台灣電力公司綜合研究所
Taiwan Power Research Institute Taiwan Power Company

Leading Diversified Innovation to Shape the Energy Future The R&D Strategy of TPC

2025 IERE-TPC Taipei Net-Zero Workshop
Special Session/2025.05.28
R&D Planning office
Dr. Hsiao-Wei Chen

Introduction

World Energy Outlook: Scenario Analysis and Future Predictions & The Role of R&D in Power Transformation

1 Global Electricity Demand Growth Trends

Year	STEPS Projection (TWh)	Description
2023 (Baseline)	29,863	-
2030	37,498	-
2035	42,766	-
2050	58,352	Demand nearly doubles

★ **Significant Growth 2023-2035**

Average increase of about 1,000 TWh annually (equivalent to Japan's annual electricity consumption)

Electricity Demand Growth Drivers

Regional Distribution

Emerging markets and **developing economies** (especially regions outside China and India) are the main sources of growth

Sectoral Contribution

The **building sector** is expected to contribute nearly **45%** of end-use electricity demand growth (by 2035); Mainly due to increased use of **air conditioning and appliances**

Advanced Economies

Demand growth primarily comes from transport electrification

2 Global CO_2 Emissions Forecast

Scenario	2023 Baseline	2030 Emissions	2050 Emissions	Projected Temperature Rise by 2100	Annual Emission Reduction	Temperature Impact
STEPS	36 Gt CO_2	31 Gt CO_2	32 Gt CO_2	2.4˚C	**Only 1% annually between 2030-2050**	**Far above climate targets**
APS		-	19 Gt CO_2	1.7˚C	About 4% annually	-
NZE		-	12 Gt CO_2	<1.5˚C	15% annually	Temperature rise will peak around 2040 (<1.6˚C), then fall below 1.5˚C

electricity demand grows significantly, but CO_2 reductions are insufficient

Achieving climate goals requires faster low-carbon energy deployment and end-use electrification

Energy transformation is key to achieving climate goals, and R&D accelerates this transformation path

Source: IEA (2024). World Energy Outlook 2024

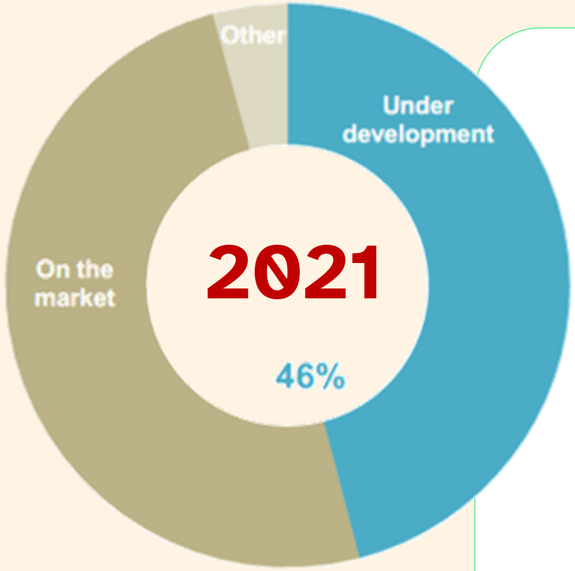
Outline

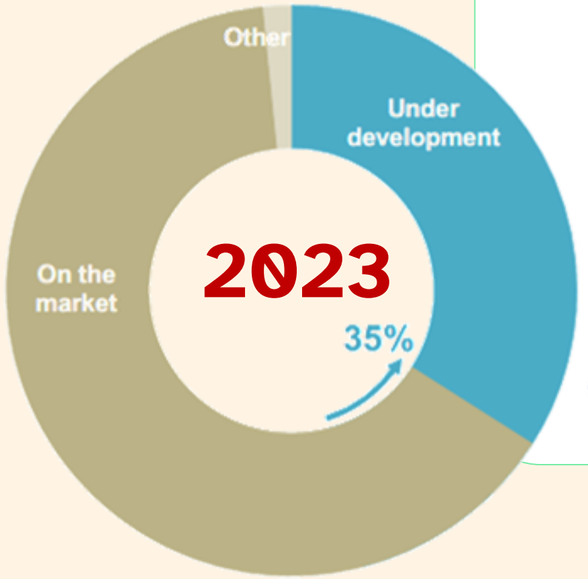
1 Net-Zero Technology Trends

2 Taipower's R&D Strategy and Key Projects for Net-Zero

3 Implementation of Taipower's R&D Applications

Power Companies Face Fundamental Changes in Net-Zero Scenarios





under development ⬇

46%

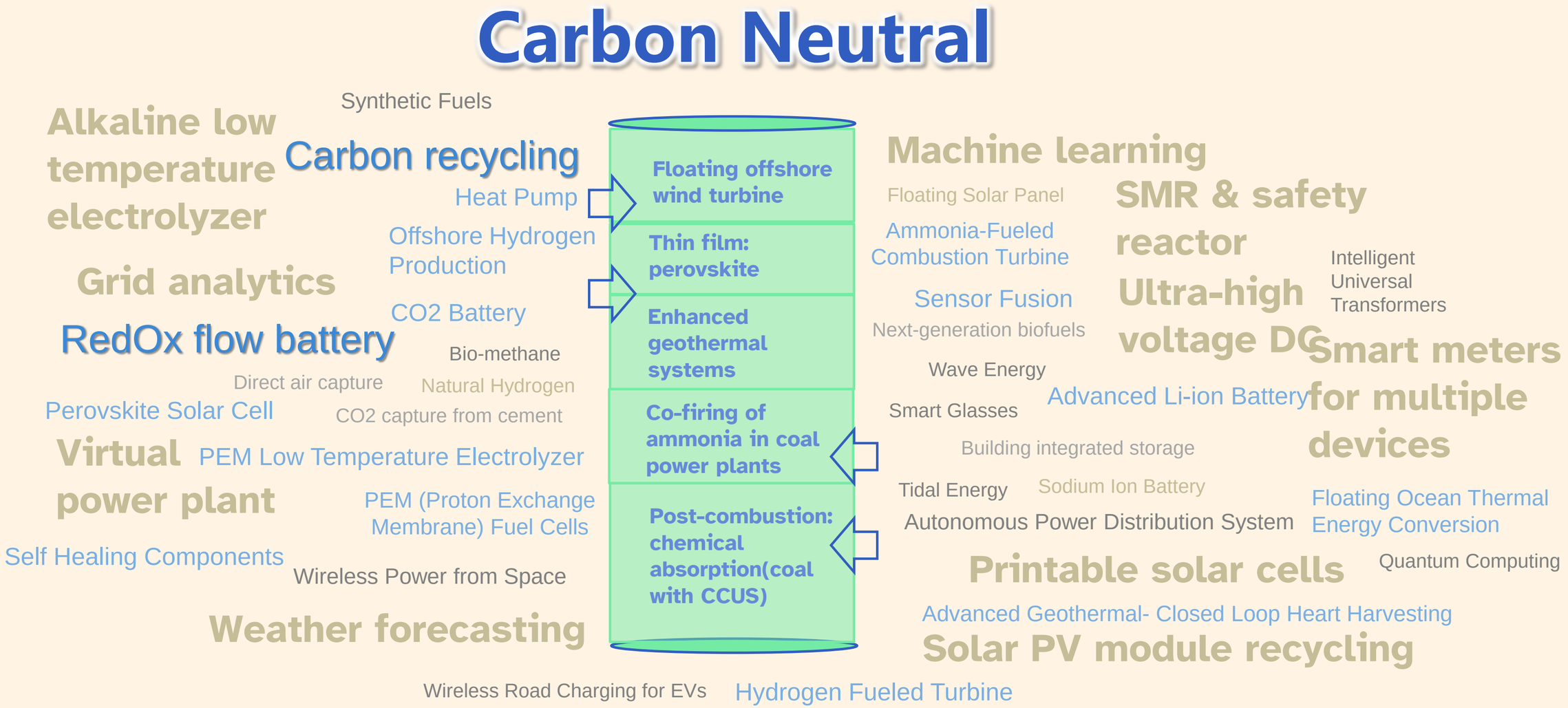
35%

On the market ⬆

TRL 2023	TRL 2025	Technology
8	8	Floating offshore wind turbine
4	5-6	Thin film: perovskite
6	6-7	Enhanced geothermal systems
4	7-8	Ocean wave
5	7	Co-firing of ammonia in coal power plants
5	5	Co-firing of ammonia in gas turbines
7	8	Pure hydrogen
-	8-9	Post-combustion: chemical absorption(coal with CCUS)
5	5	Post-combustion: solid adsorption (biomass with CCUS)

Source: IEA (2021). Net Zero Emissions by 2050: A Roadmap for the Global Energy Sector
IEA (2023). Net Zero Emissions by 2050: A Global Pathway to Keep the 1.5˚C Goal in Reach
IEA (2025). ETP Clean Energy Technology Guide.

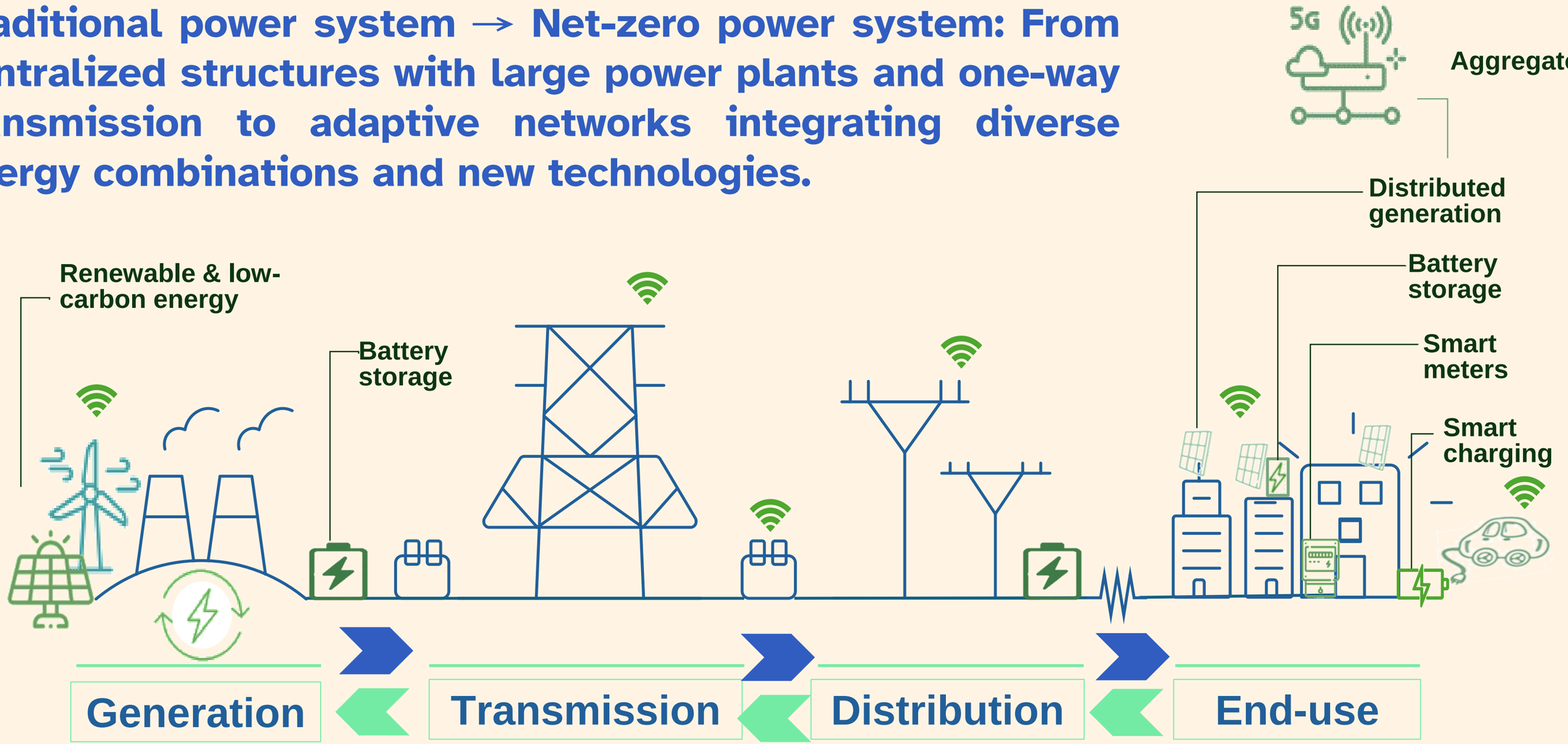
Various Technology Options for Achieving Net-Zero



Source: IERE (2023). Technology Foresight 2023
IEA (2021). Net Zero Emissions by 2050: A Roadmap for the Global Energy Sector

Power Companies Face Fundamental Changes in Net-Zero Scenarios

Traditional power system → Net-zero power system: From centralized structures with large power plants and one-way transmission to adaptive networks integrating diverse energy combinations and new technologies.

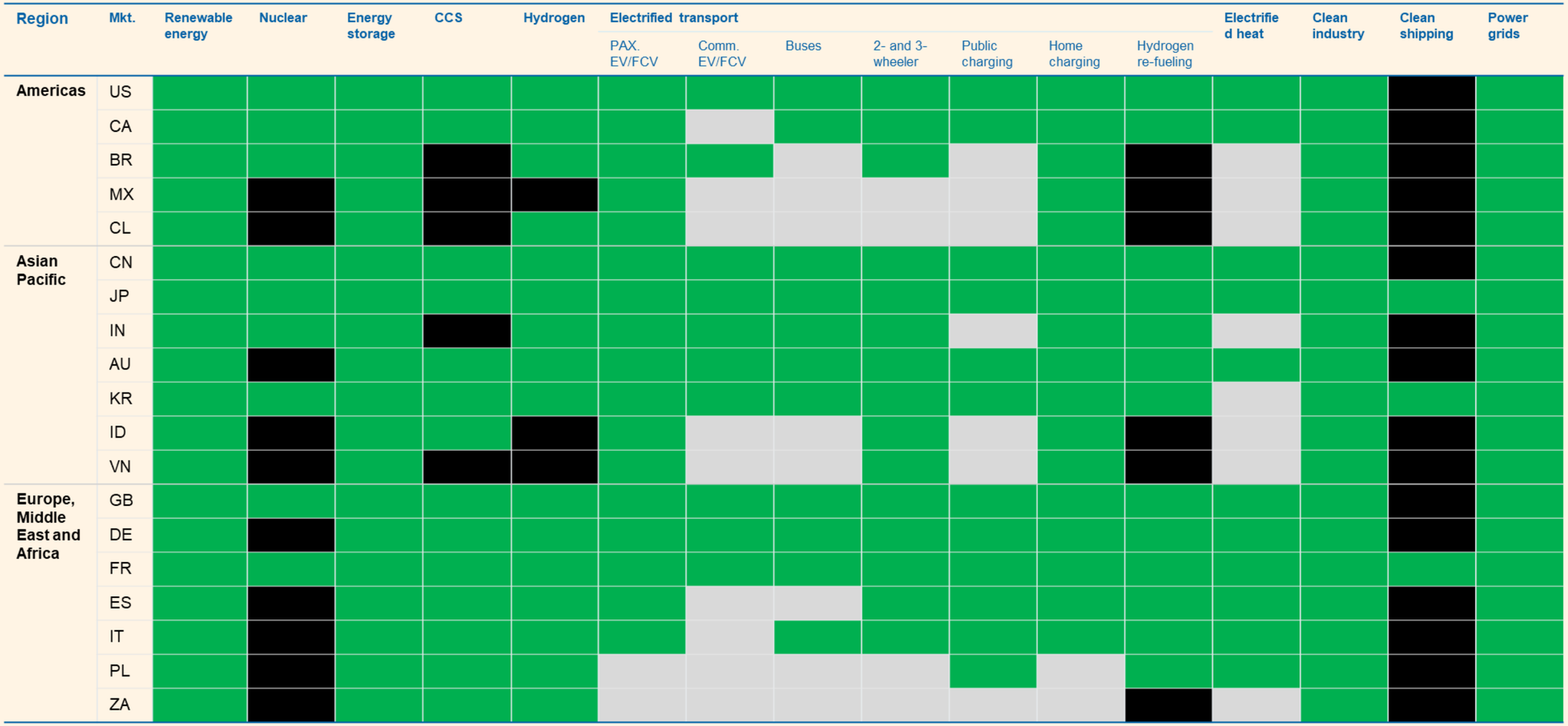


Source: IRENA (2019). Innovation Landscape for A Renewable-powered Future: Solutions to Integrate Variable Renewables

Global energy transition investment reached $2.08 trillion in 2024

energy transition investment across 19 high-priority geographies

● investment data is available ● zero or no available investment investment found ● lack of reliable data



R&D Must balance considerations of :
technical feasibility , resource compatibility , and practical implementation

Source: BNEF (2025). Energy Transition Investment Trends

Strategy Formulation Requires Assessment and Trade-offs

Introduce evaluation methods to establish strategic frameworks

0 Align with industry megatrends

1 Define strategic vision

2 Build strategic pillars (themes)

Pillar 1 (Theme 1)	Pillar 2 (Theme 2)	Pillar 3 (Theme 3)	Pillar 4 (Theme 4)
⋮	⋮	⋮	⋮

3 Craft a technology roadmap(Year 1、Year 2~3、Year 4+)

★ Partnerships

4 Governance, review & evaluation

Source: The Strategy Story, Technology Strategy: Framework and Examples (n.d.)
STPI科技政策研究與資訊中心(2022) 企業技術策略的制訂與分析
Energy Strategy Reviews (Vol.24 2019) The Role of Renewable Energy in the Global Energy Transformation

Outline

1 Net-Zero Technology Trends

2 Taipower's R&D Strategy and Key Projects for Net-Zero

3 Implementation of Taipower's R&D Applications

Current Net-Zero Challenges

Multiple Energy Generation

- Doubling Renewable Energy (60-70% share by 2050)
- Promoting Decarbonized Power Generation (Hydrogen power generation share of 9-12% by 2050)
- Expanding Low and Zero-Carbon Power Sources (Fossil fuels with CCUS technology, nuclear energy)

Intensifying Extreme Climate

- Increasing Frequency and Intensity of Climate Disasters

Infrastructure Preparation

- Integration of New Energy Items
- Meeting the Growth Needs of Electrification

Changing Demand Patterns

- New Technology Power Consumption Shows No Obvious Peak-Valley Difference

Re-industrialization

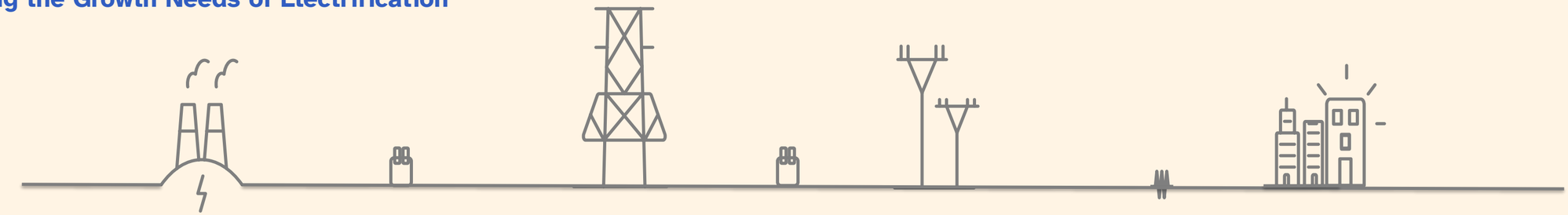
- Manufacturing Growth and AI Development

Increasing Degree of Electrification

- Complete Electrification of New Vehicles by 2040
- Net-Zero for All New Buildings and 85% of Existing Buildings by 2050

Doubling of Power Consumption

- Growth in National Power Consumption and Night Peak Load



● Supply-side challenge ● Demand-side challenge ● Grid challenge ● System-wide challenge

Source: National Development Council (2022) 臺灣2050淨零排放路徑及策略總說明、淨零轉型之階段目標及行動
Academia Sinica (2025) 114年4月17日多元綠能減碳科技第二分組會議簡報
IEA (2023) Net Zero Emissions by 2050: A Global Pathway to Keep the 1.5˚C Goal in Reach

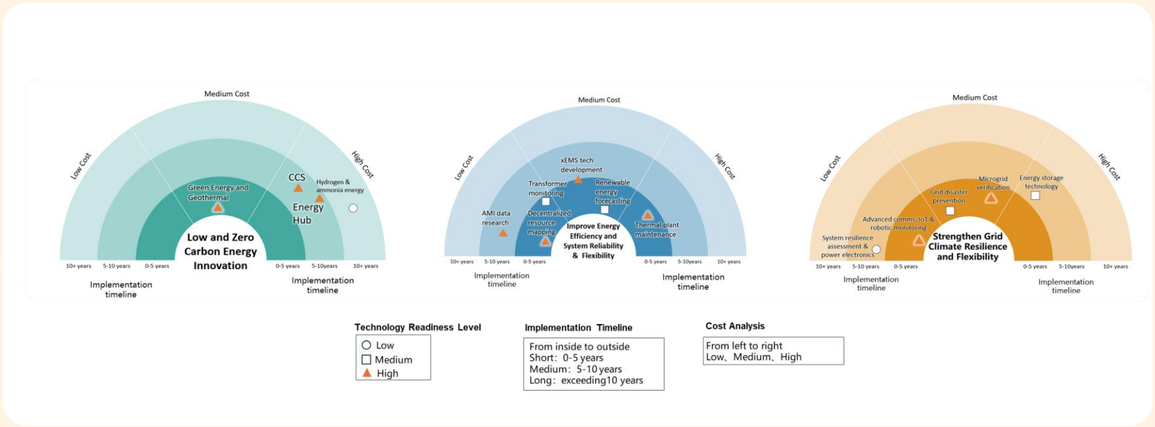
Focus on Net-Zero Carbon Reduction Technology Development and Integrated Applications

0 NET ZERO

❶ Define strategic vision

- Low and Zero Carbon Energy Innovation
- Improve Energy Efficiency and System Reliability
- Enhance System Flexibility
- Grid Adaption to Extreme Weather

❷ Build strategic pillars



❸ Craft a technology roadmap

★ Partnerships

Low and Zero Carbon Energy Innovation

Topics
Green energy development and geothermal assessment
Hydrogen and ammonia energy
Carbon capture, utilization & storage (CCUS)
Energy hub

Strengthen grid reliability and resilience

Enhance system flexibility

Topics
Thermal power plant operation and maintenance
Transformer condition monitoring and diagnosis
Decentralized resource map development platform
Renewable energy power generation forecast
AMI data application research
xEMS technology construction and promotion

Grid Adaption to Extreme Weather

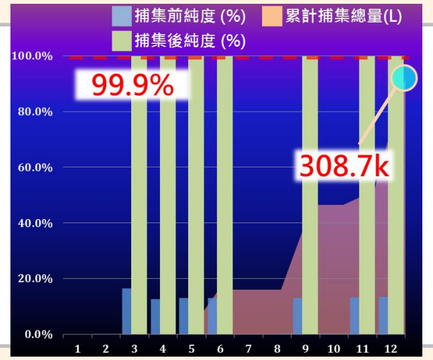
Topics
Microgrid functional verification
Energy storage technology
Power system resilience assessment and advancements in power electronics technology
Power grid disaster prevention
Integration of advanced communications technologies, IOT and robotic monitoring application

❹ Governance, review & evaluation

Highlight 1 – Carbon capture, utilization & storage (CCUS)

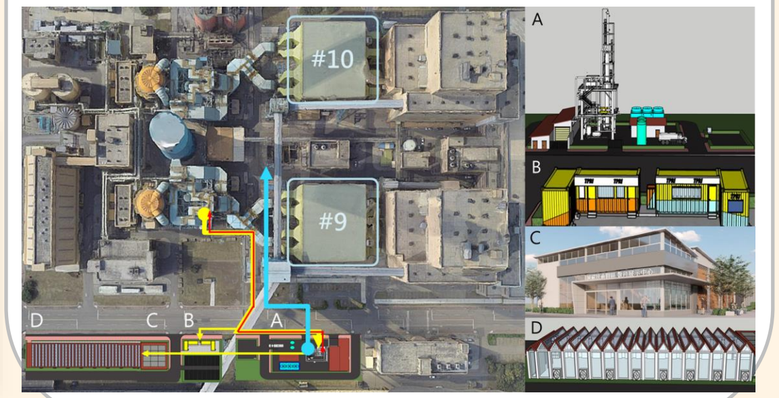
❶ Micro Testing Area

Small-scale carbon capture facilities have been established since 2019, including a 6-ton/year solid adsorption method and a 6-ton/year solvent absorption method



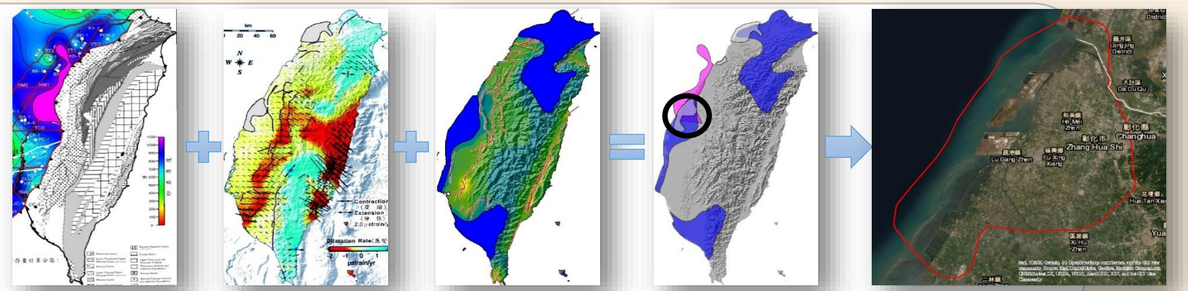
❷ 2000 ton/year capture pilot plant

- A contract has been awarded for a 2,000 ton/year carbon capture pilot plant, scheduled for completion in 2027.
- A contract has been awarded for a plant factory, scheduled for completion in 2025.



❸ Storage Site Selection

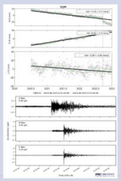
Geological surveys have been conducted in Changbin area to evaluate the Taihsi Basin near Taichung Power Plant, which could potentially store 13.7 billion tons of CO2

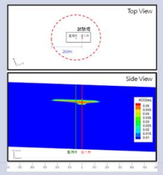


❹ 2000 ton/year storage pilot project

A contract has been awarded for a test field with a 2,000-ton/year injection capacity, scheduled for completion in 2028.

2010	2014	2018	2021	2023	2025
• Selected Taihsi Basin as the target storage area	• Completed a 3,000m exploration well	• Began establishing a regional geological monitoring network	• Initiated carbon storage experiment site feasibility study	• Carbon storage experiment site received EIA approval	• Began detailed facility design and construction permit application process



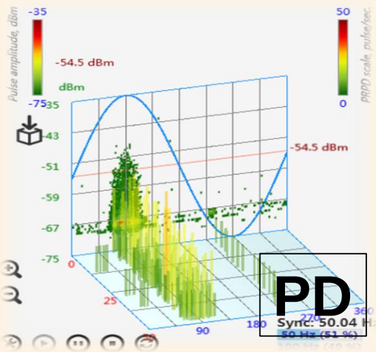


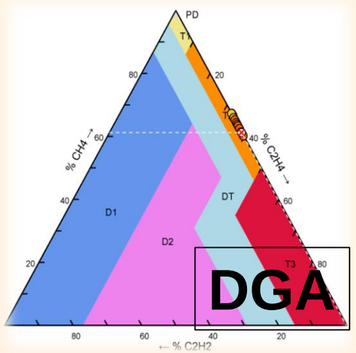
- **Technical Feasibility Verification**
- **Geological Storage Potential Assessment**
- **Development of Domestic CCUS Industry**
- **Technology Integration and Optimization Experience**
- **Evaluating future carbon reduction measures for power plants**

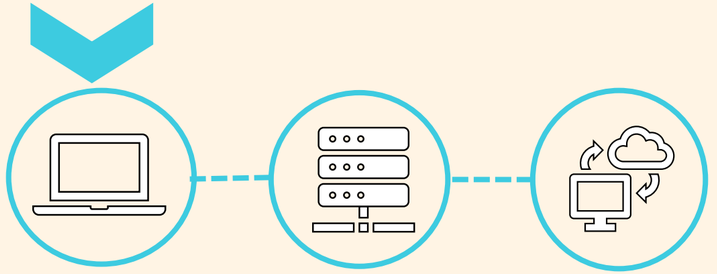
Highlight 2 – Smart Diagnostics for Power Transformers

Research and Implementation of Transformer Condition Monitoring and Diagnostic Technology

- First implementing a pilot project at 11 substations under the Taipei Power Supply District
- In 2026, an information platform for partial discharge, dissolved gas in oil, and operation monitoring will be established
- Introduction of the Electric Power Research Institute (EPRI) Transformer Expert System (PTX) in 2026







- Enhanced Grid Reliability and Stability
- Extended Equipment Lifespan and Optimized Asset Management
- Reduced Operational Costs and Improved Economic Benefits

Highlight 3 – Microgrid Technology

Demonstration and Verification of Microgrid Technology

- In 2024, introducing international ICT standards to guide domestic microgrid standardization
- Complete the establishment of microgrid integration verification field equipment by mid-2025
- Low-startup microgrid integration verification field in 2025
- Integration of low-carbon power generation resources and participation in the power trading market in 2026

Lead the Microgrid Research and Testing in Taiwan

LCMG in Shulin Campus

Microgrid Verification Site

- Enhanced Grid Integration and Coordination
- Energy Management Optimization
- Technology Standardization and Localization
- Technology Demonstration and Industrial Development

Highlight 4 – Energy Trading Platform

- Enhanced market efficiency
- Energy transition support
- Strengthened system stability
- Creation of investment incentives

2021 — Taipower Officially Launches Power Trading Platform

2022 — Introducing "Enhanced Dynamic Regulation Reserve Capacity" (E-dReg) operation mode, simultaneously executing frequency regulation and energy transfer

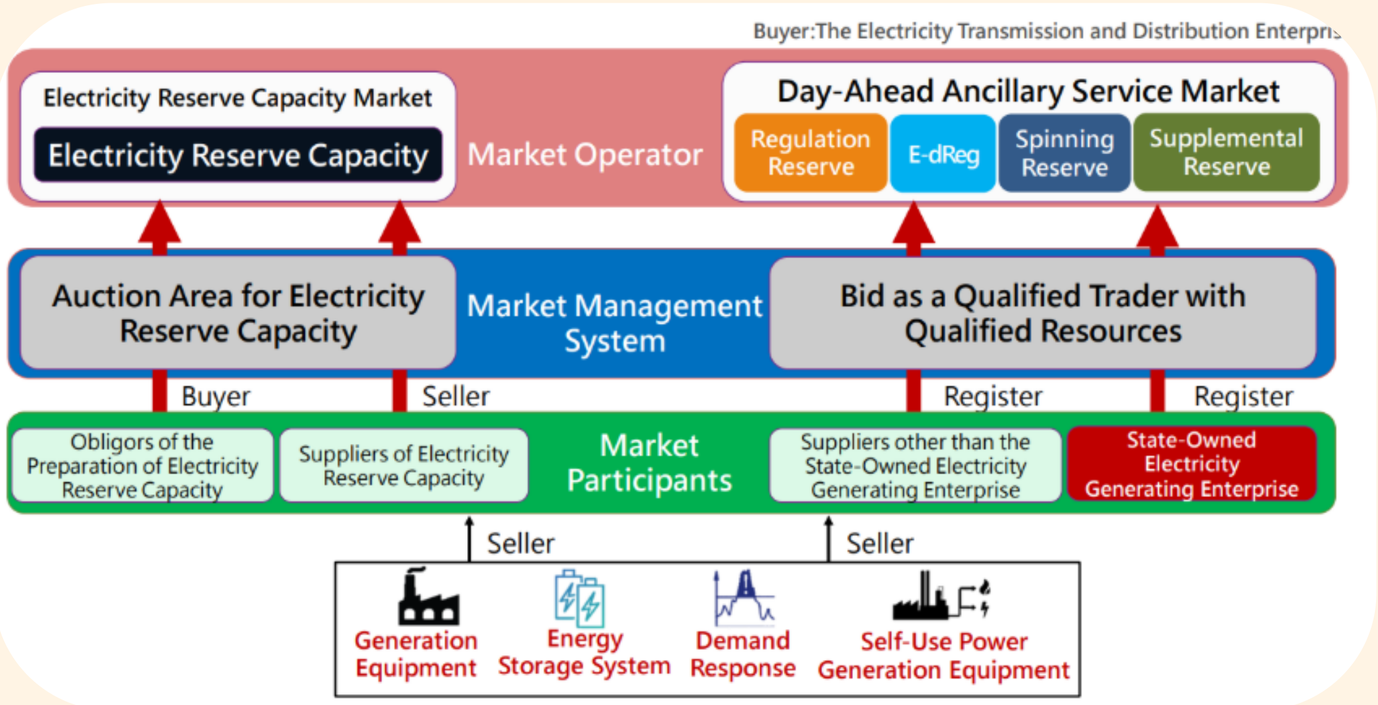
2023 — E-dReg renamed as "Energy Transfer Composite Dynamic Regulation Reserve Capacity" and established as a new independent product

2025.05 — 107 qualified private traders with 2,041MW of power resources participating

In the future

1. Behind-the-meter storage transforms loads into controllable resources and shows potential in reserve markets

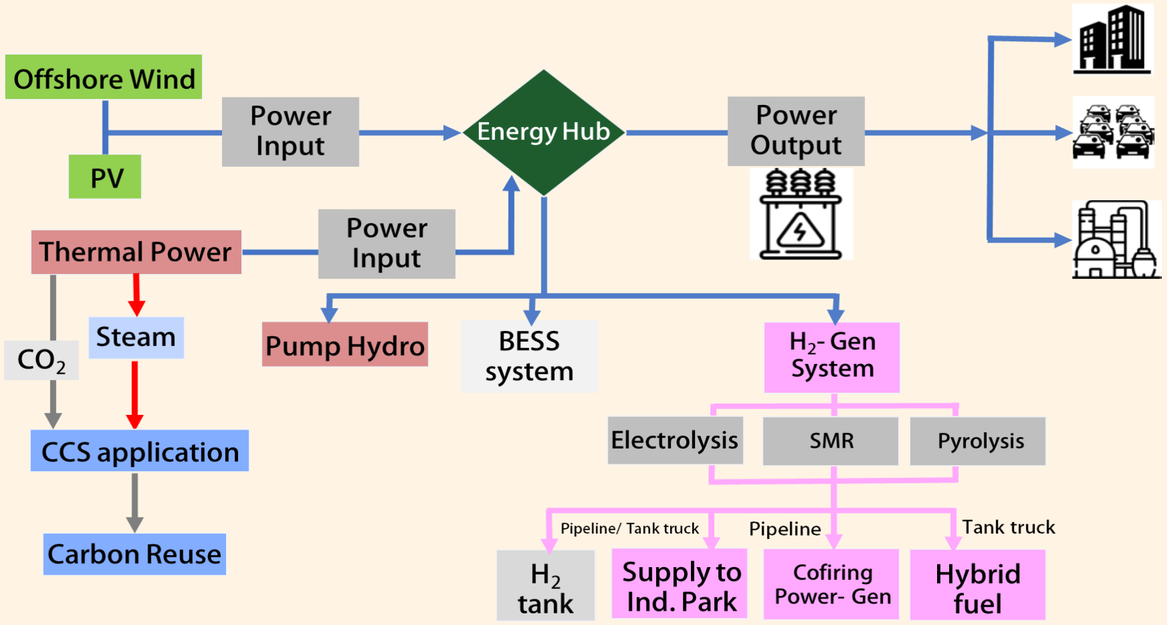
2. Incorporating renewable energy as trading products, creating green energy re-trading opportunities, and internalizing regional congestion costs to reduce external impacts

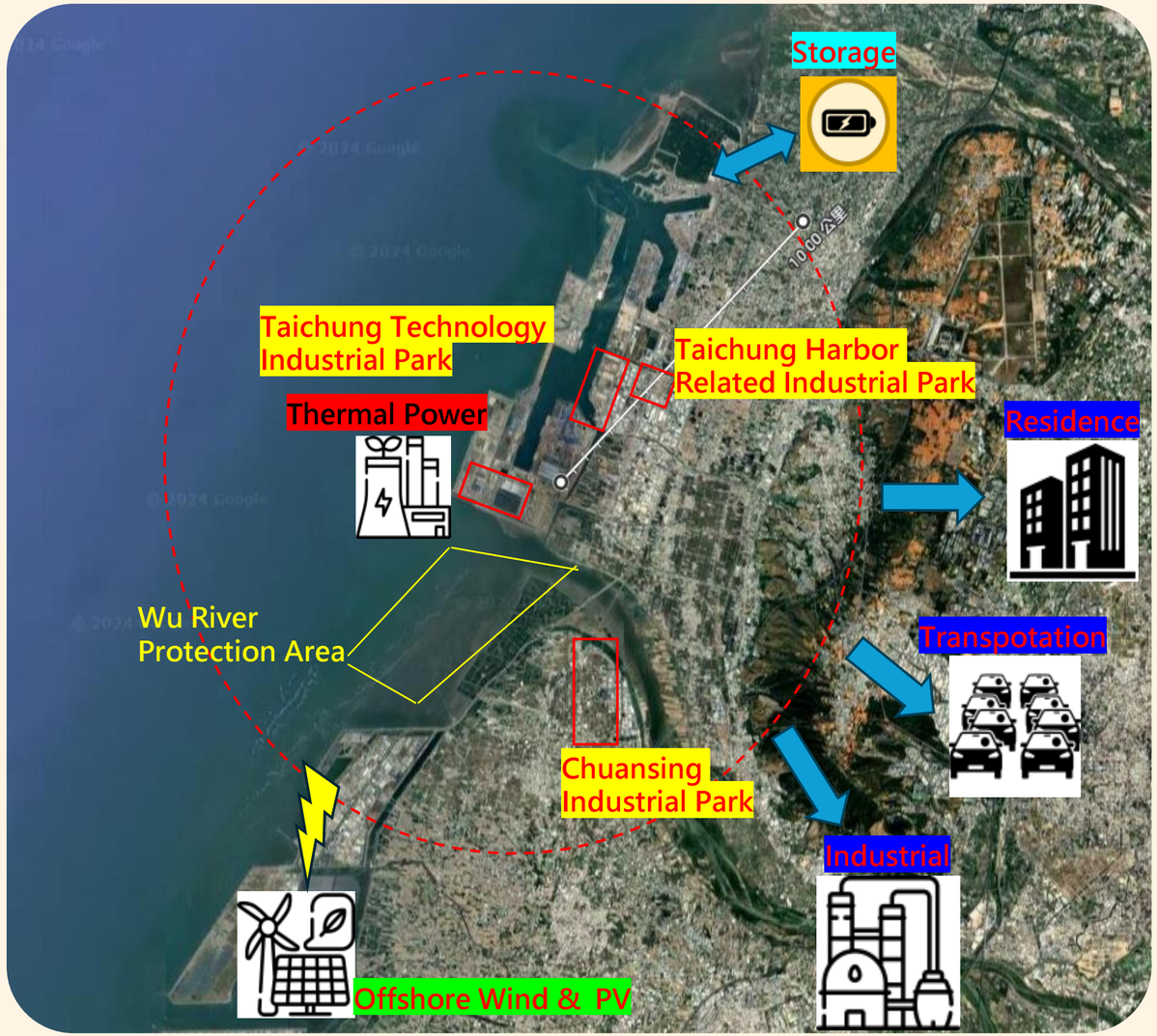


Platform Participation Status	
Day-ahead Ancillary Service Market	
Frequency Regulation Reserve	864MW
Spinning Reserve	163MW
Energy Transfer Composite Dynamic Regulation	584MW
Supplemental Reserve	430MW

Highlight 5 – Taichung Energy Hub

- Optimization and creation of designs related to EH.
- Scenario-based analysis of EH's operating models.
- Analyzing the power grid conditions related to the operation of EH.





- Diversified Application of Surplus Electricity
- Optimization Flow Control of Energy Hub
- Integrated and Flexible Use of Energy and Material Flow

Highlight 6 – 2035 Taiwan Power Prospective Scenario Planning Study(1/2)

Know → Respond → Build

Taiwan's commitment to 2050 net-zero emissions, with the power sector bearing core decarbonization responsibilities

Taipower's challenging 2035 interim targets amid multiple uncertainties

- ■ Adoption of "Scenario-Based Strategic Planning" (SBSP) methodology
- ■ Identification of high-impact, high-uncertainty key driving factors
- ■ Construction of three future scenarios
  - ✓ Most favorable scenario
  - ✓ Most likely scenario
  - ✓ Least favorable scenario

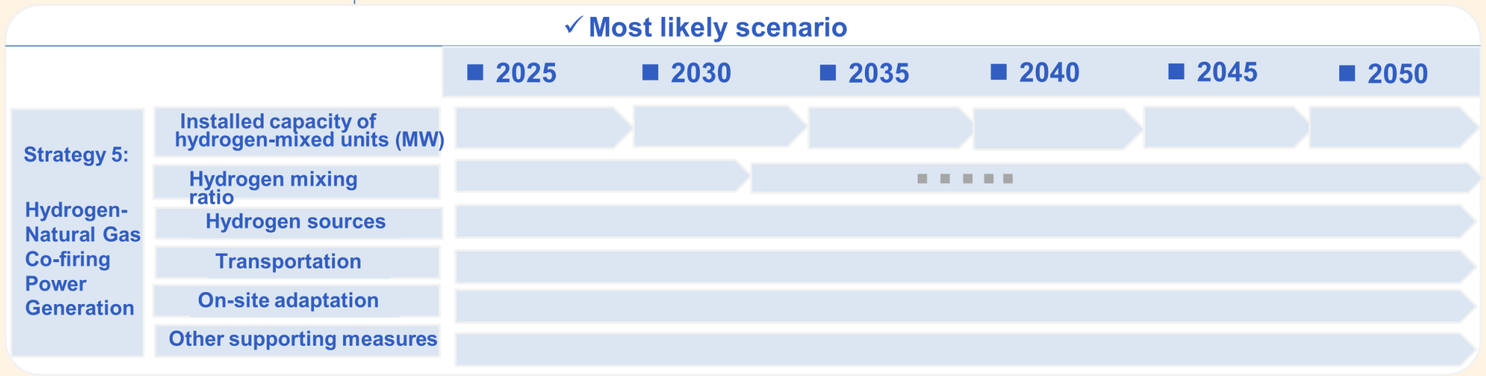
Scenario Analysis and Issue Identification Process:

- ■ Based on three future scenarios (Most Favorable, Most Likely, Least Favorable)
- ■ Identification of opportunities and threats in each scenario
- ■ Integration of analysis results to produce cross-scenario applicable key issues
  - ✓ Increase Hydrogen/Ammonia Co-firing Ratio
  - ✓ Increase CCUS Deployment and Application
  - ✓ Expand Renewable Energy Generation Share
  - ✓ Evaluate SMR Introduction Opportunities
  - ✓ Promote Energy Hub Development
  - ✓ Expand Participation in Demand Response/Time Pricing
  - ✓ Factors Related to Innovative Business Models
  - ✓ Factors Related to Strengthening Grid Smartification

Three Priority Key Issues for Analysis

Strategy 1: Develop Offshore PV (Floating Solar)
Strategy 2: Upgrade Onshore Wind Power
Strategy 3: Purchase Bidding Offshore Wind Power
Strategy 4: Develop Deep Geothermal Energy
Strategy 5: Hydrogen-Natural Gas Co-firing Power Generation
Strategy 6: Natural Gas CCS
Strategy 7: Coal-fired CCS

Regularly review and update R&D investment strategies



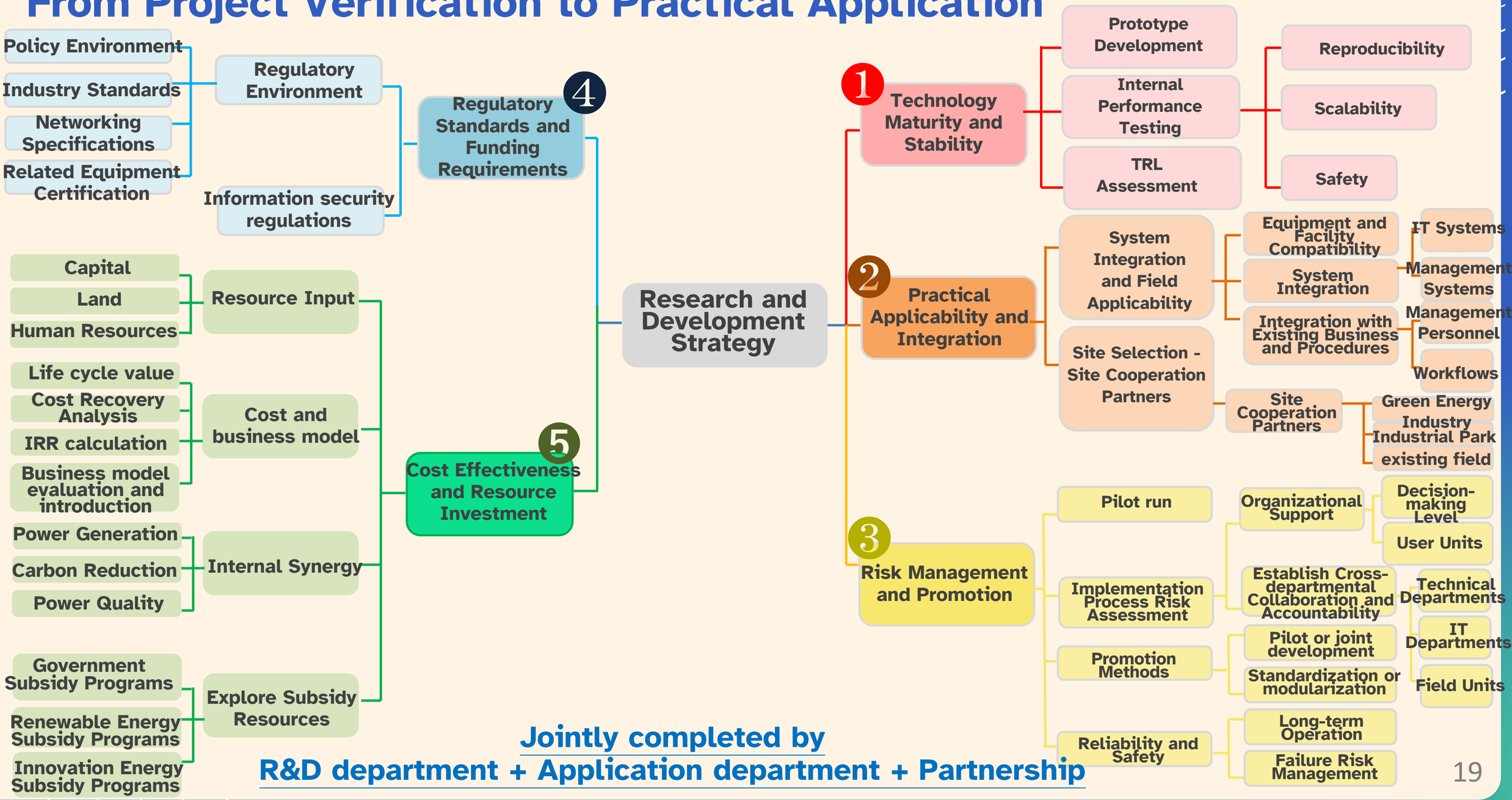
Outline

1 Net-Zero Technology Trends

2 Taipower's R&D Strategy and Key Projects for Net-Zero

3 Implementation of Taipower's R&D Applications

From Project Verification to Practical Application



Jointly completed by

R&D department + Application department + Partnership

From Project Verification to Practical Application

STRATEGIC PARTNERSHIPS

Harnessing Collective Strengths
Driving Competitive Advantage
Enhancing Organizational Agility

EPRI ELECTRIC POWER RESEARCH INSTITUTE
MITei MIT Energy Initiative
NSTC 國科會
AESIEAP
ECCT EUROPEAN CHAMBER OF COMMERCE TAIWAN 歐洲在臺商務協會 LOW CARBON INITIATIVE
BloombergNEF
IERE Electric Power Technology Platform
CRIEPI Central Research Institute of Electric Power Industry
KERI

Hsinta Power Plant hydrogen co-firing project

The Hsinta Power Plant completed a short-term demonstration project of co-firing 5% hydrogen in a gas turbine (91 MW) at the end of 2023. It is expected to increase the hydrogen blending test ratio to 7-10% this year, depending on fuel supply conditions.

Hydrogen test GT and refueling station

Decarbonized Hydrogen Co-firing

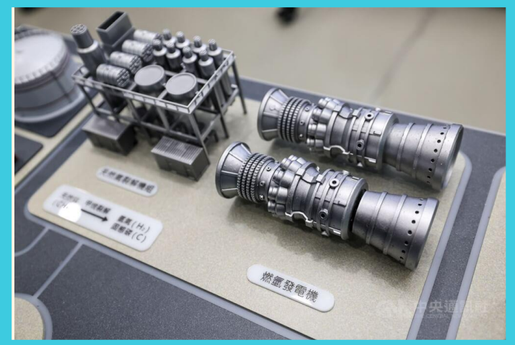
Taipower x Academia Sinica x NDC

Decarbonized Natural Gas Hydrogen-Mixed MW-Scale Power Generation Test System Construction and Trial Plan

- Collaboration Partner: Academia Sinica **(funded by government public infrastructure project budget)**
- Duration: 2025~2028

✓ Taipower and Academia Sinica completed the kW-level decarbonized hydrogen co-firing power generation application technology verification in September 2023 and are currently collaborating on plans to expand the application scale (approximately 5 MW) for technical verification.

✓ Academia Sinica is responsible for establishing pyrolysis equipment and providing hydrogen to Taiwan Power Company. Taiwan Power Company will install a 5MW hydrogen-blending turbine in the future.



Model	Capstone C65
Rating	65kW
Electrical Efficiency LHV	28%
Combine Heat and Power Efficiency	Up to 90%
Voltage	400-480VAC
Frequency	50/60Hz
Electrical Service	3-phase, 4-wire
Wide, Depth, Height	0.76mx1.95mx1.91m
Net Heat Rate LHV	12.4 MJ/kWh (11,800 BTU/kWh)
Exhaust Temperature	309°C (588°F)
Exhaust Gas Flow	0.49 kg/s (1.08 lbm/s)
Compatible Fuels	Natural Gas, Ultra Low Sulfur Diesel #2), Biogas (Landfill, Digester), Associated Gas, Sour Gas, Propane Gas

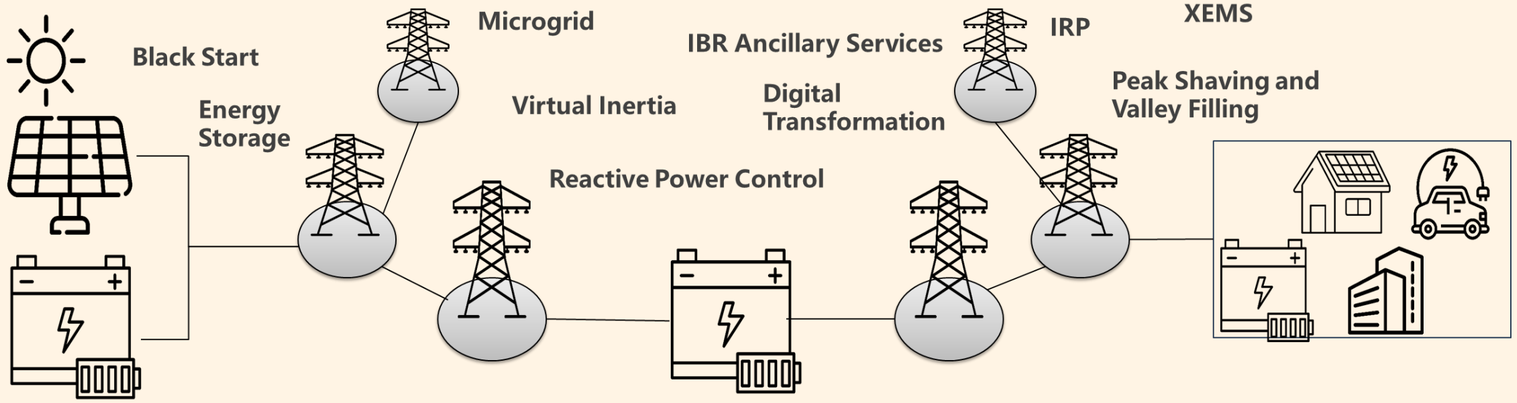
Power Grid Resilience Industry-Academic Cooperation

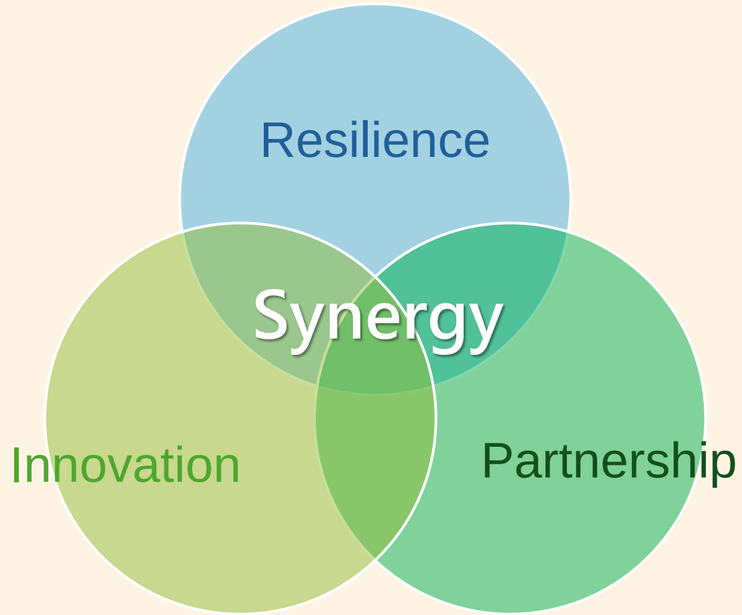
Taipower x NSYSU x NSTC

NSTC Forward-Looking Industry-Academia Collaboration Project

Building Resilient Power Systems

- Comprehensive enhancement of power grid resilience research to achieve low vulnerability and high recoverability
- Integration of cross-university and interdisciplinary R&D resources
- Long-term cultivation of master's and doctoral talent for the power industry





November 2024
Complete legal compliance and mechanism analysis

May 2025
Project application

November 2025
Begin implementation

August 2026
Proposal and implementation of the second year plan

EPRI-LCRI Collaboration Project

Building Resilient Power Systems

- Accelerate the development and demonstration of low/zero-carbon energy technologies
- Develop net-zero pathways and strategic blueprints
- Establish Energy Hub demonstration sites

May 2024

Taipower's 3 Major Exclusive Projects

- Energy Hub Planning
- Taipower Net-Zero Strategy
- CCS Application Assessment

April 2025

Applied to become the 25th Common Cross-disciplinary TPC Demonstration Project

(The only one in Asia)

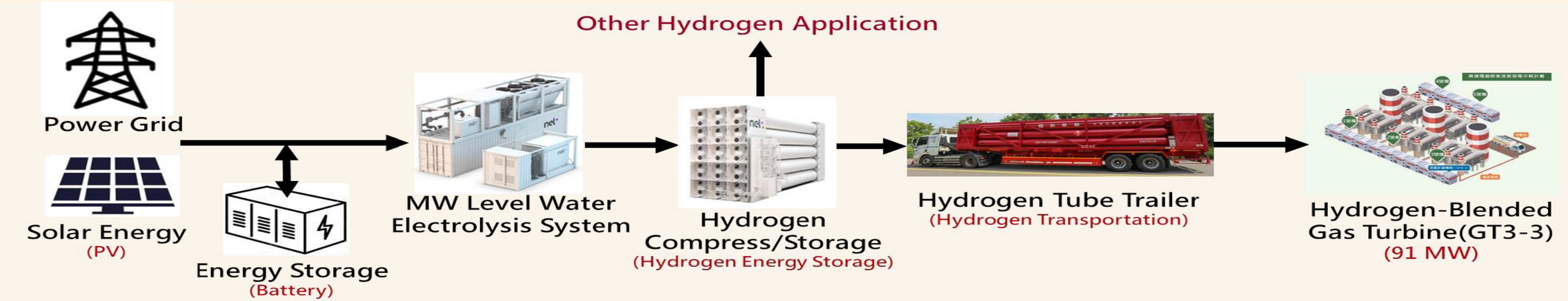
「MW scale hydrogen energy storage performance test and assessment」

MW-level hydrogen energy storage system test project

MOEA Energy Project

(TPC Demonstration Project)

Goal：Utilizing surplus renewable energy for hydrogen production and storage, employing hydrogen-based power generation during peak electricity demand periods, enhance grid resilience and maximize the efficient use of renewable energy.

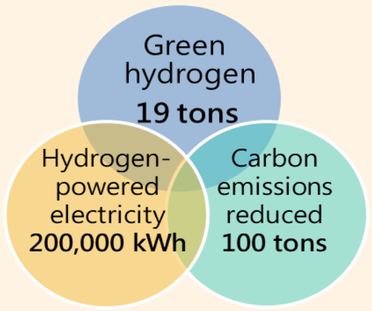


- Project Benefits：

1. **Validation**：Validate performance of the electrolysis-based hydrogen production system as a method for regulating renewable energy.

2. **Assessment**：Assess the economic feasibility of hydrogen storage and conduct an optimization matching analysis.

3. **Conjunction**：Conjunction with the co-firing power generation trials in Southern. Provide over 19 tons of green hydrogen, more than 200,000 kWh of hydrogen-powered electricity, and reduce carbon emissions over 100 tons per year.



- Project Highlights：Taiwan's first MW scale hydrogen energy storage system demonstration.

Conclusion

Creating Unique R&D Value

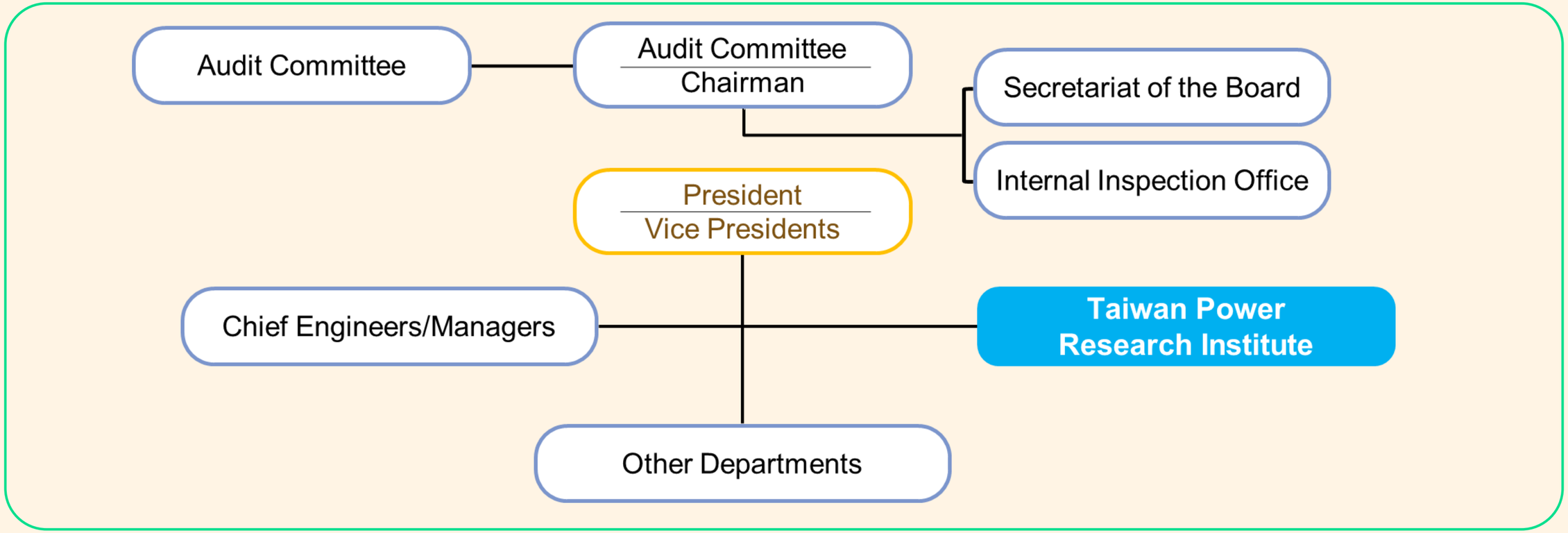
- Core philosophy: Problem-oriented, strategy-guided, practical implementation
- R&D becomes the supporting force for the company's stable power supply and sustainable transformation
- We are not chasing technology, but creating valuable solutions

Driving the future requires more than our own efforts. We must forge strategic partnerships and harness collective strengths with all sectors, moving forward together.

台灣電力公司綜合研究所
Taiwan Power Research Institute Taiwan Power Company

Thank you for your time and attention.

TPRI Organizational Structure and Strategic Vision



Vision

- Professionalism
- Sustainability
- Innovation

Goal

- Research leadership
- Think tank
- Operational pillar

Duty

- Research & Testing
- Technology foresight
- Upgrading leadership

Technology Selection Must Be Localized

Many emerging technologies are in the early stages of maturity, with high application risks and uncertainties.

Insufficient technological maturity leads to high construction costs and integration challenges.

Combining technologies from different fields presents both challenges and opportunities.

Regional differences (land, infrastructure, etc.) significantly affect technology implementation and deployment.

Policy, social, and financial measures influence the speed of technological innovation.

New operational practices, market designs, and business models are needed.

Must balance considerations of :
technical feasibility , resource compatibility , and practical implementation

Source: McKinsey Global Institute (2024). The Hard Stuff: Navigating the Physical Realities of the Energy Transition
Energy Strategy Reviews (Vol.24 2019) The Role of Renewable Energy in the Global Energy Transformation