UNDP China

Hydrogen Economy Pilot Project in China

Final Evaluation Report

December 2023

Project and Evaluation Information

Project Information

Outcome Information		
Project/Achievement Name	Hydrogen Economy Pilot in China (Rugao Project)	
Project Number	00096939	
Overall Results and Outputs	Results: The project has achieved outstanding results in science popularization and publicity, significantly increasing the city's visibility. Active participation in the formulation of fuel cell-related standards and the introduction of multiple incentive policies has resulted in a series of fruitful outcomes. Rugao has gained a certain first-mover advantage in the cultivation of the hydrogen industry, the creation of an innovative entrepreneurial ecosystem, and has secured a development lead. The constructed hydrogen economy demonstration project serves as a model, accumulating valuable construction experience for the future replication and promotion of hydrogen-based economic and societal models. Environmental improvements and sustainable green development have provided people with a cleaner, healthier, and safer living environment. Outputs: Adoption and implementation of Rugao's hydrogen economic development plan. Hydrogen production demonstration, reducing hydrogen production costs. Enhancement of technical demonstrations in hydrogen quality for fuel cells, hydrogen storage, and refueling. Application of hydrogen energy in transportation and backup power sectors. Completion of the policy framework and carbon trading demonstration applications. Improvement of public awareness and information exchange regarding the hydrogen economy.	
Country	China	
Region	Asia-Pacific Region	
Project Document Signing Date	August 2016	
Project Duration	**Start Date**	**End Date**
	2016	2024
Project Budget	**$10 million USD**	
Total Project Expenditure	$8.5683 million USD (2016-2022)	
Funding Source	Rugao Economic and Technological Development Zone Management Committee, Jiangsu Province	
Implementing Partners	China International Center For Economic And Technical Exchanges (CICETE)	

Evaluation Information

Evaluation Information		
Evaluation Type	Project/Achievement Evaluation	
Review Stage	Final Evaluation	
Project Duration	**Start Date**	**End Date**
	2016	2024
Evaluators	Liu Jianguo, Liu Ping, Hu Mingyue	
Evaluator Email Address	Liu Jianguo	jianguoliu@nju.edu.cn
Evaluation Date	**Start Date**	**Completion Date**
	September 14, 2023	November 30, 2023

Acknowledgments

During the project evaluation process, the evaluation team received strong support from the Project Management Office (PMO). The PMO not only provided the foundational documents required for the project evaluation but also coordinated and facilitated interviews with various stakeholders and conducted on-site research. The collaborating parties in the project, from different perspectives, contributed essential information and summarized their experiences. These included Dr. Zhang Weidong from the United Nations Development Programme (UNDP), Deputy Director Li Ke from the China International Center For Economic And Technical Exchanges (CICETE), Director Zhao Wei from the Office of the Hydrogen Energy Industry Park in Rugao Economic and Technological Development Zone, Ms. Wang Ju, the Project Technical Chief Advisor, and Ms. Hu Chen, the Project Assistant (a United Nations Volunteer). Guidance on the quality standards of the evaluation report was provided by Mr. Sun Qian, an official from UNDP. Representatives participating in various project activities underwent interviews with the evaluation team, sharing their experiences. We would like to express our gratitude to all interviewees for their time, patience, enthusiasm, and wisdom contributed to this evaluation.

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Abbreviations and Acronyms

CCS	Carbon Capture and Storage
CICETE	China International Center for Economic and Technical Exchanges
CPD	Country Programme Document
CTA	Chief Technical Advisor
FC	Fuel Cell
FCVC	Fuel Cell Vehicle Conference
FGD	Focus Group Discussion
GEEW	Gender Equality and Empowerment of Women
IoT	Internet of Things
KII	Key Informant Interviews
LNOB	Leave No One Behind
MTR	Mid-term Review
NPD	National Project Director
OECD	Organization for Economic Cooperation and Development
PMO	Project Management Office
PWD	Persons with Disabilities
SDG	Sustainable Development Goal
SMVIC	Shanghai Motor Vehicle Inspection and Certification
TE	Terminal Evaluation
ToC	Theory of Change
UNDP	United Nations Development Programme
UNSDCF	United Nations Sustainable Development Cooperation Framework

1. Executive Summary

This report is the final evaluation report of the Hydrogen Economy Pilot Project in China.

1.1 Project Overview

The Hydrogen Economy Pilot Project in Rugao, China, represents a collaborative effort to usher in a new era of clean energy through the use of hydrogen technologies. Initiated by the partnership of the China International Center For Economic And Technical Exchanges (CICETE), the Rugao Economic and Technological Development Zone Management Committee, and the United Nations Development Programme (UNDP), the project was generously backed with a $10 million budget. This report provides a detailed evaluation of the project from its inception in August 2016 with a planned conclusion in July 2020, which was later extended to 2024 to fully realize its comprehensive ambitions.

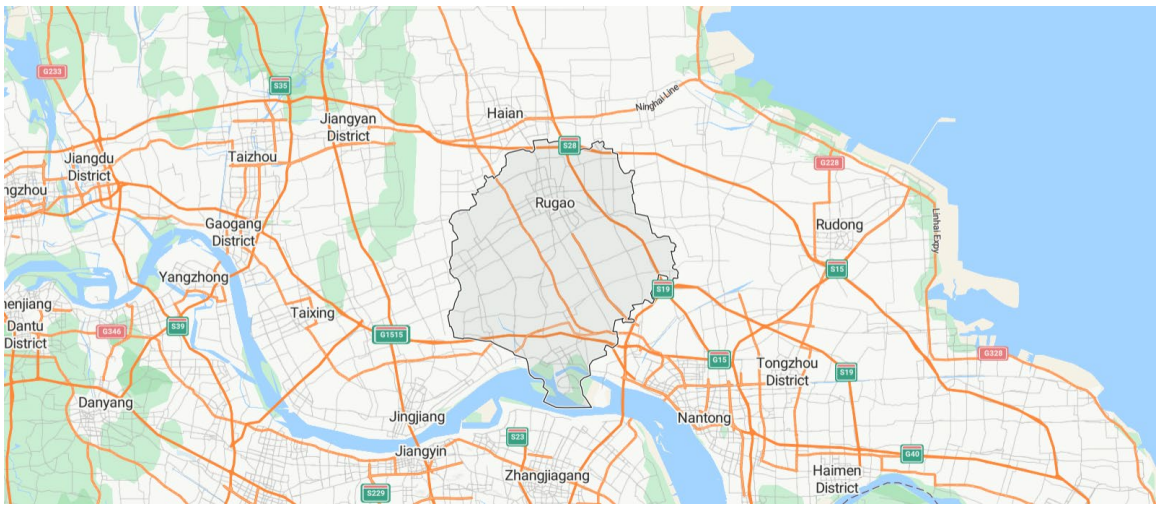

Figure 1 Map of Rugao City

1.2 Evaluation Overview

This evaluation thoroughly examines the project's implementation methods, progress, challenges, lessons learned, and best practices in the hydrogen energy sector. It provides conclusions and recommendations to advance developments and expedite the attainment of carbon peak and carbon neutrality goals. The report targets UNDP, CICETE, Rugao government, and other key stakeholders, aiming to communicate project outcomes effectively, and further to refine strategies, enhance collaboration, and promote the replication of successful practices in similar initiatives worldwide.

The evaluation adopts a theory-driven evaluation approach and outlines the main evaluation criteria based on the goals designed by the Theory of Change (TOC), including relevance, coherence, effectiveness, efficiency, sustainability, gender and cross-cutting issues. The logical framework is used for evaluation, and evaluation questions related to project goals, activities, outputs, short-term effects, long-term effects, and impacts are designed. Relevant facts and data are collected through methods such as key informant interviews, outcome harvesting, and appreciative inquiry. Data

analysis is conducted using methods such as results mapping, beneficiary evaluation, and contribution analysis to assess expected outcomes and related outputs from a full project cycle perspective.

1.3 Evaluation Findings and Conclusions Overview

This report concludes that the project has successfully met its established targets, demonstrating hydrogen energy technologies' potential and versatility. The project's design and implementation align with China's national development goals, contributing to the country's energy transition and carbon neutrality ambitions. It has been consistent with the UNDP's strategic objectives and sustainable development goals, considering gender equality and human rights throughout its various phases.

Relevance

- The project has showcased hydrogen's application in multiple sectors, supporting China's energy transformation and carbon neutrality targets.
- The design and methodology have been comprehensive, taking into account practical circumstances and the overarching goals of the project, while adhering to UNDP's gender equality and human rights policies.

Effectiveness

- The "Rugao Hydrogen Energy Development Roadmap" has guided the hydrogen industry chain effectively.
- The construction of the Rugao Hydrogen Town has provided valuable experiences for future hydrogen economy replication.
- Challenges in hydrogen production planning and renewable energy-based hydrogen production have been identified, but foundational work like the "Rugao Feasibility Study on Renewable Hydrogen Production" has been completed.
- Despite regulatory hurdles, the project has seen success in fuel cell bus demonstrations and has laid groundwork for future fuel cell vehicle production.

Efficiency

- The project has been efficiently funded, with a reasonable execution rate despite challenges such as the pandemic and procurement issues.
- Human resources have been well-allocated, with project stakeholders possessing international perspectives and extensive management experience.
- The project's monitoring and evaluation system has been effective in ensuring quality and impact.

Sustainability

- Resource investment and collaboration networks demonstrate sustainability, with significant interventions in hydrogen production, storage, transportation, and utilization. However, equipment utilization rates need improvement.
- Safety consulting activities have provided robust assurance for hydrogen utilization in industry parks, aligning with safety regulations.

Gender and cross-cutting issues

- The project design and implementation have ensured gender equality, with women's participation not falling below 50%.
- The needs and interests of diverse societal groups have been considered to encourage widespread participation.

In conclusion, the project has facilitated technical interactions and industry exchanges, providing guidance for developing the hydrogen economy in Rugao and beyond. It has accumulated valuable experience for the replication and promotion of hydrogen economy initiatives and has effectively implemented UNDP principles of gender equality and social inclusiveness.

The project's international conferences, exhibitions, and outreach have significantly contributed to advancing hydrogen and fuel cell vehicle technology. The project has set a benchmark for the industry, fostering innovation, policy support, and international exchanges. As the project concludes, the recommendations pose potential benefits for the innovation and sustainable development of not only this project but for related initiatives globally.

1.4 Lessons Learned Overview

Ideological Consensus as a Motivational Driver: The project demonstrates that when sustainability is a shared goal, it becomes a powerful motivator. The alignment with the United Nations' sustainable development ideals has created a common language that fosters collaboration, enhancing commitment and drive among stakeholders. A lesson learned here is that ideological consensus is not just beneficial for mutual understanding but also critical for maintaining momentum in cooperative relationships.

Adaptability in Organizational Networks: The economic uncertainties and trade tensions have tested the project's resilience, revealing the importance of adaptability. The rapid switch to remote work and online coordination in response to these challenges exemplifies the necessity of flexibility in project execution. This experience underscores the value of an adaptive project management approach in the face of external stresses.

Proactive Planning for Resilience: The disruptions caused by the COVID-19 pandemic highlight the need for emergency planning. Recognizing the evolving nature of global risks, the project's response demonstrates the effectiveness of being prepared. Developing comprehensive emergency plans and maintaining the capability to execute these plans is critical for ensuring project continuity amidst change.

Legal Risk Awareness and Collaboration: The project's complexity has brought to light the importance of legal risk management. Active engagement with legal consultation services has proven essential in navigating the intricate legalities surrounding demonstration projects. This reflects the broader necessity of preemptive legal risk assessment and the benefits of ongoing legal support to preemptively address potential issues.

The Impact of Solidifying Knowledge: The project's ability to create robust knowledge products that standardize and exemplify hydrogen economy development has facilitated replication and promotion beyond the immediate context. This approach provides a reference for other initiatives

and emphasizes the importance of documentation and the codification of experiences as a tool for scaling up innovations.

Engagement and Public Awareness: The vibrancy of the hydrogen energy conferences and the outreach achieved by the fuel cell car roadshows underscore the role of public engagement in industry advancement. These initiatives have significantly raised awareness and acceptance of hydrogen technologies, proving that specialized outreach can accelerate market readiness and adoption.

1.5 Recommendations Overview

Based on the findings and lessons learned, this report provides crucial strategic insights into sustainable development practices and inclusivity, which can influence both current and future projects, in the following recommendations (more detailed information can be found in the main content of the report).

Organizational Strategy and Policy Integration. Improve communication and establish interactive mechanisms with project partners to share experiences and align strategies. Strengthen cooperation with governmental bodies to facilitate the development of integrated hydrogen production and refueling stations. Create and utilize an entrepreneurial network to disseminate the "Rugao experience" and promote sustainable hydrogen development, leveraging market resources to support the hydrogen industry's growth.

Implementation Excellence and Outreach. Ensure ample resource support for project execution, including expert consultation and provision of necessary materials. Collect and analyze project data diligently to assess outcomes effectively, and utilize a dissemination matrix across various media platforms to enhance the visibility and understanding of the project's results.

Capacity Building and Inclusive Development. Maintain the momentum of the hydrogen economy demonstration by utilizing established collaborative networks. Stabilize the project team by clearly defining roles and ensuring a consistent and professional staff. Expand training opportunities and international collaborations to incorporate global advancements and best practices, fostering a broader exchange of knowledge and expertise.

Social Inclusion, Gender Equality and Cross-cutting Issues. Promote gender equality by ensuring equal opportunities in recruitment and project participation. Provide targeted resources and training to support women's professional growth within the team. Encourage women's active participation in decision-making processes and allocate resources to enhance their capacity and visibility in the project.

2. Project Overview

2.1 Background

With the gradual global consensus on carbon neutrality and energy transition, the hydrogen energy industry is emerging as a new and competitive sector among major economies worldwide. Hydrogen, as the most promising secondary clean energy source of the 21st century, plays a crucial role in achieving deep decarbonization across various sectors. It is also a significant strategic direction in the global energy technology revolution and transformation.

For China, in 2016, the Resource and Environment Branch of the China National Institute of Standardization and the Fuel Cell Branch of the China Electrical Industry Association jointly released the "Blue Paper on the Development of China's Hydrogen Energy Industry Infrastructure (2016)." It presented the initial roadmap for China's hydrogen energy industry development. Since hydrogen energy was included in the government work report in 2019, China has released a series of policies supporting its industry development. The "Guiding Opinions on Energy Work in 2020" proposed promoting technological progress and industrial development in hydrogen energy. In the "14th Five-Year Plan," hydrogen energy was identified as a forward-looking industry, and the "14th Five-Year Plan for Green Industrial Development" emphasized accelerating hydrogen energy technological innovation and infrastructure construction. The "Medium and Long-term Plan for the Development of the Hydrogen Energy Industry (2021-2035)" highlighted coordinated infrastructure construction, demonstration applications in transportation, and expanded use in energy storage, distributed power generation, and industry. In March 2023, the "Guidelines for the Construction of the Hydrogen Energy Industry Standard System (2023 Edition)" was issued as the first national-level guideline for comprehensive hydrogen energy industry standards.

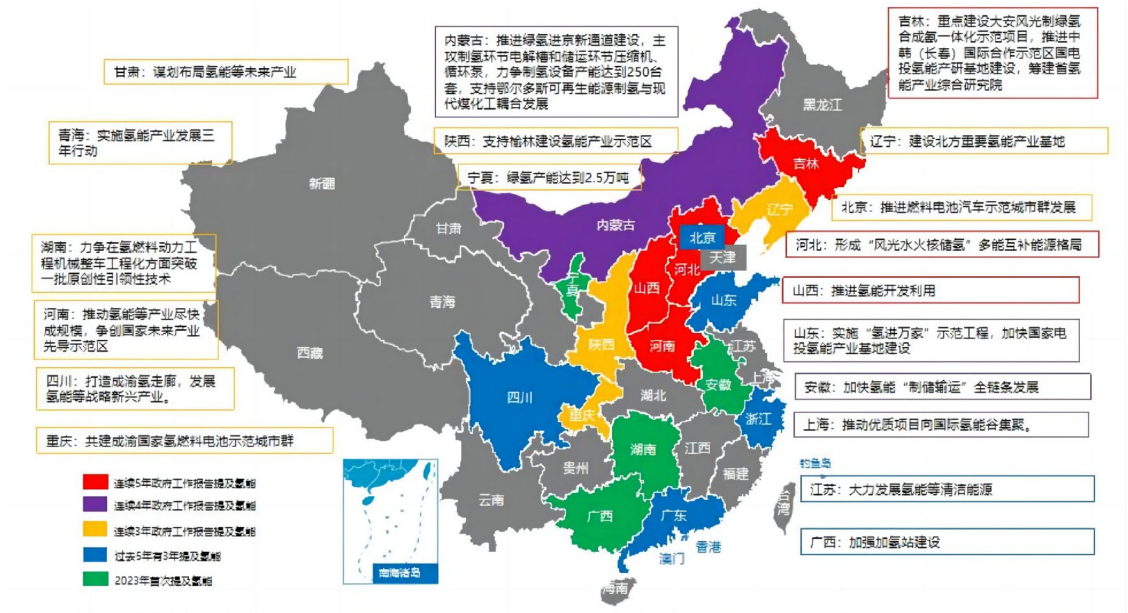

Figure 2 Inclusion of Hydrogen Energy in Government of China Work Reports[1]

[1] Translation: **Gansu**: Planning and laying out future industries such as hydrogen energy. **Qinghai**: Implementing a three-year action plan for the development of the hydrogen energy industry. **Hunan**: Striving to break through a batch of

Rugao has been strategically developing its hydrogen industry since 2010. Through a decade of persistent exploration and practice, it has emerged as one of the earliest regions in China to venture into the hydrogen energy sector. Rugao boasts the highest concentration of hydrogen industry clusters, the most comprehensive industrial chain, and significant industrial influence.

Since 2010, the Rugao Economic and Technological Development Zone has focused on empowering technology and accelerating the development of the hydrogen energy industry chain. It has improved hydrogen infrastructure, strengthened platform construction, and enhanced the competitiveness of the industrial chain. Rugao became the first city in China to be designated as a "Hydrogen Economy Demonstration City" by the United Nations Development Programme (UNDP), and "Rugao Hydrogen" has gradually become a prominent industry brand. Over the past decade, the development zone has consistently worked towards creating a hydrogen industry cluster, continuously building and perfecting the industrial ecosystem. It has expanded and broken through various links in the industrial chain, such as hydrogen production and filling equipment, key components of hydrogen fuel cells, hydrogen fuel cell stack systems, hydrogen fuel cell vehicles, and hydrogen infrastructure construction. This effort has laid the foundation for a comprehensive hydrogen energy industry chain covering hydrogen production, storage, transportation, hydrogen fuel cells, core materials, R&D and production of key components, development and manufacturing of hydrogen fuel cell vehicles, and demonstration applications of hydrogen products.

2.2 Project Interventions and Changes

This project aims to demonstrate hydrogen production and application technologies in Rugao City, establishing the first "hydrogen city" to achieve sustainable development and mitigate climate change. The evaluation will focus on the initial anticipated six outcomes of the project design. Due to various factors such as environmental policies and technologies changing over time, adjustments were made during the project execution. This subsection describes the initially expected final outcomes of the project.

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original and leading technologies in the industrialization of hydrogen fuel-powered engineering machinery. **Henan**: Promoting the rapid formation of scale in industries such as hydrogen energy, striving to create a national leading demonstration zone for future industries. **Sichuan**: Building the Chengdu-Chongqing Hydrogen Corridor and developing strategic emerging industries such as hydrogen energy. **Chongqing**: Co-building the Chengdu-Chongqing National Hydrogen Fuel Cell Demonstration City Cluster. **Shannxi**: Supporting Yulin in building a demonstration zone for the hydrogen energy industry. **Ningxia**: The green hydrogen production capacity is expected to reach 25,000 tons. **Liaoning**: Building a significant hydrogen energy industry base in the northern region. **Beijing**: Promoting the development of fuel cell vehicle demonstration city clusters. **Inner Mongolia**: Advancing the construction of the green hydrogen entry route to Beijing, focusing on key hydrogen production processes such as electrolytic cells and compression equipment in the storage and transportation stages. Striving to achieve a hydrogen production equipment capacity of 250 sets, supporting the coupling development of renewable energy hydrogen production and modern coal chemical industry in Ordos. **Shandong**: Implementing the "Hydrogen into Ten Thousand Homes" demonstration project, accelerating the construction of the State Power Investment Corporation's national hydrogen energy industry base. **Anhui**: Accelerating the full-chain development of "production, storage, transportation, and utilization" of hydrogen energy. **Shanghai**: Promoting the aggregation of high-quality projects into the international hydrogen energy valley. **Jilin**: Key construction of the Da'an Photovoltaic Green Hydrogen Synthesis Ammonia Integrated Demonstration Project, advancing the construction of the State Power Investment Corporation's hydrogen energy production and research base in the China-Korea (Changchun) International Cooperation Demonstration Zone, and planning the establishment of a provincial hydrogen energy industry comprehensive research institute. **Hebei**: Forming a multi-energy complementary energy pattern of "wind, light, water, fire, and nuclear storage hydrogen." **Shanxi**: Advancing the development and utilization of hydrogen energy.

Table 1 Project Result Matrix and Interventions

Objective: to demonstrate hydrogen production and application technologies in Rugao City, establishing the first "hydrogen city" to achieve sustainable development and mitigate climate change.	
Output 1 Adoption and enforcement of Hydrogen Economy Development Roadmap in Rugao	Activity 1.1 Provide technical support and guidance for the development and planning of the hydrogen economic development/roadmap.
	Activity 1.2 Complete the hydrogen economic development plan/roadmap.
Output 2 Reduced the costs and improving the quality of hydrogen production applied in the field of FC industry through renewable energy	Activity 2.1 Conduct renewable energy hydrogen production demonstrations according to the roadmap.
	Activity 2.2 Provide guidance on solar, waste hydrogen production, and other technologies.
	Activity 2.3 Summarize current hydrogen-related standards in China for production, storage, transportation, and refueling.
	Activity 2.4 Research and propose policy recommendations to improve hydrogen production standards and technical specifications.
	Activity 2.5 Conduct a commercialization model study for different hydrogen production technologies, including investment, technical requirements, production, operation, and CO2 emissions for different hydrogen production technologies (by-products, natural gas hydrogen production, wind hydrogen production, solar, methanol hydrogen production, waste/garbage hydrogen production, etc.).
Output 3 Improved and promoting the application of hydrogen storage and refilling technology	Activity 3.1 Feasibility study and construction of hydrogen refueling stations, including site selection, equipment procurement, and installation.
	Activity 3.2 Demonstration operation of hydrogen refueling stations.
Output 4 Application of FC technology in the transportation and cogeneration.	Activity 4.1 Completion of procurement and initiation of passenger demonstration operations for 5 fuel cell buses and 2 fuel cell cars according to the procurement invitation tender.
	Activity 4.2 Conduct vehicle demonstration operations based on the Rugao fuel cell vehicle demonstration plan.
	Activity 4.3 Select specific office areas and residential communities to carry out demonstrations of fuel cell cogeneration for fixed power stations.
	Activity 4.4 Operation of fuel cell cogeneration systems for 2-3 years.
	Activity 4.5 Conduct research on fuel cell vehicle standards and technical specifications for fixed power stations using fuel cells.
Output 5 Completed policy framework and carbon trading for hydroge	Activity 5.1 Development of support policies for low-carbon hydrogen production and hydrogen infrastructure.
	Activity 5.2 Development of support policies for the application of fuel cells in transportation and combined heat and power.
	Activity 5.3 Conduct technical and economic analysis and evaluation of the hydrogen economy.
	Activity 5.4 Conduct research and development of methods for carbon trading in industrial by-product hydrogen, transportation, and fuel cell combined heat and power.
Output 6 Enhanced acceptance of hydrogen utilization for both public and private uses via increased knowledge and awareness	Activity 6.1 Continuously engage in communication and exchange of information with international hydrogen organizations, domestic and international hydrogen demonstration projects, and enterprises in the hydrogen-related industry chain through conferences (in collaboration with the Hydrogen Alliance established by UNDP), seminars, and site visits.
	Activity 6.2 Organize workshops and international visits. Experts will provide assistance in conferences and exchange visits.

	Activity 6.3 Conduct project progress and achievement exchange, media publicity, and promote project progress and demonstration results.
	Activity 6.4 After achieving phased results, invite high-level visits from the United Nations, national, provincial, and local governments to the demonstration site.
	Activity 6.5 Organize information exchange among relevant personnel in interested demonstration cities and demonstration regions.
	Activity 6.6 Conduct replicable studies on the hydrogen economy in other cities and regions.
	Activity 6.7 Summarize and evaluate the experience, achievements, commercialization models of the demonstration area, and complete the study of the innovative mechanism of the Rudong hydrogen demonstration to accelerate the development of the hydrogen economy and hydrogen society.

The project has experienced the following major changes after its initiation compared with the above original result matrix:

1) The originally planned implementation period for the project was from August 2016 to July 2020. However, due to challenges in pandemic control, difficulties in the tendering process for large equipment, suboptimal service quality from suppliers, and issues related to the lack of legal regulations and standard specifications for hydrogen refueling stations, among other factors, there were some design changes. Consequently, the project has been extended to conclude in 2024 based on actual needs.
2) due to changes in laws and regulations, as well as technological developments, renewable Hydrogen Production Demonstration Cancelled: Due to restrictions imposed by existing regulations on hydrogen production activities and sufficient capacity for actual by-product hydrogen, the demonstration activity for renewable energy hydrogen production was canceled.
3) Transition to New Direction in Hydrogen Demonstration Applications: The fuel cell cogeneration demonstration project carried out in the talent apartment has achieved positive results. The project team, proactive in exploring new directions for hydrogen demonstration applications, adjusted its focus to the construction of an environmental warehouse and supporting facilities for the testing center.

2.3 Project Recourses

In terms of financial resources, this project is funded by the Rugao Management Committee, with a total budget allocation of 10 million USD. The government department has provided ample financial support for the project, particularly in the implementation of the Rugao Hydrogen Economy Development Plan, demonstration and implementation of hydrogen production, technical demonstrations of hydrogen storage and refueling, application of hydrogen energy in transportation and backup power, establishment of policy frameworks and carbon trading demonstrations, as well as public outreach and information exchange for the hydrogen economy. The detailed budget is presented in Table 2, outlining the six-year output budget from 2016 to 2023 (initial planned version), with amounts denoted in US dollars.

Table 2 Six-Year Output Budget (2016-2023, Initial Planned Version, Unit: USD)

Outputs	2016	2017	2018	2019	2020	2021	2022	2023
#1	157,982	464,518	0	0	0	44.60	0	0
#2	10,000	159,750	29,800	348,800	67,800	27,802	98,200	0

#3	10,000	16,000	0	0	360,000	2,371,030	396,825	358,989
#4	124,500	1,640,000	1,419,000	1,145,000	735,000	19,458	975,580	250,689
#5	11,500	111,500	204,000	179,800	99,000	79,200	20,000	8,000
#6	155,500	157,500	229,200	99,000	159,000	15,000	30,000	8,000

In terms of geographical resources, Rugao City is strategically located at the convergence of several national strategic initiatives, including the integration of the Yangtze River Delta, the Yangtze River Economic Belt, the construction of the Shanghai Free Trade Zone, the development of the modernization demonstration area in southern Jiangsu, and the national strategy for coastal development. Positioned at the core of the northern wing of the Yangtze River Delta, Rugao is closely connected to the eastern coastal economic belt and the Shanghai metropolitan area, enjoying exceptional locational advantages and natural conditions. Its comprehensive and efficient water, land, and air transportation system positions it as a new hub within the one-hour economic circle around Shanghai, making it a burgeoning development hotspot in the Yangtze River Delta with promising prospects.

In terms of human resources for the project, it is jointly implemented by the CICETE, Rugao Management Committee, and UNDP. Simultaneously, numerous entities such as the China Association for Science and Technology, Korea Hydrogen Promotion Agency, International Association for Hydrogen Energy and Fuel Cells, Society of Automotive Engineers of China, China Automotive Technology and Research Center, SAIC Group, Yutong Group, Land Hydrofoil, fuel cell enterprises, Tsinghua University, Tongji University, and several other institutions are involved in the project. Their participation provides extensive technical expertise and support for the project.

2.4 Project Stakeholders and Expected Beneficiaries

This project integrates efforts from various sectors of society, mobilizing their relevant resources and technological capabilities to support the project. The joint initiators of the project include the UNDP, CICETE, and the Rugao Economic and Technological Development Zone Management Committee. The project partners have established a Project Guidance Committee and set up a Project Management Office, located at the "Rugao Economic and Technological Development Zone Management Committee," responsible for the project's execution, daily management, and comprehensive coordination.

CICETE

The Ministry of Commerce serves as the central administrative department for the collaboration between the Chinese government and the United Nations Development Programme (UNDP). The China International Center for Economic and Technical Exchanges (CICETE), under the jurisdiction of the Ministry of Commerce and authorized and entrusted by the Ministry of Commerce, is responsible for the comprehensive coordination and management of UNDP projects in China. CICETE and UNDP jointly determine and implement cooperative projects within the framework of the United Nations Development Assistance Framework and country programs. With extensive experience in project management with UNDP, the CICETE has successfully organized and implemented over 1000 projects in various fields.

As the national executing agency for UNDP cooperative projects, CICETE, representing the government as a core partner, signs project documents and is responsible for project execution management. It collaborates with the UNDP Resident Representative Office in China to monitor, review, and evaluate the project. CICETE also provides services and support to project implementing agencies to ensure overall project quality.

CICETE guides the on-the-ground execution of UNDP projects in China, playing a crucial role as a bridge in multifaceted collaborations. It is also responsible for reviewing and executing annual work plans and budgets, financial management, auditing, and providing expert resources for project implementation.

UNDP

The UNDP has offices in over 170 countries and regions worldwide, boasting a rich international network and expert resources. Since its establishment in China in 1979, the UNDP has implemented over 1000 projects, contributing to China's sustainable development. The UNDP China Office collaborates with CICETE to monitor the demonstration project, ensuring overall project implementation quality. It provides business guidance, technical support, capacity building, and international resources to explore sustainable development cooperation goals for the demonstration project.

The UNDP China Office assists in formulating the project's strategic planning, risk management, and monitoring and evaluation. It actively participates in project design and the organization of significant activities. The office conveys the essential requirements of the United Nations Sustainable Development Goals, supervises project execution and financial management, participates in project consultation meetings, technical seminars, and oversees and promotes project activities.

Rugao Economic and Technological Development Zone Management Committee

Established in September 1992, the Rugao Economic and Technological Development Zone Management Committee is a key area for the economic and social development of Rugao. In December 1993, it became one of the first 13 provincial-level development zones in Jiangsu Province. On January 17, 2013, it was successfully upgraded to a national economic and technological development zone.

The committee is committed to implementing five major development strategies: high-end product development, industrial specialization, international perspective, integration of industry and city, and ecological sustainability. It vigorously promotes the construction of "five zones," including the most competitive national-level energy-saving and new energy vehicle industry gathering area, ecological industrial park, clothing export quality and safety demonstration zone, provincial-level intellectual property demonstration park, and transformation and upgrading reform demonstration zone. The committee focuses on the development of three emerging industries: energy-saving and new energy vehicles, new energy, and biotechnology for longevity.

Beneficiaries – City, communities, companies, and hospitals

The Hydrogen Economy Pilot Project have had a considerable impact on multiple stakeholders, shaping the future of energy consumption and infrastructure. At the heart of these outputs, Rugao City itself has become a primary beneficiary. The city has been equipped with a comprehensive hydrogen economy roadmap, thanks to the technical support and strategic planning provided by the project. The adoption of hydrogen-powered public transportation and the integration of clean energy solutions directly benefit the local communities and residents by contributing to cleaner air quality and a reduction in noise pollution, enhancing the overall living conditions in Rugao.

Another group of beneficiaries includes public transportation companies, hydrogen refueling stations, hospitals, and mobile companies. Through the enhancement of hydrogen fuel standards and the introduction of fuel cell technology in buses and backup power systems, these entities have experienced direct improvements in operational efficiency and service reliability. Public transportation companies, in particular, have benefited from the integration of fuel cell buses, which has elevated the quality of public transit while reducing environmental impact. Hospitals and mobile companies have similarly benefited from reliable and clean backup power sources, ensuring uninterrupted service.

2.5 Project Governance

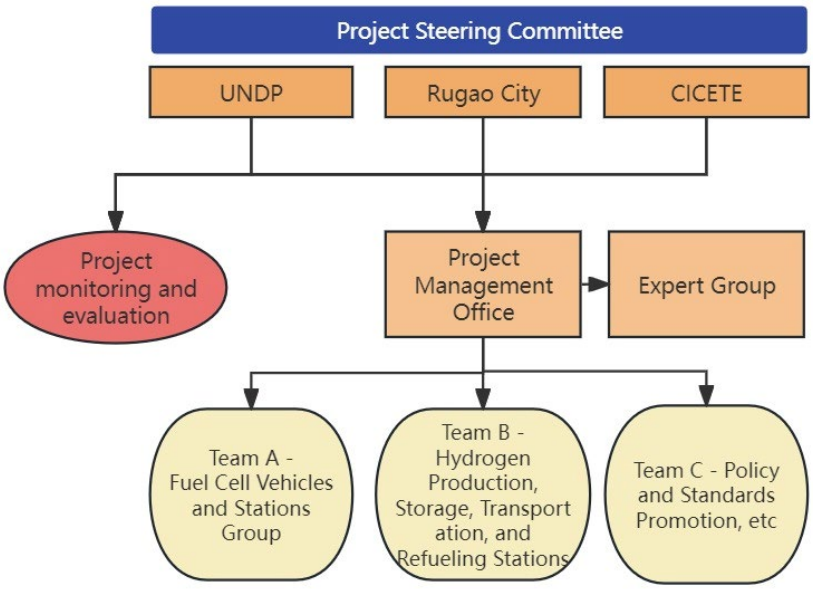

Figure 3 Project Governance Structure

The project adopts a national implementation model, establishing a dual-layer management structure that combines guidance and execution to ensure the directionality of project decisions and the effectiveness of implementation.

The highest decision-making body of the project is the Project Steering Committee, which involves key stakeholders, including the China International Center For Economic And Technical Exchanges, the UNDP China Office, and representatives from the Rugao Management Committee. During the project implementation period, the Project Steering Committee convenes 1-2 meetings

annually and holds ad-hoc meetings when significant decisions need to be made, effectively fulfilling the following responsibilities: approval of annual work plans; review of project annual work reports; provision of technical advice based on industry expertise; mobilization of policy, human, and complementary financial resources to support project implementation; coordination of differing opinions within the project to ensure collaboration among member units; comprehensive evaluation of the final project outcomes.

The project implementation is overseen by the "Project Management Office (PMO)," located within the Rugao Management Committee and operating under the leadership of the "National Project Director (NPD)." The NPD is appointed by the Rugao government and assumes the role of a chief leader, responsible for guiding and supervising project implementation. The Project Office Director, under the leadership of the NPD, is specifically responsible for project implementation and promptly reports progress to the NPD. All project activities require approval and authorization from the Project Office Director. The composition of the office includes the National Project Director and relevant personnel. The PMO is responsible for organizing and implementing project activities in accordance with the project work plan and related budgets. Specific responsibilities include developing work plans, ensuring adequate fund allocation, daily management of project implementation, monitoring project progress, facilitating knowledge exchange, and preparing regular project reports.

2.6 Project Risks and Mitigation Measures

The project, during its design phase, thoroughly considered potential risks that might arise during implementation, encompassing three main aspects: physical/environmental, institutional, and financial. Corresponding mitigation measures were proposed. However, during the project execution, certain risk factors emerged due to uncontrollable circumstances. The primary areas of concern are outlined in Table 3:

Table 3 Project Risk Log

Type	Description	Main Aspects
Physical/ Environmental	Impact of Uncontrollable Factors on the Project	1. The COVID-19 pandemic has led to the inability to conduct offline meetings and other activities. The installation conditions at the equipment user's site were not promptly met, and the equipment supplier couldn't perform construction on time. 2. Lithium batteries catching fire resulted in the environmental warehouse not being accepted on time.
Institutional	Impact of Policy and Regulations on the Project	1. Although the "energy" attributes of hydrogen are clear, there is currently no legal framework at the national level to support it. Hydrogen is still treated as a hazardous chemical, with strict approval and management. Hydrogen production needs to be in chemical industrial zones, making it challenging to construct integrated hydrogen refueling stations, carry out hydrogen production, and demonstrate combined heat and power projects.

		2. The national regulations for hydrogen stations are not clearly defined under gas management. The government does not renew or exchange gas business licenses for hydrogen stations, leading to inconsistencies between the hydrogen station's business license and the gas business license of the legal entity, posing operational risks. 3. The 3C certification for domestic 70MPa IV-type hydrogen storage cylinders has not been established to date, preventing the demonstration operation of fuel cell vehicles.
Financial	Impact of Demonstrative Effect on Project Finances	This project is a hydrogen energy demonstration project, and its economic benefits, such as the input-output ratio, should not be measured.

3. Evaluation Objectives and Methodologies

3.1 Evaluation Scope and Objectives

The purpose of this evaluation is to conduct a comprehensive, objective, and fair analysis and evaluation of the implementation effects and impacts of the Hydrogen Economy Pilot Project in China from August 2016 to October 2023. It aims to further advance developments in the hydrogen energy sector, accelerating the achievement of carbon peak and carbon neutrality goals.

The evaluation results are intended to communicate project outcomes to key stakeholders such as the Communication Center, the Rugao Municipal Commission, UNDP, among others. The evaluation seeks to summarize experiences and lessons learned and provide forward-looking, strategic advice. It will furnish crucial evidence-based information related to the project, offering technical support and experiential insights for China's efforts to achieve carbon peak and carbon neutrality.

The overarching objectives of this final evaluation are as follows:

1) Evaluate the level of control of project partners and the degree of involvement of participating institutions in the project.
2) Assess the relevance and effectiveness of the strategies employed by the project.
3) Evaluate the outcomes and impacts of intervention measures in promoting local sustainable development, particularly in the development of the hydrogen economy.
4) Assess the policy influence of the project on local governments and its potential impact on the policy environment in the Yangtze River Delta and the nation as a whole.
5) Evaluate the effectiveness of the project in enhancing the capabilities of local partners (including government and private sectors).
6) Assess the extent and effectiveness of incorporating a gender perspective into the project.
7) Evaluate the operational efficiency and sustainability of the project at the local level.
8) Examine how local governments and UNDP can continue to promote low-carbon and sustainable development based on the project's work and outcomes, and provide recommendations.

In terms of users and audiences, as one of the longest and most extensive projects of its kind, the findings are critical for the Rugao government to understand the local benefits and challenges, while for UNDP and CICETE, the evaluation offers essential insights into sustainable development practices and inclusivity that can influence current and future projects. The timing of the evaluation ensures that all stakeholders, including industry partners and community organizations, can leverage the results to refine strategies, improve collaboration, and foster the replication of successful practices in similar initiatives worldwide.

3.2 Evaluation Criteria

In alignment with the UNDP Evaluation Guidelines, our evaluation methodology encompasses a thorough analysis of the project results across five critical dimensions: relevance, effectiveness, efficiency, sustainability, and gender and cross-cutting issues.

- **Relevance**: The evaluation rigorously examines the project's congruence with national priorities, and the overarching strategic objectives of the UNDP. It scrutinizes the project's responsiveness to the evolving needs and expectations of the local communities and stakeholders it serves, as well as its adaptability to external environmental shifts.
- **Effectiveness**: Our focus here is to determine the degree to which the project has met its predefined objectives and outcomes. This includes an assessment of both anticipated and unforeseen impacts, positive or negative, as well as an analysis of the factors and risks that have influenced these outcomes.
- **Efficiency**: We evaluate the project's resource utilization—considering human, material, and financial inputs—against its operational outputs. The timeliness, quality, and volume of the project's deliverables are measured, along with the presence of strategies to enhance resource allocation and operational efficiency.
- **Sustainability**: The evaluation probes the project's potential for long-term impact, analyzing its capacity to sustain benefits beyond its immediate lifecycle. We assess the existence of supportive mechanisms and conditions, policies, and stakeholder support that may contribute to the enduring success and growth of the project's initiatives.
- **Gender Equality and Cross-cutting Issues**: The assessment pays close attention to how the project focus on gender, people with disabilities (PWD), and other vulnerable groups. It evaluates the project's effectiveness in recognizing and catering to the varied needs and roles of different gender groups, its commitment to dismantling gender discrimination and inequality, and its role in bolstering the agency and opportunities for women and marginalized communities.

3.3 Evaluation Methodologies

Theory-Driven Evaluation. The final evaluation adopts the "Theory-Driven Evaluation" method. This approach not only involves a pre- and post-comparison through the Change Model of intervention measures but also introduces an Action Model. The Action Model serves as a bridge, illustrating the causal chain between actions and the goals and outcomes. In this way, it opens the "black box" of the transition between intervention and goals, explaining how and why the project has achieved success to what extent (White 2009, Chen 2014). Simultaneously, it situates causal mechanisms within a broader policy context and a more complex dynamic system, attempting to discover the relationships of adaptation and feedback between the project and external systems.

The Hydrogen Economy Pilot Project in China follows the "Theory of Change" and proposes intervention measures to achieve the demonstration effect of hydrogen energy based on the analysis of the current situation and reasons. The Theory of Change is not only a project design and management tool but also an "outcome-oriented" evaluation framework, applied in various stages of project strategic analysis, design, implementation, and monitoring and evaluation (Gertler, Martinez et al. 2016). An evaluation based on the Theory of Change can directly reveal the degree of achievement of expected outcomes. With appropriate analytical methods, it can also explain the logical process and causal chain of result realization, helping to discover the key assumptions behind intervention measures and the impact factors on the expected target outcomes.

Following the Theory of Change of the Hydrogen Economy Pilot Project in China, the evaluation team established an integrated logical framework combining the Change Model and Action Model (Chen 2014). They systematically analyzed the logical chain of project goals, activities, outputs,

short-term effects, long-term effects, impacts, and change implementation (see Figure 4), attempting to discover the main implementation paths, underlying assumptions, and external influences from key actions to planned outputs. This is done to assess the effectiveness of project implementation and summarize improvement recommendations.

Figure 4 Schematic Representation of Analysis Steps[2]

Inclusive and gender-responsive Evaluation – Gender, PWD and other marginalized groups. The evaluation will attach an emphasis on gender equality and the empowerment of women and girls (GEEW). It will incorporate assessments that highlight gender dynamics, ensuring that the project's influence on gender relations is thoroughly examined. By engaging in gender-disaggregated data collection and analysis, the evaluation aims to uncover disparities and assess how the project's benefits are distributed among men and women. This approach is critical to understand the project's reach and to ensure that it supports gender equality as a fundamental objective.

In parallel with the focus on gender, the evaluation also prioritizes the inclusion of Persons with Disabilities (PWD) and other marginalized groups and communicates. This commitment to inclusivity involves adapting methodologies and tools to be accessible, as well as engaging with PWD through targeted outreach and consultation with organizations representing their interests. The goal is to ensure that the project's impact on PWD is clearly understood and that their unique needs and perspectives are incorporated into the project's framework.

In conclusion, this final evaluation aims to provide a detailed understanding of the Rugao Hydrogen Project's social impact, with a focus on GEEW and disability inclusion. The insights gained will inform targeted recommendations that enhance the project's social inclusivity and equity. Stakeholders, including local government bodies, international organizations, and community groups, are expected to use these findings to refine the project's approach, ensuring that the benefits of hydrogen energy are accessible to all members of society and contribute to a more inclusive and equitable model of development.

[2] Note: This figure is a schematic representation guiding the analysis steps and does not presuppose linear relationships between elements. The evaluation analysis focuses on complex nonlinear relationships and potential feedback effects between elements, providing insights into causal connections for project implementers and other users.

3.4 Evaluation Key Questions and Evaluation Matrix

Table 4 Evaluation Key Questions and Evaluation Matrix

Evaluation Criteria	Evaluation Questions	Data Collection Methods	Data Processing Methods
Relevance (Are the project's objectives and activities in line with national and local development strategies and priorities? Do they align with the gender equality and human rights policies of the United Nations Development Programme? Do they meet the needs and expectations of the target group?)	1. Are the objectives and activities of the project consistent with the three outputs and multiple indicators outlined in China's National Plan for Implementing the 2030 Agenda for Sustainable Development? 2. Do the objectives and activities of the project align with national and local policy documents such as the "Medium- and Long-Term Plan for the Development of China's Hydrogen Industry (2021-2035)" and the "Guidelines for the Construction of the Hydrogen Industry Standard System (2023 edition)"? 3. Have the objectives and activities of the project also considered the energy, environmental, and economic needs of different genders and groups, reflecting the relevance of the project? 4. Has the project provided opportunities and platforms for enhancing the abilities and well-being of the target group, thereby meeting and improving their energy, environmental, and economic needs? 5. Has the project, through the promotion of hydrogen vehicles and refueling stations, provided a cleaner and more convenient transportation service for Rugao City, thereby improving urban environments and livelihoods, and enhancing the travel and quality of life for local residents? 6. Has the project, through the construction of hydrogen energy storage and distributed energy systems, provided Rugao City with more reliable and efficient electricity supply, thereby enhancing the resilience of the city and communities and improving the work and living efficiency of local residents? 7. Has the project conducted hydrogen energy training and guidance to enhance the knowledge and skills of the target group, strengthen their awareness and participation in hydrogen energy, thereby promoting the capacity building and energy transition of the target group? 8. Has the project influenced national and international policies and standards, provided references and guidance for the formulation and implementation of hydrogen energy policies at national and local levels, supported the development and promotion of international hydrogen energy standards, provided a platform and opportunities for national and international cooperation and exchanges in hydrogen energy, and demonstrated China's international influence in the field of hydrogen energy?	Using methods such as data analysis and interviews, the project's goals and activities are examined from various perspectives and levels to assess their consistency and adaptability with national and local development strategies and priorities, the gender equality and human rights policies of the United Nations Development Programme, and the needs and expectations of the target groups.	Using methods such as logical analysis, correlation analysis, and consistency analysis, the effectiveness level and influencing factors of the project are assessed from both qualitative and quantitative perspectives.
Effectiveness (Has the project achieved its intended goals and outputs? Has it generated	1. Has the project achieved the formulation of a development roadmap for hydrogen energy in Rugao, demonstration of hydrogen production technologies, construction of hydrogen storage technologies and hydrogen refueling stations, application and standard development of hydrogen fuel cells in transportation and cogeneration,	Through literature analysis, interviews, observations, on-site surveys, etc., the project's objectives and actual outcomes	Employing techniques such as results mapping, beneficiary evaluations,

unforeseen positive or negative impacts? Has it addressed issues and challenges encountered during implementation? Has it leveraged opportunities and strengths that arose during implementation?)	research on the institutional framework for hydrogen energy policies, and methodology for carbon trading, as well as public awareness and education efforts? 2. Has the project contributed to innovation in knowledge and technology related to hydrogen energy by conducting technical demonstrations in hydrogen production, storage, transportation, and applications, thereby providing impetus and support for the innovation and development of knowledge and technology in the field of hydrogen energy? 3. Has the project facilitated the development and innovation of the hydrogen energy industry, improved energy efficiency and cleanliness, reduced greenhouse gas emissions, and contributed positively to achieving sustainable development goals? 4. During the implementation of the project, has it encountered challenges such as the maturity and reliability of hydrogen technologies, high costs and competitiveness of hydrogen energy, risks and management of hydrogen safety, lack of uniform hydrogen standards, and low awareness and misconceptions about hydrogen energy? Has the project adopted effective measures to address or mitigate these problems and challenges? 5. In the course of implementation, has the project capitalized on opportunities and advantages such as policy support at the national and local levels, cooperation and communication with international organizations and other countries, participation and investment from relevant enterprises and institutions, and meeting the demands and expectations of the public to enhance the project's influence and sustainability? 6. Has the project contributed to the hydrogen energy industry, energy transition, and carbon neutrality goals? Has it promoted the development and innovation of the hydrogen energy industry, increased the maturity and reliability of hydrogen energy technologies, lowered costs, improved efficiency, established standards and specifications for the hydrogen energy industry, expanded the market and applications for hydrogen energy, facilitated international cooperation and communication in the hydrogen energy industry, and contributed to achieving energy transition and carbon neutrality goals?	are examined from different perspectives and levels. Positive or negative impacts of the project, as well as the opportunities and challenges faced during implementation, are also assessed.	contribution analysis, and impact evaluations, the effectiveness level and influencing factors of the project are evaluated from both qualitative and quantitative perspectives.
Efficiency (Has the project judiciously utilized human, material, financial, and other resources? Have project activities and outputs been completed on time? Has an effective project management and monitoring mechanism been established? Has coordination and collaboration occurred	1. Has the project adhered to the financial and procurement rules and procedures of the United Nations Development Programme (UNDP), reasonably allocated and utilized project funds and resources, effectively controlled project costs and risks, and ensured the quality and effectiveness of the project? 2. Has the project, in accordance with project documents and work plans, completed various activities and deliverables on time, submitted progress reports and final reports in a timely manner, reflecting the project's implementation status and outcomes? 3. Has the project established project management and monitoring mechanisms such as the Project Execution Committee, Project Execution Office, and Project Technical Expert Group? Does it regularly convene project management and monitoring meetings to review and assess project progress and issues, provide suggestions for	Utilizing methods such as literature analysis, interviews, questionnaires, financial audits, and project monitoring, the project's resource utilization, completion of project activities, management and monitoring mechanisms, coordination, and cooperation are examined from different perspectives and levels.	Utilizing cost-benefit analysis, cost-effectiveness analysis, efficiency analysis, and efficiency frontier analysis, the efficiency level and influencing factors of the project are assessed from both qualitative and quantitative perspectives.

with other relevant projects and organizations?)	improvement and adjustments, and ensure the smooth implementation and achievement of objectives? 4. Has the project collaborated with other relevant projects or organizations to promote market applications? Has it engaged in collaboration and interaction with social groups, media, and the public for publicity and education, thereby expanding the project's influence and cooperation network?		
Sustainability (Has collaboration with other relevant projects or organizations taken place for market and application promotion? Have partnerships and interactions with social groups, media, and the public been undertaken for outreach and education, thereby expanding the project's scope of influence and collaboration network?)	Has the project provided technical support, policy guidance, and social foundations for the development and innovation of the hydrogen energy industry in Rugao City, laying a solid foundation for the construction of a "hydrogen city" in Rugao?	Through literature analysis, interviews, case studies, on-site investigations, etc., the promotion status of the project in the market and its applications are assessed from various perspectives and levels.	Employing sustainability analysis, risk analysis, sensitivity analysis, multi-criteria decision analysis, and other methods, the sustainability level and influencing factors of the project are evaluated from both qualitative and quantitative perspectives.
Gender and Other Cross-Cutting Issues	1. To what extent has the project considered gender equality, women's empowerment, people with disabilities (PWD), and other vulnerable groups issues in its design, implementation, and monitoring? 2. Do the gender-disaggregated data allocated to this project accurately represent the actual situation? 3. To what extent has the project promoted positive changes in gender equality and women's empowerment? Are there any unforeseen impacts?	Using literature analysis, interviews, questionnaires, gender analysis, social impact analysis, etc., the project's impact and contribution to gender equality, human rights, environment, and society are assessed from different perspectives and levels. The report investigates whether the project considers the interests and needs of different groups and whether it promotes social harmony and development.	Using gender indicators analysis, human rights indicators analysis, environmental indicators analysis, social indicators analysis, and other approaches, the levels and influencing factors of gender and other cross-cutting issues in the project are assessed from both qualitative and quantitative perspectives.

3.5 Data Collection and Analysis

The robust evaluation of the Rugao demonstration project hinges on the systematic collection and astute analysis of data, which serves as the cornerstone for an objective assessment of the project's outcomes. This section delves into the methodologies adopted for gathering both primary and secondary data, ensuring a rich tapestry of evidence. From key informant interviews that capture the nuanced perspectives of stakeholders to comprehensive document reviews for contextual grounding, the data amassed offers a multi-dimensional view of the project's efficacy and impact.

3.5.1 Primary Data Collection

The primary data collection for the Rugao demonstration project consisted of a streamlined approach combining interviews, expert consultations, focus group discussions, and on-site evaluations to collect diverse perspectives and detailed information on project performance and impact:

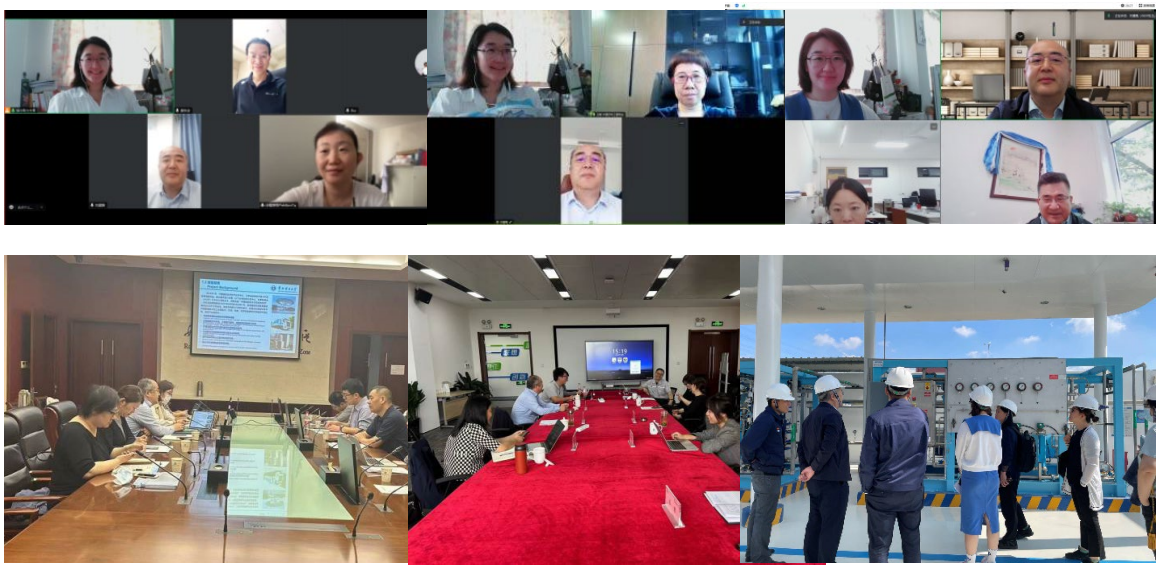

Figure 5 Images of Primary Data Collection Process

- **Online Key Informant Interviews (KII) with Project Collaborators**: Interviews were conducted with representatives from the CICETE, UNDP, Rugao Management Committee, and other collaborating entities. These online discussions were designed to gather insights from those actively involved in the project's design and implementation, focusing on project performance, execution methods, and collaboration mechanisms.
- **Offline Key Informant Interviews (KII) with Project Participants and Experts**: In-person interviews with project participants provided firsthand accounts of the project's impact, processes, and areas for future development. Parallel to this, consultations with project experts, including the technical chief advisor, offered a comprehensive understanding of the project's design principles, its contribution to sustainable development education, and its alignment with China's sustainability goals.
- **Focus Group Discussions (FGD) with Beneficiaries and Communities**: These discussions engaged participants from the project's promotional activities to reflect on their experiences, changes in perception regarding hydrogen technology, and advocacy roles

post-engagement. These group interactions served as a platform for beneficiaries and local stakeholders to share their experiences, enhancing the data's depth with varied personal insights and collective viewpoints.

- **On-site Evaluations**: The evaluation team conducted field visits to critical infrastructures, such as the Shanghai Motor Vehicle Testing and Certification Technology Research Center's Jiangsu branch and the Rugao Shenhua Hydrogen Station. These visits, supplemented by inspections of hydrogen-fueled buses and combined heat and power systems in operation, provided tangible evidence of the project's real-world application and efficacy.

By integrating key informant interviews and focus group discussions within the broader context of direct stakeholder engagement and empirical on-site assessments, the evaluation team ensured a holistic and multi-faceted data collection approach. This method provided a robust foundation for understanding the project's impact, capturing both the quantitative and qualitative outcomes of Rugao hydrogen demonstration project.

3.5.2 Secondary Data Collection

The evaluation team conducted a focused review of all available documents related to the project, including:

- Project documents and project approval letters
- Annual work plans
- Detailed expenditure reports for each year
- Annual work summaries
- Minutes of the annual tripartite review meetings and steering committee meetings over the years
- Annual audit reports
- Mid-term evaluation reports of the project
- Reports from international and domestic experts over the years
- Reports on research topics over the years
- Materials from large conferences and events
- Reports from relevant corporate services
- Media coverage related to the project

3.5.3 Data Analysis

- **Document Review**: The evaluation team conducted a succinct review of key documents, including project plans, annual reports, and financial statements. This review focused on cross-referencing information to verify the consistency and coherence of project execution and to analyze financial efficiency.
- **Case Studies**: Select landmark events, such as the International Hydrogen and Fuel Cell Conference, were examined through available reports, photos, and testimonies. The goal was to determine how these events reflected the project's objectives and to extract key lessons from their execution.
- **Results Mapping**: This technique was employed to trace the direct and indirect outcomes of the project, examining how early achievements paved the way for broader,

transformative changes. It helped in identifying behavioral changes among stakeholders and gauging the effectiveness of the project's interventions.

- **Beneficiary Feedback**: Assessments were made based on the experiences and opinions of those directly affected by the project. This approach focused on capturing the project's impact from the beneficiaries' viewpoint, especially marginalized groups, to gauge the real-world value of the project's deliverables.
- **Contribution Analysis**: A straightforward analysis was used to infer the project's influence on observed outcomes, considering both the project's interventions and other factors. This method aimed to confidently link the project's activities to its achievements, clarifying its role in the observed changes.

3.6 Ethical Considerations

The integrity of the evaluation report for the Rugao demonstration project is rooted in the adherence to the UNDP's core principles and the United Nations Evaluation Group's "Evaluation Ethics Guidelines" of 2020. The methodology and process of the evaluation are designed to reflect the UN's commitment to human rights, gender equality, and social inclusivity. This commitment is operationalized through a steadfast dedication to independence, objectivity, and impartiality; a scientific and evidence-based approach; and a transparent, communicative process aimed at meaningful project improvement. Furthermore, the evaluation upholds the highest standards for respect, anonymity, and privacy protection, ensuring that all data collected and analyzed are handled with the utmost confidentiality and integrity.

3.7 Evaluation Limitations and Mitigation Measures

Due to limitations in data monitoring, tracking critical information, and other aspects, there are certain constraints within the evaluation process. The evaluation team has implemented appropriate mitigation measures to address these limitations by supplementing information through alternative means, aiming to minimize the adverse impact of these constraints (refer to Table 5).

Table 5 Limitations of and Mitigation Measures for the Evaluation in this Project

Evaluation Limitations	Mitigation Measures
Limited Traceability of Project Participants: The planned focus group interviews could not be conducted due to a restricted number of traceable project participants.	Implemented individual in-depth interview methods, requesting participants to describe their understanding of other involved individuals. Supplementary information was gathered through summaries of theme activities, media reports, and other materials.
Incomplete Investigation of Project Collaboration Network: The exploration of potential collaboration drivers and mechanisms is constrained by an incomplete survey of the project's collaboration network.	During interviews with representatives from core collaborative institutions, respondents were asked to describe external collaboration relationships, analyzing potential collaborators, and promotional methods for the future.
Constraints on Time and Sample Availability: Large-scale surveys and quantitative analyses of project	Utilizing overall project data, the report described the project's scope of impact, beneficiary groups, and other indicators. A recommendation was made

participants were not feasible due to limitations in time and sample availability.	for the project team to strengthen communication with participating students, providing ongoing support and a platform for continuous exchange.
Constraints of Online Interviews: Online interviews to some extent restricted observational and participatory discovery.	Following online interviews, some participants supplemented the discussions by providing visually informative materials, establishing contact details. This was done to facilitate timely follow-up and verification by the evaluation team in case issues arose.

3.8 Evaluation Schedule

To ensure the smooth implementation of the evaluation work, gain a better understanding of the entire process, summarize the highlights and challenges of the activities, and provide valuable experiences and insights for future endeavors, the evaluation team have devised the following evaluation timeline and activity schedule, as detailed in Annex VI.

4. Main Findings

4.1 Findings Overview

Table 6 Overview of the Findings

Project Result Framework, TOC and M&E Arrangement	Project Result Framework Design and TOC	**Finding 1**: The TOC design of the project features an ambitious objective for the time of its launch that is broken down into a series of comprehensive outputs benefited from a systematic approach. The Result Framework of the project includes a set of straight-forward indicators on the output-level that cogently inform project monitoring.
	M&E	**Finding 2**: The project monitoring and evaluation (M&E) system of the China Hydrogen Economy Pilot Project has effectively ensured the quality, effectiveness, and impact of the project, providing robust support and valuable insights for the development of the hydrogen economy.
Relevance		**Finding 3:** The Project is highly relevant with national development priorities, UNDP's Strategic Plans (SP), Country Programme Document (CPD) and SDG targets.
		Finding 4. The overall design and methodology of the Hydrogen Economy Pilot Project in China thoroughly consider the practical circumstances and overarching goals of the project. Throughout the design and implementation phases, the project adheres to the gender equality and human rights policies of the UNDP, ensuring that activities and outcomes do not adversely affect different genders and groups. Moreover, the project adequately addresses the needs and aspirations of various target groups, catering to the energy, environmental, and economic requirements of diverse populations.
Effectiveness	Output 1	**Finding 5**: The "Rugao Hydrogen Energy Development Roadmap" comprehensively covers the entire hydrogen industry chain, from production, storage, transportation to utilization, playing a crucial guiding role in the development of Rugao's hydrogen energy economy.
		Finding 6: As the concrete implementation of the "Rugao Hydrogen Energy Development Roadmap" and the optimal carrier for the UNDP Hydrogen Economy Pilot Project in China, the planning and construction of the Rugao Hydrogen Town have accumulated valuable construction experiences for the replication and promotion of the future hydrogen energy economy and society.
	Output 2	**Finding 7:** Due to the necessity of hydrogen production planning within chemical industrial parks and the substantial difficulty in implementing renewable energy-based hydrogen production in hydrogen industry parks, hydrogen production demonstrations have not been conducted. However, the drafting of the "Rugao Feasibility Study on Renewable Hydrogen Production" report provides excellent support for future renewable energy-based hydrogen production. The

		feasibility evaluation report on vehicle-mounted aluminum alloy hydrolysis hydrogen fuel cell technology lays a solid foundation for on-demand hydrogen production.
	Output 3	**Finding 8:** The forward-looking project design successfully facilitated widespread adoption of fuel cell buses but encountered setbacks with fuel cell cars due to certification constraints for hydrogen storage cylinders. Operational challenges at the Rugao Shenhua Hydrogenation Station, stemming from regulatory gaps, led to a suspension that disrupted the use of hydrogen fuel cell vehicles. Nonetheless, the station's efforts to promote renewable hydrogen production are instrumental in shaping the "Rugao Experience," setting a benchmark for the industry's growth across China.
	Output 4	**Finding 9:** The fuel cell backup power supply and cogeneration system demonstrate positive exemplary effects. However, multiple backup power sources are idle, leading to a lower equipment utilization rate. Additionally, due to restrictions on hydrogen production in non-chemical industrial zones and safety production regulations mandating the installation of explosion-proof sheds, the cogeneration system is currently not operating normally.
		Finding 10: Although the environmental chamber's acceptance was delayed due to uncontrollable factors, such as the spontaneous combustion of lithium batteries in the experimental vehicle, the procurement of the environmental chamber will enhance the testing capabilities of the platform significantly. This procurement holds substantial importance in advancing the manufacturing technology level of fuel cell vehicles.
		Finding 11: The acquisition of additional equipment for the National Hydrogen Energy Vehicle Research and Testing Public Service Platform drastically improves its operational efficiency and service standards.
	Output 5	**Finding 12**: There have been substantial research achievements in areas such as fuel cell vehicles, fuel cells for fixed power stations, standards, and technical specifications. Nine draft standards and compilation instructions have been formulated. Additionally, industry policies such as the "Construction and Development Plan for the Yangtze River Delta Hydrogen Corridor" and the "Integrated Demonstration Plan for Fuel Cell Vehicles in the Yangtze River Delta" have been developed, propelling the development of the hydrogen energy industry
		Finding 13: Active research into carbon quota trading systems and the addition of the "Methodology Development for Greenhouse Gas Emission Reduction in Fuel Cell Applications in Transportation and Cogeneration" subcontract project promotes institutional innovations for green and low-carbon development.

	Output 6	**Finding 14**: Hosting and co-hosting multiple editions of the International Fuel Cell Vehicle Conference with high specifications, rich content, and in-depth themes have had an outstanding promotional effect. This has significantly contributed to the profound advancement of hydrogen and fuel cell vehicle technology and industry development in China and globally. The 5G+VR live broadcasting project provided attendees with a multi-perspective, panoramic, immersive experience, while 5G technology facilitated smooth, efficient live streaming, and IoT services during the conference.
		Finding 15: Organizing the 2018 and 2019 Fuel Cell Vehicle and Related Parts Exhibitions concurrently with the Hydrogen and Fuel Cell Vehicle Conference provided a platform for vehicle manufacturers and technical service providers to showcase their products and facilitated extensive networking opportunities. This fostered technical interaction and industry exchanges between different levels of the industry.
		Finding 16: Actively planning and participating in the 2018 and 2019 "Fuel Cell Vehicle Science Popularization Tour" garnered widespread attention from various sectors of society and achieved excellent science communication effects. Organizing lectures on hydrogen and fuel cell advancements and high-tech entrepreneurial project roadshows promoted technological innovation and industrial collaboration in the field, providing impetus and support for the development of the hydrogen and fuel cell industry.
		Finding 17: The project team organized visits to Japan, South Korea, Denmark, and Finland, facilitating international exchanges, drawing from advanced technological experiences and models, and thereby enhancing the project's technical expertise and management capabilities. This also served as effective promotion for the demonstration project.
		Finding 18: Production of mid-term and final promotional videos to showcase the project's goals, content, progress, and achievements aimed to increase public understanding and recognition of the project. This effort elevated the project's influence, attractiveness, stimulated widespread societal interest and involvement in hydrogen energy, and furthered the development of the hydrogen and fuel cell industry.
Efficiency	Financial management efficiency	**Finding 19**: The project funding is adequate, with an overall good execution rate. However, challenges such as the pandemic, repeated failures in public tenders for large equipment, and subpar service quality from suppliers led to lower execution rates in certain years
		Finding 20: Upon reviewing detailed annual expenditure reports and annual work summaries, analyzing the structure of project fund expenditures revealed that the project expenditure is reasonable, contributing to its sustainability.

	Human resources management efficiency	**Finding 21**: The allocation of human resources is reasonable, with clear delineation of responsibilities among the project's stakeholders. Staff and experts from collaborating entities possess broad international perspectives and extensive project management experience, ensuring the effective operation of the project with high enthusiasm and professionalism.
		Finding 22: Specifically, consultation with expert groups and local enterprises and communities provided a robust safety assurance for areas focused on hydrogen utilization within hydrogen industry parks. This ensures the safe and stable operation of demonstrations, aligning with the State Council's "13th Five-Year Plan for Work Safety."
Sustainability		**Finding 23**: Factors such as resource investment, collaboration networks, and equipment procurement exhibit high sustainability, actively contributing to achieving sustainable development goals. The project has demonstrated significant intervention in aspects like production, storage, transportation, hydrogenation, and utilization. However, the utilization rate of certain equipment remains low. Exploring feasible solutions to enhance equipment utilization is necessary to improve the project's sustainability.
Gender and cross-cutting issues	Gender	**Finding 24**: Gender factors were carefully considered in the project's design and implementation, ensuring equal participation and fair treatment for both men and women. Gender perspectives have been integrated into mainstream sustainable development projects, with the participation of young women in activities not falling below 50%. However, the project falls short in delivering specific gender-focused activities and lacks a robust framework for gender-responsive results measurement.
	Cross-cutting issues: PWD and other marginalized groups	**Finding 25**: The project has made notable strides in inclusivity, emphasizing broad participation across various societal groups and advancing women's leadership, yet it requires a more deliberate approach to fully address the needs of PWD and other marginalized communities to achieve comprehensive and equitable sustainable development.

4.2 Project Result Framework, TOC and M&E Arrangement

Finding 1: The TOC design of the project features an ambitious objective for the time of its launch that is broken down into a series of comprehensive outputs benefited from a systematic approach. The Result Framework of the project includes a set of straight-forward indicators on the output-level that cogently inform project monitoring.

The Theory of Change for this project is well-designed, with a logical sequence of activities that are expected to contribute to the accomplishment of the overall objective of establishing Rugao City as a "hydrogen city" for sustainable development and climate change mitigation.

Since this is a “first” in the field for limited experience in China and other countries to directly draw lessons from, a systematically comprehensive TOC that covers the full cycle of Hydrogen economy is designed. The project outlines a clear pathway to achieve this goal by first focusing on the adoption and enforcement of a Hydrogen Economy Development Roadmap, followed by activities aimed at reducing hydrogen production costs through renewable energy, improving hydrogen storage and refilling technology, promoting fuel cell technology in transportation and cogeneration, and developing a policy framework for hydrogen and carbon trading. Additionally, activities focused on increasing knowledge and awareness of hydrogen utilization are included. Overall, the activities align with the intended objective and logically contribute to the desired outcomes, demonstrating a sound Theory of Change framework for the project.

The fact that this project is of “piloting” nature governs that the demand for “completion” of the project undercuts the need to push every activity result to a high number, so that the full chain of policy process of establishing hydrogen economy can be demonstrated and thus inspire future endeavors in other areas. For these reasons, the indicator setting in the Result Framework of the project aligns well with the nature of the project, using simple binary indicators to indicate if each of the intended processes is completed. This allows for a straight-forward M&E process.

Moreover, through Theory-Driven Evaluation methodologies, the evaluation team found since the signing of the "Hydrogen Economy Pilot Project in China" in August 2016, the Rugao project has yielded the following impact.

- It has successively formulated the Rugao Hydrogen Development Roadmap, Hydrogen Policy Framework, Yangtze River Delta Hydrogen Corridor Construction and Development Plan, and the Integrated Demonstration Plan for Fuel Cell Vehicles in the Yangtze River Delta.
- A series of pilot applications for hydrogen products have been explored here, and through organizing consecutive sessions of the "International Hydrogen and Fuel Cell Vehicle Congress" from 2017 to 2019, as well as fuel cell vehicle and related component exhibitions, and conducting popular science tours for fuel cell vehicles in the Yangtze River Delta in 2018 and 2019, remarkable results have been achieved in publicizing and increasing the city's visibility.
- At the same time, active participation in the formulation of fuel cell-related standards, the introduction of multiple incentive policies, and a series of fruitful outcomes have given Rugao a certain first-mover advantage in fostering the hydrogen industry, and establishing an innovative and entrepreneurial ecosystem, winning a certain developmental initiative.
- Additionally, activities such as the procurement of large-scale hydrogen equipment to promote capacity building, strengthening hydrogen safety supervision, and producing promotional videos summarizing project achievements have greatly ensured the sustainability of the activities.

Finding 2: The project monitoring and evaluation (M&E) system of the China Hydrogen Economy Pilot Project has effectively ensured the quality, effectiveness, and impact of the project, providing robust support and valuable insights for the development of the hydrogen economy.

Regular M&E Design and Implementation. In the Hydrogen Economy Pilot Project in China, the UNDP China Office provides financial audit support, oversees financial expenditures, and generates an annual audit report to ensure compliance with UNDP rules. The Project Director is

fully responsible for the specific implementation of the project and has established a Project Office responsible for the project's day-to-day management. The CICETE is responsible for project supervision and management, and activities are overseen by the National Project Director appointed by the Rugao Municipal Government. Demonstration activities are carried out following approval and authorization from the National Project Director or a project manager designated by the National Project Director.

The organizational team includes the project manager, guidance committee, and others. During the project execution, biannual progress status surveys are conducted to determine the project's progress, identify bottlenecks, and assess the need for technical support during the project implementation process. The Project Guidance Committee, serving as the project's highest decision-making body, convenes as needed, ensuring the attendance of representatives from project stakeholders to discuss and decide on all major project matters.

The Project Office compiles an annual progress report, presenting it at the annual review meeting where stakeholders listen to the report, discuss, and formulate the next year's work plan and budget. The annual progress report provides a comprehensive and detailed overview of the project's progress and specific execution, serving as a primary channel for gaining insights into project implementation experiences and lessons learned. It effectively monitors the progress made since project initiation, ensuring the smooth implementation of the project.

The CICETE and Project Office submit materials such as the annual progress report and detailed financial statements to UNDP. UNDP, through annual work plans and progress reports, regularly monitors the project's progress, identifies issues, and communicates with the CICETE and Rugao Project Office to adjust work directions promptly, address corresponding issues, and ensure the project's successful implementation.

The initial M&E design included in the project document is complaint with UNDP policies, under which the project is closely monitored. As per the UNDP threshold for evaluations, the project has planned for one Mid-term Review (MTR) and one Terminal Evaluation (TE). Various other oversight activities are implemented as well.

Mid-term evaluation/review (MTR). In early September 2020, the project underwent a midterm evaluation, focusing on the implementation progress and achievements from August 2016 to August 2020. Independent evaluation experts conducted on-site inspections of the operation status, audience experience, and promotional effects of the Rugao Hydrogen Economy Demonstration Zone.

The midterm evaluation measured and assessed the goals set in the project documents, summarized the directional and output goal achievements, provided guiding opinions for the subsequent project development, and facilitated the project's successful realization.

Table 7 MTR Recommendations Matrix

#	MTR Recommendation	Completion Status
1	Given the limits that hydrogen generation is facing and the abundant actual side hydrogen capacity, it is suggested to cancel relevant activities.	Accepted by project and completed.

2	Currently, there is a shortage of 3C certification for 70MpaIV hydrogen storage bottles in China, so the demonstration of fuel cell sedans didn't hold as schedule. Since the national standard for 70MpaIV hydrogen storage bottle in still in formulation, it is suggested to demonstrate in 2021.	Accepted by project and completed.
3	In the 2020 work plan, hydrogen security data management platform and disposable back-up battery procurement as well as operation pilot activities were cancelled. It is suggested to choose among smart and safe hydrogen supply system/central hydrogen refueling station, and construction of the environment capsule of testing center.	Accepted by project and partially completed.
4	It is suggested to continue supporting the International Hydrogen and Fuel Cell Vehicle Conference and change the exhibition of fuel cell vehicles and components into the roadshow of fuel cell superiority presentations as well as high-tech startup projects.	Accepted by project and completed.
5	The improvement of relevant standards and technical regulations on hydrogen generation, storage, transportation and refueling is in line with the hydrogen economic development in China and of significance. Therefore, it is suggested to continue promoting relevant activities.	Accepted by project and completed.

2022 Project oversight. In 2022, an oversight mission to Rugao was conducted by UNDP and CICETE, with the following key recommendations identified:

Table 8 2022 Project Oversight Matrix

#	Action	By whom	Completion Status
1	To formulate the detailed timetable for the warehouse installation and testing.	Hance Co.	Completed
2	To submit the evidence of the force majeure encountered.	Hance Co.	Completed
3	To complete the warehouse installation and testing.	Hance Co.	Not completed due to fire incident
4	To complete the promotional video of this project	CICETE to Coordinate	Partially Completed
5	To kick off the final evaluation	All sides	Completed

Terminal Evaluation. The ongoing final evaluation is a comprehensive summary of project implementation, intended to evaluate the consistency of expected goals and related outputs, thus measuring the overall effectiveness of project implementation. The final evaluation will summarize and analyze the implementation effects of the UNDP demonstration project in Rugao, assess the project's contribution to promoting the hydrogen economy and clean energy development, identify project strengths and weaknesses, and propose improvements and suggestions. The aim is to provide reference and guidance for the planning and management of similar future projects.

4.3 Relevance

The Hydrogen Economy Pilot Project in China is an initiative aimed at promoting hydrogen as one of the primary energy sources in China. The goal is to demonstrate the application of hydrogen technology in various areas in Rugao, including industrial parks, transportation, consumption, and renewable energy. This project is closely related to national development priorities, the output and results of CPDs, UNDP strategic plans, and sustainable development goals.

Based on key evaluation questions related to relevance criteria, we found that the Hydrogen Economy Pilot Project in China aligns significantly with national development priorities, the output and results of CPDs, UNDP strategic plans, and sustainable development goals. Through the demonstration applications in various aspects such as carbon trading system development, hydrogen production from renewable energy, and combined heat and power, the project promotes the Theory of Change (TOC) of CPD outcomes and outputs. The overall design of the project and the relevance of its proposals are good, considering factors such as resource endowment. Throughout the project implementation, it has promoted gender equality, women's empowerment, and human rights-based approaches to a large extent, catering to the needs of different groups. Specific findings are detailed as follows.

Finding 3: The Project is highly relevant with national development priorities, UNDP's Strategic Plans (SP), Country Programme Document (CPD) and SDG targets.

Hydrogen energy is a clean, efficient, and renewable energy source, representing a crucial direction for future energy development. UNDP has initiated the Hydrogen Economy Pilot Project in China in Rugao City, Jiangsu Province, China. The project aims to promote the production, storage, transportation, and application of hydrogen through technological innovation, policy research, and social outreach, ultimately establishing the first "hydrogen city" and providing robust support for the development of China's hydrogen industry. This project not only aligns with China's national development priorities but is also consistent with the output and outcomes of CPDs, UNDP strategic plans, and Sustainable Development Goals (SDGs), showcasing significant demonstration and promotional value.

Firstly, the project aligns with China's national development priorities. As noted in the *Medium-to-Long-Term Development Plan for the Hydrogen Energy Industry (2021-2035)* issued by the National Development and Reform Commission and National Energy Administration of China,

> "*Hydrogen energy is a critical component of China's future national energy system. It serves as a significant carrier for facilitating the green and low-carbon transition in various energy end-use sectors. The hydrogen energy industry is strategically positioned as an emerging sector and a key area of focus for future industrial development in China.*[3]"

It is poised to enhance China's innovation and competitiveness in the hydrogen energy industry, promote optimization of the energy structure, ensure energy security, and bolster the endogenous dynamics of domestic circular economies. Additionally, the project is conducive to expanding international markets and collaborations, advocating for the establishment of international hydrogen standards, and strengthening the interactive effects of global circular economies.

[3] http://zfxxgk.nea.gov.cn/1310525630_16479984022991n.pdf (available in Chinese only)

Secondly, the project is a crucial component of the national strategy for the innovative development of new energy vehicles. Anticipated outcomes of the project include the formulation of a roadmap for hydrogen development in Rugao, demonstration of hydrogen production technologies, including renewable energy-based hydrogen production, establishment of storage technologies and hydrogen refueling stations, application and standardization of hydrogen fuel cells in transportation and cogeneration, research on the framework of hydrogen policy systems and methodologies for carbon trading, as well as public awareness campaigns to drive the development of the hydrogen economy. These outputs will provide robust technical support, policy guidance, and social foundations for the development of China's hydrogen energy industry.

Thirdly, the project aligns with the UNDP's 2022-2025 Digital Strategy and 2022-2025 Strategic Plan. Leveraging digital technologies to support the development of the hydrogen economy, the project aims to reduce inequality, enhance inclusivity, address climate change, and explore more economic development opportunities globally. It is also in line with the UNDP's mission and vision of promoting human and planetary development through cooperation, eliminating poverty, reducing inequality and insecurity, protecting the environment, and achieving sustainable development.

Figure 6 Project's Linkage to SDGs

Finally, the project aligns with several Sustainable Development Goals (SDGs), notably Goal 7 (Ensure access to affordable, reliable, sustainable, and modern energy services for all), Goal 9 (Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation to promote sustainable development), Goal 11 (Make cities and human settlements inclusive, safe, resilient, and sustainable), and Goal 13 (Take urgent action to combat climate change and its impacts). By advancing hydrogen production, storage, transportation, and application, the project contributes to improving energy efficiency and cleanliness, reducing greenhouse gas emissions, alleviating urban pollution and congestion, enhancing the sustainability and resilience of cities and communities, addressing climate change challenges, and making a significant contribution to achieving sustainable development goals.

In conclusion, the Hydrogen Economy Pilot Project in China is a project of great significance and value. It not only aligns with China's national development priorities but also corresponds with the output and outcomes of CPDs, UNDP strategic plans, and Sustainable Development Goals, providing a powerful demonstration and promotion for the development of the hydrogen economy.

Finding 4. The overall design and methodology of the Hydrogen Economy Pilot Project in China thoroughly consider the practical circumstances and overarching goals of the project. Throughout the design and implementation phases, the project adheres to the gender equality and human rights

policies of the UNDP, ensuring that activities and outcomes do not adversely affect different genders and groups. Moreover, the project adequately addresses the needs and aspirations of various target groups, catering to the energy, environmental, and economic requirements of diverse populations.

The Rugao Hydrogen Project represents a comprehensive and strategic endeavor that integrates hydrogen energy into the local economic fabric of Rugao, China. The initiative is built on a foundation of extensive research into current trends in hydrogen and fuel cell technologies both domestically and internationally. This research has informed the development of a roadmap for Rugao's hydrogen economy from 2016 to 2025, which is both scientific and forward-looking. The plan is ambitious, aiming to establish a complete hydrogen industry cluster that includes everything from production to application, particularly focusing on the transportation and power generation sectors. This approach is intended to foster a sustainable and green hydrogen economy within the region.

The project is designed to align with China's broader national development objectives, as well as with international sustainability and development plans, such as those proposed by UNDP. It aims to bolster China's innovative capabilities and global competitiveness within the hydrogen sector, optimize energy structures, and strengthen energy security. Furthermore, the project's efforts to improve energy efficiency and reduce greenhouse gas emissions are in direct response to urban pollution challenges and climate change, ultimately contributing to the sustainability and resilience of urban and community life.

Collaboration is a cornerstone of the project, with the UNDP and the CICETE providing expertise and support. Local government backing, particularly from the Rugao Economic and Technological Development Zone Committee, ensures policy and resource support, vital for the project's success. Stakeholder engagement has been a focal point throughout the project's planning and implementation phases, with feedback from local governments, businesses, and communities shaping project feasibility and acceptance.

The project also places a strong emphasis on inclusivity, adhering to UNDP's policies on gender equality and human rights. Efforts have been made to ensure that the project's activities and outcomes are equitable and do not exacerbate existing inequalities or discrimination. By providing equal opportunities for training, employment, and participation, the project seeks to empower women within the hydrogen and fuel cell industry, a sector traditionally dominated by men. This aspect of the project not only promotes gender equality but also aims to elevate the capabilities and status of women in this emerging field.

In addition, the Rugao Hydrogen Project is constructed as a scalable model, demonstrating the practical application of a hydrogen economy through various scenarios such as combined heat and power generation, and hydrogen refueling stations. The establishment of a hydrogen economy demonstration zone aims to serve as a pattern that can be replicated nationally and potentially adopted globally. By enhancing the maturity and reliability of hydrogen technologies and nurturing public trust and awareness, the project aspires to create a favorable social environment for the hydrogen industry's growth, paving the way for its expansion well beyond the borders of Rugao.

4.3 Effectiveness

Guided by Theory of Change, the Hydrogen Economy Pilot Project in China has established intervention measures and goal visions in areas such as development outcomes, direct solutions, potential solutions, and fundamental solutions. This section evaluates the project implementation based on effectiveness criteria, with a particular focus on inclusive issues such as gender equality and the participation of vulnerable groups.

Details of the outputs and tasks of the Hydrogen Economy Demonstration Project can be found in Table 9. The evaluation revealed that, except for the incomplete demonstration operation of two fuel cell passenger cars and the non-acceptance of the environmental warehouse, all other outputs have been completed. The following are detailed findings on the evaluation of the six outputs.

Table 9 Actual Results and Progress Table with Rating

Output	Expenditure	Indicator (Baseline/Target)	Completion Status	Key Achievements/Specific Reasons for Unfinished Aspects	Development Impact	TE Rating
Output 1: Adoption and Implementation of the H2 Economy Development Plan in Rugao	474518.81	Baseline: 0 Target: 1	Completed in full	Achievements: 1. Developed the "Rugao Hydrogen Economy Development Roadmap," covering the entire hydrogen production, storage, transportation, and utilization chain. 2. Established a hydrogen town with the vision of transforming Rugao into an international city with a distinctive hydrogen economy.	The accumulation of valuable construction experience has been achieved through the replication and promotion of hydrogen energy economies, providing insights for the future.	**HS**
Output 2: Hydrogen Production Demonstration, Cost Reduction, and Enhancement of Hydrogen Quality for Fuel Cell Use	2702565.25	Baseline: 0 Target: 3000kg	partially unfinished	Achievements: 1. Report on the Feasibility Study of Renewable Hydrogen Production in Rugao. 2. Feasibility Evaluation Report on Onboard Aluminum Alloy Hydrogen Generation Fuel Cell Vehicles. Unfinished Tasks and Specific Reasons: 1. The demonstration of hydrogen production was not conducted due to the difficulty of implementing renewable energy hydrogen production in the hydrogen industry park, which is planned to be located in the chemical industrial park.	Offering robust support for future initiatives in renewable energy-based hydrogen production has laid a strong foundation for the on-demand utilization of hydrogen.	**MS**
Output 3: Technological Advancements in Hydrogen Storage and Refueling Demonstrations	1712915.88	Baseline: 0 Target: 1	Completed in full	Achievements: 1. Rugao Shenhua Hydrogen Station successfully provided hydrogen refueling for fuel cell vehicles, demonstrating positive results. 2. During the shutdown of the hydrogen station, the entity	Actively promoting demonstrations of renewable energy-based hydrogen production, the objective is to strive for the formation of a distinctive industry chain encompassing renewable	**HS**

Output	Expenditure	Indicator (Baseline/Target)	Completion Status	Key Achievements/Specific Reasons for Unfinished Aspects	Development Impact	TE Rating
				responsible for the Rugao hydrogen station actively promoted a demonstration of renewable energy hydrogen production.	energy production, storage, transportation, processing, and utilization. This effort aims to provide a model referred to as the "Rugao experience" for regions nationwide.	
Output 4: Application of Hydrogen Energy in Transportation and Backup Power	7444137.94	Baseline: 0 Target: 5 FCBs, 2 FC cars, 2-3 FC cogeneration systems	partially unfinished	Achievements: 1. Fuel cell buses demonstrated widespread positive effects. 2. Fuel cell backup power and cogeneration systems demonstrated positive effects. 3. The procurement of an environmental warehouse improved the testing platform's capabilities. 4. The equipment of the National Hydrogen Energy Vehicle Research and Testing Public Service Platform was updated. Unfinished Tasks and Specific Reasons: 1. The lack of 3C certification for 70MPa IV type hydrogen storage cylinders in China resulted in the failure to complete the demonstration operation of fuel cell cars. 2. A self-ignition incident in the power battery of a fuel cell vehicle parked in the lightweight environmental warehouse caused partial damage to the warehouse structure. As a result, the Rugao project could not be closed as scheduled by June 30, 2023.	Providing the citizens of Rugao with a safe and pollution-free green travel experience has created conditions for the local population and the entire nation to gain a close and tangible understanding of hydrogen fuel cell vehicle technology. Additionally, the demonstrated effectiveness of fuel cell backup power sources and cogeneration systems has played a crucial role in promoting the development of the hydrogen energy industry, significantly improving its operational efficiency and service standards.	**MS**

Output	Expenditure	Indicator (Baseline/Target)	Completion Status	Key Achievements/Specific Reasons for Unfinished Aspects	Development Impact	TE Rating
Output 5: Completion of the Policy Framework and Demonstration Applications for Carbon Trading	535950.89	Baseline: 0 Target: 3 incentive policies, 4 carbon trading methodologies	Completed in full	Achievements: 1. Developed multiple standards drafts and preparation instructions. 2. Initiated early attempts in constructing the national carbon trading market.	The formulation of relevant industrial policies and standards serves as a benchmark and demonstration for global hydrogen energy development and application. The establishment of a carbon trading system has driven institutional innovation, propelling the development of green and low-carbon initiatives.	**HS**
Output 6: Enhancement of Public Awareness and Information Exchange in the Hydrogen Economy	564951.95	Baseline: 0 Target: 211,000	Completed in full	Achievements: 1. Organized three consecutive International Hydrogen and Fuel Cell Vehicle Conferences in 2017, 2018, and 2019. 2. Promoted the 5G+VR live broadcast project. 3. Planned and participated in the "Fuel Cell Vehicle Popular Science Parade" activity. 4. Conducted outreach and high-tech entrepreneurship project roadshows for the promotion of hydrogen and fuel cell advancements. 5. Organized visits to Japan, South Korea, and other countries for exchange and learning. 6. Produced mid-term and final promotional videos.	This initiative has facilitated technical interactions and industrial exchanges between upstream and downstream sectors, increasing public understanding and approval of the project. Consequently, it has heightened the project's impact and attractiveness, fostering societal interest and participation in hydrogen energy and fuel cell industry development.	**HS**

Output 1 – Adoption and Implementation of the Rugao Hydrogen Economy Development Plan. Covering: 1.1, providing technical support and guidance for the formulation of the hydrogen economy development/roadmap plan, and 1.2, completing the hydrogen economy development plan/roadmap.

Finding 5: The "Rugao Hydrogen Energy Development Roadmap" comprehensively covers the entire hydrogen industry chain, from production, storage, transportation to utilization, playing a crucial guiding role in the development of Rugao's hydrogen energy economy.

The Rugao Hydrogen Development Roadmap serves as a crucial foundation for Hydrogen Economy Pilot Project in China, playing a pivotal role in outlining the entire project. The total budget for the initiative is $198,000, with actual expenditures matching the allocated budget. It was jointly formulated by the China Society of Automotive Engineers and the Shenhua Beijing Low Carbon Clean Energy Research Institute. The roadmap establishes the overall objectives for Rugao's hydrogen economy development from 2017 to 2030. It explicitly emphasizes hydrogen fuel cell vehicle technology as the primary focus of the hydrogen energy strategy in the field of hydrogen fuel cell applications.

The roadmap aims to comprehensively master the core key technologies of hydrogen fuel cell vehicles, including the entire vehicle and critical components, ensuring technological innovation and product capabilities reach international advanced levels. It also envisions the creation of internationally competitive industrial systems and the establishment of 1-2 fuel cell enterprises with domestic and international influence. In the hydrogen supply sector, the roadmap emphasizes a comprehensive understanding of key technologies in hydrogen production, transmission, and storage. The goal is to achieve international leadership in technological innovation and product capabilities, fostering the development of brands with international influence.

Regarding hydrogen production, the roadmap advocates for the integration of renewable energy and hydrogen, recycling industrial by-product gases for hydrogen production, and employing green and clean coal hydrogen production through CCS (carbon capture and storage). This is aimed at establishing a green and diversified hydrogen supply system, thereby enhancing Rugao's local and surrounding hydrogen source supply rates. In terms of hydrogen storage and transportation, the roadmap proposes demonstrating hydrogen transmission through pipelines and constructing the nation's first urban pipeline network for hydrogen transmission. Simultaneously, it advocates the development of technologies and equipment for long-distance and large-scale liquid hydrogen, positioning Rugao as a national supplier of hydrogen storage and transportation equipment.

Concerning hydrogen refueling stations, the roadmap suggests demonstrating liquid hydrogen refueling stations while concurrently establishing a network of refueling stations that aligns with demand. The specific implementation involves three main strategies: firstly, developing the fuel cell system component system, the hydrogen fuel cell vehicle system, and the hydrogen supply chain system to enhance the construction of the hydrogen fuel cell industry chain. Secondly, supporting innovation in fuel cell stack and power system technology, fuel cell vehicle assembly, hydrogen supply system, and hydrogen fuel cell research and testing platforms to promote technological advancements in the hydrogen fuel cell industry. Thirdly, undertaking five major projects, including fuel cell vehicle demonstration projects, modern logistics demonstration projects, fuel cell cogeneration demonstration projects, hydrogen supply system construction

demonstration projects, and renewable energy integration demonstration projects. These projects aim to build a hydrogen town, facilitate the industrial application of hydrogen fuel cell technology, and ultimately realize the vision of transforming Rugao into an internationally recognized hydrogen economy city.

As shown in Figure 7, the roadmap systematically reviews the current status of foreign hydrogen and fuel cell vehicle development, encompassing policies, technology, and industry status. It involves the analysis, summary, and evaluation of experiences from typical countries, regions, cities, and enterprises, providing a comprehensive analysis of the advantages and disadvantages of Rugao's local hydrogen economy. This, in turn, offers clear goals and paths for transforming Rugao into an internationally recognized hydrogen economy city. Furthermore, the roadmap serves as a significant reference for Hydrogen Economy Pilot Project in Chinas, exhibiting foresight and innovation. Based on an analysis of Rugao's existing resources and conditions, the roadmap establishes practical goals and indicators, employing a variety of technologies and methods across multiple domains and levels. Additionally, it aligns closely with national development priorities, the outputs and outcomes of CPDs, the United Nations Development Programme's strategic plans, and sustainable development goals. This alignment positions the roadmap to contribute to achieving carbon peak and carbon neutrality goals, promoting the development and utilization of clean energy, enhancing energy security and efficiency, and reducing greenhouse gas emissions and air pollution.

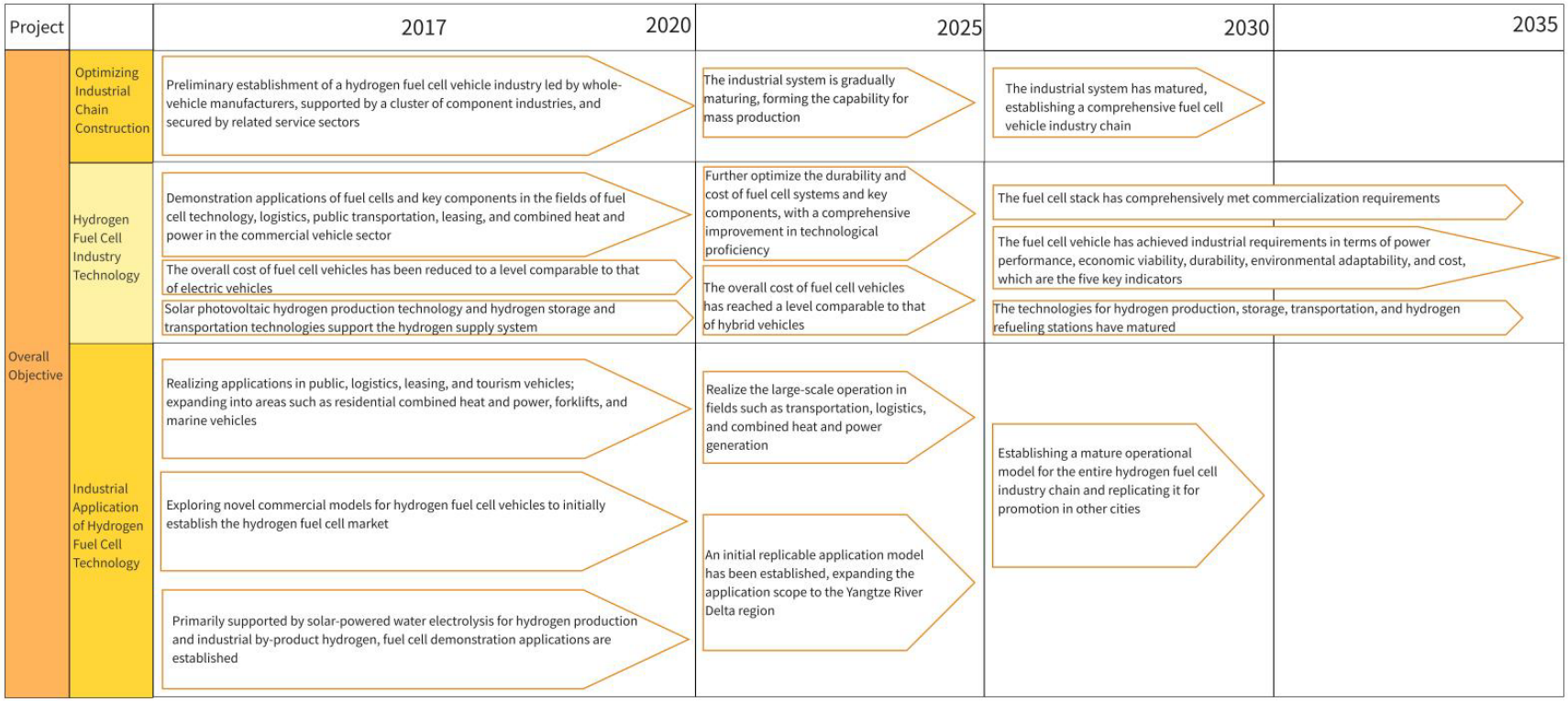

Figure 7 Gantt Diagram of Rugao Hydrogen Energy Development Roadmap

Finding 6: As the concrete implementation of the “Rugao Hydrogen Energy Development Roadmap” and the optimal carrier for the UNDP Hydrogen Economy Pilot Project in China, the planning and construction of the Rugao Hydrogen Town have accumulated valuable construction experiences for the replication and promotion of the future hydrogen energy economy and society.

The Hydrogen Energy Town serves as the optimal carrier for the UNDP Hydrogen Economy Pilot Project in China. Simultaneously, it aligns closely with the call to actively respond to Jiangsu Province's initiative to nurture and create distinctive towns. The Economic and Technological Development Zone of Rugao (Rugao Economic Development Zone) entrusted the project to the China Society of Automotive Engineers and the China Urban Science Research Association project team for the overall planning and design of the "Hydrogen Energy Town" in Rugao Economic Development Zone. The total budget for the project was 310,000 USD, with actual expenditures matching the budget. The project team conducted several on-site investigations and inspections, and after multiple rounds of revisions and adjustments, they ultimately proposed solutions and recommendations in eight parts: project background and significance, basic conditions, development positioning and goals, development strategies and paths, planning and design, investment plan, development and operation, and security measures.

The planning and construction of the Rugao Hydrogen Energy Town represent an innovative and distinctive design case, providing valuable insights and references for the development of hydrogen economies in other regions. Firstly, with hydrogen energy as the core, the project aims to construct an innovative and entrepreneurial ecosystem integrating research and development, production, testing, application, and promotion. It aspires to create the first domestic hydrogen society demonstration zone, not only focusing on the development of the hydrogen industry but also on the construction of a hydrogen society. This achieves the comprehensive utilization and popularization of hydrogen, serving as a model and guide for the transformation and upgrade of the hydrogen economy.

Secondly, focusing on key areas of the entire hydrogen industry chain, the project actively lays out upstream hydrogen production, storage, and transportation; midstream hydrogen fuel cell critical components, stacks, and systems; and downstream hydrogen fuel cell vehicles, actively promoting industrial agglomeration and fostering landmark industries at the hundred-billion level. This design case fully leverages the advantages and potential of the Rugao hydrogen energy industry, forming a relatively complete hydrogen energy industry system, achieving high-quality development and efficient operation of the hydrogen energy industry.

Thirdly, complementing and perfecting financial, policy, environmental, and service-related industrial elements, the project actively establishes public service platforms for technology research and development, outcome transformation, technical standards and testing certification, promotion, and demonstration. It constructs an open, collaborative, and shared innovation and entrepreneurial industrial ecosystem. This design case emphasizes the construction of both the soft and hard environments of the hydrogen energy industry, providing strong support and guarantees for hydrogen enterprises and projects, promoting innovation and collaboration in the hydrogen energy industry, and enhancing the competitiveness and influence of the hydrogen energy industry.

Finally, leading the coordination with provincial industry organizations, universities, enterprises, etc., the project establishes the "Jiangsu Hydrogen and Fuel Cell Vehicle Industry Innovation

Alliance," facilitating communication channels among government, industry, academia, and research, promoting win-win cooperation. Actively connecting with the China Society of Automotive Engineers, enterprises, industry experts, as well as governments in Shanghai, Nantong, Yancheng, and other places, the project participates in planning and promoting the compilation of the "Yangtze River Delta Hydrogen Corridor Construction and Development Plan." This is the first domestically formulated plan for cross-provincial and cross-regional hydrogen infrastructure construction, aiming to use the Yangtze River Delta region's highway network as a link to promote hydrogen infrastructure construction, improve the hydrogen economic application environment, and lay the foundation for the integrated development of the hydrogen economy in the Yangtze River Delta. This design case demonstrates the openness and leadership of the Rugao Hydrogen Energy Town, actively participating in and promoting regional coordination and international cooperation in the hydrogen energy industry, providing a broader space and opportunities for the development and growth of the hydrogen energy industry.

The framework of this planning and design proposal is comprehensive, logically organized, and content-rich. The research provides a detailed interpretation of relevant policy backgrounds and project locations. It also analyzes Rugao's geographical environment, resource elements, cultural elements, ecological environment, current status of the hydrogen and fuel cell vehicle industry, and the development conditions and experiences for spatial development within the planning area. The focus is on the distinctive features of Rugao's hydrogen and fuel cell vehicle industry. Using the Hydrogen Energy Town as a carrier, the project translates the elements of the hydrogen society and fuel cell vehicle industry chain into specific spatial layouts and functional zoning. The organization is appropriate, and the layout is rational. The planning and construction of the Hydrogen Energy Town represent the concrete implementation of the "Rugao Hydrogen Economic Development Roadmap," creating a model project for the hydrogen economy and accumulating valuable construction experience for the future replication and promotion of hydrogen economic societies.

Output 2 - Hydrogen Production Demonstration, reducing hydrogen production costs, improving the quality of hydrogen for fuel cells, including: 2.1 Carrying out a demonstration of hydrogen production based on the roadmap for renewable energy.2.2 Researching and proposing suggestions for the improvement of relevant standards and technical specifications for hydrogen production, storage, transportation, and refueling.2.3 Proposing policy suggestions for improving hydrogen production standards and technical specifications.2.4 Conducting a study on the commercialization models of different hydrogen production technologies.

Finding 7: Due to the necessity of hydrogen production planning within chemical industrial parks and the substantial difficulty in implementing renewable energy-based hydrogen production in hydrogen industry parks, hydrogen production demonstrations have not been conducted. However, the drafting of the "Rugao Feasibility Study on Renewable Hydrogen Production" report provides excellent support for future renewable energy-based hydrogen production. The feasibility evaluation report on vehicle-mounted aluminum alloy hydrolysis hydrogen fuel cell technology lays a solid foundation for on-demand hydrogen production.

The "Feasibility Study on Renewable Hydrogen Production in Rugao" had a budget of $85,000, and the actual expenditure matched the budget. The project was led by the Shenhua Group's Beijing Low Carbon and Clean Energy Research Institute. It involved analyzing the current status and future trends of renewable energy hydrogen production technologies both domestically and

internationally. Through on-site investigations to understand the local conditions in Rugao, viable renewable energy hydrogen production solutions were sought. The study concluded with a photovoltaic electrolysis water hydrogen production scheme, accompanied by a detailed implementation plan, providing robust support for future endeavors in renewable energy hydrogen production.

Although the "energy" nature of hydrogen has been clarified, there is currently a lack of legal regulations at the national level. Hydrogen is still treated as a hazardous chemical by default, subject to strict approval and management. The production of hydrogen gas necessitates facilities within chemical industrial parks, posing certain challenges to the hydrogen production demonstration during the project execution period. Consequently, the hydrogen production demonstration (Tasks 2.1 and 2.4) was not conducted.

Throughout the project execution, various new technologies related to hydrogen fuel cell vehicles continued to emerge. The feasibility evaluation of on-board water electrolysis hydrogen fuel cell vehicle technology is one such newly appeared technical solution. This technology involves the use of a special catalyst to convert water into hydrogen. The project assessed this new technology through on-site investigations and expert reviews, consolidating opinions from various sources to provide recommendations and guidance for the future development direction of this technology.

Given that this technology has no industrial precedents globally, the Rugao Management Committee invited relevant experts to assess the feasibility of this new technology, providing a basis and guidance for the next steps in advancing the project.

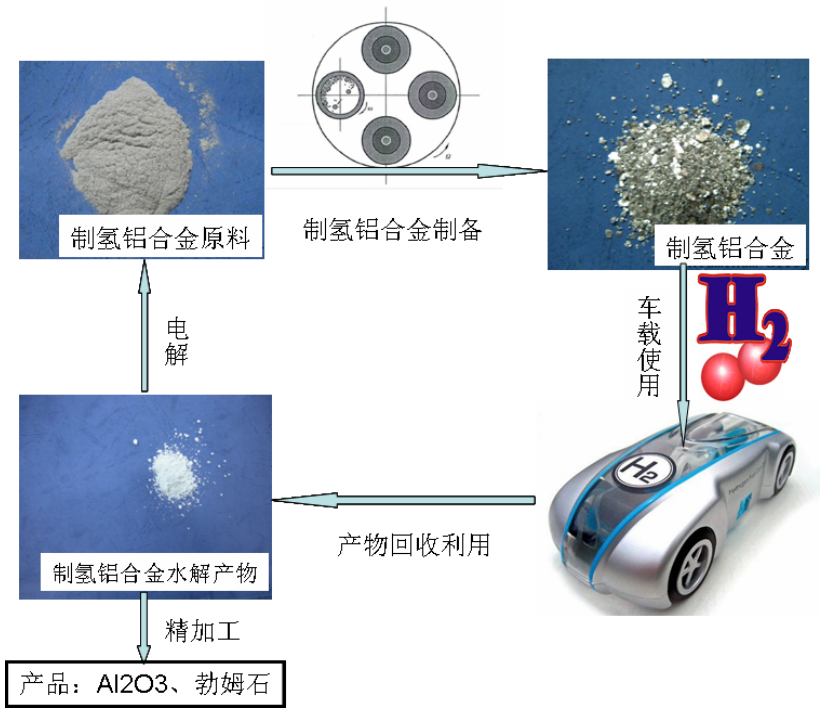

Figure 8 Project Technical Roadmap[4]

Output 3: Technological Demonstration Improvement for Hydrogen Storage and Filling, with subtasks 3.1 Feasibility Study and Construction of Hydrogen Filling Stations, and 3.2 Demonstration Operation of Hydrogen Filling Stations. Through evaluation, it is found that all tasks have been successfully completed.

Finding 8: The forward-looking project design successfully facilitated widespread adoption of fuel cell buses but encountered setbacks with fuel cell cars due to certification constraints for hydrogen storage cylinders. Operational challenges at the Rugao Shenhua Hydrogenation Station, stemming from regulatory gaps, led to a suspension that disrupted the use of hydrogen fuel cell vehicles. Nonetheless, the station's efforts to promote renewable hydrogen production are instrumental in shaping the "Rugao Experience," setting a benchmark for the industry's growth across China.

Between 2017 and 2019, the project consistently advanced the demonstration operation of hydrogen fuel cells. Five fuel cell buses, produced through the collaboration between Ludefangzhou and Jiangsu Qingneng, were officially delivered in 2019. They were put into demonstration operation in Rugao, providing the local citizens with a safe, zero-pollution, and entirely new green travel experience. This initiative created conditions for the people of Rugao, and indeed the entire nation, to have a close and concrete understanding of hydrogen fuel cell vehicle technology.

[4] Translation (starting from the top left corner, clockwise): Production of hydrogenated aluminum alloy raw materials; Preparation of hydrogenated aluminum alloy; Hydrogenated aluminum alloy production; Vehicle use; Product recycling and utilization; Hydrogenated aluminum alloy hydrolysis products; Products: Al2O3, boehmite.

Rugao became the first county-level city in the country to open a hydrogen fuel cell bus route. Following this pioneering effort, cities such as Zhangjiakou, Zhengzhou, Shanghai, and Wuhan successively launched hydrogen-powered bus demonstration routes. Rugao's early adoption resulted in widespread social demonstration effects.

The 70MPa IV-type hydrogen storage tank, using plastic materials as its base, offers advantages such as light weight, low cost, and high hydrogen storage density. It is particularly suitable for use in passenger vehicles. Therefore, most foreign hydrogen fuel cell cars essentially adopt the 70MPa IV-type storage tank. Currently, China mainly uses 35MPa and 70MPa III-type tanks, with a national standard still missing for the 70MPa IV-type tank. Consequently, the original plan for the purchase and demonstration operation of hydrogen fuel cell cars equipped with the 70MPa IV-type tank could not be completed.

The Rugao hydrogen station, constructed with high safety standards meeting national technical specifications, was at the time the country's first commercially operated hydrogen station with the highest daily hydrogen compression capacity, daily fixed hydrogen storage capacity, and daily hydrogen filling capacity. It also became China's first internationally standardized, 35MPa/70MPa dual-mode, and all-weather commercial hydrogen station. Construction commenced in August 2018, and production testing was completed in September 2019. During the World Hydrogen Energy Conference held in Rugao in 2019, the station successfully fueled hydrogen fuel cell vehicles in the Yangtze River Delta region and local buses, contributing actively to expanding the influence of hydrogen energy demonstrations. The hydrogen station obtained the "Gas Business License" in April 2020 and officially commenced operations on December 12, 2020. After operating for some time, the Shenhua hydrogen station applied for a change of legal entity at the municipal administrative approval bureau to replace the operating license. The administrative approval bureau, citing safety supervision issues, requested the withdrawal of the operating license as Rugao was unwilling to be the first local government nationwide to issue a hydrogen station operating license. In theory, the Rugao hydrogen station still meets the conditions for hydrogen filling. However, internally, Shenhua believes that the original legal entity is inconsistent with the current actual legal entity, and hydrogen filling is not allowed until the legal entity is changed. The hydrogen station ceased operations on February 9, 2021.

The closure of the hydrogen station resulted in hydrogen fuel cell vehicles being unable to refuel and operate. As of the end of January 2023, five hydrogen fuel cell buses remain idle at the public transportation company. With various regions accelerating the layout of hydrogen infrastructure, many places have issued regulations for managing hydrogen stations. The Rugao government is actively coordinating with various departments to establish local regulations for managing hydrogen stations, aiming to quickly resolve certification issues and restore hydrogen station operations.

Furthermore, during the period of hydrogen station shutdown, the entity responsible for the Rugao hydrogen station actively promoted a demonstration of hydrogen production using renewable energy, which deserves commendation. Since Jiangsu Province still treats hydrogen as a hazardous chemical, production must occur in a chemical industrial park. Consequently, the demonstration application for hydrogen production was canceled during the project execution. However, with policies in various places such as Hebei and Guangdong explicitly supporting/encouraging reasonable planning of hydrogen production outside chemical industrial parks, Guohua

Corporation (the Shenhua hydrogen station's main body) plans to carry out a demonstration of renewable energy + valley electricity hydrogen production - pipeline hydrogen transportation - local consumption. This aims to form a distinctive industrial chain of renewable hydrogen production - storage - transportation - filling - use, providing a "Rugao experience" for regions across the country.

Output 4: Hydrogen production is applied in the fields of transportation and backup power. Subtasks include 4.1 completing procurement and conducting passenger demonstration runs with 5 fuel cell buses and 2 fuel cell cars, 4.2 evaluating the demonstration runs of vehicles and hydrogen refueling stations, 4.3 demonstrating the application of fuel cells as backup power sources, 4.4 operating fuel cell cogeneration systems for 2-3 years, 4.5 conducting research on fuel cell standards and technical specifications for vehicles and stationary stations, and 4.6 constructing environmental warehouses and supporting infrastructure. Due to the lack of 3C certification for 70MPa Type IV hydrogen storage cylinders domestically, the demonstration run activities for fuel cell cars in 4.1 were not completed (see Discovery 8), but all other tasks have been completed.

Finding 9: The fuel cell backup power supply and cogeneration system demonstrate positive exemplary effects. However, multiple backup power sources are idle, leading to a lower equipment utilization rate. Additionally, due to restrictions on hydrogen production in non-chemical industrial zones and safety production regulations mandating the installation of explosion-proof sheds, the cogeneration system is currently not operating normally.

The Economic and Technological Development Zone of Rugao, as the forefront in promoting the development of the hydrogen energy industry in Rugao, actively promotes the demonstration operation of fuel cell backup power systems. In 2017, the zone centralized the procurement of 6 pure hydrogen fuel cell backup power systems and 3 methanol reforming fuel cell backup power systems. Currently, 2 methanol reforming fuel cell backup power systems are used for the Bo'ai Hospital, and 1 is utilized for the Automobile Culture Museum as a display. Another pure hydrogen fuel cell backup power system originally intended for a mobile base station became unusable due to equipment damage. Consequently, government coordination led to Baiying Energy providing a new device free of charge to replace the damaged one for the demonstration operation of the mobile base station, showcasing a positive demonstration effect.

The existing six hydrogen fuel cell backup power systems were originally planned for a demonstration project in newly constructed hospitals and schools. However, as both the hospital and school constructions have not been completed, the equipment is currently stored in the warehouse of the supplier, Nantong Zehe New Energy Technology Co., Ltd. The utilization rate of the equipment is relatively low. It is understood that the project office has signed a custody agreement with Zehe and will monitor the progress of the hospital and school infrastructure construction to facilitate the timely deployment of the equipment into operation.

Figure 9 Backup Power System

Hydrogen fuel cell power generation possesses advantages such as cleanliness, environmental friendliness, high efficiency, and uninterrupted power generation, leading to rapid growth in the field of cogeneration. Cogeneration is an efficient form of energy utilization that produces both electricity and heat. It allows the low-grade heat generated after power generation to be used for heating, achieving energy cascade utilization and enhancing the comprehensive energy utilization efficiency.

During the project implementation, Japan and Europe achieved remarkable results in the field of micro-cogeneration projects, whereas large-scale demonstration applications in this field are yet to be widely adopted domestically. The project procured cogeneration system equipment from Yushi Energy to provide green, stable backup power and heat sources for the Rugao Science and Technology Innovation Center office building, showcasing its demonstrative effect. However, due to a change in the operating entity, the operation and maintenance of the cogeneration system require a certain amount of investment. The first party believes that the equipment lacks economic viability, and the legal requirements stipulate that hydrogen production should occur within a chemical industrial park. Consequently, no budget has been allocated, and difficulties in coordinating interests, legal regulations, and policies have resulted in the cogeneration system not being used as intended.

Figure 10 Cogeneration System

Finding 10: Although the environmental chamber's acceptance was delayed due to uncontrollable factors, such as the spontaneous combustion of lithium batteries in the experimental vehicle, the procurement of the environmental chamber will enhance the testing capabilities of the platform significantly. This procurement holds substantial importance in advancing the manufacturing technology level of fuel cell vehicles.

Considering the National New Energy Vehicle Big Data Alliance as a link and bridge for the sharing of new energy vehicle data, it has successfully coordinated, integrated, and developed the utilization of resources. It provides high-quality data services for the government, businesses, and the public. The 2020 work plan, including the Hydrogen Safety Data Management Platform and one-time purchase and operation demonstration activities for backup power sources, was canceled. Instead, one of the three projects, namely the construction of the testing center's environmental chamber for the Smart Hydrogen Supply System or centralized hydrogen stations, was chosen as an alternative activity. The final selection of the testing center's environmental chamber construction as the alternative activity will enhance the testing platform's capabilities significantly and contribute significantly to advancing fuel cell vehicle manufacturing technology.

Firstly, the environmental chamber can enhance the reliability and safety of hydrogen products, preventing faults and accidents caused by environmental factors. The chamber can simulate various extreme conditions, such as high temperature, low temperature, humidity, thermal shock, etc., conducting comprehensive tests and evaluations of hydrogen products. It checks performance indicators like stability, durability, and interference resistance, identifying and eliminating potential defects and hazards. This ensures that hydrogen products can operate normally in different environments without performance degradation, parameter deviations, structural damage, leaks, explosions, etc.

Secondly, the environmental chamber can provide a scientific basis and reference for the design and manufacturing of hydrogen products. Based on the test results in the chamber, optimization and improvements can be made to the structure, materials, processes, parameters, etc., enhancing the adaptability, compatibility, and flexibility of hydrogen products. It reduces the weight, volume, cost, energy consumption, etc., and improves the efficiency, effectiveness, and benefits of hydrogen products.

Furthermore, the environmental chamber can foster innovation and progress in hydrogen technology, enhancing its international competitiveness and influence. The chamber provides favorable conditions and a platform for the research and innovation of hydrogen technology. Through tests and evaluations in the chamber, the strengths and weaknesses of hydrogen technology can be discovered, new problems and challenges proposed, inspiring new ideas and solutions. This drives breakthroughs and innovations in hydrogen technology, forming new theories and methods, and developing new products and applications.

Lastly, the environmental chamber can provide strong support and assurance for the promotion and application of hydrogen technology. Through tests and evaluations in the chamber, the feasibility and reliability of hydrogen technology can be demonstrated, showcasing its advantages and effects. This enhances the trust and recognition of hydrogen technology, promoting its widespread use and accessibility, increasing its visibility and influence.

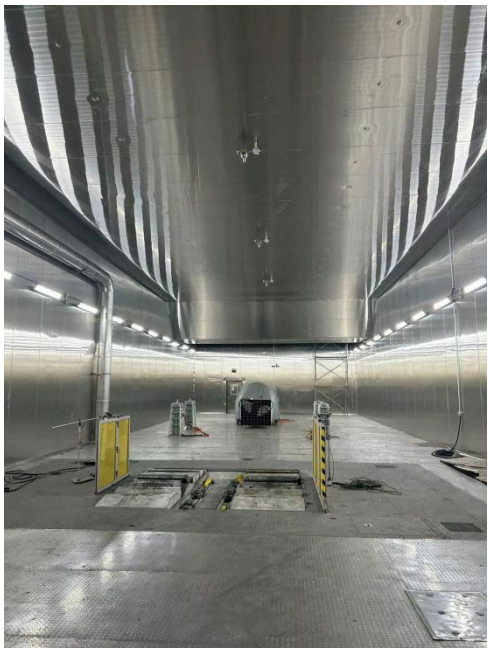

Figure 11 Detection Center Environmental Chamber

Finding 11: The acquisition of additional equipment for the National Hydrogen Energy Vehicle Research and Testing Public Service Platform drastically improves its operational efficiency and service standards.

According to the 2022 work plan, the project supports the procurement of new equipment with a total budget of 6 million RMB, divided into four projects based on equipment usage needs. Project One is the construction project for the electrical stack, system electronic load, and testing accessory capabilities, including two sets of electronic load equipment and two charging stations. Project Two is the construction project for a multi-directional vibration table testing system, including one set of a multi-directional vibration table testing system (with an added vertical direction table). Project Three is the construction project for the fuel cell vehicle's whole-vehicle refueling equipment system, including one set of 35MPa+70MPa grade hydrogen/nitrogen pressurization and refueling equipment. Project Four is the construction project for the low-temperature test system for the electrical stack, which was terminated due to the supplier's refusal to sign the contract, citing excessive penalties for certain breach of contract clauses.

The update of electronic load equipment ensures response speed at the domestic advanced level, effectively meeting testing requirements. Due to the rapid iteration of the electrical stack updates, the original load equipment cannot effectively meet its testing tasks. With the support of project funds, the testing center upgraded the load equipment. The response speed increased from the original 600A/ms to 1000A/ms, and the power increased from 150kW to 220kW, both of which are at an advanced level domestically. In addition to the upgrade in current power, the equipment supports various modes such as constant pressure, constant power, and constant current, meeting testing needs and enhancing testing quality.

The multi-directional vibration table testing system project procured one set of multi-directional testing system, including a vertical direction table. The addition of the table shortened the original

vibration table flip time, improving testing efficiency and reducing safety risks. The project pre-reserved hydrogen pipelines in the environmental chamber walls, allowing for running tests on the table in the future. In terms of safety, the environmental chamber is equipped with air conditioning pipelines for rapid hydrogen purging. The construction of the environment and the procurement of equipment are forward-looking, expanding business scope, meeting various testing requirements, and significantly enhancing the overall testing capabilities of the system.

The 35MPa+70MPa grade hydrogen/nitrogen pressurization and refueling equipment, along with the charging equipment, meet the hydrogen vehicle's refueling and fast charging needs, reducing the test preparation time by nearly half and greatly improving efficiency and service levels. Before installing the hydrogen refueling equipment, the testing center could not meet the refueling needs of heavy-duty vehicles, thus unable to serve customers with heavy-duty vehicles. After installing the hydrogen refueling equipment, the center can now meet the testing needs of different vehicle types, expanding its business scope and improving service quality. Additionally, before purchasing the charging stations, the process of adjusting SOC ranges before testing had to be conducted externally. The temporary chargers at the testing center couldn't meet the charging needs of heavy-duty vehicles. After installing the charging stations, the test preparation time was reduced from two days to one day. Users can also adjust the vehicle's SOC status according to their needs. The fast charging station installation solved the charging problem for heavy-duty vehicles. In terms of efficiency, vehicles weighing over 4.5 tons can now complete charging within 1-3 hours in the factory area, while small vehicles, originally taking 16-24 hours for slow charging, now take 8 hours for slow charging and 1 hour for fast charging.

Output 5: The framework of policy system and the demonstration application of carbon trading are completed. Subtasks include 5.1 formulating supportive policies for low-carbon hydrogen production and hydrogen infrastructure, 5.2 formulating supportive policies for the application of fuel cells in transportation and cogeneration, 5.3 conducting technical and economic analysis and evaluation of the hydrogen economy, and 5.4 researching and formulating methods for carbon trading. The project has formulated multiple supportive policies according to the tasks, actively researched carbon quota trading systems, and hired domestic experts to analyze the technical and economic lifecycle of fuel cell technology. However, due to the cancellation of hydrogen production activities, supportive policies for low-carbon hydrogen production were not formulated.

Finding 12: There have been substantial research achievements in areas such as fuel cell vehicles, fuel cells for fixed power stations, standards, and technical specifications. Nine draft standards and compilation instructions have been formulated. Additionally, industry policies such as the "Construction and Development Plan for the Yangtze River Delta Hydrogen Corridor" and the "Integrated Demonstration Plan for Fuel Cell Vehicles in the Yangtze River Delta" have been developed, propelling the development of the hydrogen energy industry.

To promote the standardization and normalization of hydrogen energy technology, enhance the quality and safety of hydrogen products, and facilitate the development of the hydrogen energy industry, improving the relevant standards in the hydrogen energy industry is one of the crucial tasks of Hydrogen Economy Pilot Project in China. The project has achieved significant results in various aspects, such as fuel cell vehicles, stationary fuel cell standards, and technical specifications. Multiple standards drafts and drafting instructions have been formulated, including:

1) Proton exchange membrane fuel cell modules for road vehicles.
2) Stationary fuel cell power systems Part 1: Safety.
3) Stationary fuel cell power systems Part 3: Installation.
4) Micro fuel cell power systems Part 2: Performance test methods.
5) Small stationary fuel cell power systems Performance tests - Drafting instructions.
6) Small stationary fuel cell power systems Performance test methods.
7) Direct methanol fuel cell systems Part 1: Safety.
8) Direct methanol fuel cell systems Part 1: Safety - Drafting instructions.
9) Direct methanol fuel cell systems Part 2: Performance test methods.
10) Direct methanol fuel cell systems Part 2: Performance test methods - Drafting instructions.
11) Proton exchange membrane fuel cells Part 1: Terminology.
12) Proton exchange membrane fuel cells Part 1: Terminology - Drafting instructions.
13) Proton exchange membrane fuel cell power system low-temperature characteristic test methods.
14) Proton exchange membrane fuel cell power system low-temperature characteristic test methods - Drafting instructions.

These standards drafts and drafting instructions have not only met but exceeded the project's expectations, providing technical support and guidance for the research, production, application, and regulation of hydrogen technology. They have laid a foundation for the establishment and expansion of the hydrogen market. It is understood that these standards drafts and drafting instructions have been submitted to the National Standardization Management Committee, with some already officially published or about to be published, and others still under review or modification. They have attracted widespread attention and application in the field of hydrogen energy, serving as a reference for the innovation and promotion of hydrogen technology. Simultaneously, the primary audience for these standards drafts and drafting instructions includes government departments, research institutions, universities, businesses, social organizations, and the general public interested in hydrogen energy.

These standards drafts and drafting instructions can assist them in acquiring relevant knowledge and information, enhancing the awareness and understanding of hydrogen technology, and building trust and support for hydrogen energy technology. Additionally, other countries, regions, and personnel involved in developing hydrogen technology and other new energy technologies can benefit from these standards drafts and drafting instructions. They can serve as a reference for standardizing and normalizing hydrogen energy technology, helping them establish and improve the standards system for hydrogen technology, and promoting international cooperation and exchange in hydrogen energy technology.

In summary, the standards drafts and drafting instructions have improved the quality and safety of hydrogen energy technology, reduced the risks and costs associated with it, increased its competitiveness and attractiveness, promoted innovation and development, facilitated its application and popularization, expanded the market and demand for hydrogen technology, enhanced social acceptance and support, raised public awareness and participation, created a favorable atmosphere and environment for hydrogen technology, and fostered international cooperation and exchange. They showcase China's leading position and contribution in hydrogen energy technology, making a positive contribution to the global development and application of hydrogen energy technology.

Promoting the formulation of relevant industrial policies is also one of the crucial tasks of the UNDP Hydrogen Economy Pilot Project in China. The project office has developed several key documents, including the "Yangtze River Delta Hydrogen Corridor Construction and Development Plan," the "Integrated Demonstration Scheme for Fuel Cell Vehicles in the Yangtze River Delta," the "World Hydrogen and Fuel Cell Vehicle Industry Development Report," the "Guidance on Accelerating the Promotion of Hydrogen Fuel Cell Vehicle Technology and Industry Development," and the "Action Plan for Building World-Class Hydrogen Industry Clusters in Some National-Level Economic Development Zones." These policies aim to drive the development of the hydrogen and fuel cell vehicle industry in the Yangtze River Delta, achieve efficient utilization of hydrogen, promote low-carbon transformation, and establish world-class hydrogen industry clusters and demonstration areas, serving as a reference and demonstration for global hydrogen development and applications.

1) The "Yangtze River Delta Hydrogen Corridor Construction and Development Plan" and the "Integrated Demonstration Scheme for Fuel Cell Vehicles in the Yangtze River Delta" focus on the construction of hydrogen infrastructure in the form of linear and grid-based inter-city zones within the Yangtze River Delta urban agglomeration. They also consider hydrogen infrastructure within key cities to meet inter-city hydrogen refueling needs. These plans aim to proactively build infrastructure to balance the development of hydrogen infrastructure and fuel cell vehicles.
2) The compilation of the "World Hydrogen and Fuel Cell Vehicle Industry Development Report" in 2018 and 2019 serves to support the UNDP Hydrogen Economy Pilot Project in China. The report provides a comprehensive understanding of the global trends in the hydrogen and fuel cell vehicle industry. It serves as a reference for Chinese authorities, decision-makers in the hydrogen and fuel cell vehicle industry, strategic research institutions, and domestic and foreign investors. The report covers the current status and trends of technology, applications, and industrial policies through investigation, research, analysis, and summarization, facilitating in-depth discussions on hydrogen and fuel cell vehicles at both domestic and international levels, offering guidance for the healthy and sustainable development of the industry.
3) The formulation of the "Guidance on Accelerating the Promotion of Hydrogen Fuel Cell Vehicle Technology and Industry Development" aims to establish a comprehensive hydrogen fuel cell vehicle research and development system within 10-15 years. The goal is to achieve key core technologies at an international advanced level and build a globally competitive industry support system. The document provides detailed plans in areas such as policy support, infrastructure construction, fiscal and tax policies, financing channels, industry management, and collaborative applications. It aims to create a hydrogen infrastructure supply system that meets the demand for fuel cell vehicles, ensuring the commercialization of hydrogen fuel cell vehicles.
4) The compilation of the "Action Plan for Building World-Class Hydrogen Industry Clusters in Some National-Level Economic Development Zones" focuses on utilizing national-level economic and technological development zones ("Economic Development Zones") as a foundation. These zones, characterized by knowledge-intensive and technology-intensive modern industries, enjoy special preferential policies and provide an investment environment conforming to international standards. They play a leading role in the practice of industrial clusters in the park category. This document proposes building a world-class

hydrogen and fuel cell vehicle industry cluster relying on Economic Development Zones, leveraging prior development foundations and favorable policy conditions. This initiative is expected to play a key role in nurturing, aggregating, and promoting China's hydrogen industry and facilitating the transformation and upgrading of the country's automotive industry. Seizing the strategic opportunities of the rapid development of the hydrogen and fuel cell vehicle industry, optimizing the energy consumption structure, and developing the hydrogen economy are crucial directions for industrial upgrading and sustainable economic development in the new era.

5) The compilation of the "Research on Management System for Recycling and Utilization of Fuel Cell Vehicles" addresses the significant differences between fuel cell vehicles and traditional vehicles, leading to incomplete applicability of existing management measures and related standards. The research focuses on policies for the recycling and utilization of fuel cell vehicles, providing a basis for the construction of management systems. This research holds significant importance for the sustainable development of the fuel cell industry. The study initially covers the entire industry chain, analyzing policies promoting fuel cell vehicles domestically and internationally, market development, and the industrial supporting environment. It comprehensively understands the development status and predicts trends in the upstream industry of the industry chain. Subsequently, it delves into recyclability, starting with the critical components of fuel cell systems. Through vehicle dismantling analysis and an examination of technological advances in recycling and utilization, the study comprehensively analyzes the recyclability of fuel cell vehicles, focusing on key technological points. Finally, scientific policy recommendations are proposed. Building on the analysis of the development of the fuel cell vehicle industry and the recyclability of fuel cell vehicles, combined with the management situation of power battery recycling and utilization in traditional and new energy vehicles in China, the study conducts a comprehensive applicability comparison of management systems and standard systems, putting forward specific policy suggestions.

Finding 13: Active research into carbon quota trading systems and the addition of the "Methodology Development for Greenhouse Gas Emission Reduction in Fuel Cell Applications in Transportation and Cogeneration" subcontract project promotes institutional innovations for green and low-carbon development.

China is the country with the highest carbon emissions globally. However, before 2018, the essence, content, and procedures of carbon trading were still in a phase of attention and exploration. In November 2017, after communication between the CICETE and UNDP, it was decided to expand the subcontracting project on the 'Development of Methodology for Greenhouse Gas Emission Reduction through Fuel Cell Applications in Transportation and Cogeneration,' with a total budget of $95,000 and an initial payment of $76,000.

According to the plan, the subcontractor successively conducted research on relevant industries and enterprises, gaining in-depth insights into the production and operation of fuel cells, basic and operational parameters, etc. The research focused on the technical methods of using fuel cells in transportation, cogeneration, setting project boundaries, benchmark scenarios, leakage, project emissions, project emission reductions, monitoring, and related aspects. This effort resulted in two achievements: the 'Methodology for Calculating Emission Reductions in Hydrogen Fuel Cell

Passenger and Freight Vehicle Projects' and the 'Methodology for Calculating Emission Reductions in Hydrogen Fuel Cell Power Generation and/or Heating Projects.'

The first achievement applies to projects aimed at reducing emissions by introducing fuel cell vehicles and/or hybrid vehicles in passenger or freight transport, replacing vehicles using fossil fuels. The annual emission reduction for project activities does not exceed 60,000 tons of CO2. The second achievement applies to hydrogen fuel cells used in power generation and heating projects. The generated electricity and heat will be provided to existing or new users/facilities to replace the use of fossil fuels with higher carbon emissions in the baseline. The annual emission reduction for project activities does not exceed 60,000 tCO2e.

These two achievements serve the following purposes:

They provide scientific quantification and accounting methods for greenhouse gas emission reductions in the field of transportation and cogeneration using fuel cells, offering technical support for the construction and operation of carbon trading markets. These methodologies can assist fuel cell project developers and participants in determining crucial parameters such as project boundaries, benchmarks, leakage, emissions, emission reductions, and in formulating effective monitoring plans to ensure the emission reduction effectiveness and environmental benefits of the project.

They establish economic incentives and reward mechanisms for greenhouse gas emission reductions in the field of transportation and cogeneration using fuel cells, creating market demand and value for the promotion and application of fuel cells. These methodologies can help fuel cell project developers and participants convert project emission reductions into carbon assets through the verification of voluntary emission reductions (CCER), thereby trading or offsetting the emission reductions in the carbon trading market to gain economic benefits and social recognition.

They provide guidance and demonstration effects for policies related to greenhouse gas emission reductions in the field of transportation and cogeneration using fuel cells, offering policy support and signals for the development and innovation of fuel cells. These methodologies can help governments and various sectors of society understand the emission reduction potential and advantages of fuel cells, promoting the formulation and implementation of policies related to fuel cells, driving technological research and development, and industrial development related to fuel cells, contributing to achieving the country's carbon neutrality and green development goals."

Output 6: Enhancement of Public Awareness and Information Exchange in the Hydrogen Economy: 6.1 Engage in communication and establish collaboration through conferences, seminars, and inspection visits with various stakeholders.6.2Convene workshops and international inspections.6.3 Facilitate communication on project progress and achievements, media publicity.6.4 Invite high-level representatives from relevant institutions and governments to inspect demonstration sites.6.5 Organize information exchange among relevant personnel in interested demonstration cities and regions, reinforcing corporate collaboration.6.6 Conduct replicable research on hydrogen economy in other cities and regions.6.7 Summarize and evaluate the demonstration work experience, achievements, and commercialization models of demonstration zones.

Finding 14: Hosting and co-hosting multiple editions of the International Fuel Cell Vehicle Conference with high specifications, rich content, and in-depth themes have had an outstanding promotional effect. This has significantly contributed to the profound advancement of hydrogen and fuel cell vehicle technology and industry development in China and globally. The 5G+VR live broadcasting project provided attendees with a multi-perspective, panoramic, immersive experience, while 5G technology facilitated smooth, efficient live streaming, and IoT services during the conference.

On November 9-10, 2017, the second International Fuel Cell Vehicle Conference was grandly held at the Rugao Automobile Culture Museum in Jiangsu Province. The total budget for the project was $99,000, and the actual expenditure was $99,000. Co-organized by the International Hydrogen Fuel Cell Association (provisional) and the Society of Automotive Engineers of China, the conference was hosted by the People's Government of Nantong City and the People's Government of Rugao. The high level of the conference attracted enthusiastic participation from leading domestic and international enterprises and representatives from various fields. Over 50 government guests from more than 20 countries and regions, over 100 CEOs of domestic and foreign companies, vice presidents, industry executives, academicians, think tanks, research institutes, universities, and more than 400 elites from domestic and foreign automobile and component enterprises, as well as over 100 mainstream automobile media from home and abroad, attended the conference.

The conference had rich content and in-depth themes, spanning two days with 51 speeches and one high-level interview. The 74 invited hosts and speakers were all leading figures in the hydrogen fuel cell vehicle industry, with half of them being foreign executives. These global leaders in the hydrogen industry discussed the commercial application of fuel cell vehicles comprehensively, covering aspects such as technology, policy, infrastructure, and market. Additionally, four sub-sessions with themes like "Fuel Cell Technology Commercialization," "Hydrogen Production and Storage Technology Development and Application," "Fuel Cell Stacks and Key Components," and "Standards, Regulations, and Testing Technology" delved deeper into the development of the hydrogen fuel cell industry, offering predictions and prospects for the future.

The conference adopted a combination of exhibition and conference, with international giants like Toyota, Honda, and Hyundai jointly showcasing their latest fuel cell cars in China for the first time, providing test-driving activities for guests to experience firsthand. SAIC and Weichai also displayed their developed fuel cell vehicles. Furthermore, fuel cell and hydrogen component manufacturers showcased their latest technologies and products. The conference integrated deeply with local economic and social development, contributing to the development of the local industry. The successful convening of the conference gave Rugao's hydrogen industry a splendid appearance on the world stage.

To further strengthen global cooperation across the entire hydrogen and fuel cell industry chain and promote the commercial development of hydrogen and fuel cell vehicles, the project organized the "Third International Fuel Cell Vehicle Conference" in Rugao from October 23 to 25, 2018. The conference was co-organized by the International Hydrogen Fuel Cell Association (provisional) and the Society of Automotive Engineers of China, with the support of the People's Government of Nantong City and the People's Government of Rugao. This conference had broad participation, attracting 2,636 representatives from more than 20 countries in Europe, America, and Asia. The high-level guests and internationalization were notable, with Mr. Wan Gang, Vice Chairman of the

National Committee of the Chinese People's Political Consultative Conference and Chairman of the China Association for Science and Technology, delivering a speech. Representatives from important international hydrogen fuel cell government organizations, including the U.S. Department of Energy Fuel Cell Office, the German National Hydrogen and Fuel Cell Technology Organization, the European Union Fuel Cell and Hydrogen Joint Undertaking, the Japan New Energy Industry Development Organization, the Korea Hydrogen Promotion Agency, and leaders and senior representatives from the Hydrogen Council, gathered in China for the first time, delivering speeches and participating in interviews. The conference lasted three days, featuring one main venue and five sub-venues, with 84 professional speeches, one leadership forum, one closed-door special discussion, and one closed-door council meeting. This conference also became an important platform for the release of new information, new products, and new technologies by the government and enterprises. The "Yangtze River Delta Fuel Cell Vehicle Integration Demonstration Implementation Plan 2020-2022" was jointly signed by the China Society of Automotive Engineers, the People's Government of Nantong City, the Shanghai Municipal Science and Technology Commission, the People's Government of Rugao City, and the Changshu National High-tech Industrial Development Zone. Hyundai Motor and Rugao Economic and Technological Development Zone signed a strategic cooperation agreement on hydrogen fuel cell commercial vehicles, planning to invest in a hydrogen fuel cell commercial vehicle production base in Rugao. The "National Hydrogen Energy Vehicle Research and Testing Public Service Platform" held its unveiling ceremony at the conference, symbolizing the official operation of the first third-party hydrogen fuel cell comprehensive testing service institution in the Yangtze River Delta region.

Continuing from the successful hosting of the International Hydrogen and Fuel Cell Vehicle Conferences in 2017, 2018, and 2019, the fourth conference was held in Rugao from September 26 to 28, 2019. Co-hosted by the China Society of Automotive Engineers and the International Hydrogen Fuel Cell Association (provisional), and organized by the People's Government of Nantong City and the People's Government of Rugao, the conference received support from various enterprises and institutions, including UNDP, the CICETE, the Korea Hydrogen Promotion Agency, Anglo American, Toyota Motor Corporation, Hyundai Motor, China Automotive Technology and Research Center, Tsinghua University, Tongji University, and the Canadian Hydrogen and Fuel Cell Association. The three-day conference featured one plenary session, six themed sessions, and five side sessions, offering over 100 thematic speeches and sharing sessions. Leaders and industry giants from well-known enterprises in various fields worldwide delivered speeches on the latest technologies and products, making the conference content rich and diverse. The conference attracted more than 2,000 representatives from over 20 countries in Europe, America, and Asia, with over 1,500 self-funded registered guests, including participants from various fields such as industry chain enterprises, government departments, schools and research institutes, media, and industry organizations. The conference became an important platform for various industries to release new information, new technologies, and new products. The China Society of Automotive Engineers, the People's Government of Nantong City, the Shanghai Municipal Science and Technology Commission, the People's Government of Rugao City, and the Changshu National High-tech Industrial Development Zone jointly signed the "Yangtze River Delta Fuel Cell Vehicle Integration Demonstration Implementation Plan 2020-2022." Hyundai Motor signed a strategic cooperation agreement on hydrogen fuel cell commercial vehicles with Rugao Economic and Technological Development Zone, planning to invest in a hydrogen fuel cell commercial vehicle production base in Rugao. The "National Hydrogen Energy Vehicle Research and Testing Public Service Platform" held its unveiling ceremony at the conference, symbolizing the official operation

of the first third-party hydrogen fuel cell comprehensive testing service institution in the Yangtze River Delta region.

The consecutive hosting of the International Hydrogen and Fuel Cell Vehicle Conferences in 2017, 2018, and 2019 has been a complete success, providing a good international exchange, display, and cooperation platform for the hydrogen and fuel cell fields, achieving industrial win-win cooperation. It has also had a profound significance for the publicity of Rugao's hydrogen industry demonstration zone and has far-reaching implications for promoting the technological and industrial development of hydrogen and fuel cell vehicles in China and the world.

Figure 12 International Hydrogen and Fuel Cell Vehicle Conference

To maximize the dissemination impact of the conference and enhance the overall experience for all participants, the project innovatively integrates 5G and VR technologies for comprehensive live streaming of the conference venue and the location of the event—Hydrogen Town. Compared to 4G mobile networks, 5G offers a significant increase in network speed, up to a hundredfold, and millisecond-level latency. VR is highly sensitive to latency; to achieve the "this is all real" experience, latency must be maintained in the millisecond range to alleviate any sense of dizziness. Therefore, the combination of VR and 5G technologies realizes a multi-angle, panoramic, immersive experience for conference attendees, allowing them to virtually witness the entirety of Hydrogen Town. Additionally, this marks the debut of 5G technology in Rugao, providing the conference with smooth and efficient live streaming and Internet of Things (IoT) services.

Finding 15: Organizing the 2018 and 2019 Fuel Cell Vehicle and Related Parts Exhibitions concurrently with the Hydrogen and Fuel Cell Vehicle Conference provided a platform for vehicle manufacturers and technical service providers to showcase their products and facilitated extensive networking opportunities. This fostered technical interaction and industry exchanges between different levels of the industry.

Organizing the Fuel Cell Vehicles and Related Components Exhibitions in 2018 and 2019 as concurrent events of the 3rd and 4th International Hydrogen and Fuel Cell Vehicle Conferences, respectively, provided a platform for automotive representatives and technical service providers to showcase their innovations. It also offered a broader opportunity for conference attendees to engage in discussions, effectively promoting technical interaction and industry exchange between upstream and downstream sectors.

The 2018 Fuel Cell Vehicles and Related Components Exhibition, held concurrently with the 3rd International Hydrogen and Fuel Cell Vehicle Conference, marked the first extension of the technical conference into a commercial exhibition. The exhibition provided a showcase platform for automotive representatives and technical service providers, fostering extensive networking opportunities for conference attendees and facilitating effective technical interaction and industry exchange between different sectors. The exhibition covered an area of 6,000 square meters and saw the participation of 52 companies from 7 countries, including complete vehicle manufacturers (such as Toyota, Honda, SAIC, FAW, NIO, Youth Auto, Land Space, and Byton), fuel cell stack and system integrators (Xiongtao Hydrogen Hero, Zhejiang Hydrogen Way, Reshape, Forsa, Derun Power, etc.), hydrogen infrastructure companies (Air Products, Furuie Hydrogen Energy, Beijing Kotek, Zhongcai Technology, PDC from the United States, McPhy from France), and core components and materials providers (Garett, Ionbond, Germany Cordoban, Pushev Vacuum, Sijia Tobo, etc.) across four major exhibition areas, creating a convergence of companies along the entire hydrogen fuel cell vehicle industry chain. Seven companies from the Jiangsu Qingneng, An Sizhuo Energy, Baiying Energy, Jintong Ling, Sijia Tobo, Youth Auto, Land Space, and Gaokai Auto, in the Rugao area, also showcased their latest products. The exhibition attracted over 8,000 visitors, demonstrating significant influence.

The 2019 Fuel Cell Vehicles and Related Components Exhibition, held concurrently with the 4th International Hydrogen and Fuel Cell Vehicle Conference, covered a total area of 10,000 square meters and featured the participation of 111 exhibitors, drawing more than 5,000 professional visitors from around the world. Participating companies were categorized into five groups: complete vehicle manufacturers, core components and materials enterprises, fuel cell stack and system integrators, production equipment and testing equipment/system enterprises, and hydrogen production, storage, and hydrogenation-related equipment enterprises. Thirteen automotive companies participated, showcasing a variety of vehicle types, including passenger cars, logistics vehicles, postal vehicles, and buses, presenting nearly the latest and most comprehensive products domestically and internationally. For the first time, the exhibition invited four Canadian companies, Ballard, Hydrogenics, Rebitco, and Greenlight Innovation, to attend in the form of an exhibition group, further enhancing the internationalization of the event. The on-site activities included technical presentations, "Media Talks Hydrogen," "H2 in Holland," and other concurrent events that continuously added excitement to the exhibition, providing a platform for more conference attendees to build collaborative and mutually beneficial partnerships.

Finding 16: Actively planning and participating in the 2018 and 2019 "Fuel Cell Vehicle Science Popularization Tour" garnered widespread attention from various sectors of society and achieved excellent science communication effects. Organizing lectures on hydrogen and fuel cell advancements and high-tech entrepreneurial project roadshows promoted technological innovation and industrial collaboration in the field, providing impetus and support for the development of the hydrogen and fuel cell industry.

To further promote the development of the local hydrogen energy industry, enhance public awareness of hydrogen energy, increase public participation in hydrogen energy city planning, and strengthen public perception of fuel cell vehicles, a comprehensive and professional hydrogen fuel cell vehicle popularization campaign is being conducted. The goal is to build social consensus and drive the marketization process of hydrogen fuel cell vehicles.

The budget for this project is $800,000, and it was officially launched on October 12-15 after being announced on July 19, 2018, during the "Third International Hydrogen Energy and Fuel Cell Vehicle Conference" and the "2018 Yangtze River Delta Hydrogen Energy Fuel Cell Vehicle Popular Science Tour" press conference in Rugao. The event lasted four days and covered three stations, starting from Rugao, a United Nations hydrogen economic demonstration city, passing through the new energy vehicle industry base in Nantong, and concluding in Shanghai, a leading city in the development of hydrogen fuel cell vehicles in China. This is the first large-scale public-oriented hydrogen fuel cell science popularization activity in the country.

The event brought together 13 of the latest fuel cell vehicles from 12 domestic and international manufacturers, covering various types of vehicles such as passenger cars, logistics vehicles, and buses. These vehicles were showcased to the public for test rides, and many fuel cell vehicles underwent long-distance test drives on actual roads between Rugao and Nantong, marking the first such attempt in China. Numerous companies presented fuel cell stacks, compressors, on-board hydrogen cylinders, mobile hydrogen refueling stations, and other equipment for on-site popular science demonstrations. Additionally, there were live demonstrations of water electrolysis and fuel cell vehicle teaching aids, as well as VR devices to help the public gain a more intuitive understanding of hydrogen fuel cells. Renowned figures in the industry and experts from various companies delivered multiple popular science lectures.

Furthermore, the first set of hydrogen fuel cell vehicle popular science hand-drawn comics in China made its debut during the event. These comics, colored by students from local primary schools, were presented to local governments, leaving a unique imprint at each station. The three-station event attracted over a thousand attendees on-site, with over 2.2 million online viewers participating through network videos and live text and image broadcasts.

In September 2019, the project organized the "2019 Yangtze River Delta Fuel Cell Vehicle Popular Science Tour," featuring 15 of the latest and most comprehensive fuel cell vehicles from both domestic and international manufacturers. Starting from Shanghai, passing through Changshu and Nantong, and concluding in Rugao after covering a total distance of 216 kilometers on actual roads, the event provided a test ride experience. Additionally, media teams and 20 "Science Popularization Ambassadors" from various universities nationwide served as experiential participants, communicators, and practitioners of the "hydrogen" clean and environmentally friendly concept, further expanding the popular science demonstration effect of the tour.

Figure 13 Yangtze River Delta Hydrogen Fuel Cell Vehicle Popular Science Tour

According to the recommendations from the mid-term evaluation of the project, the "5th Fuel Cell Vehicle Conference (FCVC)" event, as originally planned, is to be canceled. Instead, it will be replaced with an event titled "Hydrogen Energy and Fuel Cell Advanced Advocacy and High-Technology Entrepreneurship Project Roadshow." This event is built upon the broad platform of FCVC, providing an opportunity for external advocacy and showcasing projects on a significant scale. The city of Rugao will conduct entrepreneurship project roadshows, evaluating the research and development capabilities and technological advancements of participating start-ups, ultimately identifying outstanding projects.

The forum has garnered attention from professionals and media across various sectors. Through a combination of conferences, exhibitions, and demonstrations, the forum facilitates a close integration of capital into industry. It has brought together 13 domestic and international start-ups spanning the entire hydrogen energy industry chain. Each participating company has presented detailed information on their product characteristics, market positioning and scale, business models, team capabilities, competitive advantages, and product development.

The advocacy of advanced concepts in hydrogen energy and fuel cells is a crucial component of the project. By inviting renowned experts, scholars, and entrepreneurs from both domestic and international arenas, the event aims to disseminate the latest technological advancements, market prospects, policy support, and other relevant information. This approach seeks to enhance public awareness and trust in hydrogen energy and fuel cells, stimulate widespread interest and participation across society, and attract investors, partners, and consumers. The exhibition of innovative, forward-looking, and viable entrepreneurial projects related to hydrogen energy and fuel cells is intended to promote the refinement and development of the entire hydrogen energy and fuel cell industry chain.

The initiative has bolstered public understanding and acceptance of hydrogen energy and fuel cells, establishing a solid social foundation for their promotion and application. It has further spurred technological innovation and industrial cooperation in the field of hydrogen energy and fuel cells, providing momentum and support for the development of the industry. The event showcases

Rugao's strengths and achievements in hydrogen energy and fuel cells, elevating its profile and influence domestically and internationally.

Finding 17: The project team organized visits to Japan, South Korea, Denmark, and Finland, facilitating international exchanges, drawing from advanced technological experiences and models, and thereby enhancing the project's technical expertise and management capabilities. This also served as effective promotion for the demonstration project.

The project team organized visits to Japan and South Korea for exchange and research purposes. During the stay in Japan, they attended the Hydrogen Energy Exhibition and subsequently visited Toyota's East Fuji Research Institute, Iwatani Corporation's Iwatani Hydrogen Station, the Hydrogen Town in Kitakyushu, and Gore Membrane Electrode Company. They gained insights into Japan's advancements and achievements in hydrogen infrastructure development, promotion of hydrogen-powered vehicles, and the establishment of hydrogen-powered communities. Moreover, during the Hydrogen Energy Exhibition in Japan, the delegation from Rugao engaged in in-depth discussions with participating companies.

In South Korea, they visited the Hyundai Motor Company's Fuel Cell Research Institute and Kolon Company, understanding South Korea's experiences and practices in hydrogen policy formulation, hydrogen technology research and development, and the growth of the hydrogen industry. This international exchange facilitated research on fuel cell vehicles, standards for fuel cells used in stationary power stations, technical specifications, thereby enhancing the project's technological expertise.

At the end of May 2018, the Rugao project team accompanied a delegation to Denmark and Finland. In Copenhagen, Denmark, they participated in the "Global Electric Vehicle Demonstration City Development Project" conference and engaged in discussions at the concurrent seminar on "Scaling up Electric Vehicles to Support Urban Clean Energy Transformation." In Helsinki, Finland, they attended the "2018 Electric Vehicle Demonstration City Forum" and delivered a keynote speech representing the Chinese side. These activities effectively promoted Rugao's hydrogen industry and the "UNDP Hydrogen Economy Pilot Project in China."

The project team actively pursued international learning and exchanges, leveraging advanced technologies, experiences, and models in the hydrogen and fuel cell fields from abroad. This initiative elevated the project's technical prowess, strengthened collaborations with countries and regions such as Japan and South Korea in the hydrogen and fuel cell industries, expanded Rugao's international influence, boosted project visibility, and garnered attention from more investors, entrepreneurs, consumers, and stakeholders interested in the hydrogen industry.

Figure 14 International Exchange and Research Visits by the Project Team

Finding 18: Production of mid-term and final promotional videos to showcase the project's goals, content, progress, and achievements aimed to increase public understanding and recognition of the project. This effort elevated the project's influence, attractiveness, stimulated widespread societal interest and involvement in hydrogen energy, and furthered the development of the hydrogen and fuel cell industry.

The production of the mid-term promotional video has enhanced public understanding and recognition of the Rugao project. The video showcases the project's goals, content, progress, and achievements, thereby increasing its impact and attractiveness. It disseminates information on advanced technologies, market prospects, and policy support in hydrogen and fuel cell technologies, sparking interest and participation from various sectors of society. This, in turn, facilitates the development of the hydrogen and fuel cell industry.

The video highlights Rugao's strengths and accomplishments in the field of hydrogen and fuel cells, elevating Rugao's visibility and influence both domestically and internationally. This heightened profile attracts more investors, partners, consumers, and other stakeholders. Furthermore, the video underscores the strong relationships between the UNDP and multiple stakeholders, including the Chinese government, local authorities, businesses, and communities, fostering mutual trust and friendship. This, in turn, lays the groundwork for potential future collaborations.

Figure 15 Mid-term Promotional Video

According to the 2022 work plan and the resolution of the Steering Committee on July 12, 2022, it is proposed to produce a final outcome promotional video to summarize the overall project and demonstrate its impact. The selected production unit for the promotional video is the Mid-term Promotional Video Service Provider, namely the Shanghai Jigao Film and Culture Center. Currently, the final promotional video has been reviewed and approved.

4.4 Efficiency

Finding 19: The project funding is adequate, with an overall good execution rate. However, challenges such as the pandemic, repeated failures in public tenders for large equipment, and subpar service quality from suppliers led to lower execution rates in certain years

As shown in Figure 16, the budget expenditures for this project from 2016 to 2022 were $599,500, $3,028,000, $2,007,000, $2,002,600, $169,200, $2,694,800, and $1,100,000, respectively. The actual expenditures were $246,200, $2,229,500, $1,977,200, $1,643,700, $122,800, $1,766,700, and $582,300, respectively. Calculations yield annual project execution rates of 41%, 74%, 99%, 82%, 73%, 66%, and 53% for the respective years.

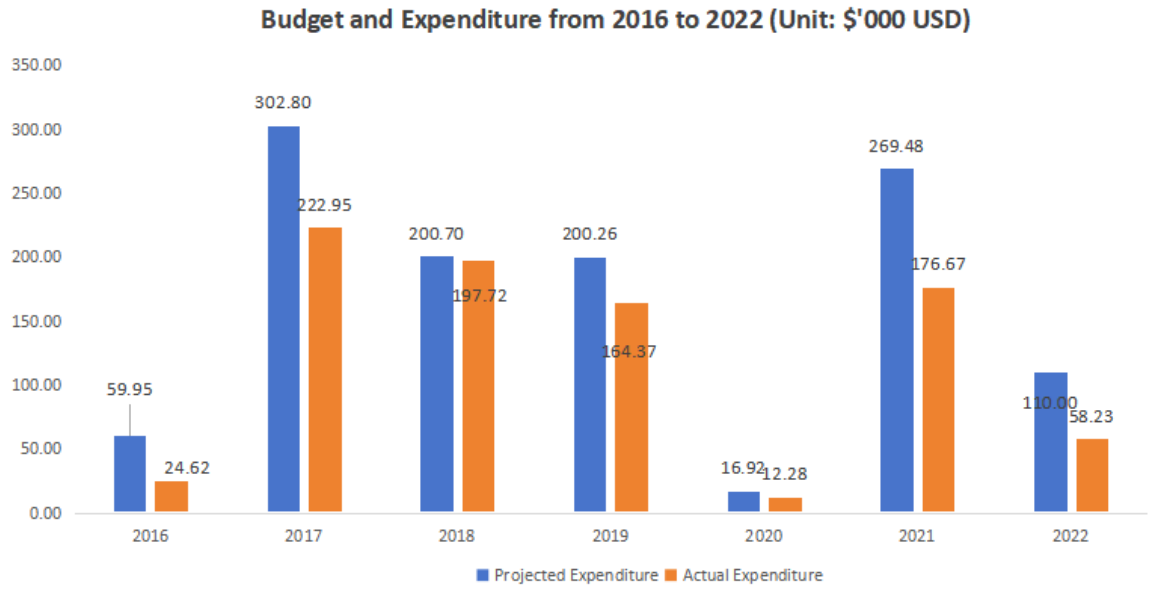

Figure 16 Budget and Expenditures for 2016-2022

From the perspective of fund expenditure structure, during the years 2017-2019, the project expenditure exceeded $1.5 million annually, with a project execution rate consistently surpassing 70%. Notably, in 2018, the execution rate soared to an impressive 99%. However, by the end of 2019, the efficiency of fund expenditures was impacted by the pandemic, resulting in a decline in the project execution rate to 73% in 2020. Subsequently, the execution rates remained below 70%. As the financial data for each year is typically compiled around March of the following year, and the final evaluation concluded on November 30, 2023, the project's execution rate for the year 2023 is not included in the evaluation. The specific reasons for the lower execution rates in 2016, 2021, and 2022 are analyzed below.

Table 10 Specific Reasons for the Lower Execution Rates in 2016, 2021, and 2022

2016	The main reason for the low execution efficiency in 2016 was the lack of a comprehensive system in China's hydrogen energy policy. The absence of legal support for the energy attributes of hydrogen led to challenges in planning hydrogen production lines in chemical industrial parks. Issues such as incomplete standards, unclear land use, and construction approval authorities in the hydrogen industry zone hindered the normal progress of commercialization studies and demonstration activities related to various hydrogen production technologies.
2021	1. Multiple tender failures and delayed deliveries by the eventual supplier resulted in slow progress in the procurement of hub environment warehouses for fuel cell vehicles. The annual plan was not completed. 2. The early termination of the fuel cell distributed power generation equipment operation service agreement. The UNDP Hydrogen Economy Pilot Project in China, through bidding with Nantong Zehe New Energy Technology Co., Ltd., signed a contract for the operation service of fuel cell distributed power generation equipment. Subsequent loss of technical personnel prevented the continued provision of technical support.

2022	1. The supplier of hub environment warehouses for fuel cell vehicles failed to complete the service according to the specified date, leading to delayed delivery. 2. The pre-awarded supplier, List Testing Equipment (Shanghai) Co., Ltd., for the "Low-Temperature Experiment System Capacity Building Project for Fuel Cell Stacks," refused to sign the contract, citing that certain penalty clauses for breach of contract within the agreement were deemed excessively severe. Subsequently, following a resolution by the project steering committee, the procurement activity was terminated, and there are no plans to reopen the bidding process.

Finding 20: Upon reviewing detailed annual expenditure reports and annual work summaries, analyzing the structure of project fund expenditures revealed that the project expenditure is reasonable, contributing to its sustainability.

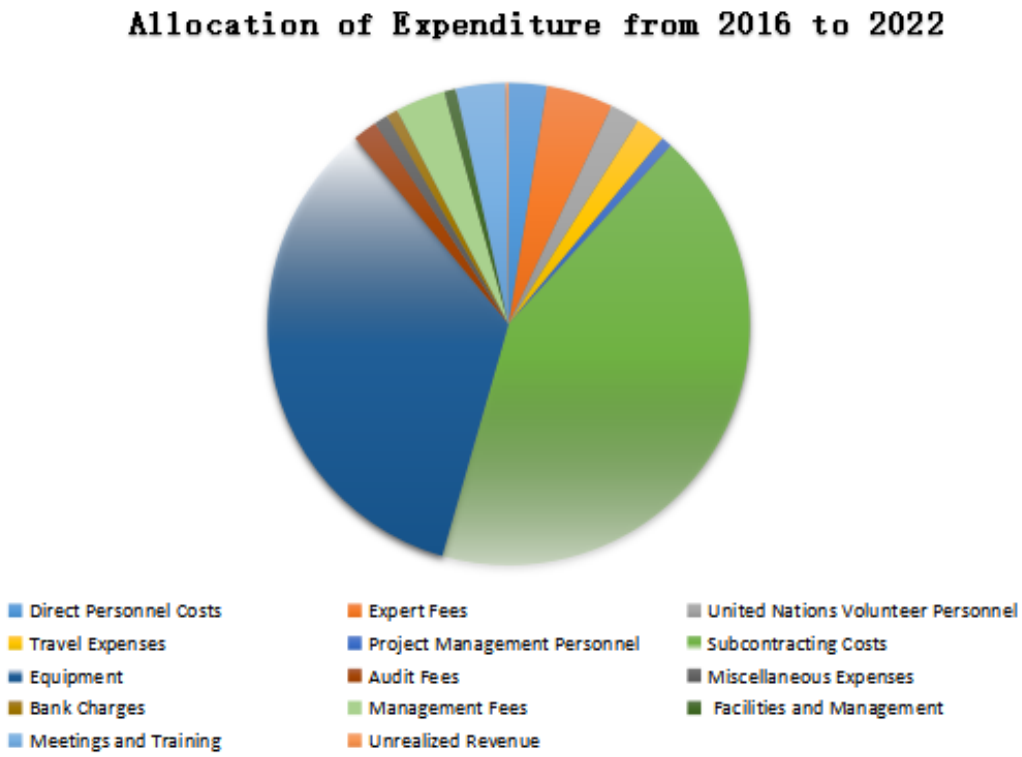

Figure 17 Allocation of Expenditure from 2016 to 2022

Figure 17 illustrates the expenditure structure of the project from 2016 to 2022. As depicted in the chart, 77.26% of the project funds were allocated for project subcontracting and equipment procurement, with 42.69% designated for project subcontracting and 34.57% for equipment procurement.

Firstly, the financial expenditure structure aligns with the goals and objectives of the project. According to the project documents, the primary goal is "to enhance the environment and promote sustainable green development, enabling people to enjoy a cleaner, healthier, and safer environment." The main components of the project include "building hydrogen infrastructure,

conducting hydrogen technology research, fostering the hydrogen industry, enhancing hydrogen promotion, and training, among others." The distribution of project funds, with 77.26% allocated to project subcontracting and equipment procurement, reflects a commitment to the implementation of activities and the construction of supporting facilities. This contributes to the development of the hydrogen industry, effectively reducing emissions, and enhancing the environment for people to enjoy a cleaner, healthier, and safer setting, consistent with the project's goals and objectives.

Secondly, the financial expenditure structure optimizes resource allocation and efficiency. Project subcontracting and equipment procurement account for 77.26% of the project funds, while personnel expenses, travel expenses, training costs, and other expenses constitute 22.74%. This indicates that the project's management and operational costs are relatively low, thereby favoring increased efficiency and benefits for the project.

Finally, the project's financial expenditure structure promotes project implementation and enhances sustainability. Within the 77.26% of project funds, 42.69% is allocated for project subcontracting, and 34.57% for equipment procurement. This allocation demonstrates that the project not only emphasizes the execution of activities but also considers the post-project development and operation, thereby fostering the healthy growth of the hydrogen industry.

In conclusion, the project expenditure structure is deemed reasonable, ensuring the alignment of technological proficiency and operational effectiveness. The extended lifespan of equipment beyond the demonstration project period contributes to the sustainability of the project.

Finding 21: The allocation of human resources is reasonable, with clear delineation of responsibilities among the project's stakeholders. Staff and experts from collaborating entities possess broad international perspectives and extensive project management experience, ensuring the effective operation of the project with high enthusiasm and professionalism.

As shown in Figure 18, the project has a clear organizational structure with well-defined responsibilities among the three collaborating parties. The UNDP China Office's main responsibilities include providing financial audit support for the project, overseeing financial expenditures, designating an independent audit firm, and ensuring that the project is executed in accordance with UNDP rules. The China International Center for Economic and Technical Exchanges, as the national executing agency, is responsible for supervising and managing the effective implementation of the project according to the work plan. This includes, with the approval and authorization of the National Project Director (NPD), hiring domestic and international experts, organizing service subcontracts and equipment procurement, signing contracts, and overseeing the effective use of project funds by project implementation agencies to ensure timely, efficient, and transparent execution.

The Rugao Economic and Technological Development Zone Management Committee, as the project implementation agency, appoints the National Project Director and establishes the Project Management Office. The Project Management Office, under the guidance and supervision of the National Project Director, is led by the Project Office Director, who is responsible for organizing and implementing specific project activities according to the work plan and relevant budget. This includes ensuring the achievement of outputs and outcomes as specified in project documents. The

Project Office is responsible for daily project management, resource allocation, personnel assignment, monitoring and inspection, and evaluation reports.

The expert group provides consultation and technical guidance, facilitating the scientific, efficient, and orderly implementation of various project activities.

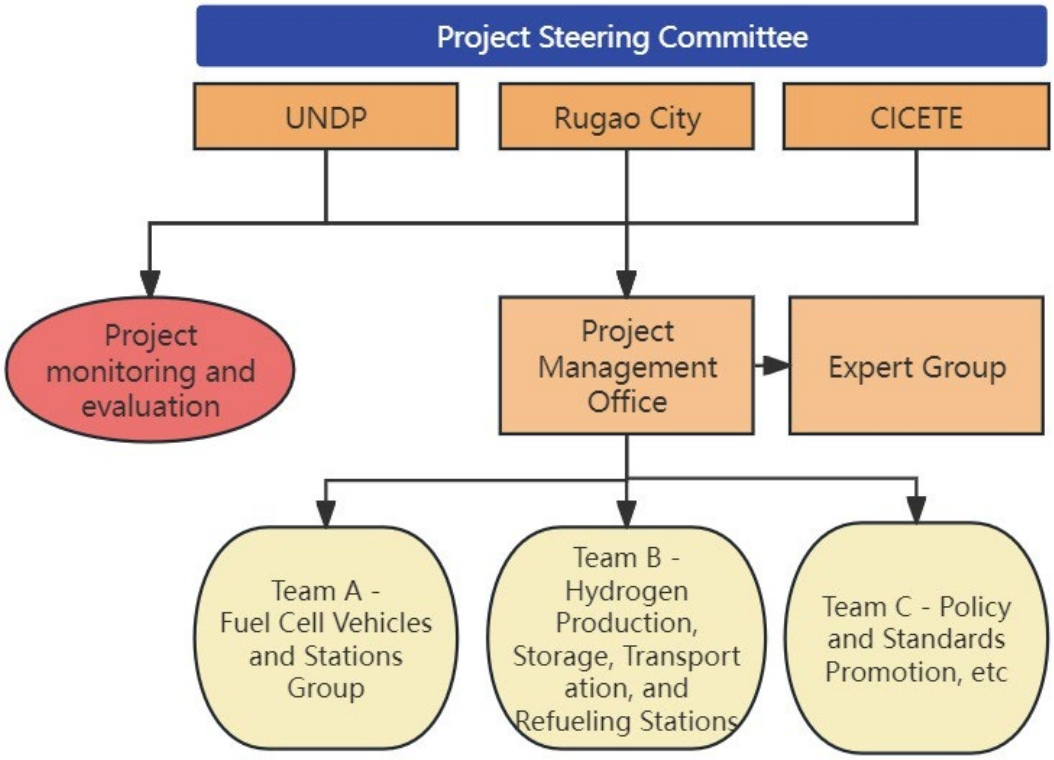

Figure 18 Project Organizational Structure

Based on the minutes of annual tripartite review meetings, steering committee meetings, expert reports, and interviews, it is evident that UNDP, the Rugao local government, the CICETE, the China Automotive Engineering Society, the China Automotive Technology Research Center, SAIC Motor Corporation, Yutong Bus, Land Hydrogen Boat, fuel cell enterprises, universities, research institutions, industry associations, hydrogen production, and hydrogenation enterprises are all involved in the demonstration project. They collectively communicate and discuss the progress of activities.

The orderly progress of the Hydrogen Economy Pilot Project in China relies on the hard work of project partners. The activities involved in the project cover various aspects of hydrogen production, storage, transportation, and utilization, and the scale is considerable. The execution of the project has also been affected by the pandemic. Project office members have complemented each other's strengths, learned from one another, worked overtime, and ensured effective coordination at various stages of the annual plan, including planning, execution, and summarization. Secondly, based on the belief that everyone is a "disseminator of sustainable development goals," in international hydrogen and fuel cell conferences, roadshows, and other events, all parties contribute their efforts

to enhance the influence and demonstration effect of the Rugao hydrogen energy demonstration project, achieving excellent publicity results. For example, the International Hydrogen and Fuel Cell Conference, sponsored by the International Hydrogen and Fuel Cell Association and the China Automotive Engineering Society, hosted by the People's Government of Nantong City and the People's Government of Rugao City, guided by the Ministry of Industry and Information Technology and the China Association for Science and Technology, co-sponsored by UNDP, the CICETE, Toyota Motor Corporation, the Korea Hydrogen Promotion Bureau, the China Automotive Technology Research Center, Tsinghua University, Tongji University, Wuhan University of Technology, and supported by many other units, had abundant human resources, laying an important foundation for the successful hosting of the conference. The conference featured presentations from over a hundred experts, and the staff and experts from partner organizations all possessed broad international perspectives and extensive project management experience, contributing with great enthusiasm and professional competence to the effective operation of the project.

Finding 22: Specifically, consultation with expert groups and local enterprises and communities provided a robust safety assurance for areas focused on hydrogen utilization within hydrogen industry parks. This ensures the safe and stable operation of demonstrations, aligning with the State Council's "13th Five-Year Plan for Work Safety."

Before the commencement of the safety consulting project, the current state of safety management is as follows: From a regulatory perspective, there are issues of risk accumulation and inadequate monitoring. The industrial park houses multiple enterprises, and the identification of risk accumulation is unclear, making it susceptible to a domino effect. The regulatory capacity within the park is weak, leading to an unclear baseline for enterprise risks and the existence of regulatory blind spots. Additionally, there are issues with unclear regulatory entities and baselines. At the enterprise level, there are problems with weak safety awareness, a sense of complacency, and the absence of a practical safety structure, resulting in a management vacuum.

To address the aforementioned safety issues, the project promptly adjusted its plan, introducing a comprehensive park management platform and professional safety technical services. The park's comprehensive management platform integrates regional emergency command, dynamic supervision, and enterprise management functions. Through the participation of various roles, such as the park management committee, deployed institutions, enterprises, professional service companies, and government entities, the project aims to clarify the safety responsibilities within the jurisdiction, streamline the safety regulatory system, strengthen safety and emergency management, integrate regional resources, implement primary responsibilities, and ensure the safe development of the industrial park.

The project utilizes an innovative and socialized service safety management system and methods, emphasizing proactive safety production prevention, simultaneous emphasis on source control and emergency response. It strengthens risk classification, hazard identification, and governance, pushing the safety production focus further upstream. The emergency command involves overall coordination, multi-party collaboration, information sharing, collaborative supervision, implementation of primary responsibilities, and ensuring the safe development of the jurisdiction.

The Industrial Park Safety Technical Service Center brings three major defense lines to the park: comprehensive and consolidated safety risk control, hazard identification and governance, and emergency accident management. This center provides the park's government regulatory authorities with the means to mitigate risks and responsibilities, strengthens the park's regulatory duties, compels enterprises to fulfill primary responsibilities, and offers robust safety assurance.

4.5 Sustainability

Finding 23: Factors such as resource investment, collaboration networks, and equipment procurement exhibit high sustainability, actively contributing to achieving sustainable development goals. The project has demonstrated significant intervention in aspects like production, storage, transportation, hydrogenation, and utilization. However, the utilization rate of certain equipment remains low. Exploring feasible solutions to enhance equipment utilization is necessary to improve the project's sustainability.

The cooperation relationships within the Hydrogen Economy Pilot Project in China are sustainable. The resources and advantages of the collaborating parties are highly complementary. The government of Rucheng County regards promoting the development of the hydrogen energy industry as a crucial task and will continue to support the sustainable development of the hydrogen energy industry, contributing to the energy transition in Rucheng. The three parties involved in the project have established close collaborative relationships during the execution process, serving as a sustainable core force for project implementation.

The project has explored demonstration activities to promote the development of the entire hydrogen production, storage, transportation, and utilization industry chain, gaining significant influence in China and even globally. On the one hand, it has accumulated rich experience in hydrogen technology, and on the other hand, it has formed a continuously developing and mature policy system, ensuring sustainability and replicability in the future development of the hydrogen energy industry.

The investment in project equipment has promoted the development of related hydrogen industries, contributing to the reduction of greenhouse gas emissions and addressing climate change while protecting the environment. Various equipment was purchased during the project construction. After the project's completion, the CICETE can sign a "Non-Consumable Equipment Property Transfer Certificate" with the project implementation agency. The equipment's property rights are transferred from the CICETE to the project implementation agency, which is responsible for the registration, storage, insurance, and usage of the purchased equipment. The equipment can continue to operate after the demonstration, actively contributing to sustainable development goals, such as improving efficiency, supporting various modes, and enhancing service levels.

As the project development and construction progressed, the overall hydrogen energy system was essentially completed, and several related conferences and online broadcasts were conducted, demonstrating its positive impact. However, there is an urgent need to address the low utilization rate of some equipment. In 2017, Rucheng Economic and Technological Development Zone purchased six pure hydrogen fuel cell backup power systems and three methanol reforming fuel cell backup power systems. Currently, two methanol reforming fuel cell backup power systems are used in the Boai Hospital, and one is used in the Automobile Culture Museum for display. Another

pure hydrogen fuel cell backup power system, originally intended for a mobile base station, was replaced by Bay Energy due to equipment damage, demonstrating a positive example. The six pure hydrogen fuel cell backup systems were initially planned for demonstration projects in new hospitals and schools. However, due to the delay in the construction of hospitals and schools, the equipment is stored in the warehouse of the supplier, Nantong Zehe New Energy Technology Co., Ltd., with a low utilization rate. The project office has signed a storage agreement with Zehe and will follow up on the progress of hospital and school construction to ensure timely equipment operation.

During the World Hydrogen Energy Conference held in Rucheng in 2019, hydrogen fuel cell vehicles and local buses in the Yangtze River Delta were successfully refueled, contributing significantly to expanding the influence of hydrogen energy demonstrations. The hydrogen refueling station obtained a "Gas Business License" in April 2020 and officially operated on December 12, 2020. However, during the period of operation, when the legal entity was adjusted, the station was forced to stop operating on February 9, 2021, due to the lack of clear national regulations on the management of hydrogen refueling stations (gas/hazardous materials). This also resulted in hydrogen fuel cell vehicles being unable to refuel and remaining idle for several years.

The procurement of a cogeneration system by Yushi Energy to provide a green and stable backup power and heat source for the Rucheng Science and Technology Innovation Center highlights its demonstration effect. However, due to restrictions on hydrogen production in non-chemical industrial parks, the economic inefficiency of equipment operation by the first party, unwillingness to allocate budget for operation, and reluctance to assume regulatory responsibilities (such as installing explosion-proof sheds as required by safety production regulations), the system is currently not in normal use.

To address the issue of low utilization of some equipment, it is recommended to consider establishing leasing or sharing agreements with other regions or project organizations for joint equipment use, cost sharing, and expanded demonstration effects. Simultaneously, active communication with relevant departments is essential to improve hydrogen-related policies and promote the dissemination of hydrogen knowledge, fostering understanding and utilization of hydrogen energy.

4.6 Gender and Cross-cutting Issues

Finding 24: Gender factors were cautiously considered in the project's design and implementation, ensuring equal participation and fair treatment for both men and women. Gender perspectives have been integrated into mainstream sustainable development projects, with the participation of young women in activities not falling below 50%. However, the project falls short in comprehending and implementing GEEW, or delivering specific gender-focused activities and lacks a robust framework for gender-responsive results measurement.

In the design and implementation of the project, careful consideration has been given to the diverse needs and interests of both men and women. The encouragement of joint participation of men and women in the decision-making, implementation, and evaluation processes of the project is emphasized. Through education and training, awareness of the importance of gender equality is

raised to ensure fair resource allocation and prevent issues of gender inequality. Monitoring and evaluation mechanisms are established to ensure equal participation and benefits for both genders.

Taking the example of the 5th International Hydrogen and Fuel Cell Vehicle Conference, it featured 100+ keynote speeches and roundtable guests, nearly 1,000 participants, representing 7 countries and regions, with 300+ institutions/companies and 5,500+ professional visitors. Women were actively involved in many key functional positions. For instance, Ms. Ge Yingying was responsible for the agenda and speeches, Ms. Jiang Guomei was in charge of exhibition cooperation, and Ms. Shen Jiayi handled media cooperation. The project actively promotes gender equality and contributes to inclusive and sustainable development in society.

Among the project partners, such as UNDP, the CICETE, and the PMO, there is a significant proportion of female project managers. Ms. Wang Jujun has been continuously appointed as the Chief Technical Advisor (CTA) for UNDP's Hydrogen Economy Pilot Project in China for several years by the CICETE. Simultaneously, many women are actively involved in subcontractors deeply engaged in the project, such as in hydrogen safety subcontracting.

In summary, the entire project proactively adheres to the principles of gender equality. Table 11 below provides a statistical summary of the percentage of female participants in the 3rd and 5th International Hydrogen and Fuel Cell Vehicle Conferences.

Table 11 Gender Distribution of Participants in the International Hydrogen and Fuel Cell Vehicle Conference

Activity Name	Keynote Speeches/Speakers/ Roundtable Guests	Participants	Professional Visitors	Female Percentage
5th International Hydrogen and Fuel Cell Vehicle Conference	100+ individuals	1000+ individuals	5500+ individuals	55%
3rd International Hydrogen and Fuel Cell Vehicle Conference	82 individuals	584 individuals	856 individuals	53%

While it sets a positive example for gender equality in project participation, the absence of deeper, systematic gender mainstreaming and GEEW practices indicates significant room for improvement. The lack of deep, systematic GEEW mainstreaming practices and dedicated gender-specific activities limits the project's potential GEEW impact. The absence of comprehensive gender-responsive indicators for setting and monitoring is a critical gap that must be addressed to enhance the project's effectiveness and contribute more profoundly to GEEW outcomes.

Finding 25: The project has made notable strides in inclusivity, emphasizing broad participation across various societal groups and advancing women's leadership, yet it requires a more deliberate approach to fully address the needs of PWD and other marginalized communities to achieve comprehensive and equitable sustainable development.

The Rugao Hydrogen Project has taken positive steps to acknowledge and incorporate the needs of diverse societal groups, with an intent to foster inclusive participation and uphold the principle of "Leaving No One Behind" (LNOB). The project's design and implementation are structured to cater to the varied needs of different social strata, including marginalized and disadvantaged communities, thus promoting equitable access to resources and opportunities.

Monitoring and evaluation mechanisms have been established to gauge progress and make necessary adjustments to the project's trajectory, ensuring responsiveness to the evolving needs of these groups. The project has been proactive in convening coordination meetings, setting standards, and engaging a wide array of social groups to contribute to the hydrogen industry's growth. Its efforts to improve air quality and reduce CO2 emissions are exemplary, demonstrating the positive impact that technology can have on society.

Furthermore, the project leverages platforms such as academic seminars and video broadcasts to disseminate knowledge about hydrogen technology, offering a valuable exchange of experiences with other regions grappling with similar challenges. This approach not only fulfills the project's immediate goals but also aligns with the broader vision of fostering a human community with a shared destiny.

However, the project exhibits a notable deficiency in a systematic and comprehensive strategy specifically addressing the needs of Persons with Disabilities (PWD) and other marginalized groups. The current approach lacks a tailored framework that ensures full inclusivity and accessibility for these individuals, which is essential for truly inclusive development.

Although strides have been made towards women's empowerment and the integration of cross-cutting issues such as LNOB, there is a clear opportunity for enhancement. The project has laid a valuable groundwork through awareness-raising, promotion of women in leadership roles, and advocacy for equitable development. The accomplishments to date promise to deliver substantial benefits to the region and act as a learning base for subsequent initiatives. These experiences will contribute to the knowledge pool on navigating gender inequality and bolstering sustainable development in a way that is inclusive and empowering for all societal groups.

5. Conclusions

In summary, the project has brought about positive changes to the target groups, stakeholders, and society, enhancing their capabilities and well-being, increasing their awareness and participation in hydrogen energy, improving their ecological environment and health conditions, and promoting their economic development and social progress. The project has contributed to the hydrogen energy industry, energy transition, and carbon neutrality goals, driving the development and innovation of the hydrogen energy industry, increasing the maturity and reliability of hydrogen energy technology, reducing the cost of hydrogen energy, and enhancing benefits. It has established standards and specifications for the hydrogen energy industry, expanded the market and application of hydrogen energy, promoted international cooperation and communication in the hydrogen energy industry, and made contributions to achieving energy transition and carbon neutrality goals. The project has influenced national and international policies and standards, providing references and insights for the formulation and implementation of hydrogen energy policies at the national and local levels, supporting and contributing to the development and promotion of international hydrogen energy standards, and serving as a platform and opportunity for national and international hydrogen energy cooperation and communication, showcasing China's international influence in the field of hydrogen energy. The project has fostered innovation in hydrogen energy knowledge and technology, proposing new technical solutions and business models through technical demonstrations of hydrogen production, storage, transportation, and application. It has addressed some technical challenges and bottlenecks, raised the level and competitiveness of hydrogen energy technology, and provided momentum and support for the innovation and development of hydrogen energy knowledge and technology.

5.1 Relevance Conclusions

The Hydrogen Economy Pilot Project in China has been rigorously aligned with the nation's developmental strategies and the SDGs, UNDP Strategic Plan and CPD, showcasing its relevance in fostering a transformative energy landscape. The project has notably contributed to the establishment and promotion of carbon trading systems, the initiation of renewable hydrogen production, and the application of combined heat and power technologies. Its design and implementation have taken into account a broad array of factors, including resource availability and the integration of gender equality, ensuring that the project resonates with the needs and aspirations of a diverse demographic.

However, the project's relevance has been tested by the unforeseen disruptions caused by the COVID-19 pandemic. The impact on the project's schedule and the delay in equipment deliveries have led to missed opportunities in accelerating the demonstration activities. Despite these setbacks, the project’s relevance remains intact, though its execution has been challenged by the pandemic's constraints, highlighting the need for greater resilience in planning and implementation strategies for future projects of similar scope.

5.2 Effectiveness Conclusions

After walking through all planed outputs, the evaluation team concluded that it is evident that the Rugao Hydrogen Development Roadmap has been a critical guiding force, shaping the development of a comprehensive industry chain from hydrogen production to end-use. The project

has successfully demonstrated key technologies and established a robust foundation for research on hydrogen policy frameworks and carbon trading methodologies. It has propelled the hydrogen economy forward in Rugao, fostering developments that have improved energy efficiency, reduced greenhouse gas emissions, and contributed positively to the sustainability and resilience of urban communities.

Challenges such as the absence of uniform standards for hydrogen technologies and limited public awareness have been addressed through proactive measures, including the promotion of international hydrogen standards and extensive educational campaigns. The project has capitalized on policy support and engaged with a variety of stakeholders, from government bodies to private enterprises, enhancing its effectiveness and influence. Despite these efforts, the project has occasionally encountered obstacles that have restricted its ability to achieve all intended objectives, reflecting the complexities inherent in pioneering energy projects.

5.3 Efficiency Conclusions

The project's financial management has been a testament to efficiency, with a balanced distribution of funds ensuring the successful procurement of equipment and the execution of subcontracted tasks. The comprehensive financial planning has been crucial in maintaining the project's momentum and ensuring that each phase is well-resourced and executed according to plan. The human resources allocated to the project have been characterized by their vast international experience and dedication, which have been pivotal in navigating the complexities of the project and delivering on its promises.

The project has also excelled in establishing and nurturing partnerships that have been vital for its execution. The formation of a cohesive project team and the cultivation of formal partnerships with private and social organizations have amplified the project's reach and impact. The monitoring and evaluation system instituted has provided a robust framework for self-assessment, enabling timely adjustments and maintaining operational efficiency even in the face of external challenges.

5.4 Sustainability Conclusions

The project has laid a solid groundwork for the long-term viability of hydrogen energy in Rugao. It has formulated a comprehensive development strategy for hydrogen energy, conducted valuable technical demonstrations, and provided policy guidance and public education that have collectively bolstered the hydrogen industry. These actions have contributed to the economic enrichment of the local community, the improvement of urban environmental quality, and the enhancement of energy resilience.

While the project has established significant infrastructure and demonstrated the potential of hydrogen energy, certain assets have not been fully utilized, suggesting an area for improvement. To ensure the project's enduring impact, strategies to increase the utilization rates of existing equipment and infrastructure must be developed. Addressing these usage inefficiencies will be critical to enhancing the overall sustainability of the project and maximizing its return on investment.

5.5 Gender and Cross-cutting Conclusions

The project has demonstrated commendable dedication to gender equality and the principle of 'leaving no one behind.' Efforts to integrate gender perspectives and ensure equal participation have been evident throughout the project, with women comprising a significant proportion of the participants in demonstration activities. The project has also given due consideration to the needs of various social groups, ensuring that resources are distributed fairly and that marginalized groups, such as rural youth and individuals with disabilities, are included in its benefits.

Despite the progress made, the evaluation team concluded that the evaluation still has huge room for improvement for a systematic and comprehensive strategy specifically addressing the needs of Persons with Disabilities (PWD) and other marginalized groups. Future activities could expand their reach to more underdeveloped areas, fostering deeper and more sustained collaborations and directing resources to further the agenda of inclusivity and social equity. This would not only enhance the project's social footprint but also contribute to the broader socio-economic development goals of the region.

5.6 Unfinished or Slow-Progressing Activities

Using the theory-driven evaluation approach, it was found that there are unfinished or slow-progressing activities, or problems as outlined below:

- **Low Equipment Utilization Rate:** Despite high sustainability in factors such as project resource investment, collaboration networks, and equipment procurement, contributing positively to sustainable development goals, some equipment, such as backup power sources, hydrogen fuel cell buses, and combined heat and power equipment, is not operating normally due to factors like policy and regulations. This has resulted in a low equipment utilization rate. It is recommended to explore feasible solutions and promptly address the issue of idle equipment.
- **Delayed Environmental Warehouse Acceptance:** Due to force majeure and other factors leading to delays in equipment delivery and installation, as well as incidents such as a lithium battery fire at the on-site installation of the equipment user, the environmental warehouse has been unable to complete installation and acceptance in a timely manner. Disputes should be resolved promptly in accordance with the law, and equipment installation should be completed.
- **Incomplete Demonstration of Hydrogen Fuel Cars:** The lack of 3C certification for 70MPa IV-type hydrogen storage cylinders domestically has resulted in the failure to complete the planned demonstration activities for fuel cell cars. Given that the national standard for 70MPa IV-type hydrogen storage cylinders is currently under development, it is recommended to proceed with demonstration activities after the standard is issued.

In conclusion, the completion rate of the Hydrogen Economy Pilot Project in China is relatively high, with a good execution rate. Through hydrogen demonstration activities, it has not only brought multiple benefits to Rugao City in terms of environment, economy, and society but also provided a replicable and promotable model and case for hydrogen development in China and globally. The utilization rate of some project equipment needs to be strengthened, and equipment management should be enhanced. Equipment procurement should be fulfilled in a timely manner according to the contract, and issues should be promptly reported and intervened. Retaining written

documentation is essential for clarifying the rights and responsibilities of all parties in the event of force majeure. The specific conclusions of the evaluation are detailed below according to the evaluation criteria.

6. Lessons Learned

6.1 Conceptual Consensus Creates Motivational Force

The project's success in blending the concept of sustainable development with the vision of a shared future for humanity demonstrates the power of conceptual consensus in motivating stakeholders across the board. By aligning with the United Nations' sustainable development ideals and articulating China's hydrogen development story on a global platform, the project has cultivated a reciprocal value system that resonates with local needs and national priorities. This synergy has been a cornerstone in mobilizing resources and talent, ensuring cohesive progress among all parties involved.

Moreover, this shared vision has proven to be a driving force, enhancing mutual understanding and action, and fostering the enthusiasm necessary for sustainable industrial development. For instance, Rugao's government's initiative in establishing strategic frameworks and actively recruiting talent has set a precedent in developing a competitive edge for the local hydrogen industry. The lesson here is clear: a shared ideological foundation is essential for fostering collaboration and innovation, and it is a principle that can be emulated in future developmental projects to ensure success and stability.

6.2 Risk Management: Adaptability in Response to the COVID-19 Pandemic

The project's adaptability in the face of the global economic downturn and the challenges brought on by the COVID-19 pandemic has been a testament to its resilience. The project office's ability to quickly adjust execution strategies and leverage remote work and online activities has ensured that the project's momentum was maintained. This adaptability, underpinned by robust communication channels and flexible decision-making processes, has been critical in overcoming the hurdles presented by the pandemic.

For example, the project's response to the impact on international forums and the shift to virtual meetings to maintain progress, as well as the innovative strategies to engage and motivate enterprises to continue their involvement, showcase the importance of adaptability in project execution. The creation of dedicated infrastructure such as the "Hydrogen Industry Park" during such challenging times demonstrates the project's commitment to fostering growth and innovation, regardless of external pressures..

Table 12 Project Risk Mitigation

Risk type	Description	Risk Details	Risk migration measures
Physical/ Environmental	Uncontrollable Factors' Impact on the Project	1. The COVID-19 pandemic has resulted in the inability to conduct offline activities such as meetings. The venue provided by the equipment user did not meet the installation requirements in a timely manner, and the equipment supplier was unable to carry out construction on schedule. 2. The lithium battery caught fire, resulting in the environmental warehouse being unable to complete installation and acceptance.	1. Strengthen organizational leadership and systematically implement online meetings; under conditions permitted by epidemic prevention and control, promptly organize on-site construction to advance progress. 2. When recognizing contractual constraints and ineffective communication, initiate legal and insurance procedures promptly to maximize the protection of project interests.
Institutional	Policy and Institutional Impact on the Project	1. Despite the clear "energy" attributes of hydrogen, there is currently no legal framework at the national level to support it. It is still treated as a hazardous chemical by default, with strict approval and management. The production of hydrogen requires facilities in chemical industrial parks, posing certain difficulties in constructing integrated hydrogen production and refueling stations, conducting hydrogen production, and	1. The project's collaborating units conducted an analysis of the current status and future trends of renewable energy hydrogen production technologies both domestically and internationally. Through on-site investigations of the actual conditions in Rugao, they identified a feasible renewable energy hydrogen production scheme tailored to the local context. Ultimately, they devised a photovoltaic electrolysis water hydrogen production plan and formulated detailed implementation strategies. This effort aims to provide robust support for future initiatives in renewable energy hydrogen production. Furthermore, ongoing research will be conducted, and collaboration with relevant entities in the hydrogen energy industry will be strengthened.

		demonstrating combined heat and power projects. 2. The national regulations do not clearly specify the management of hydrogen refueling stations as gas facilities. The government does not process the renewal of gas business licenses for hydrogen stations, resulting in inconsistency between the business license of the hydrogen station and the legal entity of the gas business license, leading to operational risks. 3. The 3C certification for domestic 70MPa IV type hydrogen storage cylinders has not been established to date, preventing the demonstration operation of fuel cell vehicles.	2. With several provinces and cities nationwide expediting the construction of hydrogen refueling stations through targeted policies covering development planning, financial support, and construction management, the project's collaborating partners are actively advancing and experimenting with hydrogen station management methods to facilitate operational progress. 3. In recent years, China has developed 70MPa products for Type III hydrogen storage cylinders, and these products and technologies are becoming mature, entering the promotion stage. Moreover, there are corresponding standards for domestic 70MPa Type III cylinders, such as GB/T35544-2017, "Vehicle Compressed Hydrogen Aluminum Alloy Inner Liner Carbon Fiber Fully Wrapped Cylinder." However, the regulatory standards for 70MPa Type IV cylinders in China remain blank. China's Type IV hydrogen storage cylinders are currently in the research and development stage, facing challenges such as outdated processes, poor performance of carbon fiber and resin, and the absence of standards. The widespread application of these cylinders requires joint efforts from businesses and research institutions.
Financial	Demonstration Effect on Project Financials	This project is a hydrogen energy demonstration project, and economic benefits such as the input-output ratio should not be the sole measure of its success.	The project strictly adheres to the financial plan jointly formulated by all parties, taking into full consideration the demonstration social effects. In response to actual problems encountered during project progression, all parties involved proactively adjust project outputs and inputs to ensure smooth project execution. Given the project's characteristics, achieving economic equivalence between input and output is not feasible.

The prolonged impact of the COVID-19 pandemic has underscored the necessity of proactive planning and the development of comprehensive emergency response plans to enhance the project's resilience. The project office's systematic approach to transitioning activities to virtual platforms and devising alternative plans has been a key factor in the smooth continuation of most tasks. The development and implementation of risk mitigation measures, considering various potential challenges, have played a pivotal role in the project's ability to maintain progress.

This experience highlights the importance of being prepared for emergencies and the need to establish a framework that allows for rapid adaptation and response. The ability to maintain a bottom-line mindset and to have contingency plans ready for implementation is crucial for managing risks and ensuring the successful execution of projects in the face of unforeseen events.

6.3 Strengthening Collaboration with Legal Consultation Services System

The project has illuminated the critical role of legal services in navigating the complexities and risks inherent in demonstration projects. Engaging with legal experts has allowed for the timely resolution of issues such as contractual breaches and unforeseen incidents, emphasizing the need for ongoing legal vigilance. Effective legal risk management has proven to be crucial in safeguarding the project's interests and ensuring smooth implementation.

This aspect of project management highlights that legal expertise should be integrated into the planning and execution phases of development projects. It serves as a reminder that strengthening ties with legal consultation services can provide the support necessary to navigate legal complexities and mitigate risks effectively.

6.4 Solidifying Knowledge Products for Favorable Replication and Promotion

The project's establishment of standardized processes, frameworks, and reference models, such as the Rugao Hydrogen Town and the comprehensive development plan, has provided a blueprint for replication and promotion. These efforts have contributed to the broader goals of creating distinctive and sustainable urban developments. The research and feasibility studies conducted under the project's auspices have laid a solid foundation for future renewable energy hydrogen production, showcasing the project's dedication to sustainable practices and innovation.

The creation of these knowledge products has not only provided a replicable model for hydrogen economy development but has also ensured the promotion of sustainable development practices within the community. They stand as a testament to the importance of establishing clear, standardized processes and frameworks to guarantee the success and flexibility of future projects.

6.5 Demonstrating Vibrancy through Hydrogen Energy Conferences and Fuel Cell Vehicle Outreach Tours

The dynamism of the International Hydrogen Energy Conference and the Hydrogen Fuel Cell Vehicle Roadshow has been pivotal in propelling the hydrogen energy agenda forward. These events have not only advanced industry collaboration and promotion but have also been instrumental in increasing public awareness and acceptance of hydrogen energy technologies. The

project's outreach and education campaigns have built a strong social consensus, highlighting hydrogen energy's promise and potential.

These activities have exemplified how engaging events and outreach programs can significantly contribute to the promotion and understanding of new technologies. They underscore the importance of continued advocacy and education to strengthen the relationship between project services and sustainable development goals. By utilizing platforms such as the Hydrogen Town more effectively and establishing closer cooperation with event organizers, future projects can leverage these dynamic activities to promote sustainable development more effectively.

7. Recommendations

Through demonstration projects, such as the successful implementation of hydrogen refueling and fuel cell applications in Rugao, notable social demonstration effects have been achieved. These efforts have accumulated valuable experiences for the development of the hydrogen energy industry, fostering technological innovation, policy support, societal awareness, and international exchanges in the field of hydrogen energy.

Since the establishment of hydrogen energy and fuel cell initiatives in 2009, Rugao has nurtured the inception of the first local hydrogen energy enterprise. Over more than a decade of exploration and practice, a conducive environment for the development of the hydrogen energy industry has been cultivated, marked by government support, societal acceptance, corporate leadership, and market participation. With robust support from governmental bodies and the United Nations Development Programme, the China International Hydrogen Energy and Fuel Cell Industry Development Conference held in Rugao attracted widespread global attention. Demonstrative applications such as the pioneering trials of hydrogen fuel cell vehicles, hydrogen refueling stations, and combined heat and power generation have generated broad societal demonstration effects, accumulating invaluable experiences for the development of the hydrogen energy industry and propelling technological innovation, policy support, societal awareness, and international exchanges in the field.

While this project is nearing closure, the evaluation team proposes the following recommendations, aspiring not only to facilitate the project's closure process but also to influence and benefit other relevant projects.

Table 13 TE Recommendations Matrix

Area	Recommendation	Priority
Project Management and Governance	1. Strengthen communication and coordination among project collaborators, summarize demonstration project experiences, and facilitate the leading role of policies and regulations.	High
	2. Enhance deep collaboration with government departments, adjust strategies to align with hydrogen development, and promote the integrated development of hydrogen production and refueling stations.	Moderate
	3. Establish an entrepreneur network to leverage existing achievements of demonstration projects and mobilize market resources.	Moderate
	4. Foster connections with social organizations in the same field.	Low
Implementation	5. Provide Adequate Resource Support for Project Execution.	High
	6. Enhance Project Monitoring and Process Evaluation.	Moderate
	7. Build a Dissemination Matrix for the Demonstration Project.	High
Capacity Building	8. Utilize the Sustainability of Demonstrative Achievements.	High

	9. Ensure a Dedicated Team for the Project.	High
	10. Provide Diverse Training Methods for Knowledge Sharing and Experience Exchange.	Moderate
Social Inclusion	11. Provide Equal Opportunities and Advocate for Gender Equality.	Moderate
	12. Resource and Training Support. Offer necessary resources and training support within project teams for women to develop professional skills and leadership.	Moderate
	13. Enhance the Participation Capacity of Women and Encourage Their Voices.	Moderate
	14. Allocate Adequate Resources for Social Inclusion.	Moderate

7.1 Recommendations on Project Management and Governance

The project collaborators constitute the core force driving project execution. After a period of collaboration during the project execution, a well-established communication mechanism has been formed. However, different organizations vary in capabilities, administrative culture, and other aspects. In necessary situations, it is crucial to leverage respective strengths, seek common ground while respecting differences, and achieve mutual benefits. The demonstration project, in alignment with strategic objectives, has strengthened deep collaboration with relevant national departments and local governments, enhancing the influence and exemplary nature of the hydrogen economy. Starting from the practical aspects of departmental and local work, identifying points of integration with the project can facilitate the advancement of green development by supporting public-sector efforts.

- **Strengthen communication and coordination among project collaborators, summarize demonstration project experiences, and facilitate the leading role of policies and regulations**. Collaborators are the core force in project execution, having developed a good communication mechanism during the project period. While consensus has been reached on project goals, different organizations differ in priority, capability advantages, and administrative culture. Therefore, deeper communication is needed to leverage the lessons learned from the demonstration project, establish a sharing mechanism, and closely cooperate in large-scale activities related to China's hydrogen economy. This collaboration can help avoid redundant efforts in related activities and promote learning and growth within organizations.
- **Enhance deep collaboration with government departments, adjust strategies to align with hydrogen development, and promote the integrated development of hydrogen production and refueling stations.** Using the successful collaboration project, such as the Hydrogen Town in Rugao, as an example, seek opportunities to strengthen collaboration with national and local governments in the context of strategic alignment. Starting from the practical aspects of departmental and local work, identify points of integration with the project to support the public sector's efforts in promoting green development and establish sustainable collaborative relationships. It is recommended to summarize communication strategies with government departments during the project execution period to ensure timely conveyance of project-related information and smooth implementation of relevant departmental policies. Given the lack of unified approval standards and management norms for hydrogen refueling stations, deep collaboration with government departments is

essential to promote the issuance of relevant approvals and management norms, ensuring the operational success of hydrogen refueling stations and consolidating local demonstration results.

- **Establish an entrepreneur network to leverage existing achievements of demonstration projects and mobilize market resources**. Utilize the established hydrogen industry entrepreneur network, especially the network encompassing hydrogen production, storage, transportation, and refueling, to disseminate the concept of sustainable hydrogen development. Showcase the potential and effectiveness of sustainable hydrogen development to entrepreneurs, attracting market resources to support the continuous development practices of local hydrogen departments and fulfill corporate social responsibility. Considering the limitations during the project execution period, where hydrogen production demonstrations were restricted to chemical industrial zones due to hydrogen being treated as a hazardous substance in Jiangsu Province, it is recommended to continue supporting enterprises in strengthening communication and collaboration with the government. This will aid in forming a distinctive industry chain of renewable hydrogen production, storage, transportation, refueling, and utilization, providing a "Rugao experience" for regions across the country.
- **Foster connections with social organizations in the same field.** In recent years, social organizations and research institutions related to the development of the hydrogen economy have rapidly grown, including international and domestic hydrogen associations, renewable energy associations, hydrogen alliances, universities, and more. It is recommended to establish a sharing mechanism with social organizations in the same field to share the outcomes and experiences of the demonstration project. Gradually, the project can evolve into a hub organization for the development of the hydrogen economy, aggregating resources from various sectors of society.

7.2 Recommendations on Project Implementation

During the overall implementation process of the project, data collection and accumulation have already taken place. It is suggested to strengthen data analysis and utilization, particularly in the analysis of accumulated data from the summary evaluation of large-scale activities. This is beneficial for monitoring the consistency between project execution and expected goals through self-evaluation. Considering the imminent closure of the project, it is recommended to enhance the dissemination of demonstration project outcomes through mainstream media, official websites, WeChat public accounts, official microblogs, and other communication channels. Additionally, the evaluation team provides the following recommendations for project execution, with the aim of not only facilitating the closure process but also influencing and benefiting other relevant projects.

- **Provide Adequate Resource Support for Project Execution**. Utilize the resources provided by partners to leverage their advantages, such as technological leadership, substantial funding, and abundant talent. This collaboration can expand the demonstration effects of the project, recommend project progress, and achieve mutually beneficial cooperation. Close cooperation with partners can also facilitate technical exchanges and sharing experiences, thereby enhancing the overall technical competence and competitiveness of the team. Alongside selecting typical demonstration content, it is essential to provide additional resource support, including expert consultation on demonstration project technology and the provision of laboratory equipment and raw

materials based on the project's demonstration needs. These resources aid in conducting technical experiments or validations related to the demonstration project, ultimately improving project quality and efficiency.

- **Enhance Project Monitoring and Process Evaluation**. Strengthen data collection, accumulation, and analysis of project execution to ensure that all results contributing directly and indirectly to the project are captured. Improve data accumulation and analysis during the evaluation of significant activities to monitor the consistency of project execution with expected goals through self-evaluation. This aids in promptly identifying issues and making necessary adjustments.
- **Build a Dissemination Matrix for the Demonstration Project**. In the era of new media, diversification in communication platforms is evident. The achievements of the demonstration project can be promoted through a dissemination matrix primarily comprising mainstream media, official websites, WeChat official accounts, official microblogs, etc. In the future, other related projects can leverage similar organizational channels for dissemination through methods like "one-click sharing" and online live broadcasts to enhance the publicity of the demonstration project.

7.3 Recommendations on Capacity Building

During the project execution, the capabilities of project team members have been outstanding, but they face challenges due to high personnel turnover. Considering the imminent closure of the project, the evaluation team suggests the following recommendations at the capacity-building level, aiming to not only facilitate the closure process but also positively influence other related projects.

- **Utilize the Sustainability of Demonstrative Achievements**. Based on the project's demonstration goals and outcomes, collaborate with the project office and the center to utilize existing demonstrative achievements and effects, conducting sustainable hydrogen-related activities through promotion and practical implementation.
- **Ensure a Dedicated Team for the Project**. While the project team members possess excellent capabilities, the complexity of tasks during project execution has led to significant personnel turnover and challenges in understanding the project. Strengthen the project management team by leveraging the resources of initiating and participating units, specifying the roles and responsibilities of project members, enhancing the leading role of the project office in the implementation process, and ensuring the stability of the dedicated project team.
- **Provide Diverse Training Methods for Knowledge Sharing and Experience Exchange**. Leverage resources from project stakeholders, including experts, professional training institutions, etc. Utilize global network resources from organizations like the United Nations for intellectual support in training methods and activity design. Encourage project participants to share knowledge and exchange experiences, promoting mutual learning and growth. Organize forums, workshops, and other activities to allow participants to share successful practices and challenges experienced in the project.

7.4 Recommendations on Promoting Social Inclusion

During the implementation period of the demonstration project, there was a strong emphasis on social inclusion, ensuring equal participation opportunities for both women and vulnerable groups.

The project addressed the needs and characteristics of groups such as women, ensuring their involvement and sustainable development throughout the execution process. As the project is approaching closure, the evaluation team proposes the following recommendations on the aspect of social inclusion, aiming not only to facilitate the project's closure process but also to influence and benefit other related projects.

- **Provide Equal Opportunities and Advocate for Gender Equality**. During the execution period, the demonstration project placed a high importance on social inclusion, advocating for gender equality and raising awareness of it. Women were provided with equal opportunities for participation, ensuring that the project offered a level playing field. With the project nearing its conclusion, it is recommended that future projects emphasize merit-based recruitment, selection, and promotion processes rather than gender-based considerations. This ensures sustainable development opportunities for women.
- **Resource and Training Support. Offer necessary resources and training support within project teams for women to develop professional skills and leadership**. This could include providing hydrogen energy training courses, financial support, and other resources to empower women to play more significant roles in demonstration projects.
- **Enhance the Participation Capacity of Women and Encourage Their Voices**. Integrating gender equality as an integral part of the project involves not only ensuring the participation of women in various activities but also conducting a more in-depth analysis of the needs, strengths, and barriers faced by women in sustainable development. Propose more inclusive action plans for women, encouraging their involvement in decision-making processes within demonstration projects to ensure that their voices are heard and valued.
- **Allocate Adequate Resources for Social Inclusion, in particular for people with disabilities.** Commit a designated portion of the project's budget to ensure that the infrastructure and services are fully accessible to PWD, adhering to the principles of universal design. Concurrently, define and implement precise objectives and performance metrics that advance gender equality, ensuring that project activities and opportunities are equally available and promoted among women. This dual-focus approach aims to not only foster an inclusive environment for PWD but also to leverage the project as a platform for societal transformation, championing both the active engagement of women in the hydrogen industry and the broader cause of gender equality.

Annex I. Evaluation TOR

As separately attached and uploaded in ERC.

Annex II. Projects Results Framework

Intended Outcome as stated in the UNDAF/Country [or Global/Regional] Programme Results and Resource Framework: Outcome 2, more people enjoy a cleaner, healthier environment as a result of improved environmental protection and sustainable green growth.					
Outcome indicators as stated in the Country Programme [or Global/Regional] Results and Resources Framework, including baseline and targets: Outcome 2, more people enjoy a cleaner, healthier environment as a result of improved environmental protection and sustainable green growth.					
Applicable Output(s) from the UNDP Strategic Plan: 1.4 Coverage of cost-efficient and sustainable energy, disaggregated by rural/urban					
Project title and Atlas Project Number: Hydrogen Economy Pilot in China Atlas Project Number 00092045					
EXPECTED OUTPUTS	**OUTPUT INDICATORS**	**DATA SOURCE**	**BASELINE**	**TARGETS**	**DATA COLLECTION METHODS & RISKS**
Output 1 Adoption and enforcement of Hydrogen Economy Development Roadmap in Rugao	1.1 Number of enforced Hydrogen Economy Development Roadmap in Rugao	Local government bulletin	0	1	Desk review through Internet Government publications
Output 2 Reduced the costs and improving the quality of hydrogen production applied in the field of FC industry through renewable energy	2.1 Amount of hydrogen gas (delivered) produced from renewable energy in Rugao by EOP	Hydrogen refilling station	0	3000kg	Annual report Records Log at refilling station Interview with staff
Output 3 Improved and promoting the application of hydrogen storage and refilling technology	3.1 Number of application of hydrogen storage and hydrogen refilling stations at EOP in China	Local government bulletin	0	1	Site visits
Output 4 Application of FC technology in the transportation and cogeneration.	4.1 FCV numbers and FC cogeneration application in transportation and stationary in Rugao.	Project website	0	5 FCBs, 2FC cars, 2-3 FC cogeneration systems	Annual report, Site visits
Output 5 Completed policy framework and carbon trading for hydroge	5.1 Number of incentive policy and carbon trading methodology adopted at EOP	Local government bulletin	0	3 incentive policies, 4 carbon trading methodologies	Annual report, Government publications
Output 6 Enhanced acceptance of hydrogen utilization for both public and private uses via increased knowledge and awareness	6.1 Number of people who are aware and interested in the application of hydrogen economy by EOP	Project website	0	211,000	Questionnaire and site visits, annual report, bus companies TV programs, interviews

Annex III. Evaluation Matrix and Questions

Evaluation Criteria	Evaluation Questions	Data Collection Methods	Data Processing Methods
Relevance (Are the project's objectives and activities in line with national and local development strategies and priorities? Do they align with the gender equality and human rights policies of the United Nations Development Programme? Do they meet the needs and expectations of the target group?)	1. Are the objectives and activities of the project consistent with the three outputs and multiple indicators outlined in China's National Plan for Implementing the 2030 Agenda for Sustainable Development? 2. Do the objectives and activities of the project align with national and local policy documents such as the "Medium- and Long-Term Plan for the Development of China's Hydrogen Industry (2021-2035)" and the "Guidelines for the Construction of the Hydrogen Industry Standard System (2023 edition)"? 3. Have the objectives and activities of the project also considered the energy, environmental, and economic needs of different genders and groups, reflecting the relevance of the project? 4. Has the project provided opportunities and platforms for enhancing the abilities and well-being of the target group, thereby meeting and improving their energy, environmental, and economic needs? 5. Has the project, through the promotion of hydrogen vehicles and refueling stations, provided a cleaner and more convenient transportation service for Rugao City, thereby improving urban environments and livelihoods, and enhancing the travel and quality of life for local residents? 6. Has the project, through the construction of hydrogen energy storage and distributed energy systems, provided Rugao City with more reliable and efficient electricity supply, thereby enhancing the resilience of the city and communities and improving the work and living efficiency of local residents? 7. Has the project conducted hydrogen energy training and guidance to enhance the knowledge and skills of the target group, strengthen their awareness and participation in hydrogen energy,	Using methods such as data analysis and interviews, the project's goals and activities are examined from various perspectives and levels to assess their consistency and adaptability with national and local development strategies and priorities, the gender equality and human rights policies of the United Nations Development Programme, and the needs and expectations of the target groups.	Using methods such as logical analysis, correlation analysis, and consistency analysis, the effectiveness level and influencing factors of the project are assessed from both qualitative and quantitative perspectives.

	thereby promoting the capacity building and energy transition of the target group? 8. Has the project influenced national and international policies and standards, provided references and guidance for the formulation and implementation of hydrogen energy policies at national and local levels, supported the development and promotion of international hydrogen energy standards, provided a platform and opportunities for national and international cooperation and exchanges in hydrogen energy, and demonstrated China's international influence in the field of hydrogen energy?		
Effectiveness (Has the project achieved its intended goals and outputs? Has it generated unforeseen positive or negative impacts? Has it addressed issues and challenges encountered during implementation? Has it leveraged opportunities and strengths that arose during implementation?)	1. Has the project achieved the formulation of a development roadmap for hydrogen energy in Rugao, demonstration of hydrogen production technologies, construction of hydrogen storage technologies and hydrogen refueling stations, application and standard development of hydrogen fuel cells in transportation and cogeneration, research on the institutional framework for hydrogen energy policies, and methodology for carbon trading, as well as public awareness and education efforts? 2. Has the project contributed to innovation in knowledge and technology related to hydrogen energy by conducting technical demonstrations in hydrogen production, storage, transportation, and applications, thereby providing impetus and support for the innovation and development of knowledge and technology in the field of hydrogen energy? 3. Has the project facilitated the development and innovation of the hydrogen energy industry, improved energy efficiency and cleanliness, reduced greenhouse gas emissions, and contributed positively to achieving sustainable development goals? 4. During the implementation of the project, has it encountered challenges such as the maturity and reliability of hydrogen technologies, high costs and competitiveness of hydrogen energy, risks and management of hydrogen safety, lack of uniform hydrogen standards, and low awareness and misconceptions about	Through literature analysis, interviews, observations, on-site surveys, etc., the project's objectives and actual outcomes are examined from different perspectives and levels. Positive or negative impacts of the project, as well as the opportunities and challenges faced during implementation, are also assessed.	Employing techniques such as results mapping, beneficiary evaluations, contribution analysis, and impact evaluations, the effectiveness level and influencing factors of the project are evaluated from both qualitative and quantitative perspectives.

	hydrogen energy? Has the project adopted effective measures to address or mitigate these problems and challenges? 5. In the course of implementation, has the project capitalized on opportunities and advantages such as policy support at the national and local levels, cooperation and communication with international organizations and other countries, participation and investment from relevant enterprises and institutions, and meeting the demands and expectations of the public to enhance the project's influence and sustainability? 6. Has the project contributed to the hydrogen energy industry, energy transition, and carbon neutrality goals? Has it promoted the development and innovation of the hydrogen energy industry, increased the maturity and reliability of hydrogen energy technologies, lowered costs, improved efficiency, established standards and specifications for the hydrogen energy industry, expanded the market and applications for hydrogen energy, facilitated international cooperation and communication in the hydrogen energy industry, and contributed to achieving energy transition and carbon neutrality goals?		
Efficiency (Has the project judiciously utilized human, material, financial, and other resources? Have project activities and outputs been completed on time? Has an effective project management and monitoring mechanism been established? Has	1. Has the project adhered to the financial and procurement rules and procedures of the United Nations Development Programme (UNDP), reasonably allocated and utilized project funds and resources, effectively controlled project costs and risks, and ensured the quality and effectiveness of the project? 2. Has the project, in accordance with project documents and work plans, completed various activities and deliverables on time, submitted progress reports and final reports in a timely manner, reflecting the project's implementation status and outcomes? 3. Has the project established project management and monitoring mechanisms such as the Project Execution Committee, Project Execution Office, and Project Technical Expert Group? Does it regularly convene project management and monitoring meetings to review and assess project progress and issues, provide	Utilizing methods such as literature analysis, interviews, questionnaires, financial audits, and project monitoring, the project's resource utilization, completion of project activities, management and monitoring mechanisms, coordination, and cooperation are	Utilizing cost-benefit analysis, cost-effectiveness analysis, efficiency analysis, and efficiency frontier analysis, the efficiency level and influencing factors of the project are

coordination and collaboration occurred with other relevant projects and organizations?)	suggestions for improvement and adjustments, and ensure the smooth implementation and achievement of objectives? 4. Has the project collaborated with other relevant projects or organizations to promote market applications? Has it engaged in collaboration and interaction with social groups, media, and the public for publicity and education, thereby expanding the project's influence and cooperation network?	examined from different perspectives and levels.	assessed from both qualitative and quantitative perspectives.
Sustainability (Has collaboration with other relevant projects or organizations taken place for market and application promotion? Have partnerships and interactions with social groups, media, and the public been undertaken for outreach and education, thereby expanding the project's scope of influence and collaboration network?)	Has the project provided technical support, policy guidance, and social foundations for the development and innovation of the hydrogen energy industry in Rugao City, laying a solid foundation for the construction of a "hydrogen city" in Rugao?	Through literature analysis, interviews, case studies, on-site investigations, etc., the promotion status of the project in the market and its applications are assessed from various perspectives and levels.	Employing sustainability analysis, risk analysis, sensitivity analysis, multi-criteria decision analysis, and other methods, the sustainability level and influencing factors of the project are evaluated from both qualitative and quantitative perspectives.
Gender and Other Cross-Cutting Issues	1. To what extent has the project considered gender equality, women's empowerment, people with disabilities (PWD), and other vulnerable groups issues in its design, implementation, and monitoring?	Using literature analysis, interviews, questionnaires, gender analysis, social impact analysis, etc., the	Using gender indicators analysis, human rights indicators analysis,

	2. Do the gender-disaggregated data allocated to this project accurately represent the actual situation? 3. To what extent has the project promoted positive changes in gender equality and women's empowerment? Are there any unforeseen impacts?	project's impact and contribution to gender equality, human rights, environment, and society are assessed from different perspectives and levels. The report investigates whether the project considers the interests and needs of different groups and whether it promotes social harmony and development.	environmental indicators analysis, social indicators analysis, and other approaches, the levels and influencing factors of gender and other cross-cutting issues in the project are assessed from both qualitative and quantitative perspectives.

Annex IV. Evaluation Schedule and List of Interviews and Sites Visits

Phase	Dates	Evaluation Activities	Description
Phase 1: Evaluation Preparation, Contract Signing, and Document Review	Sep 19 - Sep 28	Preliminary communication, contract signing, preparation, and participation in the evaluation kick-off meeting.	
		Participate in the UNDP-organized project report training.	
		Review relevant documents	including but not limited to: □Project documents □Annual work plans □Mid-term evaluation reports □Annual work reports □Business travel reports (BTOR) □Minutes of Project Review Committee (LPAC) meetings □Minutes of Project Steering Committee (PSC) meetings □Project audit reports □Other financial reports □Reports and knowledge outcomes produced by the project □Third-party reviews and evaluation reports □Any other documents related to project outcomes.
		Participate in coordinating and planning on-site visits and interview schedules. Prepare interview plans and relevant documents.	Key interview subjects include: - UNDP - Officials from the Communication Center Project Local Government Representatives - Project Office - Project Beneficiaries - Project-Related Businesses - Other Stakeholders in the Project
	Oct 9 - Oct 13	Conduct interviews with various project stakeholders	Engage government departments to understand the adoption and implementation status of the hydrogen economy development plan.

Phase 2: On-Site Visits and Interviews		and other relevant parties in Beijing or Rugao.	Participate in project implementation briefing sessions.
			Visit the Shanghai Motor Vehicle Inspection and Certification Technology Research Center Limited Jiangsu Branch, the National Energy Group Shenhua Hydrogenation Station, and others to understand operational status.
			Conduct research at the Rugao Public Transport Company, which employs hydrogen-powered buses.
			Conduct research at combined heat and power supply equipment facilities, units operating renewable hydrogen production equipment, hydrogen-powered backup power demonstration points at communication base stations, and operational demonstration points for fuel cell backup power to gain insights.
			Assess public acceptance and the extent of promotion of hydrogen energy.
Phase 3: Initial Drafting of Project Report, Reporting, Modification, Finalization, and Translation	Oct 17 - Oct 28	Complete and submit the initial draft.	Draft the outline of the evaluation report.
			Write an abstract.
			Evaluate the adoption and implementation status of the hydrogen economy development plan, assessing interventions promoting local sustainable development, especially the achievements and impacts in developing the hydrogen economy.
			Write about the relevance and effectiveness of the strategies employed in the project, assess the project's impact on local government policies, and the potential impact on the policy environment in the Yangtze River Delta and at the national level.
			Document the demonstration of hydrogen storage, transportation, and refueling technologies in the project; describe the application of local hydrogen energy in the fields of transportation and backup power, and assess the operational efficiency and sustainability of the project.
			Evaluate the completion status of the policy framework and carbon trading demonstration application and document it.
			Assess the improvement in public awareness and information exchange about the hydrogen economy and document it.

			Write a summary and outlook.
	Oct 30 - Nov 3	Feedback on the evaluation report.	After completing the initial draft, present the evaluation conclusions and recommendations, and record the modification suggestions from various experts.
	Nov 6 - Nov 17	Modify based on the feedback and submit the final draft.	Modify the content based on the feedback from the participants.
	Nov 20 - Nov 30	Finalize and translate.	Finalize the draft and translate the report into English.

Annex V. List of Documents Reviewed

1. Project Files and Approval Letters

- UNDP Hydrogen Economy Pilot Project in China Approval Letter
- Reply to UNDP Hydrogen Economy Pilot Project in China Approval Letter
- [Chinese Version] UNDP Hydrogen Economy Pilot Project in China Project File
- [English Version] UNDP Hydrogen Economy Pilot Project in China Project File
- Letter Regarding the Designation of Rugao as a Chinese Hydrogen Economy Demonstration City_20160825

2. Annual Work Plans Over the Years

- 2016 AWP - 96939
- 2017 AWP - 96939
- 2018 AWP - 96939
- 2019 AWP - 96939
- 2020 AWP - 96939
- 2021 AWP - 96939
- 2022 AWP - 96939
- 2023 AWP - 96939
- [2018 Project Plan]
- [2019 Project Plan] Activities Planned for Rugao Project in 2019
- [2020 Project Plan] Activities Planned for Rugao Project in 2020
- [2022 Work Plan]_20220324
- [2023 Work Plan]_20230116

3. Annual Expense Details

- 2016 Expense Details
- 2017 Expense Details
- 2018 Expense Details
- 2019 Expense Details
- 2020 Expense Details
- 2021 Expense Details
- 2022 Expense Details

4. Annual Work Summaries

- 2020 Annual Work Summary 21.01.29
- Other Summaries
- Rugao Hydrogen Project 2021 Annual Work Summary
- Rugao Hydrogen Project 2022 Annual Work Summary
- Rugao Project 2018 Annual Work Summary and 2019 Plan (Final)
- Project Office Version 2017 Annual Summary and 2018 Annual Plan
- Project Office Version 2019 Annual Work Summary

5. Annual Trilateral Review Meeting Minutes and Steering Committee Minutes

- 2017 Annual Review Meeting Minutes
- 2018 Mid-term Review Meeting Minutes
- 2018 Annual Review Meeting Minutes
- 2019 Annual Review Meeting Minutes
- 2020 Annual Review Meeting Minutes

- 2021 Annual Review Meeting Minutes
- 2022 Annual Review Meeting Minutes
- Other Steering Committee Meeting Minutes
- [Meeting Minutes] UNDP Hydrogen Economy Pilot Project in China 2022.7.12 Steering Committee Meeting (Trilateral Signed Version)
- [Meeting Minutes] Rugao Hydrogen Project 2022.11.30 Working Meeting
- [Meeting Minutes] Rugao Hydrogen Project 2023.05.21 Steering Committee Meeting (Trilateral Signed Version)
- Steering Committee Meeting Minutes 20211026
- Steering Committee Minutes 2021.05.20
- Hydrogen Economy Demonstration Project March 22, 2021 Meeting Minutes - Clean Draft Version

6. Annual Audit Reports

- 2018 Audit Report
- 2019 Audit Report
- 2020 Audit Report
- 2021 Audit Report
- 2022 Audit Report

7. Mid-term Evaluation Report

- Rugao Hydrogen Economy Demonstration Project Mid-term Evaluation V5 Final-English/Chinese Comparison

8. Annual International and Domestic Expert Reports

- Zhang Jinhua's 2017 Expert Summary Report
- Wang Ju's 2017 Summary of Expert Work.doc
- 2018-12-05 Annual Report - Andreas Truckenbrodt
- 2018 Expert Summary Report - Wang Ju
- Summary Report_Bluebook Andreas Truckenbrodt
- Zhang Jinhua's 2019 Expert Summary Report
- Summary Report_Bluebook John
- Summary Report_Report on the Developments in Fuel Cell Vehicle Technology in 2019.doc
- 2021 Expert Technical Summary Report - Wang Ju - 2021122
- Zhang Jinhua's 2021 Expert Summary Report
- 2022 Wang Ju Expert Summary Report
- Wang Ju's 2023 First Half Expert Summary Report (Updated)

9. Annual Research Project Reports

- Action Plan for Building a World-Class Hydrogen Industry Cluster in Selected National Economic Development Zones. V1(1).doc
- Conceptual Planning and Design of Rugao Hydrogen Town - Final Submission Version.pptx
- Summary Report of the World Hydrogen and Fuel Cell Vehicle Industry Development Report (2018)_ Nuclear Red Sample
- World Hydrogen and Fuel Cell Vehicle Industry Development Report (2018)
- Research Report on the Promotion and Standardization of China's Hydrogen Industry Technology (final)

- Guiding Opinions on Accelerating the Development of Hydrogen Fuel Cell Vehicle Technology and Industry - 2018.6.11-
- Guiding Opinions on Accelerating the Development of Hydrogen Fuel Cell Vehicle Technology and Industry
- Action Plan for Building a World-Class Hydrogen Industry Cluster in Selected National Economic Development Zones. V1(1).doc
- Rugao Hydrogen Economy Development Technology Roadmap 2017~2030 (2017-8-22)
- Research on Rugao Hydrogen Economy Development Roadmap
- Summary Report of the World Hydrogen and Fuel Cell Vehicle Industry Development Report (2019) Chinese
- Summary Report of the Yangtze River Delta Hydrogen Corridor Construction Development Plan
- Research on Management System for Recycling and Utilization of Fuel Cell Vehicles
- Research Report on the Standardization Roadmap for Fuel Cell Vehicles
- Research Report on Annual Summary of Standardization for Fuel Cell Vehicles
- Research Report on Policy Research to Promote the Development of Fuel Cell Vehicles
- Feasibility Study on Renewable Hydrogen Production - 20171026
- Research Report on the Conclusion of the Research Project on the Management System for Recycling and Utilization of Fuel Cell Vehicles
- Research Report on Systematic Research in the Field of Fuel Cells
- Yangtze River Delta Hydrogen Corridor Construction Development Plan - Final Draft
- Yangtze River Delta Hydrogen Corridor Construction Development Plan -2018.7.19.pptx
- Yangtze River Delta Hydrogen Corridor Construction Development Plan

10. Fuel Cell Technology Standardization Research

- Support Document: Research Report on the Systematic Research in the Field of Fuel Cells - Submission Version
- Stationary Fuel Cell Power Generation System Part 1: Safety - Approval Draft
- Stationary Fuel Cell Power Generation System Part 1: Safety - Preparation Instructions - Approval Draft
- Stationary Fuel Cell Power Generation System Part 3: Installation - Approval Draft
- Stationary Fuel Cell Power Generation System Part 3: Installation - Preparation Instructions - Approval Draft
- Performance Test of Small Stationary Fuel Cell Power Generation System - Preparation Instructions - Approval Draft
- Performance Test Methods for Small Stationary Fuel Cell Power Generation System - Approval Draft
- Micro Fuel Cell Power Generation System Part 2: Performance Test Methods - Approval Draft
- Micro Fuel Cell Power Generation System Part 2: Performance Test Methods - Preparation Instructions - Approval Draft
- Direct Methanol Fuel Cell System Part 1: Safety - Approval Draft
- Direct Methanol Fuel Cell System Part 1: Safety - Preparation Instructions - Approval Draft
- Direct Methanol Fuel Cell System Part 2: Performance Test Methods - Approval Draft
- Direct Methanol Fuel Cell System Part 2: Performance Test Methods - Preparation Instructions - Approval Draft

- Proton Exchange Membrane Fuel Cell Part 1: Terminology - Approval Draft
- Proton Exchange Membrane Fuel Cell Part 1: Terminology - Preparation Instructions - Approval Draft
- Low-Temperature Characteristics Test Methods for Proton Exchange Membrane Fuel Cell Power Generation Systems - Approval Draft
- Low-Temperature Characteristics Test Methods for Proton Exchange Membrane Fuel Cell Power Generation Systems - Preparation Instructions - Approval Draft
- Proton Exchange Membrane Fuel Cell Module for Road Vehicles - Approval Draft
- Proton Exchange Membrane Fuel Cell Module for Road Vehicles - Preparation Instructions - Approval Draft

11. Large Conferences and Event Materials

- Materials for the International Hydrogen and Fuel Cell Vehicle Conference from 2017 to 2019
- Co-sponsored Materials for the International Hydrogen and Fuel Cell Vehicle Conference from 2020 to 2021
- Hydrogen and Fuel Cell Advanced Propagation and High-Tech Entrepreneurship Project Roadshow - Refer to FCVC2020 Conference
- Fuel Cell Vehicle and Related Parts Exhibition - Refer to FCVC18-19 Conference
- Yangtze River Delta Fuel Cell Vehicle Popular Science Parade

12. Related Enterprise Service Reports

- Rugao Hydrogen Industry Park Safety Consulting Service Summary Report - Signed and Sealed Version

13. Progress Summary of Environmental Warehouse Issues

- UNDP Hydrogen Economy Pilot Project in China Environmental Warehouse Issue Overall Situation Report_v6

14. Media Publicity

- Speech by Chen Xiaodong at the International Fuel Cell Conference on November 9, 2017
- Press Release on June 8, 2018: "Future Cars in Full Speed: Rugao Economic Development Zone's 611 Fuel Cell Bus Delivery Ceremony (Scheduled)"
- October 23, 2018: "Advancing Rugao: Blue Hydrogen City (Scheduled)"
- September 26, 2019: Keynote Speech by He Yijun at the Fourth International Hydrogen and Fuel Cell Vehicle Conference (Hydrogen New Dream, Small City Big Strategy)
- Our Region Organizes the "UNDP Hydrogen Economy Pilot Project in China" 2019 Annual Plan Review Meeting