacity: MOEA, EPA, and COA



5. Strategies and Methods - Geothermal Power Promotion Plans (1/4)

Economics: Policies Drive Market

- 1-1 Feed-in-tariff to Increase Investment Incentives: rolling wave planning of Feed-in Tariff and its associated incentives.
- 1-2 Formulate the Geothermal Power Generation Demonstration Awards, reward local governments for investment promotion, and to share exploration risks among developers.



The Geothermal Power Generation Demonstration Awards

Apply for rewards in installments according to the exploration progress to reduce the initial financial burden of developers

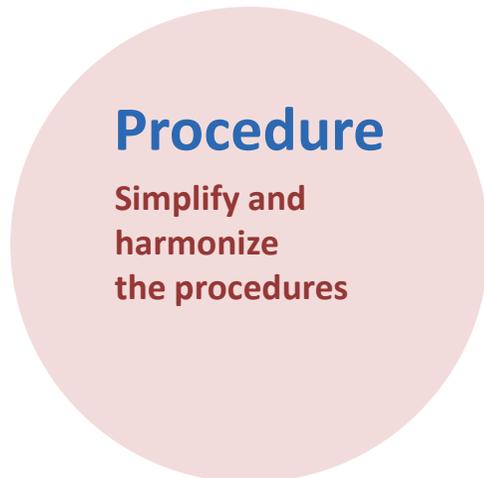
	Investment Promotion Reward	Exploration Reward
Reward objects	local government	developers
Reward amount	Maximum 3 million NT dollars	Maximum 100 million NT dollars
Reward items	<ul style="list-style-type: none"> Investment Promotion Promotion or counseling measures related to investment promotion 	<ul style="list-style-type: none"> Surface Survey Cost Geothermal Well Drilling Cost



5. Strategies and Methods - Geothermal Power Promotion Plans (2/4)

Regulation: Interministerial Coordination and Optimization of Geothermal Development Procedures

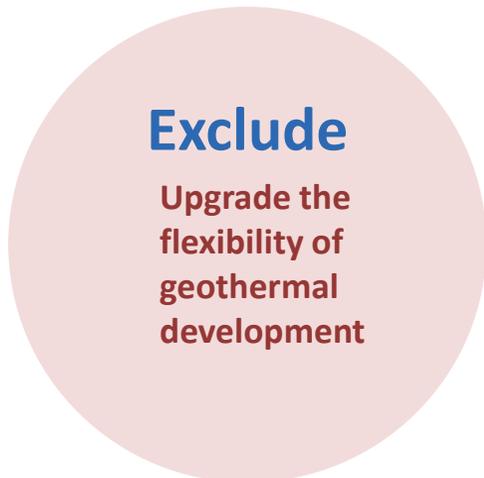
1-3 Revise the Renewable Energy Development Act Amendments to the Renewable Energy Development Act



- **Unify and clarify** geothermal exploring and developing procedure.
- Joint review by central and local governments.



- Water right: **up to 20 years.**



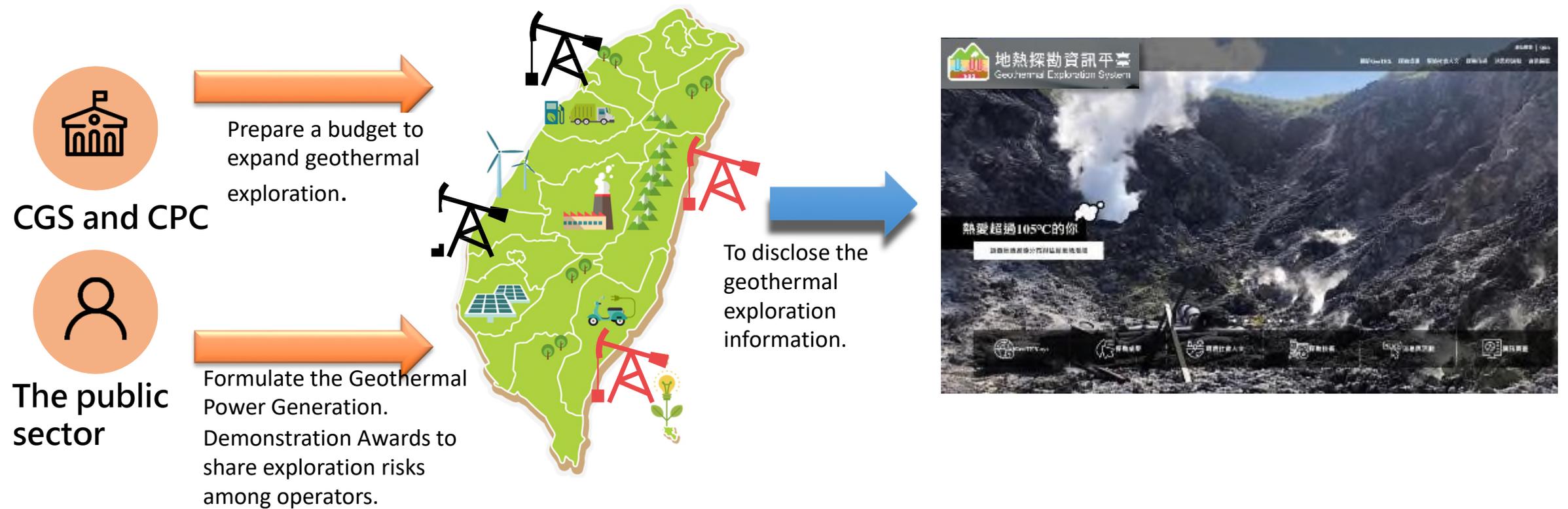
- Enhance the development of geothermal power by **excluding** selected sections of the Hot Spring Act.



5. Strategies and Methods - Geothermal Power Promotion Plans (3/4)

Resource: Expand Geothermal Resource Exploration and Disclose the Geothermal Exploration Information

- 1-4 The public sector implement exploration: Engage in the drilling of exploration wells and resource assessment around the whole country.
- 1-5 Geothermal Exploration System website to disclose the geothermal resource information: Compile and publish geothermal survey results.





5. Strategies and Methods - Geothermal Power Promotion Plans (4/4)

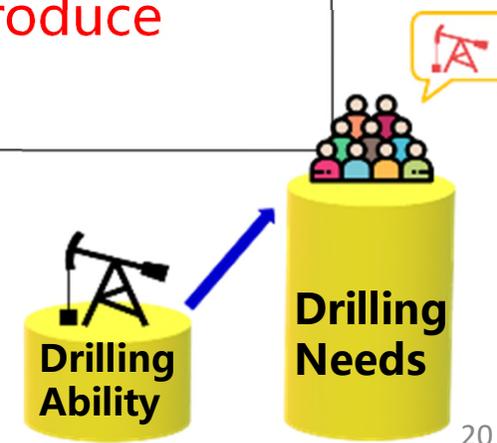
Technology: Technology Optimization & Ability Improvement

1-6 CPC promotes drilling ability to accelerate the construction of geothermal sites

- **Import** high-efficiency **drilling rigs**, **expand** drilling **teams**, and strengthen drilling ability.
- Investigate drilling requirements of geothermal developers, match **drilling teams** and **developers**.

1-7 Aim to cutting-edge geothermal technology

- **EGS & AGS** : Collect development roadmap of **EGS & AGS**.
- **Introduce cutting-edge geothermal technology**: To evaluate and **introduce** suitable advanced geothermal technology for Taiwan.





5. Strategies and Methods - Bioenergy Promotion Plans (1/3)

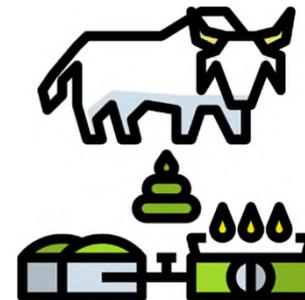
Continuing to Construct the Infrastructure

2-1 Driving the biomass/waste-to-power market by FIT and subsidy incentives

- **Policy Promotion:** Encourage enterprises to use biofuel by setting the FIT rates timely and subsidy incentives.
- **Biomass energy** (Biogas): **5.1842 NTD/kWh** ; **Wastes(MSW, industrial wastes): 3.9482 NTD/kWh**; **Wastes (Agricultural Waste, added in 2022) : 5.1407NTD/kWh.**

2-2 Promote SRF, Agricultural Waste, and Biogas Power Plant Practically

- Continuously promote new construction and modification of biomass/waste energy systems.





5. Strategies and Methods - Bioenergy Promotion Plans (2/3)

Establish Large-scale Bio-power System

2-3 Introduce biomass-fired power system

■ Technology Introduction and Development:

- Transform large-scale coal-fired power plant to **biomass-fired** power plant.
- Establish the management **experience** of large-scale system.

2-4 Develop overseas biomass feedstock market

■ Inventory and Scheme Overseas Biomass Feedstock

- Develop overseas **biomass feedstock** (wood pellet) **market** to improve domestic supply chain capability.
- Establish domestic supply chain. (e.g. for delivery and storage)



Drax power plant



Transformation of coal-fired power plant (Hsing-ta Power Plant)



5. Strategies and Methods - Bioenergy Promotion Plans (3/3)

Optimize Technology to Expand Capacity

2-5 Develop high efficiency biomass conversion technology

■ Improve power generation technology and performance

- Develop **diverse energy conversion** technologies for biomass/waste gasification and **biogas** power system.

2-6 Utilize the by-products for improving economic benefits

■ Verify high-value application for by-products

- Promotion of reuse combustion by-products: Evaluate the high-value application/resourcezation technology of biomass **derived by-products** (e.g. co-fired ash, biomass ash, slurry, and sludge) and their feasibility.





5. Strategies and Methods - Ocean energy Promotion Plans (1/3)

Ocean Energy Supporting Policy Measures

3-1 Rolling Revision of Marine Energy FIT

■ Yearly Revising FIT

- Providing reasonable incentives to encourage relatively mature technologies to enter the market as soon as possible.
 - Ocean energy: NT\$**7.32/kWh (2022~)**

3-2 Clarifying the Application and Installation Procedures for Ocean Energy System

■ Completing the Process for Application and Installation of Ocean Energy

- Collecting and tracking development projects, analyzing development risks.
- Encouraging industries to apply for government R&D programs and invest in ocean energy system R&D, tests, and installation.





5. Strategies and Methods - Ocean energy Promotion Plans (1/3)

Ocean Energy Technology Development

3-3 Identifying Proper Ocean Energy Development Sites.

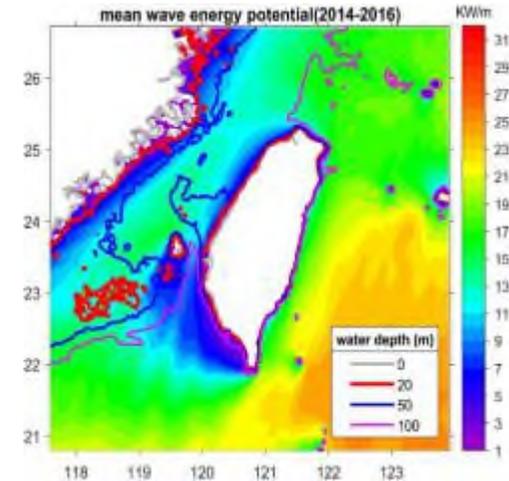
■ Evaluating the Potential Power Generation Capacity of Marine Energy.

- Calculating and evaluating the potential marine energy based on marine meteorological data.
- Assessing the potential of marine energy and identifying proper development areas.

3-4 Assessing the Technical Feasibility of Hybrid Ocean Energy Systems and Optimizing Utilization of Marine Space.

■ Key Technologies for Frontier Ocean Energy

- Frontier technologies in deep-water mooring, anchoring, power generation, and transmission.
- Assessing the viability of hybrid ocean energy technologies.



Taiwan wave energy distribution simulation



Combined power plant illustration (wind energy + wave energy)



5. Strategies and Methods - Ocean energy Promotion Plans (3/3)

Ocean Energy Technology Development

3-5 Advancing or Adopting Critical Technologies, Such as Typhoon Weather-Tolerant Technologies, High Reliability and High Efficiency of Ocean Energy Systems.

- **Advancing or Adopting Critical Technologies for Demonstration.**
 - Advancing or adopting key technologies and system of wave power energy.
 - Setting up test and demonstration areas for ocean energy.

Source: Eco Wave Power ; European Marine Energy Centre (EMEC)



Key technologies for typhoon-weather tolerant system.



Test equipment for critical transmission mechanisms.



5. Strategies and Methods -Budget

2023~2024

Geothermal Power Generation



Bioenergy



Ocean Energy



BOE, MOEA

NT\$ 680 M

CGS, MOEA

NT\$ 1.39 B

Taipower

NT\$ 40 M

CPC

NT\$ 1.978 B

BOE, MOEA

NT\$ 0.283B

TSC

NT\$ 1.736B

BOE, MOEA

NT\$120 M

TPC

NT\$226 M

NSTC

NT\$140 M

OAC

NT\$200 M

Academia Sinica

NT\$120~140 M

NT\$ 4.088 B

NT\$ 2.019 B

NT\$ 806~826 M



5. Strategies and Methods – Social Communication Planning



To respect the opinions of the general public and stakeholders, the MOEA held a social communication meeting on the key strategy of “Wind/Solar PV” on December 17th, 2022.

Geothermal Power Generation

- Understand the need for assistance in local development and provide assistance to **local government**.
- Participate in **large-scale exhibitions** to help students or the public understand the basic concepts and advantages of geothermal power generation.
- Cooperate with NGOs to organize geothermal related **forums or seminars** to strengthen social participation and communication with stakeholders.

Bioenergy

- Through **propaganda or technical shows**, the general public or relevant industries can understand the benefits of developing bioenergy and be guided towards investment.
- Inviting **industries and experts** for discussions to ensure the promotion of bioenergy can achieve carbon reduction and promote the benefits of environmental sustainability.

Ocean Energy

- Discussing with relevant government departments to **clarify the application procedure** and construct the development environment.
- Raising stakeholder' s understanding of the advantages of developing ocean energy by **promotions and technology demos**.

6. Expected Benefit

Geothermal Power Generation



Bioenergy



Ocean Energy



	2025	2030		2025	2030		2025	2030
Cumulative Installation Capacity	20 MW	56~192 MW	Cumulative Installation Capacity	778 MW	805-1,329 MW	Cumulative Installation Capacity	0.1 MW	1.0 MW
carbon emission reduction*	65,000 tons	18~620,000 tons	carbon emission reduction*	2.06 M tons	2.18-4.00 M tons	carbon emission reduction*	130 tons	1,300 tons

Expected Benefits

- Clarify geothermal potential areas and accelerate the promotion of geothermal sites.
- Promote drilling ability to drive domestic industrial demand.
- Aim to **cutting-edge geothermal technology** and expand the numbers of power plants.

- Developing **efficient and diverse** (solid/liquid/gas) bioenergy technology.
- Introduce **large-scale bio-power systems** to accelerate green power supply and carbon reduction.
- **Develop domestic and overseas biomass feedstocks** to meet domestic carbon reduction needs.

- Promoting policy and supporting measures and to encourage industry investment.
- Adopting or R&D key technologies to **accelerate development of ocean energy system.**

* Carbon reduction calculation is based on the 2020 Electricity Emission Factor (0.502kg CO₂e/ kWh).



7. Management and Examination Mechanism

Management and Examination Planning

- ❑ Supervision and examination by **the authority** to Precisely control the overall execution progress of the project.
- ❑ By holding **task meetings** from time to time, review the action content and implementation results, adjust the implementation method or revise the indicators in a timely manner, and improve the implementation effect.

Management and Examination Mechanism in Different Areas

Geothermal power Generation	Bioenergy	Ocean Energy
<ul style="list-style-type: none">❑ Regularly supervise and promote by means of biweekly reports and adjudicate related action plans	<ul style="list-style-type: none">❑ Ongoing project tracking policy :<ul style="list-style-type: none">● Stay informed of the progress and ensure achievement of the planned goals.❑ Progress control :<ul style="list-style-type: none">● Periodically reviewing the development plan and strategy.	<ul style="list-style-type: none">❑ The main governing body, NTSC, is holding cross-departmental meetings for tasks division and promotion.



8. Conclusion- Future Prospects

Geothermal Power Generation

- To **expand the investigation of resources in geothermal potential areas, optimize the legal and administrative environment, implement supporting measures, and aim to cutting-edge geothermal technology**, and also continue to review and gradually invest in geothermal resources to drive the development of Taiwan's geothermal industry.

Bioenergy

- To expand biomass feedstock market, **optimize technology** (thermochemical gasification, and anaerobic biogas fermentation), and establish **large-scale biopower system**, increase utilization of the by-products (ash or biogas residues). Continuously review and adjust the allocation of input resources.

Ocean Energy

- To Encourage investment, adoption, and R&D of key technologies and **installation of marine energy system** by setting **reasonable feed-in tariffs (FITs)**, installation regulations, and other policies or support measures. Considering the **just transition topics**, such as impacts on marine ecological environment, fisheries, waterways, and underwater cultural sites or assets, developers should engage in public discussion and exchange of opinions with **stakeholders** to jointly promote the development of ocean energy.



8. Conclusion- Assessments Involving Just Transition

Geothermal Power Generation

Bioenergy

Ocean Energy

Objects and Categories that May Be Affected

- Stakeholders involved include **aboriginal tribes around geothermal development bases, hot spring developers, land owners, and people affected** during construction, etc.
- It is necessary to reconcile the balance between indigenous land rights, competition and cooperation of hot spring resources, environmental ecological impact, agricultural land use control, and hillside safety.

- The collection and transportation of materials and requires the participation of **farmers, industry, the public, and bioenergy producers**, among other stakeholders.
- Utilize the **by-products**(ash or biogas residues) involves stakeholders such as **power generators, reuse industry, or farmers**.

- The scope of impacts includes **living environments, reefs, fisheries, and natural ecological environment**.
- Environmental issues include **ecology and water discharge control in the sea dykes, nearshore, and offshore areas**. The **economic and social topics** include the fishing industry and sailing safety.

Strategies for Just Transition and Promoting Mechanism

- Feed-in-tariff: **benefit-sharing mechanism for aboriginal peoples**.
- Set up the **Single Service Window for Taiwan Geothermal Power** to assist developers to communicate with other groups.
- Amendments to the **Renewable Energy Development Act(§15-1~5)** to protect the rights of the aborigines and the hot spring industry .
- Attract developers to invest in the development of geothermal power plants and the increase of the **employment** in domestic geothermal energy-related fields.

- Expand the circulation of bioenergy derivative by-products reduces the cost of bioenergy use and **increases the willingness of industry to invest**.
- By promoting the market for bioenergy and waste energy through feed-in tariffs and subsidy incentives to **increase the employment population**.

- Developers should apply for mandatory permits issued by **environmental protection, fishing industry authorities, or local government**.
- **Panel** explaining the participation mechanism and promotion direction to win over **community support** and reach consensus.



Thank you



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