GEF-8 REQUEST FOR CEO ENDORSEMENT/APPROVAL

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General Project Information

Project Title China Green Hydrogen: from Production to Hard-to-Abate End Uses	
Region China	GEF Project ID 11271
Country(ies) China	Type of Project FSP
GEF Agency(ies): UNIDO	GEF Agency Project ID 210197
Project Executing Entity(s) International Hydrogen and Fuel Cell Association (IHFCA) Ministry of Industry and Information Technology (MIIT)	Project Executing Type CSO Government
GEF Focal Area (s) Climate Change	Submission Date 6/12/2024
Type of Trust Fund GET	Project Duration (Months) 60
GEF Project Grant: (a) 16,000,000.00	GEF Project Non-Grant: (b) 0.00
Agency Fee(s) Grant: (c) 1,440,000.00	Agency Fee(s) Non-Grant (d) 0.00
Total GEF Financing: (a+b+c+d) 17,440,000.00	Total Co-financing 139,704,000.00
PPG Amount: (e) 300,000.00	PPG Agency Fee(s): (f) 27,000.00
Total GEF Resources: (a+b+c+d+e+f) 17,767,000.00	
Project Tags CBIT: No NGI: No SGP: No Innovation: Yes	
Project Sector (CCM Only) Technology Transfer/Innovative Low-Carbon Technologies	

Taxonomy

Focal Areas, Climate Change Mitigation, Climate Change, Private Sector, Stakeholders, United Nations Framework Convention on Climate Change, Nationally Determined Contribution, Capacity Building Initiative for Transparency, Sustainable Urban Systems and Transport, Energy Efficiency, Renewable Energy, Transform policy and regulatory environments, Influencing models, Deploy innovative financial instruments, Strengthen institutional capacity and decision-making, Large corporations, Gender Equality, Capacity, Knowledge and Research

Rio Markers

Climate Change Mitigation	Climate Change Adaptation	Biodiversity	Land Degradation
Principal Objective 2	No Contribution 0	No Contribution 0	No Contribution 0

Project Summary

Provide a brief summary description of the project, including: (i) what is the problem and issues to be addressed? (ii) what are the project objectives, and if the project is intended to be transformative, how will this be achieved? iii), how will this be achieved (approach to deliver on objectives), and (iv) what are the GEBs and/or adaptation benefits, and other key expected results. The purpose of the summary is to provide a short, coherent summary for readers. (max. 250 words, approximately 1/2 page)

China is the world's largest emitter of Greenhouse Gases (GHGs) by far, suffers energy insecurity due to massive petroleum imports, and has concerning urban air pollution. China's leadership has targeted energy transition and achievement of net zero carbon emissions by 2060. Green hydrogen produced by renewable energy based power generation is considered a key path to a diversified energy portfolio and net zero economy. Yet, the cost of green hydrogen far surpass that of grey hydrogen (that made from fossil fuels). Further, there is a lack of experience with the full value chain of this nascent industry. The value chain is extensive, spanning: (i) upstream - renewable energy power generation, typically intermittent (PV and wind), and green hydrogen production; (ii) intermediary - transport and storage of hydrogen; and (iii) downstream - end uses, particularly in hard-to-abate industrial sectors and in heavy duty vehicles, as well as in hydrogen refueling stations (HRSs) for those vehicles. In addition to experience, technological improvements, new business models, and policy innovations are needed. Many in China have jumped on the green hydrogen bandwagon and begun to plan green hydrogen projects, with some achieving implementation. Yet, there is a lack of green hydrogen projects that: involve multiple companies, strategically and transparently address the multiple key issues along the value chain, provide data to the public such that costs and technical levels can be assessed, and provide innovative models for replication. The best strategy of the project is to combine general incentives for hard-to-abate sector and heavy-duty vehicles in the demo cities with concurrent incentives for the use of green hydrogen that would ultimately reduce the cost to compete with and further drive below that of grey hydrogen. The project is structured to promote the broader adoption and sustained development of green hydrogen, and to help create favorable conditions for green hydrogen's future growth. The *China Green Hydrogen Project* aims to fill these gaps by: (i) taking a systems approach to address the multiple problem points along the upstream, intermediary, and downstream hydrogen value sub-chains; (ii) combining both heavy duty vehicles and hard-to abate industries downstream so as to maximum GHG emission reduction benefits; and (iii) addressing cross-cutting functional areas of need as well. The Project leverages the current inflection point of strong interest in green hydrogen via its systems approach to address the many barriers that could prove intractable without such a systematic approach. As such, the Project aims to:

- Develop a comprehensive and strong planning, policy, and standards framework for green hydrogen, bringing together the piecemeal and insufficient elements issued to date;

- Demonstrate integrated, multi-player green hydrogen value chains in less developed parts of the country (in the northwest in Ningxia Province's Nindgong City and in the northeast, in Liaoning's Shenyang and Dalian Cities);

- Build capacity and talent to support eventual ramping up of the industry; develop knowledge pieces that provide solid data to inform directly; and
- Feature technical, business model, and policy innovations.

Through this work, the project will contribute to the ultimate goal of GHG emission reductions, aiming to achieve 11.4 million tons in direct emission reductions, and to set the stage for larger and larger emissions reductions by creating an enabling environment for more and greener hydrogen value chains with hard-to-abate end uses to be deployed.

Project Description Overview

Project Objective

To facilitate the development and replication of comprehensive green hydrogen industrial value chains in China, with demand pull from hard-to-abate sectors (heavy duty transport and hard-to-abate industrial fields) and with stimulus and support across the value chain from policy, strategic planning, standards, successful demonstration in Ningdong, Dalian, and Shenyang using renewable energy, technical innovation, new business models, improved technical and cost viability, information dissemination, capacity building, and human networks.

Project Components

1. Policy, Plans, Standards, Institutional Support, Information Products, Innovation, and Replication/ Scale-Up

Component Type	Trust Fund
Technical Assistance	GET
GEF Project Financing ($)	Co-financing ($)
3,190,000.00	22,330,000.00

Outcome:

1: China's pipeline policies, plans, and standards, as well as information, and innovation related to green hydrogen and its value chain increase from a very limited baseline to a significant level that raises the motivation and confidence of industry and other players to participate in the green hydrogen industrial chain.

Output:

1.1: China National Green Hydrogen Industrial Chain Technical Roadmap incorporates input from industry and national government, receives endorsement from national government, and provides strategic guidance to companies, which incorporate aspects of the Roadmap into their plans and strategies.

1.2: National and local policies related to green hydrogen and its value chain developed, are gender responsive, and are adopted or successfully enter the review and adoption pipeline, stimulating greater supply of and demand for green hydrogen via incentives, cost reduction, and confidence-building.

1.3: Methodology for computing carbon emission reductions attributable to green hydrogen developed, endorsed, piloted, and/or adopted at national or local (provincial or municipal) level, paving the way for green hydrogen producers (and/or, possibly users) to participate in carbon trading systems, thus attracting more investment into green hydrogen production.

1.4: "Standards tree" for the green hydrogen industrial chain and high priority standards identified, designed (including gender responsive aspects), and adopted, in the pipeline for adoption, and/or endorsed at national or group level, increasing confidence in and development pace of the green hydrogen economy.

1.5: Ongoing support from planners, regulators, and associations of relevant hard-to-abate industrial sectors for development of the green hydrogen industrial chain, manifested as green hydrogen supporting content in their policies, regulations, and industry plans in their respective sectors, with gender responsive content as relevant.

1.6: Project information and data products provide evidence and insights along the entire green hydrogen value chain, becoming materials that can increase confidence, know-how, and momentum for the green hydrogen economy in China and abroad

1.7: Plans for replicating, extending, and scaling up the project's green hydrogen industrial chains and related activities in China and abroad are developed, documented, and receive funding or other strong signals of commitment for realization.

1.8: New, profitable business models and innovations for various links in the green hydrogen industrial chain nurtured and implemented, with gender responsive considerations addressing barriers faced by women entrepreneurs, supporting viability and growth of the industrial chain.

2. Demos and Innovation

Component Type	Trust Fund
Investment	GET
GEF Project Financing ($)	Co-financing ($)
10,750,000.00	102,004,000.00

Outcome:

2: Integrated demonstration of complete green hydrogen value chains successfully realized, featuring innovative technologies and approaches and showing improved technical and cost viability as compared to baseline, including green hydrogen production, its storage and transport, and its use in hard-to-abate industrial sectors and in various heavy-duty vehicle types and scenarios (supported by hydrogen refueling stations).

Output:

2.1: Demonstration of a complete green hydrogen industrial chain in Ningdong, Ningxia Province, shows improved technical performance and reduced costs as compared to baseline and covers green hydrogen production, its storage and transport, use of green hydrogen in a hard-to-abate industry (chemicals industry), and use of green hydrogen in heavy duty truck scenarios supported by HRSs, featuring innovations across the value chain which lead to this enhanced viability
2.2: Demonstration of a complete green hydrogen industrial chain and other demos and subprojects in Shenyang, Liaoning Province, shows improved technical performance and reduced costs as compared to baseline and covers green hydrogen production, its storage and transport, use of green hydrogen in chemicals production, and use of green hydrogen in promising heavy duty vehicle scenarios supported by HRSs, featuring innovations across the value chain which lead to this enhanced viability.
2.3: Demonstration of a complete green hydrogen industrial chain in Dalian, Liaoning Province, shows improved technical performance and reduced costs as compared to baseline and covers green hydrogen production, storage and transport, hydrogen refueling stations, use of green hydrogen in promising heavy duty vehicle scenarios, and use of hydrogen in electricity generation, featuring innovations across the value chain which lead to this enhanced viability.

2.4: Establishment and operation of Green Hydrogen Industrial Chain Innovation Grant Fund, whose grant investments in innovative green hydrogen industrial chain technology start-ups result in advancements and barrier removal (e.g. reduced costs, improved performance) in the industry, including special attention to barriers faced by women entrepreneurs.

3. Capacity Building and Bridges to Human Talent

Component Type	Trust Fund
Technical Assistance	GET
GEF Project Financing ($)	Co-financing ($)
600,000.00	4,200,000.00

Outcome:

3: Increased knowledge and capacity of government, industry, experts, technical personnel, engineers, and students regarding green hydrogen and its industrial chain, along with improved mode of connecting human talent to needs/ projects, leads to increased availability of qualified persons across domains to ensure success of the industry.

Output:

3.1: Conference-based capacity building and experience sharing related to technical aspects, planning, policy, regulations, and demonstration (and with meaningful participation of women and dissemination of best practices in the gender dimension), leads to increased problem solving and know-how related to the green hydrogen industrial chain and enhances the capabilities of technical personnel, government officials, business persons, GEF Green Hydrogen global program partners, and others to ensure the success of the project demos and bring green hydrogen and its applications to other cities and/or improve and scale up such efforts

3.2: Capacity building via focused side-event sessions (at events held by other organizations), and having meaningful participation by women, results in the solving of specific problems or in achieving dissemination of specific project concepts or demo ideas for replication.

3.3: Small focused problem solving events/ discussion meetings of experts, business persons, and policy makers involved in the green hydrogen industrial chain, with around 20 persons in attendance at each and meaningful participation of women, facilitate open discussion and problem solving and build capacity of participants via learning from each other and learning by doing.

3.4: Development of educational materials related to the green hydrogen value chain and their piloting in university courses results in expanded offerings of related coursework, with attention to promoting the materials to women students.

3.5: Green hydrogen industrial chain platform established for connecting both experienced and emerging technical talent to companies and projects and for connecting organizations to each other, leading to the more robust development of the industry and providing opportunities for talent to continue to build their capacity, with special attention to female talent.

4. Knowledge Dissemination, Awareness Raising, International Exchange, and Information Sharing

Component Type	Trust Fund
Technical Assistance	GET
GEF Project Financing ($)	**Co-financing ($)**
300,000.00	2,100,000.00

Outcome:

4: Knowledge dissemination, awareness raising, international exchange, and information sharing on the green hydrogen industrial chain results in active engagement of companies in upstream and downstream links of the value chain, increased confidence in hydrogen (particularly green hydrogen) and support thereof from government officials, and increased interest of the public in green hydrogen and its applications.

Output:

4.1: Dissemination of both general and detailed technical and economic information on the project demos and of other relevant information developed by the project supports efforts to stimulate replication in other cities in China and elsewhere in the world, with emphasis on GEF Green Hydrogen global program partners.
4.2: Extensive social media/ "self-media" efforts combined with outreach to external media result in substantially increased awareness and knowledge of green hydrogen industrial chains by the public, as well as specialized groups, including GEF Green Hydrogen global program partners, with inclusion of content on best practices in the gender dimension.
4.3: International exchange supports the coming together of Chinese and international entities along the green hydrogen value chain for cooperation in technology, production, and/or demonstration, and includes leverage of the GEF's Green Hydrogen global program as relevant and gender best practices.
4.4: Green hydrogen outreach program for hard-to-abate industrial sectors results in greater interest and participation in the green hydrogen value chain by companies in these sectors.
4.5: Project green hydrogen industrial chain website and information exchange platform attract strong attention and achieve wide dissemination of project results (including best practices for the gender dimension) and active discussion on key issues in the industry, with involvement of the GEF's Green Hydrogen global program partners.
4.6: Implementation of additional awareness programs according to newly identified barriers to and needs of the green hydrogen industrial chain in years 2, 3, 4, and 5 contributes to the expansion of the green hydrogen industrial chain and leverages best practices in the gender dimension.

M&E

Component Type	Trust Fund
Technical Assistance	GET

GEF Project Financing ($)	Co-financing ($)
400,000.00	2,000,000.00

Outcome:

Quality monitoring and evaluation work throughout project provides impetus for quality results and course correction as needed, as well as specific, actionable recommendations for follow up work and future projects.

Output:

5.1: Periodic and ongoing project monitoring ensures the project stays on course and adopts adaptive management as needed with monitoring of gender dimensions included.

5.2: Project Mid-Term Review and Terminal Evaluation facilitate course correction if needed (MTR), recommendations for building on project results (TE), and learning lessons for future projects (MTR and TE) and assessment of gender dimensions (MTR and TE).

Component Balances

Project Components	GEF Project Financing ($)	Co-financing ($)
1. Policy, Plans, Standards, Institutional Support, Information Products, Innovation, and Replication/ Scale-Up	3,190,000.00	22,330,000.00
2. Demos and Innovation	10,750,000.00	102,004,000.00
3. Capacity Building and Bridges to Human Talent	600,000.00	4,200,000.00
4. Knowledge Dissemination, Awareness Raising, International Exchange, and Information Sharing	300,000.00	2,100,000.00
M&E	400,000.00	2,000,000.00
Subtotal	**15,240,000.00**	**132,634,000.00**
Project Management Cost	760,000.00	7,070,000.00
Total Project Cost ($)	**16,000,000.00**	**139,704,000.00**

Please provide Justification

PROJECT OUTLINE

A. PROJECT RATIONALE

Describe the current situation: the global environmental problems and/or climate vulnerabilities that the project will address, the key elements of the system, and underlying drivers of environmental change in the project context, such as population growth, economic development, climate change, sociocultural and political factors, including conflicts, or technological changes. Describe the objective of the project, and the justification for it. (Approximately 3-5 pages) see guidance here

1. Global and national environmental problems the project will address, related trends, and underlying drivers: For 18 years, since 2006, China has been the world's largest emitter of GHGs (greenhouse gases). It currently has over twice the emissions of the US, the next largest emitter. In 2023, according to the IEA, China emitted 12.6 billion tons of CO_2eq (carbon dioxide equivalent), compared to almost 56 billion tons emitted globally. Thus, China is responsible for around 23% of global GHG emissions. China's very large population of 1.4 billion persons is one obvious driver of these high levels of emissions. For decades, China was the world's most populous nation until recently, in mid-2023, India surpassed China. In 2023, China's GHG emissions rose, despite China's rapidly increasing deployment of renewable energy based power installations. According to the IEA, this is explained in that China's post-Covid growth (as with pre-Covid growth) has been relatively energy intensive and the nation's energy intensity (e.g. energy consumption per unit GDP) has actually increased. Major drivers of growth in energy consumption and thus CO_2 (carbon dioxide) emissions in China are continuing investment in infrastructure, manufacturing, and real estate, which tend to be relatively energy intensive. Rising incomes and consumption also contribute to increasing emissions. As some have described it, China is "exploding" with growth, with ubiquitous new high rises, expansion of urban areas, and rising standards of living. These drivers make reductions in fossil fuels all the more difficult. For example, China now has more than 400 million vehicles on the road, while the US (number two globally) has less than 300 million.

Despite recent emission trends, China's carbon policy calls for GHG emissions to peak in 2030 and plummet thereafter for China to reach net zero (that is, GHG emissions minus sinks equals zero) in 2060[1][1]. Drivers that may eventually counter the rising emissions and energy intensity are China's increasing technical prowess and business growth in renewable energy, energy efficiency, electric vehicles, hydrogen, and other alternative energy options. China's emissions face an uncertain future as these opposing drivers (energy intensive growth versus progress and promotion of low carbon technologies and energy transition) play out in the future. While mandatory reductions are not yet in place, many expect hard-to-abate heavy industries and the road transport sector will eventually be both important avenues through which the Chinese Government will seek to achieve its carbon reduction targets. The hard-to-abate industrial sectors include petrochemicals, iron and steelmaking, and cement – those sectors that are highly energy and carbon intensive. Essential to achieving the just energy transition that China seeks are cooperation between government, the private sector, international organizations, academia, industry stakeholders, youth, and gender advocates.

Besides global warming concerns, China has two other very strong motivations to diversify its energy mix away from fossil fuels. China is the world's largest importer of petroleum and has strong concerns about energy security. And, urban air pollution continues to be a vexing problem.

The Project's long-term **goal or vision** - towards which the objective of *China Green Hydrogen: from Production to Hard-to-Abate End Uses* aims to serve as a first step - is to reduce substantially greenhouse gas emissions, fossil fuel consumption, and pollutant emissions by mainstreaming the production and application of green hydrogen in China (with green hydrogen becoming a significant component of the national end use energy mix), particularly by using renewable energy resources in the less developed regions of the nation and maturing innovative technologies, thus supporting national aims of decarbonization and the energy transition. Transitioning industrial processes in hard-to-abate industrial sectors to green hydrogen could be essential to reducing CO_2 emissions and pollution in industry. And, transitioning heavy duty vehicles to green hydrogen, particularly those more suited to hydrogen than direct use of electricity, could be critical to decarbonization of the transport sector.

Green hydrogen offers benefits in both its production and end uses, as compared to both the status quo and other low carbon pathways. Considering the vehicle sector: China has seen very strong success in promoting its electric vehicle (EV) industry through a mix of subsidies and other preferential policies. Prices of EVs have dropped substantially and their driving ranges per charge have risen. Yet, there continues to be impetus in China to diversify into zero carbon hydrogen-fueled vehicles. In addition to government preference for taking a "portfolio approach" strategy in technology development (developing more than one technology concurrently to reduce risks), the impetus considers (as compared to EVs) the better performance of hydrogen fuel cell vehicles in cold environments, their better suitability in the case of heavy duty vehicles, and their relatively fast refueling characteristics. Zero-carbon hydrogen would present the major emissions advantage in the industrial sector of replacing "grey" hydrogen (made from fossil fuels), which is used in industry both as a raw material and a fuel. Considering upstream (the production of green hydrogen from isolated grids, not part of the main grid[2][2]), as the Chinese grid reaches to the pace of increase in of how much intermittent renewable energy it will accept, the idea arises that green hydrogen based heavy duty fuel cell vehicles, along with green hydrogen use in hard-to-abate industrial sectors, may offer an attractive alternative in getting to net zero. At present, green hydrogen is most reliably supplied by large installations of solar photovoltaic (PV) or wind power in "isolated grids" – grids not connected to the main grid and thus not limited by the grid's capacity to absorb renewables or stringent regulations imposed by the State Grid Corporation of China (SGCC). As indicated in Exhibit 1, the share of renewables in China's total power generation and the share of intermittent renewables (wind and solar) are both expected to rise dramatically between now and 2060. On a practical level, however, PPG findings suggest China's grid is not accepting as much renewable energy based power generation as investors are willing to develop. Thus, isolated grid green hydrogen production will provide another outlet for renewable energy deployment, offering a means of gaining additional experience in developing the sector beyond what would be possible with grid-connected systems alone.

The development of fuel cell vehicles and the production and use of green hydrogen for both vehicles and industrial applications have faced technology and cost barriers. Despite impressive and ongoing drops in the cost of PV and wind installations and ongoing efforts through nationally supported R&D and donor projects, the cost of green hydrogen is still much higher than that of grey hydrogen. Similarly, the price of fuel cell vehicles is much higher than that of internal combustion engine vehicles (ICEVs) or battery electric vehicles. Yet, drivers in favor of advancement of the green hydrogen industry are that China has become very strong in R&D and motivated to win in the green hydrogen industry. The Chinese model in which government and industry work hand in hand to develop technologies and commercial deployment may also be seen as a driver, given that many local governments are interested in the development of green hydrogen. Investors and large companies in China are also showing interest and optimism about the sector. And, globally, others are beginning to put strong efforts into green hydrogen. Europe, in particular, is pursuing the sector and supporting other potential supplying countries (with strong RE resources) to do so. Finally, ongoing drops in the price of PV and wind power lead some investors to believe that price parity of green hydrogen with grey hydrogen is not too far off into the future. Recent estimates are that China's PV costs are as low as 0.2 RMB per watt, including balance of system, which is, at lowest, less than USD0.03 per watt.

2. Key elements of the system (baseline situation and trends): Effective promotion of green hydrogen entails ensuring that the full value chain is operating healthily without major bottlenecks or roadblocks. That value chain currently includes renewable energy (mainly PV and wind) to provide power to produce green hydrogen, green hydrogen production via electrolyzers (which separate the oxygen and hydrogen in water via electric current to produce hydrogen), storage and transport of the green hydrogen, and use of the green hydrogen, particularly in hard-to-abate industrial sectors or in heavy duty fuel cell vehicles, the latter depending on hydrogen refueling stations (HRSs) for their access to hydrogen.

***Renewable energy**:* China's renewable energy based power generation sector has grown at a breathtaking pace. China far surpasses the rest of the world in installed capacity of grid connected solar PV and grid connected wind power and has the lowest ex-factory prices in the world for corresponding equipment. On top of this, China's installed PV capacity is growing fast, with 55 percent growth of total installed capacity in 2023 (about 215 GW in annual additions that year) and total installations (at 609 GW end of 2023) far surpassing the US, the country with the second largest capacity. The story is similar with regard to installed wind capacity, though now with a lower annual growth rate in total capacity. China's total wind installations reached 440 GW in 2023. Annual additions in 2023 were 63.7 GW, for an annual growth in total capacity of 17%. Prices of both solar PV and wind power equipment continue to drop, which is a critical point as the price of renewable energy based power generation is considered the key factor in green hydrogen prices that are not yet competitive with other options. Exhibit 1 shows the great increases in China's total annual power generation over the past two decades, the increasing share of renewable power in total power generation (reaching 33.5% in 2023), and the increasing share of wind and PV (as hydropower's share goes down) in total renewable energy based power generation. Exhibit 1 also shows forecasts for 2030, 2040, 2050, and 2060 based on government planning and strategy documents. The targets imply an 80% share of total power production is renewable by 2060. While green hydrogen is envisioned to focus on power provision by isolated grids, the forecasts of very strong ramp ups in renewable capacity in the power sector imply continued cost decreases and technical progress and bode well for the availability of renewable energy based power generation to power green hydrogen production.

Exhibit 1. China's Total Electric Power Generation, Share of Renewables in Total Power Generation, and Share of Top Types of Renewables in Renewable Power Generation 2003, 2013, 2023 and forecasts for 2030, 2040, 2050 and 2060

Year	Total Power Generation	Share of Renewables in Total Power Generation	[redacted]	Share of Top Renewable Sources in Total Renewable Power Generation			
				Hydropower	Wind	Solar	Biomass
2003	1,910 TWh	15.0%		88%	6%	4%	2%
2013	5,372 TWh	21.0%		78%	12%	7%	3%
2023	8,700 TWh	33.5%		42%	28%	22%	8%
2030	11,673 TWh	40%		35%	30%	25%	10%
2040	15,855 TWh	60%		30%	35%	30%	5%
2050	18,500 TWh	75%		25%	40%	30%	5%
2060	20,000 TWh	80%		20%	45%	30%	5%

Sources for 2003, 2013, and 2023: National Bureau of Statistics (total power production), International Energy Agency (IEA, share of renewables in total power production), and *China Renewable Energy Development Report* (share of top renewable sources in total renewable power generation). For 2030, 2040, 2050, 2060 forecasts: China National Energy Administration (total power production in *Carbon Neutrality Goals*), IEA (share of RE in *World Energy Outlook*), China Renewable Energy Engineering Institute (CREE, share of top renewables in total renewable power, in *Renewable Energy Development Plan*). Forecasts are based on official government plans and strategies, such as five-year plans, *Energy Development Strategy Action Plan*, and *Carbon Neutrality Goals for 2060*.

***Green hydrogen production*:** Exhibit 2 shows that China's hydrogen production (over 99% grey hydrogen) has grown immensely, from 12 million tons in 2003, to 23 million tons in 2013, to 35 million tons in 2023. While exact figures on green hydrogen production for those years are lacking, estimates via interpolation suggest green hydrogen still comprised less than 1% of hydrogen production in China in 2023, but that production has been ramping up.[3][3] Sources, considering government plans and strategies, forecast rapid increases in green hydrogen production and concomitant decreases in grey hydrogen production, with green hydrogen comprising almost 50% of China's hydrogen output by 2030 and 80 to 100% by 2060. While the government has not published any such ambitious green hydrogen targets, sources base the estimates on broader ambitions of the government, particularly its net zero by 2060 target. In renewable energy based power production, China has shown a track record of exceeding government targets. Yet, for green hydrogen production to contribute substantially to the net zero target, much action is needed and thus the motivation behind the *China Green Hydrogen Project*.

Exhibit 2. China's Annual Hydrogen Production (Past and Forecast) and Grey- Green Breakdown

Year	Total Hydrogen Production	Grey Hydrogen Production	Green Hydrogen Production	Share of Green Hydrogen in Total Production
2003	12 million tons	12 million tons	1,200 tons*	<1%
2013	23 million tons	23 million tons	5,000 tons*	<1%
2023	35 million tons	35 million tons	200,000*	<1%
2030	46.4 million tons	23.4 million ton	23 million tons	50%
2040	89.1 million tons	20.1 million tons	69 million tons	70%
2050	100.1 million tons	9.1 million tons	91 million tons	91%
2060	120 million tons	0.0	120 million tons	100%

Sources for 2003, 2013, 2023: PtXhub, ARC Group, *South China Morning Post*, World Economic Forum, *Global Times,* IEA

*Green hydrogen projections for 2003, 2013, 2023 are very rough estimates based on interpolation, the last is based on *South China Morning Post* estimate of 220,000 tons for 2024

Source for forecasts: Hydropower and Water Conservancy Planning and Design Institute. China Hydrogen Alliance has estimated 100 million tons by 2060 – so similar, but a bit less.

The most common and cost-effective means of green hydrogen production is electrolyzers. There are two types of electrolyzers receiving the most focus at present, alkaline electrolyzers, which are more common, and polymer electrolyte membrane (PEM) electrolyzers, which are more expensive but considered by some to be the future of green hydrogen. PEM electrolyzers are not as challenged in handling the fluctuating power output of intermittent renewable energy (RE) as are alkaline electrolyzers. Manufacturers of both types of equipment continue to work to improve their products.

***Storage and transport*:** Right now, most shipping of hydrogen in China via tube trailer trucks is at a pressure of 35 MPa (megapascal). This is also the storage pressure of the on-board hydrogen fuel canisters of most fuel cell vehicles (FCVs) in the market. Recently, China has issued standards for Type IV cylinders, which have a pressure of 70 MPa. Yet, the market has not yet had significant uptake of these, perhaps because of a need to get vehicles with such cylinders approved. Such higher pressure cylinders, with less materials and less weight per unit hydrogen shipped, would lower transport costs. Industry insiders widely point out that China's tendency in regulating a new industry, such as hydrogen, is to be extra careful in terms of safety. This may be why the higher pressure containers were slow to be approved. Long distance hydrogen pipelines, another transport mode for gaseous hydrogen, are not common but may be a lower cost option for the future when usage is high enough to make them economically viable. At the same time, thorough assessment of the risks will be required.[4][4] One stakeholder suggests scaling up to 20,000 FCVs in an eastern city could create the demand needed to support a hydrogen pipeline from areas with rich renewable energy resources in western China. It is envisioned that, further into the future, hydrogen transport may include hydrogen in the liquid and solid states. Some experts suggest that this is an area that could benefit from standards development in China.

***Applications*:** Hydrogen is used in industry as both a raw material, such as to make ammonia or methyl alcohol, and as an energy source. Industry uses mainly grey hydrogen (made from fossil fuels). China is the largest manufacturer and consumer of hydrogen in the world, with annual consumption at around 33 million tons. The majority of this amount is used for petrochemicals (refining, methanol, ammonia) production. There is especially high production and use of hydrogen in China's coal chemicals sector, which accounts for over half of the nation's production and consumption. Breakdown of China's hydrogen consumption by end use in 2023, according to one source, is as follows: 29.6% petroleum refining, 28.9% methanol, and 27.1% ammonia, with industrial uses accounting for 14.3% and other uses (including transport) accounting for only 0.1%. Other sources give a larger share to ammonia (up to 40+%), but, in general, among all sources, the three end uses of ammonia, methanol, and petroleum refining make up the vast majority of hydrogen consumption in China at present. In the future, it is expected that metallurgy (for which green hydrogen presents strong carbon reduction potential) and transportation will play larger roles in demand. In terms of ultimate end uses (at present), about 70% of China's ammonia is used in fertilizer production for the agricultural sector and most of the rest is used to produce other organic and inorganic chemicals, with some sectors served being textiles, pharmaceuticals, explosives, and refrigeration. Ammonia has the potential to be used as a fuel. While that is not very common today, its use as a fuel is expected to be quite significant by 2050. The top two uses of methanol in China are formaldehyde production and alternative fuels. Formaldehyde, in turn, is used in the construction/ building materials, chemicals, agriculture, textile, and pharmaceuticals industries.[5][5] For the ultimate end uses of the other top use of hydrogen in China, petroleum refining, the large majority results in fuels. Other end products are lubricants, asphalt, and petrochemical feedstock used to produce chemicals and plastics.[6][6]

Recently, there have started to be some green hydrogen projects in China's hard-to-abate industrial sector. Many projects are indicated to be planned, but only a small number have been realized. Sinopec has large petrochemical green hydrogen projects in Kuqa, Xinjiang, and Erdos, Inner Mongolia. Reports about the Kuqa project indicate it will use a mix of isolated grid renewable energy based power and grid power, raising some questions about what counts as "green," in terms of hydrogen production.

For many years, China has been working to develop its fuel cell vehicle industry, which comes second after industrial uses as a main application of hydrogen in China. Over the past few years, China has developed a demonstration program based on five city clusters with the cities in each cluster working together to demonstrate the vehicles. These cities do not necessarily focus on green hydrogen, but there have been some such efforts in participating cities, such as in Zhangjiakou, Hebei Province. For vehicles, HRSs are an important element. According to some sources, China has about 300 HRSs. While more continue to be built, there is a concerning situation that a large portion (perhaps one-third) are not operating. China has substantial success in promoting EVs, so the question arises of whether FCVs, which have a lower efficiency of conversion of energy to miles traveled, are needed. For heavy duty vehicles, FCVs have advantages over electric vehicles that may outweigh the standard conversion efficiency numbers given above. Heavy duty EVs must carry a very heavy load of batteries, which reduces the payload that the vehicle can carry to fulfill its economic purpose. An advantage more generally across vehicle types, but particularly in the case of heavy duty logistics vehicles or long-route buses, is that FCVs typically have a longer range and can refuel more quickly. Lastly, FCVs do not face the same cold weather challenges that EVs do.

3. Barriers, gaps, and overall justification of the project

Barriers to the development of green hydrogen value chains in China: There are a number of barriers inhibiting the effective development of the green hydrogen sector and its industrial chain in China. Addressing these barriers, which exist across multiple domains, will be at the core of the project's strategic systems approach to supporting progress. Barrier domains are to some extent interrelated, and include cost/ economic; technical; policy, planning and regulatory; industry development; financing; information; and capacity and awareness. Exhibit 3 summarizes key barriers by barrier domain. The following text provides elaboration.

Exhibit 3: Key Barriers to Development of the Green Hydrogen Industrial Chain in China

Cost/Economic
• The cost of green hydrogen is substantially higher than that of grey hydrogen. The cost of renewable energy based power generation is considered a key factor in this high cost. • PEM electrolyzers are costly. • Hydrogen transport by tube trailer trucks and at lower pressures is costly. Yet, demand is not high enough to support pipeline development. Standards have been issued for a higher pressure of containers for tube trailer trucks and FCVs than is currently used, but market uptake is extremely limited, perhaps due to need for approval of vehicles incorporating them. • It is difficult for HRSs to be profitable businesses, due to high costs and lack of sustainable demand. • Despite substantial reductions in fuel cell cost per kW, heavy duty FCVs are still substantially more expensive than their ICE or EV equivalents.
Technical
• Alkaline electrolyzers have difficulty handling the intermittency of renewable energy based power generation. • The intermittency of renewable energy makes it difficult for green hydrogen projects to provide steady ongoing supply to hard-to-abate industrial sector users, such as in the chemical and petrochemical industries. • Technical advances are needed with regard to viability of hydrogen pipeline development and with regard to transporting hydrogen in liquid or solid state. • Improvements are needed in lifetime and durability of alkaline and PEMs electrolyzers (for green hydrogen production) and of fuel cell stacks (for heavy duty FCVs).
Policy, Planning, Regulatory, and Standards

• The healthy development of the industry is impeded by lack of quality, lack of harmonization among manufacturers, and concerns about safety. • High costs along the green hydrogen value chain, without sufficient policy support to lower costs, limit development of the industry. • Currently, hydrogen is treated as a hazardous chemical, which may be produced only in chemical parks. Many suggest this treatment is too strict and raises costs for the industry. Yet, safety related to hydrogen continues to be an area about which there is a lot of uncertainty.
Industry Development
• Costs for fuel cells are higher than they might otherwise be, given the need to import certain parts. • Businesses are uncertain which technical paths should be pursued - which have the best potential and which will be supported by policy in the future - thus weakening progress. • Confidence and resolve remain low vis-à-vis various entities pursuing green hydrogen industrial chain projects due to the newness of the sector.
Financing
• There is only limited financing available for projects related to various parts of the green hydrogen industrial chain, impeding progress. • There is only limited financing support for start-ups related to the green hydrogen industrial chain.
Information
• There is uncertainty regarding details of the industry, so that confidence of various entities to invest in various parts of the green hydrogen industrial chain is low. • Past projects related to various parts of the green hydrogen industrial chain have not made data on costs and technical performance publicly available, so there is still a major information gap. • Past experience related to various aspects of green hydrogen industrial chains, such as experience with pilot policies, has not be leveraged as it might be.
Capacity and Awareness
• There is a shortage of personnel with capabilities to carry out green hydrogen industrial chain projects; and it is difficult to build the experience base of talent that does enter this field. • Companies have difficulties connecting with and recruiting experienced personnel in the sector. • There is an insufficient pipeline for talent for the future of the green hydrogen industrial chain sector.

Cost / economic barriers: Cost issues are prominent in impeding progress along the green hydrogen industrial chain. The high cost of green hydrogen production is perhaps the most prominent barrier. Given that power costs make up a large part of the cost of green hydrogen, reduction in renewable energy power generation costs is one of the most important levers to advance. At the same time, reduction in costs of other aspects, such as electrolyzers and transport, could also be important and may be levers that this project can address more effectively than that of the cost of renewable energy power generation. PEM electrolyzers, which are considered more effective than alkaline electrolyzers in dealing with renewable energy power generation intermittency, are particularly costly and may have levers for cost reduction in the near future. Transport at higher pressures than used at present may lower costs. Although China has issued standards for higher-pressure vessels, higher-pressure vessels have not yet been adopted in the market. Hydrogen pipelines may be even more important in the long run for lowering transport costs, but, as noted, scale-up of demand is needed and progress in pipeline material is needed as well. At present, due to the high cost of hydrogen transport, locating end use of green hydrogen near its production is a short-term means of making green hydrogen projects more viable; and the project demos have adopted this approach. In the long-term, however, given the great potential demand in eastern coastal areas, which often lack the potential for lowest cost renewable energy power generation, eventually alternative hydrogen transport solutions will be needed. HRSs on their own (without other fuel types at the same station) are not profitable. Many of the HRSs established in China (estimated at about 100 of around 300 total stations) are not operating. Lastly, heavy duty FCVs remain more expensive in terms of purchase price than their ICE and EV equivalents, so that more cost reducing work is needed with regard to the fuel cell stack and its cost per kW output.

Technological barriers: Related to cost and despite much progress made, technical barriers also impede the solid take-off of green hydrogen industrial chains. The intermittency of renewable energy based power generation raises challenges for both green hydrogen supply and hard-to-abate industrial sector end use. Alkaline electrolyzers (lower in cost than other options and responsible for the greatest capacity at present) have technical challenges in adjusting to changes in power input such as presented by renewable energy based power generation. Hard-to-abate industrial sector end users that use hydrogen require a constant supply of hydrogen for their production. Yet, green hydrogen produced by renewable energy based power generation is not produced in constant amounts over time due to the intermittency of renewable energy resources. To address the high costs of hydrogen transport (noted above), technical advancements in the materials for pipelines are needed as hydrogen embrittlement (brittleness of pipeline material due to the influence of hydrogen) has been a problem in developing hydrogen pipelines. Given the high cost of hydrogen transport via tube trailer trucks, another avenue that may be pursued but is not technologically developed enough is transport of hydrogen in its liquid or solid states. Lastly, there is a need to improve the lifetime and durability of both alkaline and PEM electrolyzers and of heavy duty FCV fuel cell stacks to increase the viability of green hydrogen value chains.

Policy, planning, regulatory, and standards related barriers: There are many needs and barriers within the policy, planning, regulatory, and standards area as well. While a number of relevant standards have been developed, particularly product standards, there is a lack of a detailed, comprehensive framework and gap analysis regarding standards for the green hydrogen industrial value chain. In particular, there is a need to consider standards developed by standards committees other than hydrogen focused ones. And, the gaps that are identified, both in terms of specific standards related to safety, operation, and management along the value chain and in terms of specific product standards (e.g. the energy efficiency and lifetime of electrolyzers), need to be addressed by the development of new standards or revision of existing ones. In terms of policies, due to the high costs across the value chain, there is a great need to elaborate and expand incentive policies to stimulate the industry, whether by direct subsidies, preferential tax treatment, or other incentives, such as toll free passage, right to use roads at certain times, or even a means for green hydrogen production projects to enter China's voluntary carbon trading scheme. Another policy area in which barriers and gaps exist is related to safety management for hydrogen production, transport, and use. Currently hydrogen is treated as a hazardous chemical, such that it may only be produced in chemical parks. Many suggest this treatment is too strict, raises costs for the industry, and that hydrogen should be treated as a fuel (like gasoline or natural gas) instead. At the same time, a comprehensive safety management system for the sector is lacking.

Barriers to industry development: In terms of industry development, there is a need for domestication of parts, guidance to industry, and demonstration. As for parts manufacturing in China, key parts/components of fuel cells that are still not fully domesticated include membrane, catalyst, and carbon paper. If these attain good quality via domestic production in China and are accepted by Chinese fuel cell manufacturers, this could help substantially in reducing fuel cell costs and, thus, heavy duty FCV costs. As for guidance, companies associated with the green hydrogen industrial chain need information on which technical directions/ options (e.g. alkaline versus PEM electrolyzers) make sense to pursue (including government priorities) and on what timelines.

Lastly, lack of comprehensive and well publicized demos of the full green hydrogen value chain, with detailed information on their experience (per information barriers below), makes it difficult to raise confidence of others to initiate such projects or move forward with plans for such projects that are stalled. While there have been some full chain projects focused on the petrochemical/ chemical industries (e.g. Sinopec's Kuqa, Xinjiang, Project), these have not published data on their results; and these have typically involved just one company (with three "hats" - RE generator, green hydrogen producer, and green hydrogen consumer) rather than demonstrating cooperation among multiple companies in the green hydrogen industrial chain. China's Hydrogen Energy City Cluster projects have been quite active, but most of their focus is on downstream FCVs, and not on green hydrogen production or even HRSs.

Financing barriers**:** Many links in the green hydrogen industrial chain require substantial up front financing, such as isolated grid renewable energy power installations and green hydrogen production facilities. Moreover, while there is a need to develop innovative technologies, there is a lack of specialized funding support for start-ups in the green hydrogen industrial chain field.

Information barriers**:** Publicly available, reliable information on costs and technical viability of the segments in the green hydrogen industrial chain is sorely needed. While there have been past projects related to various segments of the chain, these have typically not made detailed information on cost and technical viability available. Further, there is uncertainty as to what policies and business models are effective. Comprehensive and easily analyzable information on those policies and business models that have been piloted has not been provided. Synthesis of such information would yield recommendations of which policies to pursue at the national level and which business models to replicate.

Capacity and awareness barriers**:** The green hydrogen industrial chain is a new area, so there is limited of understanding about it among those who may play a role in it in the future. There is limited technical and business knowledge regarding the industrial chain. There is further a need for an effective means of connecting human talent with experience in the field to projects, so that the projects may be successful and the talent may gain more experience. Lastly, there is a big gap in terms of courses and materials at the undergraduate level to prepare students for careers in the green hydrogen industrial chain. If the green hydrogen sector is going to grow, there will be a need for more and more talented personnel and researchers to enter it. And, in order to grow the sector, quality information on cost and technology is needed, as well as that on innovative technologies, business models, and policies (as addressed under information barriers).

Systems approach and overall justification of the Project: The foregoing depicts a situation of barriers up and down the value chain and across the value chain in various functional areas such as policy or technology. Thus, despite the existence of green hydrogen value chain projects and many pipeline projects on paper, there is a clear need for a systems approach that address barriers in the following areas: cost; technology; policy, planning, regulatory, and standards; industrial development; information; financing; and capacity and awareness. Such a systematic approach in these functional areas, combined with demonstrations of whole value chains, could serve to support the healthy development of the sector. Comprehensive demonstrations across the full value chain that involve multiple companies and that share information with the public are another important justification of the project. Such demos, heretofore unavailable in China, could stimulate learnings and replication.

A systems approach is also adopted by scanning across all end uses of hydrogen and ultimate end uses to look for leverage points. The project has chosen its leverage points based on hard-to-abate sectors of (a) hard-to-abate industrial (especially chemicals) and (b) heavy duty transport. Beyond that, the project will provide intelligence through its information product work (in particular, Activity 1.6b.2) on the ultimate end use sectors that are associated with the greatest hydrogen consumption at present or in the future. These ultimate end use sectors will be those that make use of the products that are made from ammonia or methanol or petroleum refining (the current top three uses of hydrogen in China). For example, a top use of methanol is formaldehyde production and a top use of formaldehyde is the construction and building materials industry, which would then be considered an "ultimate end use sector" of hydrogen.

***Addressing the question of use of renewable energy for green hydrogen production*:** Some may ask, as did one reviewer of the PIF of this project, whether renewable energy should be "taken away" from the grid for these isolated grid green hydrogen projects. At this time, China is turning away applications for intermittent (PV and wind) grid-connected projects, presumably because of concern of the capacity of the grid for intermittency. Independent power producers' (IPPs') solar PV or wind project connectivity to the grid often faces stringent regulations for grid integration, non-cost reflective tariff, or cumbersome and time-consuming bureaucratic requirements by the State Grid Corporation of China (SGCC). Therefore, the conversion of onsite RE into green hydrogen usable fuel is may be more viable for such companies once costs are reduced/ return improved. As such, the large isolated grid projects that are being set up are not only not "*taking away*" from the grid, they are also providing additional opportunity to install large scale RE infrastructure that will presumably assist in continuing to drive down the cost of PV and wind, precisely what is needed to overcome a key barrier to green hydrogen -- it's cost.

***Impact of trends, impact on trends, and concerns that project will lead to more coal-based hydrogen production*:** Earlier in this explanation of project rationale, trends in renewable energy power production and in grey and green hydrogen production were presented (see Exhibits 1 and 2 and accompanying text). The systems approach of this project also considers these trends. While renewable energy based power generation costs remain an important barrier to the cost competitiveness of green hydrogen with grey hydrogen, renewable energy based power generation past trends and forecasts based on government plans and strategies suggest continued ramp up and concomitant technological efficiency and cost reductions. These will support removal of the "renewable energy power production cost bottleneck" to green hydrogen proliferation. One risk raised by some is that the *China Green Hydrogen Project* will stimulate increased demand for hydrogen that cannot be met by green hydrogen production and thus result in increased GHG emissions from increased production and use of coal-based hydrogen. The trends that experts predict for green hydrogen in China, however, suggest that grey hydrogen production will be reduced substantially and replaced by green hydrogen. These bold forecasts reflect the seriousness with which the 2060 net zero target is being taken by both government and industry, which, in turn, mitigates the risk of grey hydrogen production being increased by increased hydrogen demand. Thus, what's left is a need to facilitate the rapid progress forecasted via efforts such as the *China Green Hydrogen Project*. That is, the project needs to facilitate achievement of the forecast trends and, thus, in the process, mitigate the very risk that it may stimulate the production of more grey hydrogen during a period when production of grey hydrogen is forecast to drop.

Baseline projects and past and concurrent donor efforts: Baseline green hydrogen value chain projects in China (realized and pipeline) are listed in Exhibit 3, though many of the pipeline projects appear stalled, so should not be interpreted as likely capacity in the near future. As discussed, there are some green hydrogen industrial chain projects in China in the hard-to-abate industrial sectors. Typically, these projects are handled by only one major company that invests in the renewable energy power production and the green hydrogen production and uses the product in its own petrochemical or chemical facilities (either new or pre-existing and formerly using grey hydrogen). Such projects tend not to share much information on their results with the public. In addition to these green hydrogen projects that have begun construction or are operational, there are many in the pipeline without much progress, probably because of the high costs of green hydrogen.

On the vehicle side, full value chain projects are less common and green hydrogen is not a major area of focus. Most of the work to date, if not done through donor projects, has been over the past few years in China's Hydrogen Energy City Cluster Program. Most of these projects are focused on FCVs only and, even though HRSs are involved, the projects have not really worked to remove barriers to HRSs, such as through pilot preferential policies. Green hydrogen and, in fact, any hydrogen production at all has not been a focus of most of these projects. A notable exception is Zhangjiakou, which with locally generated renewable energy based power produced green hydrogen used in FCVs.

Exhibit 4. Current and Pipeline Green Hydrogen Projects in China (*not including project demos*)

Name (Investor/ Company)	Province	Type of RE (grid status)	RE capacity (MW)	Electrolyzer Type	Green hydrogen output – tons per year (tpy)	End use of green hydrogen
Operational						
1. Baicheng Distributed Power Generation Hydrogen Production and Hydrogenation Integrated Demonstration Project	Jilin	Wind, PV, (grid connected)	10.6 MW	Alkaline, PEM	300 tpy	FCV
2. Sinopec Xinjiang Kuqa Green Hydrogen Demonstration Project (Sinopec)	Xinjiang	PV (isolated grid & grid-connected)	300 MW	Alkaline	20,000 tpy	Petroleum refining
3. Yangtze Power China Three Gorges Green Power and Green Hydrogen Demonstration Station	Hubei	NA (grid connected)	NA	PEM	NA	Fuel cell boat
4. Ningxia Baofeng Energy Group	Ningxia	PV (NA)	200 MW	NA	27,000 tpy, but questionable [7][7]	Chemicals industry
Under Construction						
1. Shanghai Lingang Fourth Group Sino-Japanese Industrial Park Hydrogen Energy Demonstration Project (Phase I)	Shanghai	PV (NA)	2 MW	Alkaline	NA	NA
2. 100 MW wind power generation and hydrogen production project in Xiamen Township, Hailuo Kongtong District, Pingliang, Gansu Province	Gansu	Wind (grid connected)	100 MW	Alkaline	NA	FCVs
3. Sinopec Inner Mongolia Ordos City Landscape and Solar Integration Green Hydrogen Demonstration Project	Inner Mongolia	Wind and PV (NA)	720 MW	Alkaline	30,000 tpy	Chemicals industry
4. Yining City Photovoltaic Green Power Hydrogen Production Source Grid-Load Storage Integration Project	Xinjiang	PV (NA)	1,000 MW	Alkaline	NA	FCVs, chemical industry, etc.
5. Jiden Electric Co., Ltd. Da'an Wind-solar Green Hydrogen Synthetic Ammonia Integrated Demonstration Project (Jilin ePower Stock Co.) (with Baofeng)	Jilin	Wind and PV (NA)	800 MW	Alkaline, PEM	32,000 tpy	Synthetic Ammonia (180,000 tpy)
Undergoing Bidding						
1. Heilongjiang Boli County 200,000 kilowatt wind power hydrogen production joint operation demonstration project	Xinjiang	Wind (NA)	200 MW	Alkaline	NA	FCVs

Agreement Signed						
1. Ordos City Yijinhuoluo Banner Shengyuan Energy Wind-PV Hydrogen Production and Hydrogenation Integrated Project (Shenyuan Energy)	Inner Mongolia	Wind, PV (grid connected)	175 MW	Alkaline	5,400 tpy	FCVs
2. Baotou City Damao Banner International Hydrogen Energy Metallurgical Demonstration Zone New Energy Hydrogen Production Demonstration Project	Inner Mongolia	Wind (grid connected)	500 MW	Alkaline	28,000 tpy	Synthetic ammonia
3. National Energy Alxa High-tech Zone Million-kilowatt Wind, Solar, Hydrogen and Ammonia + Infrastructure Integrated Low-Carbon Park Demonstration Project	Inner Mongolia	Wind, PV (grid-connected)	600 MW	Alkaline	22,300 tpy	Synthetic ammonia
4. CSSC Wind Power Tongliao 500MW Wind Power Hydrogen and Ammonia Integrated Project	Inner Mongolia	Wind (NA)	500 MW	Alkaline	NA	Synthetic ammonia
5. Shaanxi Yulin Fugu County Green Power Hydrogen Production Ammonia and Hydrogen Storage Battery Industry Chain Project	Shaanxi	NA (NA)	NA	Alkaline	NA	Synthetic ammonia
6. China Energy Construction Bayannur Wulate Middle Banner Green Power Hydrogen Production Ammonia Comprehensive Demonstration Project	Inner Mongolia	Wind, PV (isolated grid)	260 MW	Alkaline	10,000	Synthetic ammonia, sales to third parties
7. State Power Investment Corporation and China Railway Zhangjiakou Yangyuan County Wind and Solar Green Hydrogen Synthesis Green Ammonia Project (State Power Investment, China Rail)	Hebei	Wind, PV (NA)	2,400 MW	Alkaline	90,000	Synthetic ammonia
8. Fengzhen City Wind-solar Hydrogen Production Integrated Project	Inner Mongolia	Wind, PV (NA)	NA	Alkaline	3,300	NA
9. Envision Technology Chifeng City Energy Internet of Things Zero-carbon Hydrogen Ammonia Integrated Demonstration Project (Envision Science and Technology)	Inner Monglia	Wind, PV (grid-connected)	500 MW	Alkaline	24,200	Synthetic ammonia
Planning Stages						
1. Xing'an League Jingneng Coal Chemical Renewable Energy Green Hydrogen Substitution Demonstration Project	Inner Mongolia	Wind (isolated grid)	500 MW	Alkaline	26,800 tpy	Synthetic ammonia
2. Jingneng Chagannur Wind Power Hydrogen Production Integrated Project (Jingneng)	Inner Mongolia	Wind (isolated grid)	12 MW	Alkaline	400 tpy	Power plant cooling, FCVs
3. Sany Heavy Energy Uradzhong Banner Ganqimaodu Port Processing Park Wind, Solar, Hydrogen and Ammonia Integrated Demonstration Project (Sany Heavy Energy)	Inner Mongolia	Wind, PV (isolated grid)	500 MW	Alkaline	36,000 tpy	Synthetic ammonia
4. CNNC Youqianqi Wind Storage Hydrogen and Ammonia Integrated Demonstration Project (CNNC)	Inner Mongolia	Wind (grid-connected)	500 MW	Alkaline	21,600 tpy	Synthetic ammonia
5. China Power Construction Chifeng Wind-solar Integrated Hydrogen Production Demonstration Project	Inner Mongolia	Wind, PV (grid-connected)	490 MW	Alkaline	18,600 tpy	Synthetic ammonia
6. Datang New Energy Duolun 150,000 kilowatt wind-solar hydrogen production integrated demonstration project (Dataing New Energy)	Inner Mongolia	Wind, PV (grid-connected)	150 MW	Alkaline	5,400 tpy	FCVs

7. 100,000 tons/year liquid sunlight—carbon dioxide plus green hydrogen to methanol technology demonstration project	Inner Mongolia	Wind, PV (grid-connected)	625 MW	Alkaline	21,000 tpy	Synthetic methanol
8. Ulanqab Xinghe County wind and photovoltaic power generation hydrogen production and ammonia integrated project	Inner Mongolia	Wind, PV (grid-connected)	500 MW	Alkaline	25,700 tpy	Synthetic ammonia, urea
9. Tengger 600,000-kilowatt wind-solar hydrogen production integrated demonstration project	Inner Mongolia	Wind, PV (grid-connected)	600 MW	Alkaline	20,800 tpy	Synthetic ammonia
10. Ordos Kubuqi 400,000-kilowatt wind-solar hydrogen production integrated demonstration project	Inner Mongolia	Wind, PV (grid-connected)	400 MW	Alkaline	15,500 tpy	Chemical industry

Source: IHFCA research

Additional insights about baseline projects from review of Exhibit 4 include the following:

- 4 projects are operational, 5 under construction, and 1 is under bidding for a total of 10 out of 29 that are clearly confirmed or likely to go forward. Another 9 have signed agreements and the remaining 10 are just in the planning stages. Thus, a total of about 19 out of 29 are not confirmed to be moving forward beyond the planning stage towards realization.

- Out of 19 projects on which there is information as to the nature of the grid providing power for the "green hydrogen," only 4 are completely isolated grid with a 5^{th} being partially isolated grid and the other 14 (74%) being fully grid-connected. This raises concerns about the definition of green hydrogen. Some sources (e.g. European sources) suggest that green hydrogen must be produced by isolated grid renewable energy in order to be truly green. The GEF Project's three demonstration sites will all use isolated grid electricity.

- Alkaline electrolyzers predominate, though three of the 29 projects are known to include PEM electrolyzers (one as the only electrolyzer and the other two in combination with alkaline electrolyzers).

- As for end uses, chemicals/ petrochemicals are significantly more common than FCVs. FCVs are present in 8 of 27 projects that provide end use of information. One of those is in combination with petrochemicals. As for chemicals/ petrochemicals, 20 of 27 projects list these as an end use. Of these, synthetic ammonia, listed 14 times, is the most common chemical/ petrochemical end use of the baseline green hydrogen projects.

Exhibit 4 includes one large, already operational project in one of the demo cities, the Baofeng 200 MW PV project in Ningdong, Ningxia. It is said to produce 27,000 tpy hydrogen, though, as in the footnote associated with the entry in the table, the output figure is questioned. Baofeng is a private company, whereas the lead partner in the Ningdong, Ningxia project demo is a state-owned enterprise. The source also points out that the Baofeng project was unknown to most industry players until after its commissioning. This is quite in line with the need for the GEF project, which will monitor and publicize its results for the good of the industry. Further, the Baofeng project appears to be an example of a single organization project, where the hydrogen producer is also the user of the hydrogen, whereas the GEF project aims to involve multiple organizations in the value chain. Lastly, the Baofeng project focuses only on chemicals production with green hydrogen, whereas the GEF project includes both chemicals and heavy duty vehicle transport. The latter is seen to have high potential in Ningdong as the project and city will implement policies, standards, and technical support for these vehicles.

Exhibit 4 does not include progress to date related to the project demos. Prior to GEF project launch, the demo cities have made some progress on their project demo installations, particularly with regard to renewable energy power generation installations, green hydrogen production, and HRSs. Yet, evidence shows that early investments of the demo cities were stimulated by early discussions (pre-PPG/ProDoc submission and, in some cases, pre-PIF submission) regarding the GEF Project with IHFCA. The Ningdong and Dalian demo concepts are not entirely new to the cities. Yet, no progress was made until well after discussions with the GEF project were initiated. IHFCA began to discuss the GEF project with the cities in 2021. The challenges the cities had faced in moving forward with their preliminary concepts were lack of funding and lack of integration of the demos into a cohesive whole. The potential of GEF funding, GEF TA support, and GEF "branding," as with previous GEF projects in China, was found to very strongly stimulate government support and action, finally pushing some of the early green hydrogen demo concepts forward. And, the technical support during project concept development and project design supported the development of these initial ideas into well-integrated, high-quality green hydrogen industrial chain plans. The PIF proposal for this project was submitted in April 2023. Work on construction of Ningdong's 120 MW isolated PV grid began in August 2023. Work on its two green hydrogen production facilities began in May 2023. And work on its two HRSs began in March 2023. Construction on the Dalian tidal flats PV and hydrogen production demo was initiated in January 2023. The data and monitoring platform for the Dalian demo was initiated and completed in the first half of 2024. Shenyang's demo concepts do appear to predate the PIF. In terms of progress, Shenyang's Hydrogen Industrial Park was targeted for construction during the period of 2023-2025. Its partner for isolated grid wind power and green hydrogen production has completed a pilot project of 5 MW of wind and associated green hydrogen production. The GEF project will support this partner's work on scale up, first to 50 MW (which will provide hydrogen for 210 heavy duty FCVs) and then to 450 MW, for supply of green hydrogen to green methanol production.

Exhibit 5 shows some key past and current donor projects in China and abroad related to green hydrogen, hydrogen, and FCVs. Most notable among these for lessons learned has been a series of three GEF projects in China over the years focused on FCVs. Chinese sources indicate the GEF platform via these three projects provided strong benefits in advancing the FCV industry in China. They explain that this past success is what makes the Chinese Government interested in pursuing such a substantial fourth project with GEF funds, this time focused on green hydrogen. A concurrent initiative that may have synergies with the proposed project is the International Hydrogen Energy Center (IHEC) in Beijing, launched in July 2021 with the support of UNIDO and the Chinese Government. IHEC activities include research and development (having a more technical orientation than this project), promotion of scale-up of industrial applications, and an environmental, carbon neutral focus. IHEC demos to date or to be initiated include 850 fuel cell buses to transport Winter Olympic athletes in 2022 (using green hydrogen produced in Zhangjiakou, Hebei Province, completed), a green hydrogen demo in the metallurgical and chemical industry in Baotou, Inner Mongolia (construction initiated in 2023, to be operational in 2025), and heavy duty fuel cell logistics vehicles and China's largest HRS in Daxing County, Beijing (to be implemented). A last project concurrent with the proposed project and promising to have good synergies is an 8-country GEF project focused on promoting green hydrogen in industry – the GEF Green Hydrogen global program. It is expected that learnings from the China project will be helpful to the 8 countries of this other project. Exchange with the partners in this program has been designed into the China Green Hydrogen Project. GEF funding for the global program, now in the midst of detailed design, is about USD13 million. The involved countries include: Algeria, Ecuador, Egypt, Malaysia, Namibia, Nigeria, Philippines, and South Africa.

Lessons learned and recommendations from the three completed GEF projects in Exhibit 5 have been carefully reviewed and have informed the design of this project. The most important lesson may be that of how to work with demo cities and ensure buy-in pre-project by extensive exchange and preparatory work prior to GEF project launch. For the *China Green Hydrogen Project*, there was extensive exchange; and the demo cities provided detailed feasibility studies and also filled in spreadsheets of information for the project, as requested during the PPG stage. PPG experts visited each city and provided advice to the cities of how to improve their demos. And the demo teams also came to Beijing to further exchange with experts and project designers and to finalize plans. Some more specific recommendations and lessons from past projects and adopted/ incorporated into this project are as follows: (Note: The focus here is on the last of the three projects, the Terminal Evaluation (TE) of which was completed in 2021, as compared to the first and second projects, the second's TE being completed in 2011.) China DevCom FCV TE's Recommendation 2 is: "Support the demonstration and promotion of renewable energy hydrogen production through a GEF-supported project that provides more focus on the energy-related aspects of hydrogen production." DevCom FCV clearly identified the priority next step of green hydrogen production, which is an important focus of this project. Another recommendation of DevCom FCV is: "The GEF should continue to support decarbonization of transport through FCVs in China." The recommendation further indicates that, while the Government of China may support public buses and HRSs, GEF support may be needed for other heavy duty vehicles. Urban service vehicles, industrial vehicles such as fork lifts, and heavy duty trucks are all mentioned. So, this recommendation is partially taken up by the *China Green Hydrogen Project* with its work in the heavy duty vehicle area. Recommendation 3 of DevCom FCV is "Strengthen the system of cultivating technical talent for fuel cell and hydrogen energy value chains." While the recommendation elaborates on cooperation with a technical college, the general concept of cultivating talent for the industrial chain is well addressed in *China Green Hydrogen* project design with: its preparation of textbooks, its capacity building and international exchange, and its human resource and project platform – the last facilitating exchange between experts and companies.

Exhibit 5. Past and Current Donor Projects in China Related to Green Hydrogen and/or FCVs

Project or Initiative	Partners, Timeline, Financing	Main Content
1. China Fuel Cell Bus Project – Phase One *(completed project)*	UNDP-GEF-China Ministry of Science and Technology (MOST), 2003-2007, USD5.815 M	Aim was to catalyze cost-reduction of fuel-cell buses (FCBs) for public transit applications in Chinese cities by supporting significant parallel demonstrations of FCBs and their fueling infrastructures in Beijing and Shanghai, as well as supporting capacity building.
2. China Fuel Cell Bus Project – Phase Two *(completed project)*	UNDP-GEF-China Ministry of Science and Technology (MOST), 2007-2011, USD5.767 M	
3. China Development and Commercialization of Fuel Cell Vehicles ("China DevCom FCV") *(completed project)*	UNDP-GEF-MOST, 2016-2021, USD8.234 GEF funding	FCV and FC technology improvement/cost reduction and demonstrating 109 FCVs across 4 demo cities, capacity building, hydrogen production and HRSs, policy, awareness, and information dissemination.
4. China International Hydrogen Energy Center (*ongoing initiative*)	UNIDO and Chinese Government, initiated in 2021 and ongoing	Research and development (having a more technical orientation than this project), promotion of scale-up of industrial applications, and an environmental, carbon neutral focus. Completed demonstration of green hydrogen in Zhangjiakou fueling winter Olympics buses; ongoing green hydrogen industrial project in metallurgy and chemical industry; ongoing heavy duty logistics fuel cell vehicles and HRS scale-up in Daxing County, Beijing.
5. Global Green Hydrogen Program (Algeria, Ecuador, Egypt, Malaysia, Namibia, Nigeria, Philippines, South Africa) (*pipeline initiative*)	UNIDO-GEF and national governments, 2024-2029, USD13.129 GEF funding	Eight-country project focused on green hydrogen in industry. Concurrent with the *China Green Hydrogen Project*, which will share learnings with the eight countries.

Potential for Lasting Impact, Replication, and Scale-Up: The *China Green Hydrogen Project* is designed for lasting impact and for promoting replication and scale-up. Its elements are strongly focused on results that will propel green hydrogen industrial chains forward in a way that is sustainable and will extend beyond project close. For example, targeted results in policy and standards, if adopted at the national or local levels, could continue to have impacts well beyond project close. Demonstrations, combined with dissemination of results, are also designed to have impacts beyond project close. To support this kind of impact of the demos, the project has specific activities designed to ensure that the demos, or at least elements of them, are replicated in other cities in China and cities in other countries. There are also activities focused on scale-up either within the demo cities or in a cross-region scenario. Findings on renewable energy power generation trends and forecast trends in green hydrogen production (with concomitant declining grey hydrogen production expected), as shown in Exhibits 1 and 2, imply the project will be able to make critical contributions to the positive forecast green hydrogen trends without having the negative impact of increasing grey hydrogen use, so long as barrier removal work and efforts related to policy, cost reductions, and other aspects are achieved. Lastly, efforts in capacity building, human talent, and awareness will offer the potential for sustainable results. Outputs such as university textbooks and a talent platform for the industry, for example, can be sustainable if the project develops and carries out appropriate exit strategies to ensure these items are well utilized beyond project close.

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[1] *China - Country Climate and Development Report*, World Bank 2022

[2] Green hydrogen production most ideally makes use of power generated by off-grid/ isolated grid renewable energy power production. This ensures the hydrogen is truly "green." As the main electricity grid in China reaches Limits as to how much renewable energy based power production it will accept, the envisioned increase in isolated grid renewable energy power production to produce green hydrogen will be beneficial to the continued uptake of renewable energy based power in China and thus the continued technological and cost reducing progress of renewable energy power production.

[3] In 2023, 57.7% of hydrogen production in China was coal-based, 22.4% methane-based, 18.5% hydrogen was derived as a byproduct of other processes, and 1.4% was from other hydrogen production methods. (Source: Saidi Consulting, referenced at https://xueqiu.com/7842369805/289781783.)

[4] Safety and environmental risks of hydrogen pipelines include embrittlement of the steel pipeline (which makes it more prone to cracks), risk of leaks (due to hydrogen's small molecular size, which can lead to explosions or indirect GHG emissions), ecosystem impact, and pipeline corrosion, which can impact the environment.

[5] Saide Consulting, Hydropower and Water Conservancy Planning and Design Institute, ChemAnalyst, and Statista

[6] US Energy Information Administration

[7] An expert interviewed by one source indicates that even if this project's 150 MW of electrolyzers were running around the clock (which they cannot due to lack of sunshine), total production would just be 23,700 tpy. *Upstream*: "Baofeng Energy brings world's largest green hydrogen project on line in China," Feb. 2022.

B. PROJECT DESCRIPTION

This section asks for a theory of change as part of a joined-up description of the project as a whole. The project description is expected to cover the key elements of good project design in an integrated way. It is also expected to meet the GEF's policy requirements on gender, stakeholders, private sector, and knowledge management and learning (see section D). This section should be a narrative that reads like a joined-up story and not independent elements that answer the guiding questions contained in the guidance document. (Approximately 3-5 pages) see guidance here

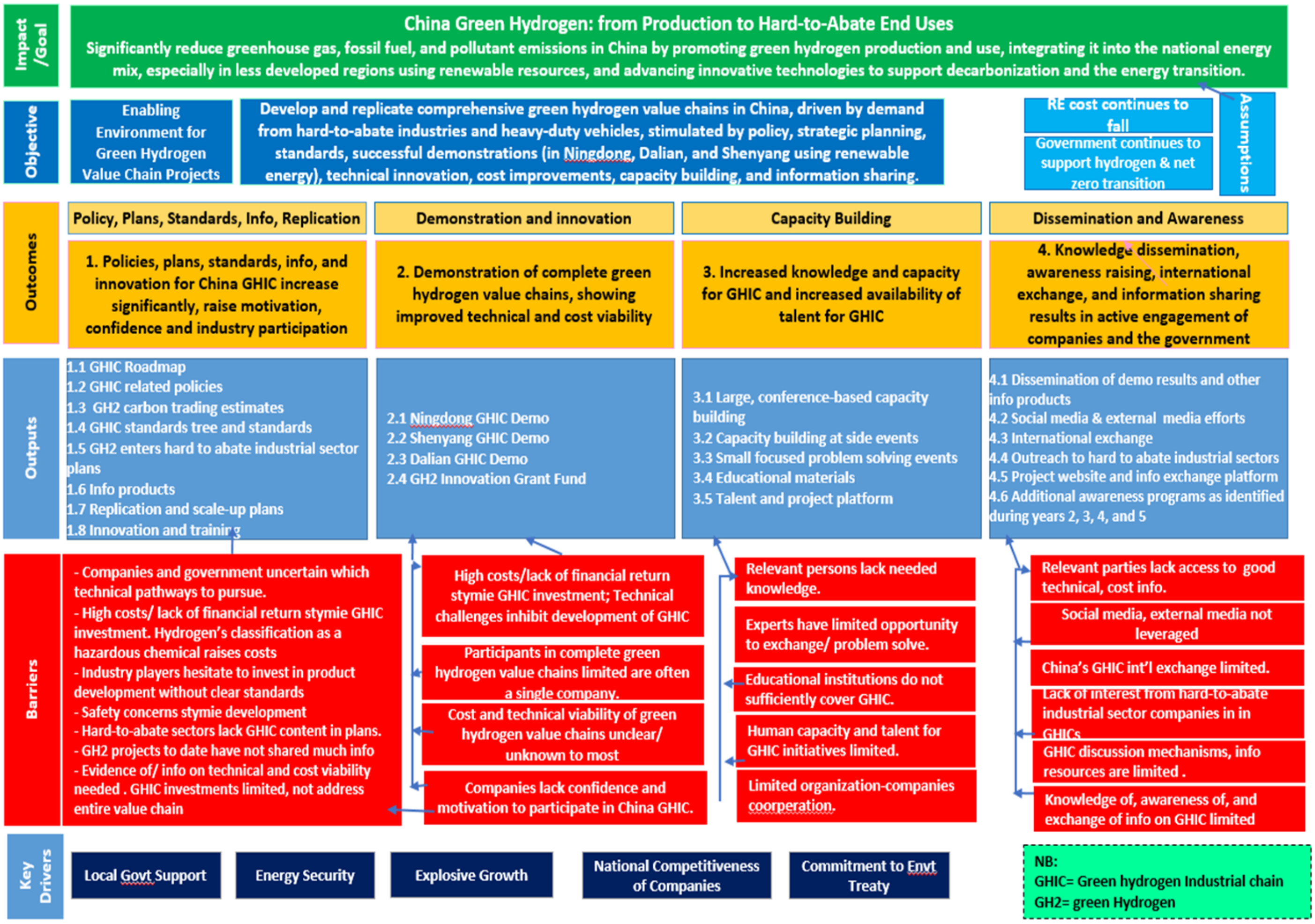
Considering the foregoing, the project adopts the following **objective:** To facilitate the development and replication of comprehensive green hydrogen industrial value chains in China, with demand pull from hard-to-abate sectors (heavy duty transport and hard-to-abate industrial fields) and with stimulus and support across the value chain from policy, strategic planning, standards, successful demonstration in Ningdong, Dalian, and Shenyang using renewable energy, technical innovation, new business models, improved technical and cost viability, information dissemination, capacity building, and human networks. The project objective is the aim to which the project, along with other projects and initiatives, contributes. Thus, it can be seen that while the long term goal or vision of the project is mainstreaming and substantial use of green hydrogen, the objective is oriented at an earlier stage to kick-start the industry with comprehensive value chain and functional support using a systems approach. The project is comprised of four main components and their outcomes to contribute to the near-term objective. These include an outcome for developing a comprehensive policy, planning, and standards framework related to green hydrogen that addresses needs, building on pre-existing items as relevant, and provides information, innovation, and replication support as well. The second outcome is the demo and innovation outcome. It emphasizes whole value chain deployment, efforts to gather data and show technical and cost viability, and also has an emphasis on demonstrating innovation whether it be technical, business model, or policy oriented. The first outcome's information output will assess the results of the Outcome 2 demos and provide other needed information products. Outcome 1's replication output will aim to ensure other cities in China and cities in other countries (particularly the GEF Green Hydrogen Global Program countries) learn from the Outcome 2 demos and make plans to replicate them. The project will also have, as its third outcome, capacity building efforts. It will aim to motivate and educate those in all links of the value chain, including, on the downstream side, both those involved with heavy duty FCVs and those in hard-to-abate industrial sectors (especially chemicals). The capacity building outcome will aim to develop human talent and develop a means of connecting such hydrogen talent with projects and other opportunities. The fourth outcome, the awareness and dissemination outcome, will assist Outcome 1 in getting the info and analysis on the demos and other information products out to the right parties. It will also include social media and external media efforts to bring green hydrogen to a wider audience. It will further support a project website (for dissemination) and will support international exchange related to green hydrogen industrial chains.

This strategy of the project in leading to the project objective and then its overall goal is shown in the theory of change ("TOC") in Exhibit 6. The TOC diagram includes some of the drivers and assumptions discussed above. And, it shows relevant barriers, suggesting how specific outcomes and outputs in the TOC are addressing specific identified barriers to green hydrogen value chain deployment and scale up. The overall TOC logic is formulated around three main pillars: people, processes, and systems. As for people, the project takes a human-centric approach and aims to improve the capacity and awareness/ knowledge base of those involved in the project, as well as more generally the welfare of the general public through addressing environmental issues. As for processes, the TOC leverages various causal pathways and links between barriers, outcomes, intermediate states, and objectives of the project. As can be seen, outputs correspond to many of the barriers discussed and feed into outcomes to address broader barriers. The outcomes, in turn contribute to the intermediate state of the enabling environment for green hydrogen value chain projects, which in turn can lead to the project objective of replication of such value chains, eventually contributing to the goal of mainstreaming of green hydrogen in China to substantially contribute to GHG emission reductions. In terms of systems, the TOC considers a long-term systematic approach. Long-lasting impacts are ensured by targeted outputs that have sustainability beyond project close and contribute to outcomes such that those outcomes also have sustainability. An example of sustainable outputs are policies and standards if adopted at local and national levels. Replication activities will build on the project demos to achieve sustainability of impact as well.

Aside from GHG emissions reduction, the project has the potential of delivering a range of co-benefits. In particular, development of the green hydrogen economy can provide benefits in terms of income generation and jobs. Green hydrogen use can also cut down on local pollutant emissions, thus improving air quality and human health. Green hydrogen, domestically produced, could eventually also increase China's energy independence, an attractive prospect for the world's top petroleum importer. The project's strong efforts in gender can provide the benefit of gender mainstreaming in the new hydrogen economy, resulting in more and better opportunities for women and a greater role for women in formulating policies and plans.

The overall project design reflects some lessons and recommendations from prior GEF project work on hydrogen in China. In particular, terminal evaluation recommendations for China DevCom FCV, a UNDP-GEF project are adopted. Recommendations for that prior project that have been adopted include: (1) the development of a GEF project focused on using renewable energy based power generation to produce green hydrogen and, (2) on the vehicle side, moving beyond prior projects' focus on public buses to focus on other heavy duty vehicles, such as logistics trucks. That is, the current project, in its overall focus on green hydrogen and its focus, as one of two end use areas, on heavy duty vehicles, has adopted both of these recommendations coming out of the prior GEF hydrogen-related project in China.

Exhibit 6. Theory of Change for *China Green Hydrogen*



Outcomes, outputs, and activities: The detailed project structure of outcomes, outputs and activities is described below:

Component 1: Policy, Plans, Standards, Institutional Support, Information Products, Innovation, and Replication/ Scale-Up

Outcome 1: China's pipeline policies, plans, and standards, as well as information, and innovation related to green hydrogen and its value chain increase from a very limited baseline to a significant level that raises the motivation and confidence of industry and other players to participate in the green hydrogen industrial chain.

Rationale of Outcome 1: Outcome 1 is justified by: the currently very low level of government policies, plans and standards in support of the green hydrogen value chain; the need for such support as expressed widely in the industry; the lack of suitable and reliable information products that can support industry and others that may be interested in participating in the sector; and the need for increased innovation in the sector.

PLANNING

Output 1.1: *China National Green Hydrogen Industrial Chain Technical Roadmap* incorporates input from industry and national government, receives endorsement from national government, and provides strategic guidance to companies, which incorporate aspects of the *Roadmap* into their plans and strategies. [The *Roadmap* will have the benefit of focusing efforts on the most advantageous technologies in various functional areas across the value chain (e.g. alkaline electrolyzer versus PEM electrolyzer) for various time periods under consideration. It will put emphasis on green hydrogen: production, storage and transport, and hard-to-abate industrial sector applications (especially chemicals), given that substantial work of this kind has already been done for FCVs and HRSs,[1]8 though more limited input on the latter two areas and particularly their use of green hydrogen may be included as well. Transport of green hydrogen will be especially important, given the location of RE resources in the west of the country and potential demand centers in the east. The *Roadmap* will be issued by IHFCA, but work will aim for portions of the roadmap to be adopted by the national government and incorporated into their own issuances and for large companies' product/ planning and design work also to reflect interconnection with the *Roadmap*.]

Activity 1.1.1: Research, consultations and written outreach, and technology assessment on various technologies and links in the green hydrogen industrial chain as inputs to the *Roadmap*. Work will cover green hydrogen production, transport, storage, refueling, and applications (especially hard-to-abate industrial sectors and, particularly, chemicals). [Note: FCV and HRS work for CSAE's analogous NEV roadmap included about 150 experts. The work for this activity may also involve input from a large number of experts, such as through questionnaires and telephone interviews. Also, less

emphasis will be put on FCVs and HRSs compared to other application areas, such as chemicals, as the former are covered in-depth in the existing NEV Roadmap. As needed, however, a comparison on the suitability of FCVs versus EVs for various applications may be carried out.]

Activity 1.1.2: Holding of a series of workshops, with workshop(s) both prior to preparation of the first draft of the *Roadmap* and following. Purpose of meetings will be to discuss its content at sessions dedicated to various links in the green hydrogen industrial chain.

Activity 1.1.3: Drafting of the *Roadmap* based on findings of Activity 1.1.1, incorporating specific inputs of industry and national government, and of the workshop(s) of Activity 1.1.2 conducted prior to drafting. The *Roadmap* will include indicators, targets, and timelines. Finalizing of the *Roadmap* (revisions) based on the workshop(s) of Activity 1.1.2 held after the draft is prepared. The *Roadmap* will map out proposed green hydrogen industrial chain industry technical developments over the next 30 or so years. The *Roadmap* will also include targets, such as electrolyzer efficiency, to be achieved in 10, 20 and 30 years.

Activity 1.1.4: Conducting of outreach to government and industry regarding formally endorsing roadmap and incorporating it into their strategies.

POLICIES

Output 1.2: National and local policies related to green hydrogen and its value chain developed, are gender responsive, and are adopted or successfully enter the review and adoption pipeline, stimulating greater supply of and demand for green hydrogen via incentives, cost reduction, and confidence-building.

Output 1.2a: Strategic set of national and local incentive policies to promote green hydrogen and its value chain (including policies for each of green hydrogen production or purchase, green hydrogen transport and storage, green hydrogen use in hard-to-abate industrial sectors (especially chemicals), FCVs, green hydrogen use in heavy duty transport fleets, and HRSs offering green hydrogen) developed and adopted, in the pipeline for adoption, and/or endorsed by experts and industry, thus stimulating demand. [Incentive policies may utilize traditional subsidies, "reward after" subsidies for parts of the value chain where there is a need to stimulate use of green hydrogen, grants, tax reductions, or special benefits, such as waiving of toll or granting right of way. Overall, it will not just be one single incentive policy/ subsidy type to promote the production and uptake of green hydrogen, but a full, strategic set of incentive policies across the value chain per below the activities. *Note:* "Local policies" may refer to provincial level, municipal level, or district (as in district of a major municipality) level. For local level policy drafting, the project will aim for promotion and uptake by more than one locality, such as more than one province or more than one municipality, as relevant. Upstream incentives will support only green hydrogen production. Furthermore, for downstream applications, project contracts will require use of green hydrogen in supported end uses. Thus, any support from the GEF for end use incentives will go only to those using exclusively green hydrogen during the project's lifetime.]

Activities 1.2a.1 – 1.2a.7: For each described type of national or local-level incentive policy, respectively: (i) Carrying out assessment for and drafting of the indicated policy/ policies. Assessment should consider differentiated barriers faced by women in participating in the green hydrogen value chain and include gender responsive aspects to the proposed policies. (ii) Carrying out consultations and final revisions of the draft policy/ policies. (These may be new incentive policies or adjustments to existing incentive policies.) (iii) Promotion of the policy/ policies to decision makers and advisors/ experts for adoption at the national or local level.

- *Activity 1.2a.1*: National or local green hydrogen upstream incentive policy that may lower the final cost and price of green hydrogen. [Aim of the incentive policy will be to address the high cost of green hydrogen in the early stages of development of the industry. Options to be considered include subsidization of installation of isolated green power grid for hydrogen production or of hydrogen production equipment, tax incentives to green hydrogen producers, direct subsidization of final price of green hydrogen.] Assessment will determine the amount of subsidy (or related similar financial incentive) needed for economic viability.

- *Activity 1.2a.2*: National or local incentive policy that attracts companies in hard-to-abate industrial sectors (especially chemicals) to utilize hydrogen (if not utilizing already) and utilize green hydrogen in particular. Assessment will determine the amount of subsidy (or similar incentive) needed to make use of green hydrogen economically viable for companies. The incentive may directly support (via subsidy) installation of relevant equipment to utilize hydrogen (if not already using hydrogen), provide tax incentives for those using certified green hydrogen, or provide direct payments to those using certified green hydrogen.

- *Activity 1.2a.3*: National or local incentive policies (or adjustment of existing incentive policies) that attract companies with fleets of heavy duty vehicles in various use scenarios to purchase heavy duty FCVs and utilize green hydrogen in them. [The policies may be tailored to various use scenarios, such as long-distance logistics (perhaps with emphasis for those travelling on fixed routes and for which toll free or reduced toll passage could serve as incentive), logistics within industrial parks, public buses[1] (which might be influenced by zero carbon requirements for public bus systems), cold storage heavy duty vehicle fleets (which might be incentivized by right of way for such vehicles when FCVs are used), use of heavy duty vehicles along designated "hydrogen highways" (which may also offer toll-free passage and/or right of way (permission to use road at certain times of day) to FCVs).][2][9] Assessment will determine the amount of subsidy (or similar incentive) needed to make purchase of heavy duty FCVs and use of green hydrogen economically viable for companies in each use scenario considered. The incentive may directly support (via subsidy) purchase of heavy duty FCVs (or pay a reward after green hydrogen use is confirmed), provide tax incentives for those using heavy duty FCVs and using certified green hydrogen in them, provide direct payments to those using heavy duty FCVs and certified green hydrogen in them, or, as mentioned above, reduce toll on "hydrogen highways" or provide other driving benefits to those using heavy duty FCVs, along with certified green hydrogen in them. (Note: There may also be a need to develop a system for confirming the use of certified green hydrogen.

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- *Activity 1.2a.4*: National or local incentive policies for the establishment of hydrogen refueling stations and, particularly, those that supply green hydrogen. Incentive policies to produce green hydrogen at HRS site and/or set up an HRS along a hydrogen highway. Assessment will determine the amount of subsidy (or similar incentive) needed to make the establishment of such stations and supply of green hydrogen by them economically viable. The incentive policy may directly support establishment of the station (via subsidy tied to the purchase of land or construction of the station), provide tax incentives for such stations (such policies as the foregoing may include one subsidy level for HRSs generally and then a higher one for HRSs that supply green hydrogen), allow such stations to be established on land types which are lower cost (e.g. industrial land)[3][10], encourage addition of hydrogen to existing gasoline stations, and/or provide payments to HRSs for green hydrogen sold. Up-front subsidies, tax reductions, or post-payment incentive policies for mobile, skid-mounted HRSs (particularly those that sell green hydrogen) may also be considered.

- *Activity 1.2a.5*: National or local incentive policies to encourage localization of parts along the green hydrogen industrial value chain that are not yet localized. (An example is parts for PEM electrolyzers.)

- *Activity 1.2a.6*: National or local incentive policies to encourage advanced methods of hydrogen transport, such as liquid H_2 or H_2 transport at higher pressures than are typically used in China at present. Incentive policies to support other options for transport, such as ammonia and methanol, as well as Type IV (higher pressure) cylinders, for which new standards will be in effect as of June 2024, but support may be needed to accelerate uptake.

- *Activity 1.2a.7*: National or local incentive policies to encourage financing of and financial investment in various links in the green hydrogen industrial value chain.

Activities 1.2a.8 – 1.2a.10: Identification and action, as relevant, on additional national or local-level green-hydrogen related incentive policies for which need is determined during project lifetime. For each activity, respectively, follow up on potential incentive policies identified will include: (i) Assessment of proposed/ identified policies and selection of high priority/ high potential ones. Assessment should consider differentiated barriers faced by women in participating in the green hydrogen value chain and include gender responsive aspects to the proposed policies. (ii) Drafting of high priority/ high potential policies selected. (iii) Consultations with government and revisions. (iv) Promotion of proposed national or local-level incentive policies to decision makers and advisors/ experts. (GEF funds will only support those incentive policies that can definitively benefit green hydrogen production or sale/ require green hydrogen to be used. Any other incentive policies, that support hydrogen use more generally, will be co-financed.)

- *Activity 1.2a.8:* Periodic consultations with industry to collect ideas on proposed national or local-level incentive policies for the green hydrogen industrial value chain.

- *Activity 1.2a.9*: Review and assessment of experience with local incentive policies related to the green hydrogen industrial chain adopted in cluster cities, in project demo cities, and in other provinces and cities to determine if any of the approaches may be adopted as national level incentive policies.

- *Activity 1.2a.10:* Identification of newly determined barriers and other national or local-level incentive policy needs in years 2, 3, 4 and 5 of the project. Work may also reference findings of novel incentive policies of interest from Activity 1.6b.4.

<u>Output 1.2b</u>: China's hydrogen safety management and supervision system assessed and adjustments proposed that are gender sensitive and successfully enter the pipeline for review and adoption at national or local level resulting in reduced costs and increased confidence for green hydrogen and its value chain. [Aim will be to: (a) "Separate fact from fiction" and potentially advise government on various aspects, which may remove barriers to the industry of overly stringent regulations or even allow for reclassification of hydrogen from a hazardous chemical to an energy source, while at the same time maintaining safe operating environments. (b) Stimulate progress towards a comprehensive safety management and supervision system for the industry, which will, in turn, facilitate its progress and scale-up. Local policies may include provincial-level, municipal-level, or district-level (within a municipality) ones. For local level policies drafted, the project may target promotion and uptake by more than one locality, such as more than one province or more than one municipality.]

The PEE will deploy different research methodologies to ensure comprehensive, robust and inclusive procedures that involve multiple stakeholders in the hydrogen value chain. The research methods will include, but not be limited to desk study, statistical analysis, expert interviews, corporate research (case studies and surveys involving companies within the green hydrogen or fuel cell industry), seminars, workshops, and brainstorming sessions to generate innovative ideas and solutions, survey questionnaires, qualitative and quantitative research (combined approach to validate findings), and telephone interviews. This will also involve the formation of working groups for discussion and review of standards on green hydrogen and fuel cells. It is envisaged that the PEE will collaborate with government bodies and industry players to conduct these research projects. Key university and research partners will include, but not be limited to the following:
The PEE will deploy different research methodologies to ensure comprehensive, robust and inclusive procedures that involve multiple stakeholders in the hydrogen value chain. The research methods will include, but not be limited to desk study, statistical analysis, expert interviews, corporate research (case studies and surveys involving companies within the green hydrogen or fuel cell industry), seminars, workshops, and brainstorming sessions to generate innovative ideas and solutions, survey questionnaires, qualitative and quantitative research (combined approach to validate findings), and telephone interviews. This will also involve the formation of working groups for discussion and review of standards on green hydrogen and fuel cells. It is envisaged that the PEE will collaborate with government bodies and industry players to conduct these research projects. Key university and research partners will include, but not be limited to the following:

Government Agencies and Government-Linked CSOs	**Universities**	**Industry Partners**
• Ministry of Industry and Information Technology • Ministry of Environmental Protection • Association for Science and Technology • China Society of Automotive Engineers (China SAE) • International Hydrogen Fuel Cell Association (IHFCA) • China Automotive Technology and Research Center	• Tsinghua University • Hunan University (for textbooks publication) • Dalian Institute of Chemical Physics, Chinese Academy of Sciences • North China Electric Power University • Tongji University • Shanghai Jiaotong University	• Hydrogen Production: Yangguang Hydrogen Energy, Peric 718 Hydrogen Energy • Storage and Transportation: Faurecia SLD • Hydrogen refueling: Sinopec, Guoneng Group • Heavy Duty Vehicles: BAIC, Foton, SAIC, Changan, Toyota, Hyundai • Fuel Cells: REFIRE, SinoHytec

Principles utilized for policy recommendations and formulation:

As part of the policy formulation and recommendation process, the PEE shall conduct the following

- *Evidence-based research:* to ensure policy recommendations are based on thorough analysis and empirical evidences from stakeholders through consultative processes.
- *Industry demand and market focus:* policies developed will address the needs of the industry, focusing on market development and the conditions of both the public and private sectors, with government support.
- *Addressing key barriers:* Recommendations will focus on key barriers to industry development identified in the project, proposing solutions to these challenges.
- *Collaborative approach:* IHFCA will work closely with local governments and relevant stakeholders to gather a baseline of information and develop inputs to policy contents and recommendations that are practical, implementable and tailored to the realities of the countries.

As a think tank and industry exchange platform, the PEE will leverage the research results and project experiences to formulate policy recommendations for the government. Based on the project design, these policy recommendations will be made in some cases to municipal governments and in others directly to relevant national ministries for different aspects concerning the green hydrogen value chain. These recommendations will include specific policy contents and the rationale for their introduction. Industry insights and feedback will be gathered to address key barriers affecting industrial development of the green hydrogen value chain. For local-level policy recommendations, the project will collaborate with local governments to establish baselines, then propose policies to promote local policy adoption. Similarly, for national-level recommendations, IHFCA will work with industry organizations and government departments to develop and advocate for the final policies. Based on China's policy release experience, final policy content will be slightly or significantly revised with government input before final release, informed by national or municipal government priorities. Hence, the project will work closely with government ministries from inception, to formulation, and to review of the relevant policies.

Activity 1.2b.1: Conducting of research and assessment on safety aspects of the green hydrogen industrial chain (e.g. green hydrogen production, transport and storage, HRSs, heavy duty FCVs, use of hydrogen in hard-to-abate industrial sectors, especially chemicals). Identification of international and domestic evidence related to hydrogen safety issues. Consideration of international practices (e.g. self-serve HRSs) and rationale behind them. Development of policy recommendations for and draft national or local policies including adjustments and improvements to China's hydrogen safety and management system, so that it is appropriate to the real risks of production and use of hydrogen, but does not excessively constrain industry development in ways that are not necessary. This activity will address various topics and needs, such as, but not limited to: (a) whether green hydrogen production should be limited to chemical parks as it now is in China or if such restrictions could be loosened so that green hydrogen production locations have more flexibility to be near green energy resources and/or near hydrogen end use facilities; (b) development of series of (hydrogen) safety management regulations/ guidelines for FCVs and associated safety monitoring system[4][11] (including addressing of the safety management of the onboard hydrogen canister); (c) safety management regulations/ guidelines for storage and use of hydrogen in chemicals sectors. Assessment should consider differentiated barriers faced by women in participating in the green hydrogen value chain and include gender responsive aspects to the proposed policies.

Activity 1.2b.2: Development of briefing materials and presentations to policy makers regarding findings related to safety aspects of the green hydrogen industrial chain and recommendations for adjustment of the nation's hydrogen safety and management system policies (or of analogous local-level policies). The content will be based on findings and recommendations of Activity 1.2b.1.

Activity 1.2b.3: Presentation of findings and outreach to decision makers and their support teams regarding the real risks of hydrogen and appropriate safety management and supervision system policies/ policy adjustments to support industry development while keeping people safe.

Activity 1.2b.4: (i) Outreach to industry regarding their input on policy needs related to management, supervision, and safety along the green hydrogen industrial chain. (ii) Review of experience with local management, safety, and supervision policies adopted in cluster cities, project demo cities, certain provinces, and other cities to determine if any of the approaches may be adopted for national level policies. (iii) Identification of new policy needs in this area (management, supervision, and safety along the green hydrogen industrial chain) in years 2, 3, 4, and 5 of the project. Work may also reference findings of novel management, environmental safeguards or safety policies of interest from Activity 1.6b.4. Based on the best candidates from (i), (ii), and (iii), development of draft national and/or local policies, consultations, revisions and promotion of draft national and/or local policies to decision makers.

Output 1.3: Methodology for computing carbon emission reductions attributable to green hydrogen developed, endorsed, piloted, and/or adopted at national or local (provincial or municipal) level, paving the way for green hydrogen producers (and/or, possibly users)[5][12] to participate in carbon trading systems, thus attracting more investment into green hydrogen production. [Purpose is to provide more incentive for companies to invest in and operate green hydrogen production facilities, thus ameliorating high production costs as compared to grey hydrogen.]

Activity 1.3.1: Research and analysis of existing methodologies for computing carbon emission reductions in carbon trading systems generally and for green hydrogen based carbon trading in particular. Work will consider the appropriate beneficiary of carbon trading related to reduced carbon emissions in green hydrogen, likely the green hydrogen producers themselves, though alternatively, or in addition, possibly their customers/ users of green hydrogen. Work will include review of green hydrogen carbon emission reduction calculation methodology and trading guidelines both internationally and in China. Preparation of report on findings and suitable potential carbon emission reduction computation models that can be used for including green hydrogen production in China's existing carbon trading framework. Report will consider results of research in this activity and results of consultations in Activity 1.3.2. Based on additional consultations with and feedback from decision makers and experts, revision and finalization of report and proposed methodologies of carbon emission reduction computation that will facilitate including green hydrogen production in China's carbon trading.

Activity 1.3.2: Consultations with government, industry, and experts regarding China's current carbon trading system in other sectors and ways to extend the carbon emission reduction computation methodologies to support inclusion of carbon credits and trading for green hydrogen production and/ or green hydrogen users. [Note: China's carbon trading system does not yet extend to green hydrogen.] Results of consultations will be utilized in report and computation methodology preparation of Activity 1.3.1.

Activity 1.3.3: Promotion to authorities at provincial and/or national level and their supporting staff of the project's carbon emission reduction computing methodologies for green hydrogen (and its use, if relevant). Support to relevant organizations in developing pilot carbon trading for green hydrogen production that incorporates the methodology for carbon emissions reduction computation developed by the project.

STANDARDS

Output 1.4: "Standards tree" for the green hydrogen industrial chain and high priority standards identified, designed (including gender responsive aspects), and adopted, in the pipeline for adoption, and/or endorsed at national or group level, increasing confidence in and development pace of the green hydrogen economy.

Output 1.4a: Comprehensive "standards tree" and "standards tree roadmap" for the green hydrogen industrial chain that maps out all standards (existing and needed), covering both product standards and management, operational, and safety standards and showing the interrelation of all standards and sequence/ timeline for filling gaps, achieves industrywide consensus. [The "tree" will include not only standards handled by hydrogen-focused standards committees, but also relevant standards falling under the purview of other standards committees. The purpose of this work will be to develop a complete green hydrogen energy and resource standards system for China, covering production, storage and transportation, fuel cells, application in heavy duty vehicles, and application in hard-to-abate industrial sectors, particularly chemicals. An important aim will be to harmonize the efforts of various national standards research institutions and streamline the standardization process across the green hydrogen value chain.[6][13]]

Activity 1.4a.1: (i) Review and assessment of all relevant existing standards (at national, industry, and group levels) and standards needs related to the green hydrogen industrial chain. Work should include a map of all relevant standards both under the purview of hydrogen-focused standards committees and under other standards committees, such as those associated with the electricity, and chemical industries. It should include both product standards and management, operational, and safety standards. The work in mapping the existing standards developed by all national committees should be used to identify overlaps, gaps, and inconsistencies. The review of current standards will involve gathering and analyzing current standards from various key standards committees, including National Hydrogen Energy Standardization Technical Committee, National Gas Standardization Technical Committee, National Fuel Cell and Flow Battery Standardization Technical Committee, Fuel Cell Vehicle Standardization Technical Committee (TC114), National Automotive Standardization Technical Committee, Pipeline Pressure Vessel Standardization Committee, technical committee for HRSs (TC309), etc. (ii) Preparation of a report on findings and drafting of the green hydrogen industrial chain "standards tree" and associated roadmap. (iii) Following stakeholder input and buy-in/ consensus (via Activity 1.4a.2), finalization of "standards tree" and "standards tree roadmap."

Activity 1.4a.2: Consultations with various groups and individuals involved in standards related to the green hydrogen industrial chain, including associations and standards committees, both before preparation of the green hydrogen industrial chain "standards tree" (and its roadmap) to gather inputs and after to gather feedback on the draft. Consultations may include small group expert workshops with representatives from the identified standardization committees, relevant industry experts, manufacturers, and regulatory bodies. The aim of such workshops will be to share insights and collaborate on improvement of the formulation of the integrated standards framework so as to comprehensively and cohesively address the entire green hydrogen industrial chain. Consultations held after preparation of draft "standards tree" and "standards tree roadmap" will aim to gather suggestions for revisions and then, post-revision, achieve industry-wide buy-in via consensus of relevant technical committees, policy makers, and companies.

Output 1.4b: Management, operational, and safety standards related to green hydrogen production and its industrial chain designed (including gender responsive aspects) and adopted, in the pipeline for adoption, and/or endorsed at national or group level. [Standards provide direction for industry, eliminating confusion, and allowing for the healthy and safe development of the sector. In terms of safety, they provide evidence-based direction for the appropriate stringency of standards. When group level instead of national level standards are pursued, efforts will still be made to make such work a step towards an eventual national-level standard.]

Activities 1.4b.1-1.4b.3: For each activity listed below, respectively, work will include: (i) gathering information and carrying out expert consultation re needs in the indicated area, as well as referring to needs identified in "standards tree" of Output 1.4a and considering experience of project demo cities, city clusters, certain provinces, and other cities; (ii) drafting of needed standards or of proposed revisions to existing standards; (iii) consultations and revision of drafts as needed; (iv) promotion of draft standards to decision makers and advisors/ experts for adoption at the national or group level, as relevant. When group standards are pursued, initial steps will still be taken to get these standards recognized/ noticed at the national level for potential eventual national adoption. Note: Assessment for the standards design should consider differentiated barriers faced by women in participating in the green hydrogen value chain; and the design should include gender responsive aspects to the proposed standards.

- *Activity 1.4b.1:* Management, operational, and safety standards at group level for green hydrogen production facilities. These will include requirements both for siting and for operation/ procedures.

- *Activity 1.4b.2*: Management, operational, and safety standards at national level (first adopted at industry level) for HRSs, including stationery ones and skid-mounted, moveable ones.[7]14 Standards will include requirements both for siting and for operation/ procedures. For the latter, standards will include procedures for operation and management, method of hydrogen refueling, and method for evaluating HRS operation, as well as maximum energy consumption for HRSs and method of evaluating energy consumption. Some specific areas of interest that completely lack standards and that should be addressed, among other items, through this work include: (a) technical specifications for the construction of integrated gasoline and hydrogen stations; (b) site specifications/ standards for mobile/ skid mounted HRSs.

- *Activity 1.4b.3*: Management, operational, and safety standards at group level for FCs and FCVs. In particular, group safety standards for FCVs will support the eventual adoption of national safety standards for FCVs, focusing on enhanced vehicle safety to support broader adoption and public trust. As part of step i, an analysis of existing safety, management, and operational measures and gap identification in FCV standards of such types will be conducted. For step ii, new standards covering critical aspects (in collaboration with industry and regulatory stakeholders vis-à-vis step iii) will be prepared. For step iv, the project will promote eventual integration of developed group safety, management, and operational standards into national regulations by engaging with policymakers and industry leaders, emphasizing the importance of these standards for public safety and FCV market growth. One specific operational area to be addressed is ensuring the purity of hydrogen used in fuel cells by requiring impurity analysis/ purity testing of hydrogen at the fuel cell or HRS to ensure the stack is not damaged and, relatedly, standards on how to determine hydrogen fuel impurities. This will require research to establish a standardized methodology for identifying the impurities in hydrogen fuel and involve collaboration with industry experts and scientists to ensure rigorous yet achievable standards taking into account existing impurity analysis / determination standards.

Activity 1.4b.4: As relevant, promotion to relevant international standards organizations of selected management, operational, and safety standards established at the group or national level through the project's Activities 1.4b.1 to 1.4b.3.

<u>*Output 1.4c*</u>: Product standards related to green hydrogen production and its industrial chain designed (including gender responsive aspects) and adopted or in the pipeline for adoption at national level and group level[8]15 (some of each, respectively). [Standards provide direction for industry, eliminating confusion, and allowing for the healthy and safe development of the sector. For standards pursued at the group level, the project will still aim to set the stage for eventual adoption at the national level.]

Activities 1.4c.1 – 1.4c.5: For each activity below, respectively, work will include: (i) gathering information, conducting research if needed, and carrying out expert consultation re standards needs in the indicated area, as well as referring to needs identified in "standards tree" of Output 1.4a, and assessment of whether national level or group level standards should be pursued if not indicated specifically in the activity; (ii) drafting of needed standards or of proposed revisions to existing standards; (iii) consultations and revision of drafts as needed; (iv) promotion of draft standards to decision makers and advisors/ experts for adoption at the national or group level, as relevant. In all cases, the project will cooperate with national standards agencies to develop the standards. In

the case of pursuit of group standards, the project will still aim to set the stage for eventual adoption at the national level. Note: Assessment for the standards design should consider differentiated barriers faced by women in participating in the green hydrogen value chain; and the design should include gender responsive aspects to the proposed standards.

- *Activity 1.4c.1:* Standards for both alkaline and PEM electrolyzers that set the bar for lifespan/ lifetime performance, efficiency, and safety. [These standards will set the requirements for performance in specific environments and include indicators to cover life span/ life cycle, green hydrogen production efficiency, and safety.]

- *Activity 1.4c.2*: Standards for containers used in hydrogen storage and transport and standards/ approval for the use of certain types of storage in FCVs. Currently China mainly uses 20 mPa long-tube trailer for hydrogen transport. To lower costs, better methods vis-à-vis containers are needed, including: (a) higher pressure gas containers and, in particular, Type IV cylinders for hydrogen; (b) containers holding hydrogen in liquid state; (c) containers holding hydrogen in solid state; and (d) hydrogen pipeline transport.[9][16] And, for each of these, national level standards (or group standards, as a step towards eventual national standards) may be needed. Universal standards are needed for the containers in each case to ensure safety. In the case of Type IV containers, new standards for the product will come into effect June 1, 2024. Yet, additional work is needed for approval of FCV models designed to use them. (While some Chinese manufacturers, at the time of drafting of these activities in April 2024, had received approval to produce Type IV cylinders, there was not yet a market for these cylinders as they were not yet being used in FCVs at the time of project design, due both to the standard not yet being in effect and lack of approval for use of the cylinders in vehicles.)

- *Activity 1.4c.3*: New or improved fuel cell related standards, particularly one addressing fuel cell stack lifetime and efficiency. [There is a need for fuel cell stack evaluation systems for different applications (e.g. cars, heavy duty vehicles, light duty vehicles, power, heating systems) to set the required lifetime and efficiency, so as to foster industry-wide consistency and enhance fuel cell technology reliability. Currently, companies produce products using their own standards, but there are no cross-company, universal standards.] For this activity, step iv promotion efforts will involve fuel cell manufacturers, vehicle producers, energy suppliers, and regulatory bodies. Promotion will include presenting the standards at industry conferences, publishing them in relevant professional outlets, and working with regulatory agencies to integrate these standards into national regulations (or to develop group standards that will be primed to eventually be integrated into national regulations).

- *Activity 1.4c.4*: New or improved product standards related to equipment for HRSs.

- *Activity 1.4c.5*: New or improved standards for key parts or systems of FCVs that currently lack standards or need improvement in their standards, with emphasis on heavy duty FCVs. [Some key parts and systems of FCVs still lack standards, such as the onboard hydrogen storage system. There is a need for related standards, such as standards for leak detection.]

Activities 1.4c.6 – 1.4c.7: Identification and action as relevant on additional national-level and group level product standards for which need is determined during project lifetime. An emphasis will be put on hydrogen-related standards for hard-to-abate industrial sectors, as needed, particularly chemicals. For each activity, respectively, follow up on potential standards identified will include:

(i) Assessment of proposed/ identified standards and selection of high priority/ high potential ones;

(ii) Gathering information, conducting research if needed, and carrying out of expert consultations;

(iii) Determination of whether national level or group level standards should be pursued if not indicated specifically in associated recommendation;

(iv) Drafting of needed standards or of proposed revisions to existing standards, including gender responsive content as relevant;

(v) Consultations and revision of drafts as needed;

(vi) Promotion of draft standards to decision makers and advisors/ experts for adoption at the national or group level, as indicated, respectively. (For group level product standards pursued, efforts will still be made to set the stage for eventual adoption at the national level.)

- *Activity 1.4c.6:* Product standard needs identified via project outreach to industry regarding their input on which standards are needed. (Conducting of outreach to industry and then items (i) – (vi) above.)
- *Activity 1.4c.7:* Other product standard needs identified during years 2, 3, 4, and 5 of the project via identification of new barriers and new needs arising or becoming more apparent or timely during project implementation. Also, promising standards emerging out of review of experience of project demo cities, city clusters, certain provinces, and other cities as relevant. (Identification of barriers and needs and then items (i) – (v) above.)

Activity 1.4c.8: As relevant, promotion to relevant international standards organizations of selected product standards established at the national or local level through the project's activities 1.4c.1 to 1.4c.7.

INSTITUTIONAL SUPPORT / SECTOR-BASED POLICIES AND PLANS IN HARD-TO-ABATE INDUSTRIAL SECTORS

Output 1.5: Ongoing support from planners, regulators, and associations of relevant hard-to-abate industrial sectors for development of the green hydrogen industrial chain, manifested as green hydrogen supporting content in their policies, regulations, and industry plans in their respective sectors, with gender responsive content as relevant. [Special emphasis will be put on the chemicals sector.]

Activity 1.5.1: Outreach to those responsible for planning and regulations in various hard-to-abate industrial sectors (particularly chemicals), which might include ministries, commissions, and quasi-government associations, to encourage them to include green hydrogen supporting content in their policies, regulations, and industry plans. Assistance to these entities, as needed, in actually drafting green hydrogen content to incorporate into their sector policies, regulations, and/or plans. This work may draw on the report prepared as a part of Activity 1.6b.2. Note: Assessment for relevant planning, policy, or regulatory content should consider differentiated barriers faced by women in participating in the green hydrogen value chain; and the design of these items should include gender responsive aspects.

INFORMATION AND DATA PRODUCTS

Output 1.6: Project information and data products provide evidence and insights along the entire green hydrogen value chain, becoming materials that can increase confidence, know-how, and momentum for the green hydrogen economy in China and abroad.

Output 1.6a: Project demo results and cost[10]17 and technical analysis thereof are prepared in reader friendly fashion so that interested parties in China and abroad can understand the bottom line of project achievements, creating potential for replication. [This output addresses the lack of publicly available information across the entire green hydrogen value chain in China, which is really needed to support the strong interest in green hydrogen projects across the nation. The data and information will cover commercial aspects and operating data, such as fault/ failure / malfunction data, accident data, safety aspects, etc.[11]18 This report will be shared with interested national and international parties as a part of information dissemination work of Outcome 4. Findings on cost and technical viability may also serve as input to work under Output 1.6b. Sharing of data will differentiate this project from others in the green hydrogen industrial chain space in China and thus provide great benefit to the industry.]

Activity 1.6a.1: Carrying out of liaison with demo cities and companies to ensure that accurate data showing technical results of work and costs of production/ operation and information about successes, challenges, and lessons across the entire green hydrogen value chain are shared with the PMU. This will include identifying which kind of data will be most useful in showing cost and technical viability (or progress towards technical and cost viability). Collecting of information from demo cities on a periodic basis. Note: While demo data will be shared, work will be done to eliminate data considered "business secrets," such as details of core technologies, and also to ensure data security in the process of data collection via data platform from the FCVs and HRSs in each city. Concrete costs of investment/ equipment will be provided. If operational costs are not provided due to business competitiveness issues, they may be estimated as part of Activity 1.6b.2. Project will differentiate itself from other efforts in the extent of data shared and benefits to the overall industry.

Activity 1.6a.2: Carrying out of analysis of demo city data and information provided, assessing costs and return on investment, as well as achievements in technical performance. Preparation of reader friendly reports that clearly show the progress towards cost and technical viability. Reports should also explain innovations, including technical innovations, business model innovations, and policy innovations, and assess their effectiveness. [Notes: This work may include estimates of operational costs, if not provided by project demo entities. Reports will be disseminated as a part of information dissemination work under Outcome 4.]

Output 1.6b. Studies/ publications on costs, technical viability, and experiences of: green hydrogen production, its use in hard-to-abate industrial sectors, and its use in FCVs in heavy duty fleets available to inform various industry players, potentially resulting in increased momentum to move forward with green hydrogen industrial chain projects.[12]19 [In the case of heavy duty FCVs, this work may include information on the total cost of ownership (TCO), TCO curves for different localities, and time to "break-even" as compared to ICEVs, considering the impact of national and local subsidies.] [Notes: This output may draw from results on cost and technical viability of the project demos as reported under Output 1.6a. Reports prepared under this output will be disseminated under Information Dissemination work of Outcome 4.]

Activity 1.6b.1: Carrying out of study on the cost of green hydrogen production and on technical issues in production. Identification of levers for cost reduction and forecast of future costs. Preparation of report and recommendations.

Activity 1.6b.2: Carrying out of study on the potential use of green hydrogen in hard-to-abate industrial sectors, including cost and technical analysis, along with experience to date and key areas for attention to improve viability. Preparation of report and recommendations. This work, in addition, will include an assessment of the current and future expected breakdown of all hydrogen use in China among various end uses, such as the primary end uses of methanol, ammonia, and other petroleum refining. It will also include an assessment of the ultimate end use sectors such as agriculture (for ammonia), building materials (for methanol), etc., coming up with estimates of what share of current and future hydrogen supply goes to each ultimate end use sector. This information can later be used under Outcome 4 to promote green hydrogen as one decarbonization pathway for various ultimate end use sectors, with quantification of how much hydrogen is currently going to each ultimate end use sector and what is expected to happen in the future with each such sector.

Activity 1.6b.3: Carrying out of study on the use of green hydrogen in fuel cells and heavy duty fuel cell vehicles, including cost and technical analysis and related future trends in the FC and heavy duty FCV sectors. This will include an assessment of how and where to develop low-cost hydrogen transport corridors. Preparation of report and recommendations.

Activity 1.6b.4: Carrying out of study on novel business models, technical innovations, and policy innovations domestically and abroad upstream and downstream in the green hydrogen value chain. [Note: Some of the innovations may be featured in the project demos, but the aim of this activity is to collect innovations from other projects as well.] Preparation of report and recommendations. This work should be done early in the project. Findings may feed into policy work of Outputs 1.2 and 1.3, business model work of Output 1.8, innovation work of Output 2.4, entrepreneurship work of Output 1.8, or even the project demos.

Activity 1.6b.5: Gathering of information and data on other cases of green hydrogen industrial chain projects (besides the project demos) and compiling of case studies and lessons learned document. Project will liaise with other green hydrogen industrial chain projects to encourage their participation in an information sharing platform of Activity 4.5.4 and/or consultations so that their results and learnings can be developed into useful case studies for the industry, while they may also benefit from the promotion of their activities.

<u>*Output 1.6c*</u>: *Annual Global Green Hydrogen Development Review* published for at least three years in cooperation with the GEF Green Hydrogen global program, reaching wide audience, such that industry development benefits from dissemination of included information.

Activity 1.6c.1: Identification of target audience for *Annual Global Green Hydrogen Development Review* and assessment of content to be included that would be most beneficial in supporting green hydrogen industrial value chain development. Outreach for feedback on content after first review is issued. This target identification and content assessment work will be carried out in cooperation with the GEF Green Hydrogen global program.

Activity 1.6c.2: Drafting of *Annual Global Green Hydrogen Development Review* (at least three annual versions) and dissemination to target audiences in China and internationally. This work will be carried out in cooperation with the GEF Green Hydrogen global program, with the China project taking the lead in contributing information on the progress occurring in China and other regions, as relevant.

Activity 1.6c.3: In cooperation with the GEF Green Hydrogen global program, development of mechanism/ exit strategy to ensure yearly publishing of *Annual Global Green Hydrogen Development Review* continues post-project.

REPLICATION PLANS AND SCALE-UP PLANS

<u>Output 1.7</u>: Plans for replicating, extending, and scaling up the project's green hydrogen industrial chains and related activities in China and abroad are developed, documented, and receive funding or other strong signals of commitment for realization.

<u>*Output 1.7a*</u>: Plans for replicating the project's demo green hydrogen industrial chains in other Chinese cities and abroad, as well as plans for scaling up green hydrogen industrial chains in the demo cities and/or elsewhere, developed, documented, and receive funding or other strong signals of commitment for realization. [This output will include work to support various cities or related entities in developing plans for green hydrogen full industrial chain demonstration. There will be outreach to and support of other cities in China and cities in other developing countries (particularly the GEF Green Hydrogen global program countries) to replicate the Project demos and develop green hydrogen industrial chain projects of their own. The Project will aim to support them in developing projects that are likely to be realized. In terms of scale-up, the Project will support its demo cities in designing plans to scale-up their demos and move progress forward towards realization. The Project will also support a cross-region scale-up plan that uses the demand pull of scale-up of the heavy duty FCV population in an Eastern developed area to much larger scale than currently exists in order to create the needed demand for a green hydrogen pipeline from a renewable energy resource rich inland region of the nation.]

Activity 1.7a.1: Carrying out of outreach to various cities and companies in China regarding their interest in developing green hydrogen full industrial chain projects, replicating the Project demos. Providing of support to selected cities in designing green hydrogen industrial chain plans and coordinating partners, so as to achieve progress towards realization.

Activity 1.7a.2: Carrying out of outreach to promising developing country cities and companies abroad regarding their interest in developing green hydrogen full industrial chain projects, replicating the Project demos. Providing of support to selected cities in designing green hydrogen industrial chain plans and coordinating partners, so as to achieve progress towards realization. This activity will focus on high potential cities/ countries identified and will leverage synergies with the concurrent GEF Green Hydrogen global program, which supports green hydrogen development in ten developing countries and, like this project, has UNIDO as its GEF Implementing Agency. The activity will also leverage the support of the International Communications Expert in pursuing international replications of *China Green Hydrogen* project demos.

Activity 1.7a.3: Developing plans for scale up of green hydrogen industrial chains in each of the demo cities of Ningdong, Ningxia Province, Shenyang, Liaoning Province, and Dalian, Liaoning Province. Coordinating partners and supporting other steps to move the scale-up plans towards realization.

Activity 1.7a.4: Developing a plan for cross-region green hydrogen industrial chain with scale-up of the heavy duty FCV population in a developed area in East China to much larger scale than currently exists in order to create needed demand for a green hydrogen pipeline from an inland region that is rich in renewable energy resources. The aim is to have the larger number of vehicles/ demand needed to support the pipeline infrastructure. Energy companies, it is believed, will not be attracted to investing in a hydrogen pipeline until scaled up demand justifies it. Coordinating partners and supporting other steps to move the scale up plans towards realization.

<u>*Output 1.7b*</u>: Plans for an extensive national green hydrogen highway network, as replication and scale-up of project's ShenDa hydrogen highway, developed and achieves approval and financing (or strong signals of likely financing) at the national level.

Activity 1.7b.1: Analysis of Shenyang-Dalian green hydrogen highway, covering infrastructure (i.e. HRSs), technology/ heavy duty vehicles, and policy mechanisms. Identification of key successes and challenges, including policy levers, such as toll-free passage and right of way (permission to use roads at certain times of day). Assessment of how to adapt the green hydrogen highway concept and tools to other regions in China. Based on findings of this work and of consultations of Activity 1.7b.2, development of recommendations for national implementation of a green hydrogen highway network. Recommendations will address infrastructure development, technology standardization, vehicle scenarios, policy incentives, and environmental and safety considerations. Based on all of the foregoing, formulation of a policy brief and supporting report, including a roadmap for implementation and monitoring framework.

Activity 1.7b.2: Engagement with stakeholders at various levels (local, provincial, national) and across various sectors (government, industry, academia) to gather insights and support for the development of a national-level green hydrogen highway framework. Facilitation of workshops and roundtable discussions to collect and build on diverse perspectives and recommendations.

Activity 1.7b.3: Promotion of the national green hydrogen highway plan through targeted outreach to key government entities, policymakers, and their advisors at the national level. This may include one-on-one efforts and/or organization of advocacy meetings, presenting the benefits and feasibility of the recommendations, and facilitating discussions on integrating these into existing national energy and infrastructure planning initiatives. Efforts may also include promotion and support for planning at the provincial level, so that provinces may adopt green hydrogen highway plans, while the national plan is developing in the pipeline.[13][20]

Output 1.7c: China's national hydrogen city cluster demonstration program[14][21] officially expanded to include more city clusters and city clusters in more regions, to emphasize green hydrogen, to include hard-to-abate industrial sectors (especially chemicals) as well as heavy duty vehicles in the applications, and to increase scale within each city as compared to previous demonstrations, with national funding and national incentive policies confirmed.

Activity 1.7c.1: Preparation of report with recommendations and associated policy brief via the following steps: (i) Based on documentation of cluster city results and findings of consultations of Activity 1.7c.2, evaluation of outcomes and framework of existing city cluster demos. Identification of strengths, weaknesses, and scalability potential. The evaluation will serve as foundation for understanding how to expand the initiative and increase impact. (ii) Considering results of step i and Activity 1.7b.2, development of a set of recommendations for relevant ministries on expanding China's hydrogen city cluster demos and incentivizing larger-scale vehicle demonstration, inclusion of green hydrogen, and inclusion of hard-to-abate industrial sectors (particularly chemicals). Recommendations should include criteria for city selection and proposed national-level incentives (financial, regulatory, and technical support) to encourage participation. They should also include mechanisms for monitoring and evaluating the impact of these demos. In terms of specific vehicle applications, the recommendations may include the most promising use scenarios, such as public bus routes with long routes and limited time for refueling and with fleets due soon for replacement (with future policy perhaps including zero carbon targets for public bus systems), cold chain transport heavy duty vehicles that follow relatively fixed routes and park in the same place each night near cold storage facilities (perhaps supported by right of way policies), and long-distance fixed-route truck logistics (perhaps supported by toll-free benefits). There may be new incentives to support establishment of HRSs or mobile HRSs in locations needed for the use scenarios, such as suburbs for the heavy duty cold storage vehicles, or loosening of requirements to make HRS investments more attractive. Such HRS related actions may be an important addition to cluster city strategy, as, to date, cluster city support has focused on hydrogen and FCVs, but not HRSs. (iii) Development of effective policy briefs and presentations tailored to the needs of decision-makers and policy influencers. The briefs should outline the benefits of expanding the city cluster demos and the positive effects of scaling up heavy duty FCV deployment (economic, social, and environmental advantages) and of including a green hydrogen focus and adding in activities for hard-to-abate industrial sectors. They should outline the recommendations for effective scale-up of the hydrogen city cluster program.

Activity 1.7c.2: Liaison with representatives from: cities that are potential new participants in the city cluster program, cities of existing clusters, government, industry, and academia to gather insights on interest, readiness, and requirements for successful expansion of the hydrogen city cluster program. This will involve identifying cities and clusters of cities with the potential infrastructure, economic conditions, environmental policies, and leadership culture conducive to replication and scale-up of green hydrogen focused heavy duty FCV demonstrations, green hydrogen production, and use of green hydrogen in hard-to-abate industrial sectors. This item may build on city-by-city project replication outreach of Activity 1.7a.1.

Activity 1.7c.3: Refinement and promotion of expansion plan for national hydrogen city cluster demo program with newly added green hydrogen focus. Organization of a workshop and discussions with stakeholders from government, industry, and academia/ research institutes to refine and promote the plan. Final promotion campaign focusing on national government decision makers and their supporting staff and advisors for adoption of the expanded city cluster program.

INNOVATION AND BUSINESS MODELS

Output 1.8: New, profitable business models and innovations for various links in the green hydrogen industrial chain nurtured and implemented, with gender responsive considerations addressing barriers faced by women entrepreneurs, supporting viability and growth of the industry.

Output 1.8a: New and profitable business models for various links in the green hydrogen industrial chain developed and implemented, with gender responsive considerations addressing barriers faced by women entrepreneurs, supporting scale-up of the industry.

Activity 1.8a.1: Consultations with business persons, experts, and policy makers and review of relevant documents/ articles to identify promising business models that, when combined with supportive policy, will yield profitable ventures along the green hydrogen industrial chain, including green hydrogen production/ sale, hard-to-abate industrial sector applications, HRSs, and heavy duty FCVs. Work should also draw on findings of novel business models from Activity 1.6b.4. Preparation of summary listing and elaborated description/ explanation of business models identified.

Activity 1.8a.2: Promotion of promising business models identified under Activity 1.8a.1 to enterprises and investors that may have an interest in implementing them. Work will be carried out with gender responsive approaches, considering the differentiated barriers women face in business.

Activity 1.8a.3: Implementation of promising business models identified in Activity 1.8a.1 and promoted in Activity 1.8a.2.

Output 1.8b: Entrepreneur training courses, with gender responsive aspects addressing barriers faced by women entrepreneurs, support success of innovative technology business ventures and innovative business model ventures along the green hydrogen industrial value chain.

Activity 1.8b.1: Preparation of content for entrepreneur training courses in the green hydrogen industrial value chain sector. Courses to include segments of active learning, where attendees prepare items, such as business plans, for later use. Content should draw, in part, from findings on novel business models and technology innovations from Activity 1.6b.4 and Output 1.8a. Content will consider the differentiated barriers women face in starting a business, such as access to financing, and include gender responsive aspects accordingly.

Activity 1.8b.2: Identification and outreach to suitable candidates for green hydrogen industrial value chain entrepreneur training courses. Work will include emphasis on ensuring women entrepreneurs are well-represented.

Activity 1.8b.3. Delivery of green hydrogen industrial value chain entrepreneur training courses.

Component 2: Demos and Innovation

Outcome 2: Demonstration of complete green hydrogen value chains successfully realized, featuring innovative technologies and approaches and showing improved technical and cost viability as compared to baseline, including green hydrogen production, its storage and transport, and its use in hard-to-abate industrial sectors and in various heavy duty vehicle types and scenarios (supported by hydrogen refueling stations).

Rationale of Outcome 2: Outcome 2 is justified by the lack of sufficient demonstration of complete value chains covering both green hydrogen production and its use in a range of applications, namely hard-to-abate industrial sectors, such as chemicals, and a range of heavy duty vehicle applications. Lack of complete value chain demonstration, in turn, correlates with a lack of green hydrogen projects that involve multiple companies instead of just one as hydrogen producer and user. And, despite the many green hydrogen projects in the pipeline or the lower number already realized, there is a lack of data and information on their costs and technical achievements to guide those who are planning or might consider planning such projects. High costs and technical challenges present strong barriers to the green hydrogen industry and its value chain. As such, there is a need for innovations in technologies, business plans (to bring economic returns in the face of high costs), and policies (ideally, new and different from what has been done before) to achieve lower costs and higher technical performance so that the industry can be scaled up. Demonstration via this GEF project allows the opportunity to test such innovations, collect data and information on results, and share these with those who may replicate them. Alongside the innovation, it will be important to monitor demo safety.

Notes on financial viability and environmental sustainability of Outcome 2 demos: (1) Each of the Outcome 2 demos will ensure financial viability of the green hydrogen for the lifetime of the installed equipment via various means, such as long-term off-take agreements and incentives subsidies to either the green hydrogen producer or the green hydrogen purchaser, so that returns on green hydrogen or its price will be at parity or even more attractive those aspects of grey hydrogen. Further, the project will sign contracts with participating companies that require, as relevant, the use of green hydrogen only. Field visits will periodically confirm compliance. (2) In terms of environmental sustainability a number of steps will be taken: (a) The project will ensure that no power from a fossil fuel (or partially fossil fuel) power grid will be used in the production of green hydrogen. (b) The project will ensure water used in electrolysis is sourced sustainably, including its supply, transport, and, in the case of Dalian, energy source for desalinization. (c) All intermediate and final products related to the consumption of the project's green hydrogen will be mapped. The green hydrogen will be used to replace fossil fuels. (d) For the production of intermediate products (particularly ammonia and methanol), it will be ensured that the green hydrogen is used in energy efficient and resource efficient production processes. Further, there will be monitoring of ultimate end uses, when possible. And, in association with these ultimate end uses, work will be done to assure that green hydrogen is the best pathway towards these final end uses in terms of energy and resource efficiency. Brief reference to these measures (1 and 2a, b, c, and d) is included in the project activities, as relevant.

Note on design process for Outcome 2: In-depth work and planning in close coordination with the demo cities and their participating companies were conducted prior to submission of the full project design. This approach reflects lessons learned from prior GEF projects in China involving hydrogen. Those lessons stress the importance of developing strong commitment from demo cities so they will stay the course with the project through its full lifetime. They also stress the importance of working out as many of the demo details in advance, so that the project will be as implementation ready as possible and not suffer delays due to uncertain direction. Both of these two lessons were adopted in the detailed planning work conducted with the cities prior to submission of this document.

Note on ensuring use of green hydrogen in demo end use sectors: The project will sign demo contracts with involved enterprises at the start of project implementation. For hydrogen purchasing enterprises, the contracts will clearly stipulate the requirement of using green hydrogen. The demo projects will undergo annual assessments to ensure compliance. Thus, in the case of the demos, the "subsidize before" approach will still effectively guarantee the use of green hydrogen while helping in the development of a complete green hydrogen industrial chain. The "subsidize after" approach is considered too advanced for the demo cities given the nascent nature of their green hydrogen industrial chains.

Note on demo city selection: The cities of Ningdong, Shenyang, and Dalian were selected for the following reasons: Given the current high cost of hydrogen transport, this green hydrogen project is designed to demonstrate full green hydrogen industrial chains, where the links of the chain are co-located in single cities or single cities and their surrounding areas, such that the hydrogen does not have to be transported long-distance. Thus, cities that have sites for potential large-scale renewable energy based power generation are needed to provide isolated grid green power for green hydrogen production. Further, the project aims to demonstrate green hydrogen industrial chains in less developed parts of the country – the Northwest (where Ningdong is located, in Ningxia Province) and Northeast (where Shenyang and Dalian are located, both in Liaoning Province). In addition, locales where there was limited development of FCVs were selected, so that the demos could support initial ramp up in this end use. The project invited proposals from interested cities and selected those cities with strong proposals that showed a commitment to following through with promised demos and providing the needed co-financing. Company partners were selected by the demo cities themselves, based on the companies' level of commitment and suitability of their proposed involvement to the project objective. This includes the selection of chemical off-takers in Ningdong and Shenyang, which are motivated to make use of green hydrogen due to anticipation of zero carbon targets and/or attractive markets for green chemical products.

Output 2.1: Demonstration of a complete green hydrogen industrial chain in Ningdong, Ningxia Province, shows improved technical performance and reduced costs as compared to baseline and covers green hydrogen production, its storage and transport, use of green hydrogen in a hard-to-abate industry (chemicals industry), and use of green hydrogen in heavy duty truck scenarios supported by HRSs, featuring innovations across the value chain which lead to this enhanced viability. [Annex K provides more details on the plans, including activities and targets, for the Ningdong demo. The Ningdong demo is comprised of a main demo with supporting sub-projects, as well as a possible phase two demo and possible partner projects.]

NINGDONG – MAIN DEMO

Activity 2.1.1: *Green power and green hydrogen production*: Constructing of two solar PV installations - a 120 MW isolated grid to support green hydrogen production at two sites, a 500 MW grid connected system to profitably sell green power and, thereby, within the green power/ hydrogen production company, offset the high cost/ low profitability of green hydrogen production. If future policy changes allow, the 500 MW system may also be connected to hydrogen production as a backup power source. Developing of two campuses for the production of green hydrogen, one having 16 alkaline electrolyzers of 1,000 Nm^3/hr (standard cubic meter per hour) capacity each and the other with 5 alkaline electrolyzers of 1,000 Nm^3/hr capacity each, together with expected yield of green hydrogen of 4,541 tons per year. Green hydrogen from the larger hydrogen production plant is sold to the chemical factory next door (estimated 3,081 tpy) and that from the smaller plant (estimated 1,460 tpy) is sold to two HRSs, one of which is right next door to the smaller hydrogen production plant. Special upstream innovations or technical/ cost achievements will include:

- Business model in which profits generated from sales of renewable energy-based electricity to the grid offset high costs/ losses associated with production of green hydrogen.
- Lower cost of alkaline electrolyzer per unit hydrogen produced as compared to previous demonstrations, reflecting cost reductions and higher efficiency in terms of m^3 hydrogen output per kilowatt-hour (kWh).
- Electrolyzer management system (by turning off some electrolyzers and keeping others on) allows production to continue when solar PV output varies and when it is as low as 20% of capacity or as high as 110%. The custom-made Energy Management System (EMS) supports the hydrogen production system in responding to changes in PV power output.
- One-click start and stop alkaline electrolyzers, the benefit of which are improved voltage control (needed due to variability of renewable energy based power generation), producing hydrogen with less power, and providing production data (pressure, temperature, volumes, viscosity, density) all with automated control, new in China, are demonstrated.
- Ex-factory cost of green hydrogen of 20 yuan per kg achieved, lower than most other efforts.
- Long-term financial viability of the green hydrogen production assured via various measures, such as off-take agreements at a price that will ensure profits commensurate with grey hydrogen profits for the green hydrogen producer and/or incentive subsidies for either the producer or the purchaser, if needed, to ensure parity or better as compared to grey hydrogen.

Activity 2.1.2: Storage and transport of green hydrogen: Transporting of green hydrogen from larger hydrogen production facility to neighboring chemical facility through 800 m stainless steel pipeline/ piping. Large hydrogen "buffer" tank on site at hydrogen production facility allows for adjustments in flow. Green hydrogen from smaller hydrogen production facility transported via piping to nearby HRS and shipped via long tube trailer trucks to other HRS about 30 km away.

Activity 2.1.3: *Use of green hydrogen in chemical industry*: Replacing of "grey hydrogen" with green hydrogen in ammonia production by an existing chemical plant next door to the larger of the two green hydrogen production facilities. The green hydrogen production facility will notify the customer in advance of changes in green hydrogen output, so that the customer can take action with regard to other hydrogen sources to maintain stability of production. The customer emits much CO_2, so use of green hydrogen for a portion of its demand is desired to reduce CO_2 emissions. Special results that will be demonstrated:

- Use of O_2 that is "by-product" of green H_2 production (via electrolysis) in chemicals industry.
- Demonstration of stable supply of green hydrogen to chemicals plant by various means, such as storage and replacement with grey hydrogen when needed. [Stable supply is one of the greatest concerns of the industry re replacing grey H_2 with green H_2.]

Activity 2.1.4: *Green hydrogen HRSs:* Establishing two HRSs that use exclusively green hydrogen and are supplied by the small hydrogen production facility, which is next door to one of the HRSs. These stations are in addition to two existing stations in Ningdong that have been using grey hydrogen. The station next door to the HRS will have refueling capacity or 3 t/ day, while the other new HRS will have capacity of 1 t/ day.

Activity 2.1.5: Heavy duty fuel cell vehicles powered by green hydrogen: Deployment of 200 new heavy duty fuel cell trucks that are powered exclusively by green hydrogen. Special achievements will include:

- Demonstration in a portion of the heavy duty vehicles in their fuel cell stacks the successful use of newly domestically produced parts, such as membrane, catalyst, and carbon paper in fuel cells, thereby achieving cost reduction.
- Demonstration of improvements in fuel cell stack power density and reliability (to meet targets set by project).

Activity 2.1.6: Monitoring platform and collection of Ningdong demo data: Establishment and operation of a digital monitoring platform for all key nodes of the Project in Ningdong including RE power generation, green hydrogen production, storage and transport, use by chemical industry, HRS refueling, and heavy duty FCV operation. Through use of this platform and other means, the Project will collect data from the Ningdong demo that allows analysis of cost improvements and technical performance improvements by introductions of new technologies and procedures.

- By virtue of including upstream links of the value chain (e.g. RE power generation, green hydrogen production, transport, and storage, etc.), this work has the potential to present new types of data to the public, which may help in the development of the green hydrogen industrial chain.

Activity 2.1.7: Local policy incentives: Designing, refining, and adopting local policy incentives in Ningdong City for various links in the green hydrogen industrial chain. Testing of these local policies as pilots. [GEF funds will support only those policies that are specific to green hydrogen.]

Activity 2.1.8: Safety and environment: Rollout of a safety and environment program for all links in the green hydrogen industrial chain in Ningdong to ensure that enterprises have access to the latest information, safeguard parameters, and occupational, safety, and environment measures for incorporation into their safety and environmental programs. This activity will be advised by the Project Safety and Environment Specialist. Among other aspects, the environment program will ensure: (a) grid-based power that has fossil fuel component is not used to produce green hydrogen; (b) water used in electrolysis is sourced and transported sustainably; (c) mapping of all intermediate and final products related to consumption of the green hydrogen, that the green hydrogen replaces fossil fuels, and that the green hydrogen is not used to transport fossil fuels or fossil fuel vehicles or parts; (d) for production of intermediate products (e.g. ammonia and methanol), assurance that the green hydrogen is used energy and resource efficiently in production processes, that there is monitoring of ultimate end uses (when possible), and that it is assured that green hydrogen is the most energy and resource efficient pathway towards the ultimate end product.

POSSIBLE ADDITIONAL NINGDONG DEMOS

Activity 2.1.9: *Additional demos*: Additional demos that may, if realized, fall under the Project via synergies with Project activities include: (a) Phase 2 of the above demo. Design includes 200 MW isolated grid electricity to power green hydrogen production, along with 100 MW grid-connected PV to generate revenues and, ideally, provide back-up power to green hydrogen production if allowed. Green hydrogen production capacity will be 20,000 m^3/ hr. Phase 2 plans calls for some PEM electrolyzers to help deal with intermittency of renewable energy-based power generation. All of the green hydrogen is earmarked for sale to the chemical industry. Innovations or advancements associated with PEM technology outlined below. At this point, it is unclear whether Ningdong Phase Two will be realized. The project will not put specific efforts into its realization, but, in the case it is realized, the project will provide support for detailed monitoring, viability assessment, and promotion of results so as to stimulate replication.

(b) Another roughly 55,000 tons per year (tpy) green hydrogen is targeted for development by other partners in Ningdong, including the private sector, and planned to be sold into or otherwise used in the chemicals industry. Notable aspects include:

- Demonstration of PEM electrolyzers used for large-scale production of green hydrogen, raising energy efficiency and utilization of power generated, given PEM electrolyzers' ability to handle voltage fluctuations of renewable energy-based power generation, not needing to be shut off as the power generated drops.
- Achievement of lower cost of PEM electrolyzers as compared to previous demonstration.

Output 2.2: Demonstration of a complete green hydrogen industrial chain and other demos and subprojects in Shenyang, Liaoning Province, shows improved technical performance and reduced costs as compared to baseline and covers green hydrogen production, its storage and transport, use of green hydrogen in chemicals production, and use of green hydrogen in promising heavy duty vehicle scenarios supported by HRSs, featuring innovations across the value chain which lead to this enhanced viability. [Annex L provides more details on the plans, including activities and targets, for the Shenyang demo.]

SHENYANG MAIN DEMO/ PHASE ONE

Activity 2.2.1: *Green power and green hydrogen production*: Constructing of 50 MW wind power station to support green hydrogen production nearby with combination of alkaline and PEM electrolyzers. Annual hydrogen output will be 2,000 tpy. A portion of the hydrogen will be sold to HRSs to supply the heavy duty vehicle sector, while the rest will be used by the green hydrogen producer in its chemicals production nearby. Profitability of green chemical sales (by same company that generates renewable energy-based power and produces green hydrogen) will, due to demand for low carbon petrochemicals, offset the high cost of green hydrogen production, leading to overall positive returns on investment. Special upstream innovations or technical/ cost achievements will include:

- Wind power based production of green hydrogen
- Lower cost of alkaline electrolyzer as compared to previous demonstrations
- Demonstration of PEM electrolyzers used for large-scale production of green hydrogen, raising energy efficiency and utilization of RE power production, given PEM electrolyzers' ability to handle voltage fluctuations of renewable energy-based power generation, and not needing to be shut off as the power generated drops.
- Achievement of lower cost of PEM electrolyzer as compared to previous demonstrations
- Achievement of green hydrogen production cost (ex-factory) of less than or equal to 11 RMB per kg and lower than previous efforts.
- If needed, long-term financial viability of the green hydrogen production assured via various measures, such as off-take agreements at a price that will ensure profits commensurate with grey hydrogen profits for the green hydrogen producer and/or incentive subsidies for either the producer or the purchaser, if needed, to ensure parity or better as compared to grey hydrogen.

Activity 2.2.2: Storage and transport of green hydrogen: Construction and operation of holding tanks at the wind-based green hydrogen production facility so the flow out of the facility can be adjusted. Transfer of green hydrogen from production facility to nearby chemical production facility by piping. Shipping of green hydrogen sold to HRSs by long tube trailer trucks. Will demonstrate truck tubes with pressure of 50 mPa if possible (the norm is 30 mPa) to reduce shipping costs. Innovative/ cost reducing measures:

- Higher pressure (50 mPa instead of 30 mPa) tubes on trailer trucks for shipping green hydrogen to HRSs, reducing costs.

Activity 2.2.3: *Use of green hydrogen in chemical industry*: Use of a large portion of the green hydrogen to replace of "grey hydrogen" in the production of ammonia and methyl alcohol by the same company producing the green hydrogen. Both export and domestic use of these green chemical products.

Activity 2.2.4: *Green hydrogen HRSs:* Establishing of four HRSs that use exclusively green hydrogen and are supplied by the green hydrogen production facilities of the Project. Two will be in Shenyang and the other two on the ShenDa green hydrogen highway. Efforts will be made to demonstrate higher pressure equipment at the station (70 mPa instead of the standard 35 mPa) to reduce costs. [Note: Of the HRSs to be added on the green hydrogen highway, at least one will likely be in Yingkou. Coordination with the provincial level will be required to achieve this HRS.] Innovations/ new technology will include:

- 70 mPa HRS equipment (instead of standard 35 mPa) demonstrated to reduce costs.

Activity 2.2.5: Heavy duty fuel cell vehicles powered by green hydrogen: Deployment of 200 new heavy duty FCVs fueled by the Project's green hydrogen across a range of applications with initial breakdown proposed as: at least 150 and up to 600 heavy duty trucks for the transport of goods, 50 refrigerated or stable temperature vans (4.5 ton) for the transport of foodstuffs, and 10 intelligent, networked heavy duty FCVs. Heavy duty trucks will be utilized on the "Green Hydrogen Highway" between Shenyang and Dalian, where goods may be loaded on ship for export or unloaded for import. Innovations or other important advancements will include:

- Demonstration of the benefit of heavy duty FCV operation in cold environment as compared to results with heavy duty electric vehicles in similar applications.
- Demonstration of green hydrogen fueled heavy duty FCVs on the Shenyang-Dalian Highway with incentives such as toll free passage and right of way (rights to use road at certain times) to encourage roll out of heavy duty FCVs using green hydrogen.
- Demonstration in a portion of the heavy duty vehicles in their fuel cell stacks the successful use of newly domestically produced parts, such as membrane, catalyst, and carbon paper in fuel cells, thereby achieving cost reduction
- Demonstration of improvements in fuel cell stack power density and reliability (to meet targets set by project)

(Aspects of this activity that are not specific to green hydrogen or its use will be fully co-financed.)

SHENYANG PHASE TWO DEMO

Activity 2.2.6: *Phase Two scale-up*: Phase Two scale-up will involve installation of 450 MW of wind utilized in the production of 19,000 tpy green hydrogen achieved by a combination of alkaline and PEM electrolyzers to address RE power intermittency. The green hydrogen will be utilized in the production of green methanol for both export and domestic use. This demo is considered a part of core project activities. With more financial viability than Ningdong Phase Two (given Shenyang Phase Two links to strong green petrochemical export markets), the project is likely to be realized. By providing a positive platform, GEF project activities aim to speed up its realization and provide support for detailed monitoring, assessment of technical and financial viability, and wide dissemination/ promotion of findings so as to stimulate replication projects.

SHENYANG SUBPROJECTS SUPPORTING GREEN HYDROGEN INDUSTRIAL CHAIN

Activity 2.2.7: Monitoring platform and collection of Shenyang demo data: Establishment and operation of a digital monitoring platform for all key nodes of the project in Shenyang including RE power generation, green hydrogen production, storage and transport of green hydrogen, green hydrogen use by chemical industry, HRS refueling (using green hydrogen), and heavy duty FCV operation (using green hydrogen). Through use of this platform and other means, the Project will collect data from the Shenyang demo that allows analysis of cost improvements and technical performance improvements by introduction of new technologies and procedures.

- By virtue of including upstream links of the value chain (e.g. RE power generation, green hydrogen production, transport, storage, etc.), this work has the potential to present new types of data to the public, which may help in the development of more green hydrogen industrial chains.

Activity 2.2.8: Hydrogen industry industrial park: Establishment of hydrogen industry industrial park in Dadong District, Shenyang, and the encouragement of companies providing upstream green hydrogen and downstream hydrogen end use related equipment to set up facilities in the park.

Activity 2.2.9: Local policy incentives: Designing, refining, and adopting local policy incentives in Shenyang City and Dadong District for various links in the green hydrogen industrial chain. Testing of these local policies as pilots. This may also include a provincial policy regarding toll and right of way (right to use road at certain times) on the Shenyang Dalian Green Hydrogen Highway.

Activity 2.2.10: Hydrogen Exhibition Hall: Establishment of a hydrogen exhibition hall, which will emphasize green hydrogen and which will have the dual purpose of presenting exhibits and serving as offices/ conference center.

Activity 2.2.11: Safety and environment: Rollout of a safety and environment program for all links in the green hydrogen industrial chain in Shenyang to ensure that enterprises have access to the latest information and safety and environment measures for incorporation into their safety and environment programs. This activity will be advised by the Project Safety and Environment Specialist. Among other aspects, the environment program will ensure: (a) grid-based power that has fossil fuel component is not used to produce green hydrogen; (b) water used in electrolysis is sourced and transported sustainably; (c) mapping of all intermediate and final products related to consumption of the green hydrogen, that the green hydrogen replaces fossil fuels, and that the green hydrogen is not used to transport fossil fuels or fossil fuel vehicles or parts; (d) for production intermediate products (e.g. ammonia and methanol), assurance that the green hydrogen is used energy and resource efficiently in production processes, that there is monitoring of ultimate end uses (when possible), and that it is assured that green hydrogen is the most energy and resource efficient pathway towards the ultimate end product.

<u>Output 2.3</u>: Demonstration of a complete green hydrogen industrial chain in Dalian, Liaoning Province, shows improved technical performance and reduced costs as compared to baseline and covers green hydrogen production, its storage and transport, hydrogen refueling stations, use of green hydrogen in promising heavy duty vehicle scenarios, and use of hydrogen in electricity generation, featuring innovations across the value chain which lead to this enhanced viability. [Annex J provides more details on the plans, including activities and targets, for the Dalian demo.]

DALIAN MAIN DEMO

Activity 2.3.1: *Green power and green hydrogen production*: Construction of 100 MW PV isolated grid dedicated to green hydrogen production located on tidal flats near the seashore. The renewable energy power generation will be combined with raising of sea cucumbers in the shading provided by the solar panels.

Desalination will be undertaken to make the seawater suitable for green hydrogen production. A combination of four alkaline electrolyzers and one PEM electrolyzer will be used. Annual green hydrogen production will average about 600 tons per year. Production cost of green hydrogen is estimated at 25 RMB per kg. Special upstream innovations or technical/ cost achievements will include:

- Solar PV in tidal flats areas combined with a sea cucumber fishery, which benefits from the solar panel shading. Salt removal from seawater for hydrogen production.
- Relatively low cost of green hydrogen compared to previous efforts around the country
- Long-term financial viability of the green hydrogen production assured, as needed, via various measures, such as off-take agreements at a price that will ensure profits commensurate with grey hydrogen profits for the green hydrogen producer and/or incentive subsidies for either the producer or the purchaser, if needed, to ensure parity or better as compared to grey hydrogen.
- Demonstration of PEM electrolyzer which provides more stability/ higher efficiency for variable renewable energy based power generation inputs.
- Lower cost PEM electrolyzer as compared to previous demonstrations
- Lower cost of alkaline electrolyzer as compared to previous demonstrations

Activity 2.3.2: Storage and transport of green hydrogen: Demonstration of Type 4 cylinders/ tanks for transport of green hydrogen. These tanks, which are higher pressure than the ones normally used, can lower cost of transport, but must receive special approval for use on specific vehicles. Innovative/ cost reducing measures:

- Higher pressure tubes on trailer trucks for shipping hydrogen to HRSs, reducing costs.

Activity 2.3.3: *Green hydrogen HRSs:* Establishing of six more HRSs in Dalian that use exclusively green hydrogen and are supplied by the large green hydrogen production facility of the Project. HRSs will use the "five-in-one" business model, where they combine hydrogen refueling with petrol, natural gas, electricity and various services. [Note: A green hydrogen HRS will also probably be added on the Shenyang Dalian Highway, perhaps in Yingkou, with coordination at the provincial level.]

Activity 2.3.4: Heavy duty fuel cell vehicles powered by green hydrogen: Deployment of 200 new heavy duty FCVs fueled by the Project's green hydrogen across a range of applications. Included, among others, are public buses that will include the latest fuel cell technology with titanium fuel cell stacks, which are lighter than stainless steel stacks. Some of the green hydrogen fueled heavy duty vehicles will be driven mainly on the Shenyang Dalian Green Hydrogen Highway and may benefit from special incentives, such as toll free trips. The currently planned breakdown of heavy duty FCV type is: 40 public buses, 30 company shuttle buses, 30 sanitation vehicles, 30 heavy duty logistics vehicles, some to be demonstrated along the Shenyang Dalian ("ShenDa") Green Hydrogen Highway, 20 dump trucks for construction of Jinzhou Bay Airport, 50 intelligent heavy duty trucks for Dalian Port and Jinpu Free Trade Zone Logistics Park. Note: The smart fleet approach for the 50 intelligent heavy duty trucks builds on prior GEF hydrogen work in China, where a fleet with a smaller number of intelligent vehicles was piloted.

Special downstream innovations or technical/ cost achievements will include:

- Latest technology fuel cell stacks which achieve higher efficiency and more durability than prior best performing models. Achievements will include increased power density and reliability (to meet targets set by project)
- Demonstration of cost reduction of fuel cell stacks as compared to previous demonstrations

- Shenyang Dalian Green Hydrogen Highway demonstrated to attract conversion to green hydrogen fueled heavy duty fuel cell trucks to benefit from toll free passage
- Demonstration of heavy duty fuel cell vehicles for port logistics.
- Demonstration in a portion of the heavy duty vehicles in their fuel cell stacks the successful use of newly domestically produced parts, such as membrane, catalyst, and carbon paper in fuel cells, thereby achieving cost reduction

OTHER DALIAN DEMOS

Activity 2.3.5: Small-scale, distributed electricity production from green hydrogen produced via rooftop PV: Installation of less than 3 MW rooftop PV to produce green hydrogen. The green hydrogen will then be used to demonstrate use of 10 hydrogen electricity generators in micro-grids (each with capacity of 100 kW, for total of around 1 MW, with targeted efficiency of hydrogen to electricity conversion such that only 0.06 kg hydrogen in used per kWh generated). In the future, such distributed small-scale green hydrogen power generation could be used to serve off-grid locations, to provide power backup to locations with load shedding, and to provide other grid benefits, such as serving as storage to balance an excess of PV power during the day with an excess of demand at night as more and more users are charging electric vehicles. It is likely that PEM electrolyzer will be used in this demo.

Activity 2.3.6: *Large-scale associated green hydrogen industrial chain demo*: GW-scale renewable energy based power production (wind or PV). The output will be 50,000 tons green hydrogen per year, which will be used to produce 300,000 tpy of green ammonia and/or green methanol. A small portion of the green hydrogen produced may serve as a back-up source of green hydrogen for the heavy duty vehicles in the main project demo.

DALIAN SUPPORTING SUBPROJECTS

Activity 2.3.7: Monitoring platform and collection of Dalian demo data: Establishment and operation of a digital monitoring platform for all key nodes of the project in Dalian including RE power generation, green hydrogen production, green hydrogen storage and transport, green hydrogen HRS refueling, and green hydrogen fueled heavy duty FCV operation. Through use of this platform and other means, the Project will collect data from the Dalian demo that allows analysis of cost improvements and technical performance improvements by introduction of new technologies and procedures. The inclusion of upstream data will make the results quite interesting, as there is not much experience monitoring the upstream of the green hydrogen industrial chain.

Activity 2.3.8: Local policy incentives, systems and regulations: Designing, refining, and adopting local policy incentives in Dalian City and Jinpu District for various links in the green hydrogen industrial chain. Testing of these local policies as pilots. This may also include a provincial policy regarding toll and/or right of way (right to use road at certain times) on the Shenyang Dalian Green Hydrogen Highway.

Activity 2.3.9: *Demonstration of progress in fuel cell stack technology*: Demonstration of advanced fuel cell stack that achieves higher power density than baseline and thus cost reduction (vis-à-vis less hydrogen needed per power output) and also achieves reduced cost per kW of fuel cell stack. Demonstration of advanced fuel cell technology will be integrated with the project demos. Various aspects that will be developed are: single stack power output of 300 kW (increasing power and power density of fuel cells), single cell preparation technology to increase quality with reduced cost in batch production, advanced plate forming technology and design technology to reduce the thickness of a single fuel cell, and other features.

Activity 2.3.10: *Testing of high-power hydrogen fuel cells under different environmental conditions*: Development of methods for testing and evaluation of on-board hydrogen fuel cell systems of various heavy duty vehicles involved in the project. The testing will emphasize performance in different environments, such as high temperature, low temperate, high humidity, high altitude, etc.

Activity 2.3.11: *Demonstration of standards and product certification*: Development of local standards for: (i) green hydrogen production from renewable energy powered water electrolysis, (ii) hydrogen safety, and (iii) high-pressure hydrogen storage and transportation equipment. Development of product certification systems for fuel cell systems and their components, heavy duty fuel cell vehicles, etc.

Activity 2.3.12: Safety and environment: Rollout of a safety and environment program for all links in the green hydrogen industrial chain in Dalian to ensure that enterprises have access to the latest information and safety and environment measures for incorporation into their safety programs. Safety testing of hydrogen tanks and other equipment to support the industry at prominent testing center in Dalian. This activity will be advised by the Project Safety and Environment Specialist. Among other aspects, the environment program will ensure: (a) grid-based power that has fossil fuel component is not used to produce green hydrogen; (b) water used in electrolysis is sourced and transported sustainably and power used for desalinization is green power (not fossil fuel based); (c) mapping of all intermediate and final products related to consumption of the green hydrogen, that the green hydrogen replaces fossil fuels, and that the green hydrogen is not used to transport fossil fuels or fossil fuel vehicles or parts; (d) for production intermediate products (e.g. ammonia and methanol), assurance that the green hydrogen is used energy and resource efficiently in production processes, that there is monitoring of ultimate end uses (when possible), and that it is assured that green hydrogen is the most energy and resource efficient pathway towards the ultimate end product.

Output 2.4: Establishment and operation of *Green Hydrogen Industrial Chain Innovation Grant Fund*, whose grant investments in innovative green hydrogen industrial chain technology start-ups result in advancements and barrier removal (e.g. reduced costs, improved performance) in the industry. [This will include establishment of methods and processes for identification and selection of promising technology startups for grant funding by *Green Hydrogen Industrial Chain Innovation Grant Fund* and effective administration and disbursement of the fund.]

Activity 2.4.1: Development of methodologies to find good companies and technologies as suitable candidates for *Green Hydrogen Industrial Chain Innovation Grant Fund*. Development of criteria and guidelines of how to rank applicant companies (i.e. evaluation criteria), select the winners (i.e. selection requirements and selection mechanism), and determine how much in funds to give to each. Determination of requirements that will be posed to winners before funds can be disbursed or fully disbursed.

Activity 2.4.2: Setting up of *Green Hydrogen Industrial Chain Innovation Grant Fund* and carrying out day to day operations as needed.

Activity 2.4.3: Implementation of outreach and search for good domestic candidate start-up companies for *Green Hydrogen Industrial Chain Innovation Grant Fund* based on methodology developed under Activity 2.4.1. Assistance of companies in developing their applications to the Fund, as needed. Company search work may consider findings on innovations of Activity 1.6b.4.

Activity 2.4.4: Selection of winning candidates for *Innovation Grant Fund* and disbursement of funds.

Activity 2.4.5: Following up with winning candidates and other promising applicants to track their progress. Promotion of these innovative green hydrogen industrial chain companies via social media and external media.

Component 3: Capacity Building and Bridges to Human Talent

Outcome 3: Increased knowledge and capacity of government, industry, experts, technical personnel, engineers, and students regarding green hydrogen and its industrial chain, along with improved mode of connecting human talent to needs/ projects, leads to increased availability of qualified persons across domains to ensure success of the industry.

Rationale of Outcome 3: Outcome 3 is justified in that green hydrogen industrial chains (and hydrogen generally) are a new field in which there is a need to raise capacities, develop talent, and also connect talent with needs in industry and vice versa. This component's emphasis reflects one of the needs identified in the prior hydrogen-related project in China, UNDP-GEF China DevCom FCV – the need for talent development.

CAPACITY BUILDING EVENTS

Output 3.1: Conference-based capacity building and experience sharing related to technical aspects, planning, policy, regulations, and demonstration (and with meaningful participation of women and promotion of best practices in the gender dimension) lead to increased problem solving and know-how related to the green hydrogen industrial chain and enhances the capabilities of technical personnel, government officials, business persons, GEF Green Hydrogen global program partners, and others to ensure the success of the project demos and bring green hydrogen and its applications to other cities and/or improve and scale up such efforts.

Activity 3.1.1: Holding of five large (estimated 100 attendees each) experience sharing and training "comprehensive"[1] conferences focused on various aspects of the green hydrogen industrial chain. Each conference may have parallel sessions for areas of diverging interest (e.g. heavy duty vehicles versus hard-to-abate industrial sectors, such as chemicals), but there will also be overall themes for each conference. Content will not be limited to the themes, but the themes will receive strong emphasis. Surveys/ mini-tests will gauge how much attendees have learned at the conference. Efforts will be made to ensure 30% of conference attendees are women[2], and that there is meaningful participation of women and women's organizations, such as having women speakers and active involvement of women in discussion groups. Further, conferences will promote best practices and lessons of the project in the gender dimension of the green hydrogen industrial chain. Three of the five conferences (i, iii, and v) will include attendance by GEF Green Hydrogen global program partners. During the conference and associated field trips they may take, there will be an emphasis on sharing with them innovative approaches of the China Green Hydrogen Project, particularly technological aspects. Preliminarily, the themes of the five conferences (including dual themes for a conference in some cases) may be:

i. (i-a. Theme 1) Experience sharing of China's hydrogen city clusters and of other cities with notable demos, (i-b. Theme 2) China's high-level policy direction for green hydrogen: The five hydrogen city clusters and other cities with interesting demo experience[3] will present their experience. The three demo cities and other cities, as well as GEF Green Hydrogen global program partners, will learn from them. The demo cities may have some gaps in their policies, which this event may help them fill. In addition, the event may support efforts to harmonize demo city policy work with what has already been done in cluster cities, so that new areas/ new needs/ new approaches are supported in the demo cities. China has many other areas besides the cluster city participants and the demo cities that have shown strong interest in developing their hydrogen industry. If possible, such cities and provinces will also be involved. To address the second theme, at this first large event of the project, national policy makers will be invited to attend to give the attendees insights into expected future high level policy directions related to the green hydrogen industrial chain.

ii. (Theme) Green hydrogen in hard-to-abate industrial sectors: This conference will emphasize policy, planning, technical aspects, demo, and networking for participants from hard-to-abate industrial sectors (e.g.

chemicals) and from cities with significant hard-to-abate industrial sector presence to discuss green hydrogen projects in those sectors. Industry players that have already developed projects (such as some large petrochemical companies) will be asked to share their experiences so that others may learn from them.

iii. (iii-a. Theme 1) Green hydrogen production, (iii-b. Theme 2) international experience sharing: For the first theme, this conference will emphasize policy, planning, technical aspects, demo, and networking with regard to green hydrogen production. For the second theme, representatives from demo city projects in other countries will be invited to share their experience with attending Chinese organizations (demo cities, city clusters, and other interested cities – including their policy makers and company participants) and GEF Green Hydrogen global program partners. [The Project executing agency, IHFCA, has many international members and international experience presenters may be drawn from these.] An effort will be made to include international cases of both hard-to-abate industrial sectors and heavy duty vehicles.

iv. (Theme) Innovative business models, technical innovation, and financing for green hydrogen industrial chains: This conference will present project findings and results related to innovative business models (that allow positive returns), key technical innovations, and financing opportunities and fund development for the green hydrogen industrial chain. As such, the content of the event will draw from Activity 1.6b.4 on innovative business models, policies, and technology, Output 2.4 on the Innovation Grant Fund and Output 1.8 on promotion of business models, technical innovation, and entrepreneurship.

v. (Theme) Project demo city green hydrogen industrial chain results: This final large conference of the project will focus on the results of the project demos and next steps for China to build on the project's results. During the event, certificates of participation will be presented to entities with significant contributions to the Ningdong demo, the Shenyang demo, or the Dalian demo. GEF Green Hydrogen global program partners will be invited to attend.

<u>Output 3.2</u>: Capacity building via focused side-event sessions (at events held by other organizations), having meaningful participation by women, result in the solving of specific problems or in achieving dissemination of specific project concept or demo idea for replication.

Activity 3.2.1: Holding of focused "green hydrogen industrial chain" side event sessions at China's annual FCV conference, each time with the purpose of addressing one or more specific issues related to green hydrogen, HRSs, or heavy duty FCVs, such as in the policy or technology areas. Efforts will be made to ensure 30% of attendees at these sessions are women and that there is meaningful participation of women and women's organizations, particularly such that there is active involvement of women in expert discussion. Results will be assessed in terms of quality of solutions developed at the sessions and/or learnings (as determined via testing) by the attendees.

Activity 3.2.2: Holding of focused side events at international hydrogen meetings or at regional low carbon meetings to promote replication of the project demos in other countries. Efforts will be made to ensure 30% of attendees at these sessions are women and that there is meaningful participation of women and women's organizations, particularly such that there is active involvement of women in expert discussion and perhaps featuring of women speakers. Results will be assessed in terms of follow up by organizations in other countries on the demo ideas presented. This work will be supported with contributions from the International Communications Expert. It will include attendance and holding of side events at meetings held by the GEF Green Hydrogen global program.

<u>Outcome 3.3</u>: Small focused problem-solving events/ discussion meetings of experts, business persons, and policy makers involved in the green hydrogen industrial chain, with around 20 persons in attendance at each and meaningful participation of women, facilitate open discussion and problem solving and build capacity of participants via learning from each other and learning by doing.

Activity 3.3.1: Organizing and conducting of results oriented small, focused problem-solving events/ discussion meetings. Agendas will be carefully curated to ensure discussions lead to quality problem solving and/or concrete recommendations. Efforts will be made to ensure 30% of attendees at these sessions are women and that there is meaningful participation of women and women's organizations, particularly such that there is active involvement of women in expert discussion. Results will be assessed in terms of the quality of proposed solutions to problems or of other recommendations resulting from the meetings, as well as follow up on the solutions/ recommendations. Preliminarily, the themes of such events will be as follows:

i. Small group event to discuss government strategies, plans, and policy priorities for promoting: technical innovation, domestication of key components (such as catalyst, carbon paper, and membrane for fuel cells), improved business models, and financing of the green hydrogen industrial chain. Selected experts with relevant know-how will be involved and guided through carefully curated discussion topics with the aim of producing useful conclusions and recommendations related to the key areas covered by the event.

ii. Small group event held towards end of project to discuss next step government priorities in policy, standards, plans, and demonstration for China to build on the results of this Project. The group will also discuss how to ensure sustainability of project results and actions that need to be taken towards the end of project to ensure such sustainability (i.e. "exit strategy").

iii. Small group events held based on capacity building and problem-solving needs determined in years 2, 3, 4, and/ or 5 of project as related to the green hydrogen industrial value chain.

Activity 3.3.2: Following each event of Activity 3.3.1 (as described in items i, ii, and iii), the Project will take steps to ensure solutions and/or recommendations emerging from the events are implemented (or a path is established for action) and solutions/ recommendations are also disseminated.

EDUCATION AND BRIDGES TO HUMAN TALENT

Output 3.4*:* Development of educational materials related to the green hydrogen value chain and their piloting in university courses results in expanded offerings of related coursework, with attention to promoting these to women students.

Activity 3.4.1: Organization of experts/ authors and drafting of training materials or textbooks for four to six courses related to the green hydrogen industrial value chain. This work will ideally cooperate with ongoing efforts at universities, some of which have already been initiated, with a few textbooks of a planned series of courses already completed. Topics of the courses for which the project will prepare textbooks or training materials may include: green hydrogen production (especially from water electrolysis), fuel cells, heavy duty FCVs, hydrogen energy storage for electricity and heating applications (CHP using hydrogen fuel), etc. Materials will be piloted in new university courses. Materials might be prepared in English as well for dissemination to other countries, potentially through the GEF Green Hydrogen global program. Efforts will be made to ensure textbooks are designed to encourage female students as well as male students in their pursuit of hydrogen studies. For example, photos of individuals in the textbooks, if any, should include women as well as men. And, special topics/ applications should address the interests of women as well as men.

Activity 3.4.2: Promotion of training materials/ textbooks to universities, including efforts to get them to offer green hydrogen industrial chain related courses that use the materials/ textbooks and to develop majors or concentrations in green hydrogen industrial chain related areas if viable.[4] If English materials prepared, promotion of materials to institutions in other countries (especially GEF Green Hydrogen global program countries) with support of the International Communications Expert. Institutions with whom the project cooperates in this way should be encouraged to try and interest women students in their hydrogen studies programs.

Output 3.5: Green hydrogen industrial chain platform established for connecting both experienced and emerging technical talent to companies and projects and for connecting organizations to each other, leading to the more robust development of the industry and providing opportunities for talent to continue to build their capacity, with special attention to female talent.

Activity 3.5.1: Establishment of a platform that will allow green hydrogen-related talent to connect with companies and for organizations to connect with each other. The aim of the platform is both to get technical problems solved, new solutions/ technologies tested, and, at the same time, prepare human talent for work in the green hydrogen sector and have exchanges between companies and participants and between organizations. The platform will include a human talent database, not only of top experts but also of young academics who will have high potential over the next ten years. And, the platform may provide an opportunity for recent grads and even current students to get practical experience in the green hydrogen field. The talent pool database could be accessed by cities developing demo projects or companies doing work in areas related to green hydrogen. Over the next ten years, the hydrogen human talent database may even become internationalized. The project can use promotional methods to let cities doing hydrogen projects know about this bridge between the talent pool and cities/ companies and between organizations. While there is already some cooperation between companies and research organizations in hydrogen related fields, the aim is to optimize and expand such cooperation. The platform and its database may be used in multiple directions. That is, while cities and companies (who are often asked by cities to lead demo projects) may use it to find talent, talent might use it to find projects they are interested in working on. And, researchers/ academics who have research results that they would like to apply in the real world may use the database to connect with those who may have the capacity for such real applications. Some companies have their own research labs that other companies or research institutes may be interested in using, so the platform could also provide a bridge for this type of cooperation. Efforts will be made to ensure that 30% of the experts in the database, when aggregated across levels (senior experts, young academics, recent graduates, and students), are women. In addition, the project will take proactive measure to encourage women to be involved and pursue careers in the green hydrogen industrial chain.

Component 4: Knowledge Dissemination, Awareness Raising, International Exchange, and Information Sharing

Outcome 4: Knowledge dissemination, awareness raising, international exchange, and information sharing on the green hydrogen industrial chain results in active engagement of companies in upstream and downstream links of the value chain, increased confidence in hydrogen (particularly green hydrogen) and support thereof from government officials, and increased interest of the public in green hydrogen and its applications.

Rationale of Outcome 4: Successful dissemination and awareness raising is critical to realizing the full potential of the project. In particular, the project demos may provide good examples and lessons, as well as data showing improved viability of green hydrogen industrial chains. Yet, dissemination is needed to get the word out. Further, because government officials and people generally are not that familiar with the concept and benefits of green hydrogen, there is a need to promote it. Promotion to government officials in particular can lead to more supportive policies, plans, and regulations. And, there is also a need for awareness raising to address some specific aspects, such as regarding misconceptions on the safety of hydrogen (if borne out vis-à-vis findings) and also the involvement of hard-to-abate industrial sectors in the green hydrogen value chain.

Output 4.1: Dissemination of both general and detailed technical and economic information on the project demos and of other relevant information developed by the project supports efforts to stimulate replication in other cities in China and elsewhere in the world, with emphasis on GEF Green Hydrogen global program partners. [Disseminated materials and content will be of two types. The first will be more general and the second more detailed and technical.]

Activity 4.1.1: Carrying out of general promotion and dissemination of the demo city experience. This may, in particular, feature innovative models that are demonstrated and have high potential for replication. There may be many areas in China and around the world with conditions suitable to replicate certain aspects of the demos. Thus, the Project's demo city experience will be promoted to other cities in China and internationally (especially developing countries and their cities) for replication as relevant. General information documents/ brochures (less detailed than those prepared under Output 1.6a) may be prepared and shared with interested parties. Side events at international hydrogen conferences may be used for the project to showcase replicable demo city models (in conjunction with Activity 3.2.2). General sessions and panel discussions at such events held by others may also be an opportunity to reach a wider range of stakeholders internationally, in presenting project achievements and learnings. The Project Executing Agency, IHFCA, may utilize its connections with member organizations to promote the models for replication internationally. IHFCA will also be organizing an international meeting in another country in 2025; and Project results will be presented there as well (in conjunction with Activity 3.2.2). The Project may work to tailor dissemination to the needs of specific Chinese cities or specific countries. Finally, dissemination work will put emphasis on GEF Green Hydrogen global program partners. With regard to these partners, there will be an emphasis on sharing with them innovative approaches of the project demos particularly technological aspects.

Activity 4.1.2: Carrying out of dissemination of detailed technical and cost results of Project demos (as developed under Output 1.6a) and of the project's other information products (as prepared under Output 1.6b and including technical and cost viability studies of green hydrogen production, heavy duty FCVs, and use of green hydrogen in hard-to-abate industrial sectors, such as chemicals; studies of innovative business models, policies, and technologies; and case studies of green hydrogen industrial chain projects carried out by others). Findings during project design reveal that parties are very interested in technical data that will be generated by the demos. Such parties include not only those who are considering investing in green hydrogen related projects, but also manufacturers that are interested in knowing how products perform on large scale and in real world scenarios. One of the important contributions of the project will be to share such data. While there are some other (typically much less comprehensive) green hydrogen projects, the sharing of data to date has been quite limited. Under Outcome 1, the project will collect demo data and carry out analysis with the results shown in reports. These reports (of Output 1.6a) and/ or their highlights can be shared across interested industry and research circles under this activity (Activity 4.1.2), along with the reports prepared under Output 1.6b. Multiple channels may be used to share such data. And, a periodic sharing mechanism in order to share updates of demo results can be developed. This sharing may use the project website (developed under Output 4.5, which will be a sub-website of IHFCA's website) and, possibly, also IHFCA's social media accounts, and the websites of the local governments carrying out the demos. Project will reach out to specific individuals/ organizations to inform them of the availability of the aforementioned documents. Finally, dissemination work will put emphasis on GEF Green Hydrogen global program partners.

<u>Output 4.2</u>: Extensive social media/ "self-media" efforts combined with outreach to external media results in substantially increased awareness and knowledge of green hydrogen industrial chains by the public, as well as specialized groups, including GEF Green Hydrogen global program partners, with inclusion of content on best practices in the gender dimension. [Based on experience with cost effectiveness of various modes of project promotion, the Project will put its greatest emphasis on "self-media" and especially social media. At the same time, the Project will still reach out in traditional ways to external media.]

Activity 4.2.1: Carrying out of social media outreach both to the general public and to more specific groups, such as policy makers, industry professionals, and GEF Green Hydrogen global program partners, to promote project results and the benefits/ strengths of green hydrogen, its use in industry, and its use in heavy duty FCVs. (Industry circles will include not only heavy duty vehicles, but also green hydrogen production, and hard-to-abate industrial sector discussion groups.) The Project will leverage the accounts that IHFCA already has on WeiXin (WeChat), XiaoHongShu, Douyin (Tik Tok), and LinkedIn. WeChat groups are an example of how

social media will be used for promotion in professional/ industry circles. Further, short videos (via Tik Tok and XiaoHongShu) can have very large coverage and will be leveraged. The project also plans to work with KOL (key opinion leaders) in relevant areas (e.g. heavy duty vehicles, hard-to-abate industrial sectors, green hydrogen production) as part of its awareness building program. Social media outreach will consider gender aspects in terms of how to attract women to the postings. It will also promote best practices and lessons learned by the project in the gender dimension. The International Communications Expert will develop a strategy to promote the project widely on social medial internationally, as well as within the GEF Green Hydrogen global program partners group. And, this international promotion strategy will be fully implemented by the project during its lifetime. For added leverage, IHFCA, when holding meetings abroad, may ask local partners to promote the project on their most effective social medial channels.

Activity 4.2.2: Promotion of the project via external media in China. Liaison with the press, preparation of press releases, etc. Led by the International Communication Expert, promotion of the project in international external media.

Activity 4.2.3: Preparation of a series of project highlight videos for global-scale promotion. This work will include collection of video clips and photos highlighting the activities under Project Outcomes 1, 2, and 3 and their aggregation into brief videos. Efforts will be made to design certain aspects of the videos to appeal to women. Further, best practice and lessons from the gender dimension will be featured. By close of project, a series of short videos will have been developed and disseminated globally via social media with the help of the International Communications Expert.

Activity 4.2.4: Preparation and wide dissemination of simple, fact-based product(s) (brochure or summary written document(s)) that addresses possible misconceptions regarding hydrogen safety, but also honestly presents the safety challenges with regard to hydrogen, thus offering viewers or readers with a balanced review of the facts with which to assess danger levels. The content of this product will draw from the assessment/ findings of Activity 1.2b.1 on hydrogen safety. This activity will enhance the packaging/ messaging and ensure the findings are then disseminated widely to government officials, other relevant parties, and the general public. A comparison of the risks of hydrogen to those of other energy sources may be provided, as well as comparison of risks of FCVs to ICEs, EVs, and natural gas vehicles. International experience with hydrogen and FCV safety may also be included. The product(s) may, in addition, address water use of green hydrogen production. The product may include different versions, one for policy makers, industry, and experts and the other for the general public, aiming to reach many and begin to influence their thinking. If there is existing usable video footage of the response of hydrogen to impact, this might be utilized, if allowed to be distributed, in conjunction with the activity's main written brochures or summaries of key findings and key points. The products will be disseminated broadly on social media to expert and non-expert circles. An English version, as well as more detailed findings from Activity 1.2b.1, will be shared with the GEF Green Hydrogen global program partners. [The aim of this output is to address negative perceptions of the safety of hydrogen, which is currently classified as a chemical hazard rather than energy source in China, thus facing more stringent restrictions than other vehicle fuels. In general, it is believed perceptions of the safety of hydrogen hinder the development of the industry. At the same time, this activity aims to get down to the bottom of things/ get the real facts and present a balanced view. This activity may also address and flesh out the facts of other aspects of concern, such as the perception that green hydrogen production will use excessive amounts of water, when it may actually use less water than some types of fossil-fuel based hydrogen production.]

<u>Output 4.3</u>: International exchange supports the coming together of Chinese and international entities along the green hydrogen value chain for cooperation in technology, production, and/or demonstration and includes leverage of the GEF's Green Hydrogen global program as relevant and gender best practices.

Activity 4.3.1: Facilitation of exchange between Chinese and foreign entities involved in the green hydrogen value chain that may have cooperation potential. This work will be carried out by the International Communications Expert in consultation with other project experts on needs of Chinese entities for international

cooperation within China and potential for Chinese entities to cooperate outside of China. Chinese companies may need advanced parts and materials produced abroad, so the project could facilitate connections with international suppliers. Cooperation to produce more advanced models of relevant equipment in China, such as PEM electrolyzers, is also needed, so building bridges with potential partners in that regard is needed. Finally, Chinese companies sell their products abroad (e.g. alkaline electrolyzers), so connecting them with projects/ end users could expand their reach and output and thus support faster improvements in their technology. This activity may include a visit of Chinese companies to another country, such as the US, or vice versa where relevant companies from the other country visit China. International cooperation may also be divided into technical cooperation (with countries that have good technology related to the green hydrogen industrial chain) and demo cooperation (with countries that have good resources/ conditions for a demo, such as low cost renewable energy/ low cost hydrogen and high demand for heavy duty trucks, other suitable heavy duty vehicles or high incentives for reducing carbon in hard-to-abate industrial sectors, such as chemicals). This activity will also leverage the GEF's Green Hydrogen global program to facilitate connections between Chinese organizations and relevant parties in countries actively pursuing green hydrogen demonstrations. It will also ensure gender best practices are adopted for involving women and giving them business-related opportunities through this activity.

Output 4.4: Green hydrogen outreach program for hard-to-abate industrial sectors results in greater interest and participation in the green hydrogen value chain by companies in these sectors.

Activity 4.4.1: Carrying out of a tailor-made green hydrogen outreach and awareness program for the hard-to-abate industrial sectors, such as chemicals. The project will reach out to the entirety of such sectors in promoting green hydrogen. This will include direct one-on-one outreach to specific entities in these sectors. The work will put special emphasis on leveraging the big energy companies to influence the rest of the industry, given that the other companies often take the big companies' leads. The aim will be to convince more companies in hard-to-abate industrial sectors (such as chemicals) to participate in green hydrogen industrial chains. This outreach effort will be linked to the project capacity building conference that will have green hydrogen in hard-to-abate industrial sectors as its theme (item ii of Activity 3.1.1). Eventually, it is expected the big energy companies could have a large impact on the green hydrogen industrial chain sector so that involving them in this outreach effort and exchange is a priority.

Output 4.5: Project green hydrogen industrial chain website and information exchange platform attract strong attention and achieve wide dissemination of project results (including best practices for the gender dimension) and active discussion on key issues in the industry, and includes leverage of the GEF's Green Hydrogen global program as relevant.

Activity 4.5.1: Design, development, and promotion of project's green hydrogen industrial chain website, which will likely be a sub-website of IHFCA's website. Uploading of key project documents and demo monitoring materials on website and promotion to increase dissemination and impact. Special efforts will be made to make certain aspects of website design attractive to women. And, the website will include a section on best practices for the gender dimension in the green hydrogen industrial chain.

Activity 4.5.2: (i) Facilitation of information exchange between cluster cities and project demo cities via member access platform on project green hydrogen industrial chain website. Facilitation of involvement of demo cities under the GEF Green Hydrogen global program as well. (ii) Facilitation of information exchange on technology aspects of green hydrogen industrial chains, so that there is no "reinvention of the wheel," via discussion board function of website. Such a platform of discussion boards could include both domestic and international companies and users, so that information on state-of-the-art situation of various components, materials, and equipment is shared.

Activity 4.5.3: Encouraging of other China-based green hydrogen industrial chain projects (besides the project demos) to share information on their experiences via a special platform on this website. Information gathered could inform the case studies of Activity 1.6b.5.

Output 4.6: Implementation of additional awareness programs according to newly identified barriers to and needs of the green hydrogen industrial chain in years 2, 3, 4, and 5 contributes to the expansion of the green hydrogen industrial chain and leverages best practices in the gender dimension.

Activity 4.6.1: Identification of additional barriers and associated awareness building needs in years 2, 3, 4, and 5 of the project. Development and implementation of awareness raising programs to address these needs. Work will include the adoption of best practices in the gender dimension as well as incorporation of lessons learned in this dimension.

Component 5. Monitoring and Evaluation

Outcome 5. Quality monitoring and evaluation work throughout project provides impetus for quality results and course correction as needed, as well as specific, actionable recommendations for follow-up work and future projects.

Rationale for Outcome 5: Results-based management/ managing to achieve results and impacts benefits highly from having a project indicator system and periodically monitoring the indicators. The opportunity for a project to course correct or carry out adaptive management is also important to the success of the project and is facilitated by periodic monitoring as well as evaluations. Lastly, evaluations also provide recommendations of how follow up work by relevant parties can build on the results of the project and ensure they are sustained.

Output 5.1: Periodic and ongoing project monitoring ensures the project stays on course and adopts adaptive management as needed, with monitoring of gender dimensions included.

Activity 5.1.1: Carrying out of all required periodic M&E assessment and reporting. In particular, assessment of the indicators in the Project Results Framework on at least an annual basis, preparation of PIRs (Project Implementation Reports as required by GEF), and preparation of annual reports. Periodic M&E assessments and annual reporting will include assessment of project achievements in the area of gender.

Activity 5.1.2: Ongoing project monitoring of timely, efficient, and effective implementation of all activities, of progress towards project results, need for course correction, and of performance of Project Executing Agency. Ongoing monitoring will also put due attention on implementation of project's Gender Action Plan.

Output 5.2: Project Mid-Term Review and Terminal Evaluation facilitate course correction if needed (MTR), recommendations for building on project results (TE), learning lessons for future projects (MTR and TE), and assessment of gender dimensions (MTR and TE).

Activity 5.2.1: Carrying out of project mid-term review, with inclusion of gender dimensions.

Activity 5.2.2: Carrying out of project terminal evaluation, with inclusion of gender dimensions.

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The project in its design aims to emphasize stakeholder engagement and development of knowledge products, their dissemination, and their long-term availability to stakeholders. It also has strong emphasis (though Component 1) on policy development and (through Component 3) capacity building. By taking a systems approach that addresses barriers up and down the value chain, the project aims to transform a sector challenged by high costs, technical gaps, policy needs, information needs, and talent needs into one that leverages China's net zero and energy sector transformation aspirations.

Already in its design phase, the *China Green Hydrogen Project* has involved numerous stakeholders. There are many stakeholders in each demo city that have been working hard to bring the demos to realization. The approach of the project design has been to maintain a high level of engagement with relevant parties and this will continue during project implementation. The Stakeholder Engagement Plan Annex (Annex P) provides more details on project strategy in this regard. The comprehensive green hydrogen value chain demos, capacity building, and awareness work will involve the commercial and private sector extensively, as well as local governments and academics/ researchers. And, the project will aim to link researchers through its talent platform with companies. Policy and standards work is expected to involve industry, government, and experts.

The various stakeholders involved already have a certain level of knowledge about green hydrogen industrial chains. The project will aim to leverage this knowledge and draw on other existing knowledge to prepare the several studies and analyses called for in the project design. The information product activities aim to develop items that are in high demand from those persons involved in the sector, such as cost and technical viability information, rather than studies that may sit on the shelf unused. Knowledge products developed under Outcome 1 will be disseminated under Outcome 4 activities and platforms, such as the project's green hydrogen industrial chain website.

Outcome 1's policy work will also make strong efforts to build on existing information, so as not to reinvent the wheel. The targeted standards tree work will build on prior efforts but expand on these and take into consideration relevant standards work by various committees to identify both completed products that address their areas well and gaps where new products are needed or revision to existing ones should be undertaken. In the safety area, for example, the project will work to compile evidence to support adjustments to existing policy and standards and develop fully new items where there are gaps.

Through its second component the project works to enhance human, institutional, and technical capacities with GEF financing. This is a critical factor of getting to the intermediate state of the "enabling environment" for green hydrogen. And, this, in turn, will be linked with other efforts. For example, relevant persons will be consulted for input on policies, plans, and standards; and small group sessions will be held as relevant to problem solve.

Leveraging stakeholder engagement, knowledge products, policy work, and capacity building, the project is intended to be transformative: It aims nothing less than to assist in moving "green hydrogen" from a high cost, experimental concept to a path towards mainstreaming. As such, some innovative technologies, business models and policies will be tested to see if they can help with this difficult task. And, all other elements needed will be brought together in a systems approach to address barriers up and down the green hydrogen value chain and in cross-cutting functional areas.

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[1] Here, the term "comprehensive" is meant to indicate the conference will cover various functional areas, such as technical, planning, policy, regulations, and demonstration. It is possible that the conferences will hold parallel sessions in these different functional areas (technology, policy, etc.) or on different applications (e.g. heavy duty FCVs versus hard-to-abate industrial sectors), or on different segments of the green hydrogen industrial chain leading up to application (e.g. hydrogen production, transport, HRSs).

[2] Based on experience in this field, typical proportion of women at such conferences is 10 to 15%.

[3] This may include Weifang, Shandong, which is the first city in China blending hydrogen with natural gas for piping to residential users via existing natural gas distribution network.

[4] Findings indicate that some universities in China have already developed hydrogen energy concentrations for students.

[1] While the GEF is financing electric public buses through its Global Mobility Program, public buses are still considered a hard-to-abate sub-sector that can benefit from green hydrogen. This is because fuel cell buses do better in cold climate than electric buses. Fuel cell buses also have longer ranges, so are especially suitable for routes that are long and for which it is inconvenient to refuel too often. Further, fuel cell buses can refuel more quickly. While rapid charging is an option for electric buses, it still presents some challenges to battery life.

[2] There are already some incentive policies for certain fleet types, such as public buses, cold chain trucks, and heavy logistic trucks on fixed long-distant routes. In such cases, this work may propose adjustment of existing incentive policies, if a need is determined.

[3] Currently HRSs must be established on commercial land, which can be very costly. Petrol stations are also required to be established on commercial land, but many were established before land prices became so high.

[4] These may be analogous to the series of safety management regulations developed for natural gas vehicles. In particular, there needs to be an updating of *China Vehicle Highway Management Policy* re what requirements FCVs need to meet to be allowed to get on the road.

[5] Project design initially concludes that the beneficiaries of carbon trading for green hydrogen will be the green hydrogen producers, because that is where the carbon emission reductions occur. There has been some activity in carbon trading at the vehicle level for electric vehicles, but this may be because the reductions are considered to occur at use when it is not green electricity in particular, but general grid electricity that is used. At the same time, FCVs are an important aspect of China's future carbon reductions; and progress in carbon reductions for heavy duty vehicles (to which FCVs are well suited) has been much less so far than for passenger cars (where much progress has been made via electric vehicles). Some experts have thus suggested that carbon trading be instituted for FCVs and that a full life cycle assessment of their carbon output be conducted, though a decision would need to be made on where in the industrial chain to allocate credits for the emission reductions gained from using green hydrogen. The work from the FCV angle may include a data platform to analyze the industrial chain and a carbon footprint evaluation system for the industry. If this approach were to be taken, the aim would be for FCVs to enter China's voluntary carbon emissions trading system represented by CCERs (China Certified Emissions Reductions). Currently, the entire road transport sector in China is not included in the nation's quotas for carbon trading.

[6] China already has a *Hydrogen Energy Industry Standard System Guide*. This guideline, however, is not as comprehensive as needed and, in particular, does not consider standards of other sectors. The proposed work under Output 1.4a will consider this framework and build on it, but also aim for a more comprehensive framework.

[7] While there is currently a national standard GB/T 34584-2017, "Safety technical regulations for hydrogen refueling station," focusing on technical requirements for HRSs, a need is seen for more complete safety *management* standards at the national level. At present, related standards to reference include Guangdong's draft (out for comment) "Safety Management Regulations for Fuel Cell Vehicle Hydrogen Refueling Stations in Guangdong Province (Trial)" and some group standards, such as "Safety Management Regulations for On-site Operation of Hydrogen Refueling Stations" (T/DLSHXH003-2020).

[8] If group standards are pursued, it will be important to involve key enterprises and avoid the problem of multiple groups pursuing their own standard for the same product. The aim should be for the group standard to be the universal standard of the industry that will eventually lead to national adoption. Given past problems with group standards, the inviting of more experts may be needed as well as the submission of strong/ verified evidence/ data.

[9] China already has some general standards related to storage and transport systems for gaseous hydrogen that would apply to hydrogen pipelines. There are three standards specific to hydrogen that have been identified by China for eventual development and to which the project might contribute if needed: (1) Hydrogen Pipeline System Integrity Management Specification, (2) Technical specification for hydrogen pipeline engineering, (3) Code of practice for the construction and acceptance of hydrogen pipeline projects.

[10] Cost data may focus more on investment costs/ capital costs for various equipment, as there may be some sensitivities of involved entities sharing their operational costs.

[11] In the case of alkaline and PEM electrolyzers, for example, there is an interest in information on stability and lifetime of large units and impacts of load changes, low loads (e.g. 30%), hot and cold start, etc. There is interest in results when electrolyzers are operated continuously and when they are started and stopped. There is also an interest in cost reduction per unit hydrogen output as compared to previous demos.

[12] To illustrate the importance of such work in informing and updating industry players on financial viability, the price of fuel cells in China is said already to have dropped from 20,000 RMB/ kW in 2018 to less than 5,000 RMB/ kW in Jan. 2024 and is expected to drop further to 3,000 RMB/ kW by end of 2024.

[13] By the end of April 2024, the PPG team was aware of the following provincial actions related to hydrogen highways: As of March 1, 2024, Shandong Province began temporarily exempting hydrogen powered vehicles (that had electronic toll collecting equipment) from toll province-wide. On April 18, 2024, Sichuan Province issued a draft policy with similar content for comments. Hubei had made progress in infrastructure with its Hanyi Hydrogen Highway, which has four HRSs.

[14] Currently, China has five city clusters that focus on FCV demonstration. These groups of cities are designed to together (within one cluster) include the complete industrial chain needed (from hydrogen production to fuel cell and vehicle manufacture). While most cities within a cluster are nearby to each other, there are sometimes further away members of a cluster. For example, Ningdong is a part of Shanghai city cluster. Given that China is large and varied with 34 provinces, but has just 5 hydrogen city clusters, it is believed that scale-up of the hydrogen value chain requires expansion to more city clusters.

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[1] Chinese Society of Automotive Engineers (CSAE) is already working on a third version of a technical roadmap for "new energy vehicles" (NEVs) that includes extensive content on FCVs and HRSs. Around 150 experts were involved in the FCV and HRS work for the NEV Roadmap.

[2] There are already some incentive policies for certain fleet types, such as public buses, cold chain trucks, and heavy logistic trucks on fixed long-distant routes. In such cases, this work may propose adjustment of existing incentive policies, if a need is determined.

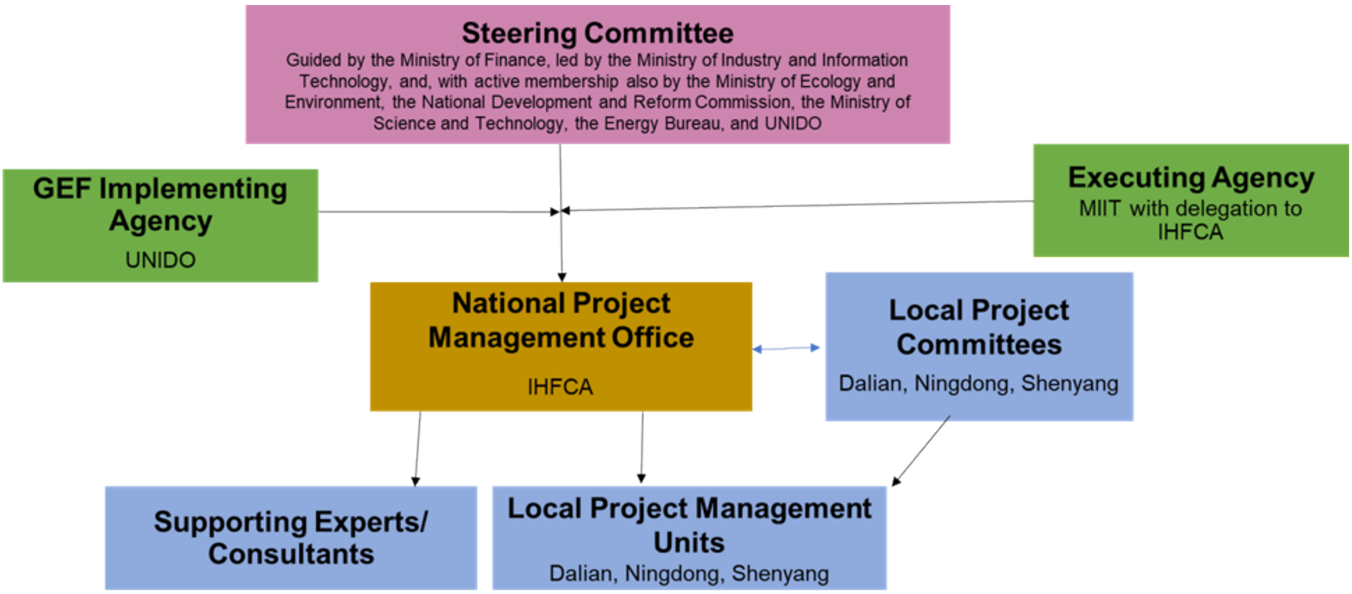
[3] Currently HRSs must be established on commercial land, which can be very costly. Petrol stations are also required to be established on commercial land, but many were established before land prices became so high.

Institutional Arrangement and Coordination with Ongoing Initiatives and Project.

Please describe the Institutional Arrangements for the execution of this project, including financial management and procurement. If possible, please summarize the flow of funds (diagram), accountabilities for project management and financial reporting (organogram), including audit, and staffing plans. (max. 500 words, approximately 1 page)

The management arrangements of the project are shown in Exhibit 7 and explained below.

Exhibit 7. Project Institutional Arrangements Organogram



Executing Partners and National Project Director:

The Executing Partners for the Project will be the International Hydrogen and Fuel Cell Association (IHFCA), a civil society organization (CSO), and the Ministry of Industry and Information Technology (MIIT), a government agency. The role of IHFCA vis-à-vis the project will be working as the delegated executing entity entrusted by MIIT. That is, the ministry (MIIT) will have oversight responsibilities of the project lead executing entity, IHFCA. IHFCA, in turn, shall execute the project, responsible for day-to-day operation, through the National PMO (project management office) and the project's satellite PMUs in each of the three demo cities. IHFCA will be involved in ensuring coordination of national counterparts, and carrying out designated project activities. The PMO shall be established within IHFCA and will be responsible for the details of project execution, including recruiting consultants and sub-contractors, keeping track of their progress, drafting technical and financial progress reports. The IHFCA team has experience in implementing GEF projects and has content expertise so will perform both project management functions and implementation of certain project activities. As the Chinese ministry responsible for industrial development, MIIT will be closely involved in the project's relevant policy initiatives, including national level plans, national level policies, and industry standards. MIIT will also act as the lead unit for relevant project activities.

The National Project Director (NPD) will be an official from IHFCA, who will be responsible for overall direction of the project team's daily work and for authorizing disbursements. The NPD will report to both MIIT and MOF.

GEF Implementing Agency: UNIDO is the project's GEF Implementing Agency. As such, UNIDO's responsibilities include quality assurance, monitoring, and evaluation. In terms of monitoring and evaluation, UNIDO will oversee both the project's mid-term review and its terminal evaluation. UNIDO will also oversee periodic monitoring efforts, such as product indicator updates and provide continuous monitoring to ensure all activities are timely and implemented towards targeted results. The Senior Technical Advisor (P5) or a designate Project Manager based in Vienna and supported by his team will lead the UNIDO Team for the Green Hydrogen Project.

In line with UNIDO Grants Manual[1][22] and UNIDO's financial rules, UNIDO will engage with MIIT through an Implementing Partner Agreement, applying the direct grant award procedure. MIIT will implement the activities under the IPA through IHFCA. The IPA will include the project implementation modality, conforming to the institutional arrangement in Exhibit 7 and detail the outcomes expected from IHFCA under Components 1, 2, 3 and 4 of the project. The required activities under the IPA will be budgeted under BL 2600 for grants provided to implementing partners as informed by the grant manual.

Project Board: The Project Board shall serve as the **Project Steering Committee (PSC)** and will be responsible for high-level oversight and advising of the project, overall monitoring, and decision-making when relevant to make changes to project activities, outputs, and/or budget allocations. The Chair of the Project Board will be from MIIT. Other members of the Project Board will include National Environmental Protection Agency (NEPA), National Development and Reform Commission (NDRC), National Energy Bureau, and Ministry of Science and Technology. The Project Board will meet at least once annually, based on a pre-determined schedule, for a minimum of five meetings over the lifetime of the project. Ad hoc meetings may occur when the project faces significant decisions requiring Project Board input.

Project Management Office: The project will be staffed by a central Project Management Office (PMO) in Beijing, which will include personnel with functional or technical expertise related to project activities as well as administrative staff. The "project management costs" budget line will cover all clear project management functions, whereas work of the PMO team directly supporting project activities will be charged to the relevant project component as PEE implemented activities. The PMO will be based in IHFCA headquarters. There will also be satellite project management units (PMUs) in each of the three demo cities (Ningdong, Dalian, and Shenyang), with salaries paid by project partners in government and the commercial sectors.

Staff of the central PMO will include

1. Project Manager: will serve under the national project director as the day to team lead of the project and be a full time member of the project team.

2. Industry Specialist: will lead efforts for Component 1 and be a full time member of the team.

3. Hydrogen Specialist 1: will support upstream hydrogen work of the project and work on the project 50 percent of the time

4. Hydrogen Specialist 2: will support downstream hydrogen work of the project and work on the project 50 percent of the time

5. FCV Expert: will support heavy duty FCV efforts and will work on the project on a 50 percent basis.

6. Supply Chain Management Expert: will assist with value chain work and will work on the project 50 percent of the time.

7. Communications and Gender Specialist: will lead the efforts for Components 3 and 4 of the project and be a full time member of the team, ensuring gender is adhered to in all aspects of the project.

8. Standards Expert 1: will assist with standards work and work on the project 25 percent of the time.

9. Standards Expert 2: will assist with standards work and work on the project 25 percent of the time.

10. Events Expert: will assist with events and work on the project 50 percent of the time.

High-Level Experts: The PMU will retain some top level experts to be close advisors of the project.

1. The Chief Technical Advisor (vehicle expert), having extensive experience in the field, will lead automotive industry initiatives and manage technical projects and work for the project 50 percent of the time.
2. Hydrogen Expert: will guide all aspects of project work related to hydrogen and will work for the project 25 percent of the time.
3. Fuel Cell Expert: working in close coordination with the Hydrogen Expert, the Fuel Cell Expert guides all aspects of the project related to fuel cells and will work 25 percent time for the project.
4. International Communication Expert: The International Communication Expert will provide part-time support to the project in its communication strategy and, in particular, in ensuring international dissemination of results.
5. Environmental and Safety Specialist: will provide part-time support to ensure that project demos are carried out with highest safety and environmental standards. The Expert will also contribute to Component 1 knowledge products and work related to safety and ensure monitoring of the project's environment and social monitoring plans.

Satellite PMUs and Demo Committees: Staff of the satellite PMUs and the Demo Committees that oversee them will be as follows:

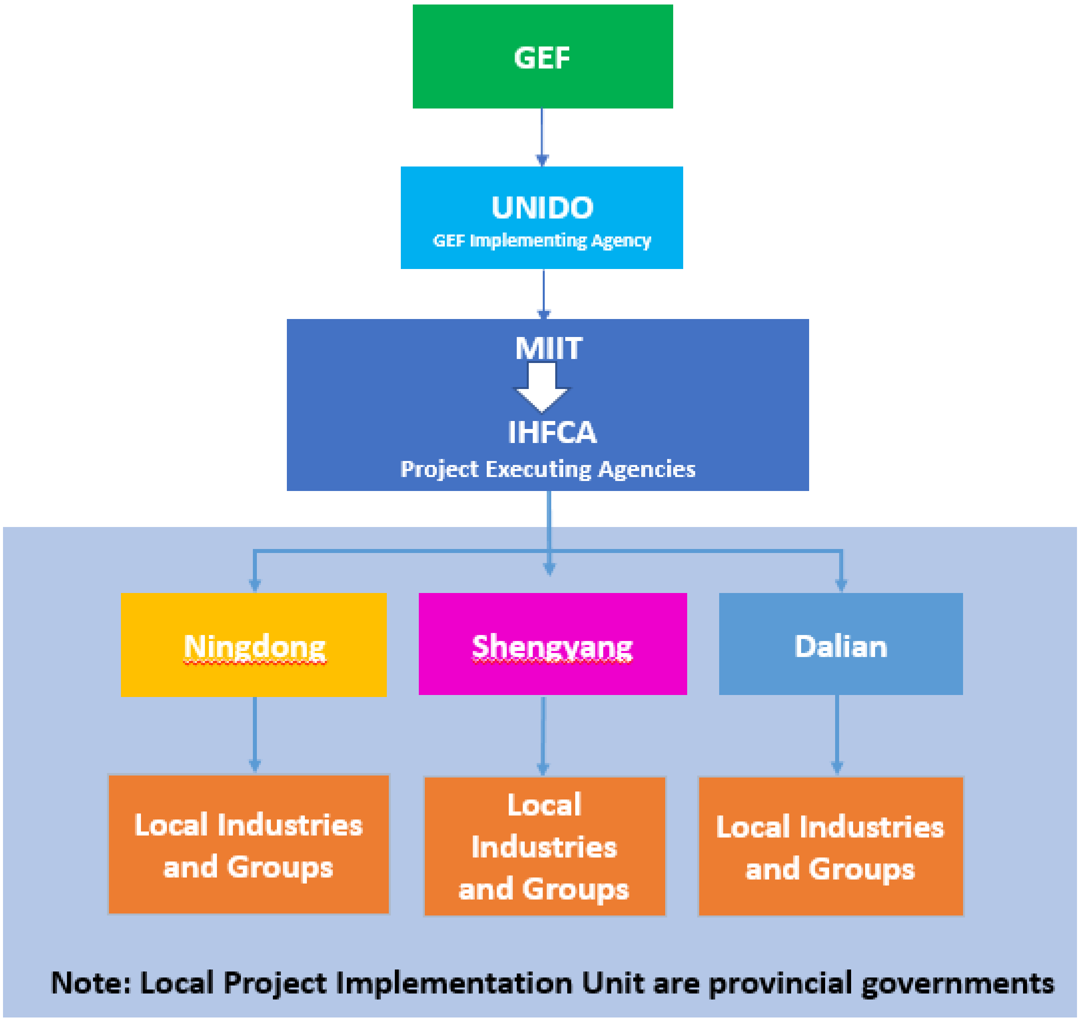
Ningdong: Ningdong's PMU main contact person is based in Guoneng Energy Ningdong (China National Energy Ningdong). Ningdong's Demo Committee is led by members of the Party Working Committee, who are government staff of the city's management committee. The main coordinator of the Ningdong Demo Committee, on behalf of leadership, is the Head of the Hydrogen Energy Development Center.

Shenyang: Shenyang's PMU main contact person is with the Dadong' District's Communications Department. Members of the Party Committee of the City Lead the Demo Committee.

Dalian: Dalian PMU's main contact person is with Dachuang Energy, a company. The Demo Committee is headed by leadership of the management committee of Jinpu New District of Dalian City.

Financial Management and Procurement: Fund flows for the project are depicted by Exhibit 8. Funds flow from the GEF (funding agency) to UNIDO (GEF Implementing Agency) to MIIT. MIIT, the Executing Agency, will then contact the work in full to IHFCA, its Delegated Executing Agency. Third party financial audits will be carried out annually; and spot audits will also be carried out. Procurement of the project will be carried out by IHFCA with monitoring by UNIDO.

Exhibit 8: Flow of Project Funds



[1] UNIDO Grants Manual 2021

Will the GEF Agency play an execution role on this project?

If so, please describe that role here and the justification.

No.

Also, please add a short explanation to describe cooperation with ongoing initiatives and projects, including potential for co-location and/or sharing of expertise/staffing (max. 500 words, approximately 1 page)

Coordination with Ongoing Initiatives and Projects: The China Green Hydrogen project will put special focus on integrating and leveraging the results of other related initiatives and assist in assessment and dissemination of their results. Thus creating a larger experience upon which China may build its green hydrogen and green hydrogen applications industry and greater momentum for the sustainable growth of the industry. In particular, the project will work to engage the many other pipeline industrial green hydrogen projects (see Exhibit 3) and the city cluster fuel cell vehicle projects. The Project will develop a platform for communication among these projects/ initiatives and also conduct one-on-one outreach with each to gather information from the projects and, in turn, provide the projects information they may need. It is hoped that Project engagements and achievements will help these other projects to resolve challenges and be successful. Based on the information gathered from these other projects, in turn, the Green Hydrogen Project will compile a compendium of China's experience and lessons learned to date with green hydrogen projects, green hydrogen application in industry, and most recent advances in fuel cell vehicle deployment.

The project will also work closely with several other UNIDO initiatives as listed in Exhibit 4. The project will cooperate with the Beijing-based and UNIDO supported Hydrogen Technology Research Center, which is affiliated with Tsinghua University. There may be synergies between the initiatives of the center and the project. Additionally, the project will coordinate with the UNIDO-GEF Global Green Hydrogen Program, which will have efforts in eight countries. It is envisioned that results of the China Project may be leveraged in some of these countries.

UNIDO will handle project monitoring. Based on previous experiences with implementing projects in China, its most effect if the PEE designated by the government takes the lead of the project. In addition, UNIDO shall closely monitor project indicators. By separating monitoring from project management, there is an opportunity for the project to benefit more the capacities of national PEE, thorough monitoring as well as the adaptive management that may arise.

It has also been well clarified consistently throughout the project document, all coordination/cooperation that the project will have with GEF Funded, UNIDO initiatives in China nationally and globally. The project also clarifies potential for scaling-up, replication and impact (under Exhibit 5) and outlines Demo phase II pipeline developments that are ongoing in industries.

Core Indicators

Indicate expected results in each relevant indicator using methodologies indicated in the GEF-8 Results Measurement Framework Guidelines. There is no need to complete this table for climate adaptation projects financed solely through LDCF and SCCF.

Indicator 6 Greenhouse Gas Emissions Mitigated

Total Target Benefit	(At PIF)	(At CEO Endorsement)	(Achieved at MTR)	(Achieved at TE)
Expected metric tons of CO_2e (direct)	17000000	11416389	0	0
Expected metric tons of CO_2e (indirect)	130000000	4566555.6	0	0

Indicator 6.1 Carbon Sequestered or Emissions Avoided in the AFOLU (Agriculture, Forestry and Other Land Use) sector

Total Target Benefit	(At PIF)	(At CEO Endorsement)	(Achieved at MTR)	(Achieved at TE)
Expected metric tons of CO_2e (direct)				
Expected metric tons of CO_2e (indirect)				
Anticipated start year of accounting	2023			
Duration of accounting	5			

Indicator 6.2 Emissions Avoided Outside AFOLU (Agriculture, Forestry and Other Land Use) Sector

Total Target Benefit	(At PIF)	(At CEO Endorsement)	(Achieved at MTR)	(Achieved at TE)
Expected metric tons of CO_2e (direct)	17,000,000	11,416,389		
Expected metric tons of CO_2e (indirect)	130,000,000	4,566,555.6		
Anticipated start year of accounting	2023	2024		
Duration of accounting	5	20		

Indicator 6.3 Energy Saved (Use this sub-indicator in addition to the sub-indicator 6.2 if applicable)

Total Target Benefit	Energy (MJ) (At PIF)	Energy (MJ) (At CEO Endorsement)	Energy (MJ) (Achieved at MTR)	Energy (MJ) (Achieved at TE)
Target Energy Saved (MJ)				

Indicator 6.4 Increase in Installed Renewable Energy Capacity per Technology (Use this sub-indicator in addition to the sub-indicator 6.2 if applicable)

Technology	Capacity (MW) (Expected at PIF)	Capacity (MW) (Expected at CEO Endorsement)	Capacity (MW) (Achieved at MTR)	Capacity (MW) (Achieved at TE)
Solar Thermal		220.00		
Wind Power		500.00		

Indicator 11 People benefiting from GEF-financed investments

	Number (Expected at PIF)	Number (Expected at CEO Endorsement)	Number (Achieved at MTR)	Number (Achieved at TE)
Female	25,000	12,000		
Male	25,000	28,000		
Total	**50,000**	**40,000**	0	**0**

Explain the methodological approach and underlying logic to justify target levels for Core and Sub-Indicators (max. 250 words, approximately 1/2 page)

Annex V provides details on how the lifetime direct emission reduction figure of 11,416,389 t CO2eq was arrived at. A simple approach is adopted for each of heavy duty fuel cell vehicles, petrochemicals, and power generation as follows:

1. For alternative scenario project demo heavy duty fuel cell vehicles that use green hydrogen from demo hydrogen production sites, it is assumed these replace diesel heavy duty vehicles in the business as usual scenario. There is no need to compare the isolated grid renewable energy emissions to grid based power emissions in the emission reduction assessments, as the carbon savings are directly incorporated by comparing diesel heavy duty vehicles to green hydrogen/ zero carbon emission heavy duty vehicles.

2. For the zero carbon green hydrogen produced via the demos that is used in the chemical or petrochemical industry, it is assumed this green hydrogen replaces grey hydrogen produced from coal (the most common type of grey hydrogen in China today) without carbon capture and storage (which is not yet common in China). Again, there is no need to compare the isolated grid renewable energy emissions to grid based power emissions in the emission reduction assessments, as the carbon savings are directly incorporated by comparing emissions in producing grey hydrogen to the zero emissions in producing green hydrogen.

3. For the small sub-project of distributed power generation from green hydrogen, it is assumed the power produced replaces grid electricity to then compute the emission reductions to be achieved.

In each of the cases above, for lifetime emission calculations, the lifetime of the limiting piece of major equipment (shortest lifetime) is considered. For heavy duty vehicles using green hydrogen produced by electrolyzers, the heavy duty vehicles' lifetime is thus considered. For green hydrogen used in the petrochemical industry, it is the electrolyzers's lifetime that is considered.

An estimate of indirect emission reductions (ERs) due to project replication work (replication plans and replication outreach) and policy, capacity building, and other efforts is also provided in Annex V. The approach estimates that replications due in part to project work result in four times the direct emission reductions (about 45.7 million tons of CO2 avoided). To this we apply a causality factor of 10%, meaning the replications are 10% attributable to the GEF project, while the other 90% is due to other factors. This results in a bottom-up indirect emissions reduction calculation for the project of 4.57 million tons CO2 avoided.

"Leakages," whereby the project stimulates increased production of coal-based hydrogen that has more GHG emissions than other fossil fuel options it might replace, are not included in the GHG emissions calculations as factors suggest such leakages will not be significant: (1) The project demos will use exclusively green hydrogen based on contracts with involved companies. (2) The project's technical assistance puts strong emphasis on green hydrogen and supporting initiatives. (3) Forecasts (see Exhibit 2) show China actually reducing grey hydrogen production between 2023 (from 35 million tons) and 2030 (down to 23.4 million tons). Green hydrogen, according to the forecasts, not only makes up the gap, but allows overall hydrogen production to grow between 2023 and 2030. The project will facilitate realization of the forecasts. Yet, at the same time, the forecasts in and of themselves reflect China's strong expected push for realization of net zero policies. Given that the forecast shows a drop in grey hydrogen over the next six years or so and beyond, it can be said the trends favor the project's efforts not to create "leakages" by stimulating greater use of grey hydrogen.

For the increase in installed renewable energy based power generation capacity, the 720 MW is comprised of the sum of the core project demo installations in each of the demo cities: 120 MW PV in Ningdong + 100 MW PV Dalian + 500 MW wind Shenyang.

Beneficiaries are calculated as total persons (and %, number of women) with new or substantially increased involvement in the green hydrogen sector via involvement in the project's demos, its capacity building, its talent development platform and programs, its policy and planning work, etc. The specific types of involvement and sub-estimates that total around 40,000 beneficiaries are: (i) Outcome 1: Persons involved in multiple working groups across different sectors and topics that develop the proposed plans, policies, standards and guidelines. Other persons whose capacity is built via Outcome 1 activities, such as entrepreneurs that are trained, persons involved in developing replication plans, persons involved in plans, policies, and regulations from hard-to-abate industrial sectors experiencing project outreach. Estimated sub-total: 13,000 persons. (ii) Outcome 2: Persons involved in all companies involved in the project demos, including business persons/ managers, technical persons, on-site production and service staff, heavy duty FCV drivers, etc. Persons involved in companies that compete for grants from the project's Innovation Grant Fund. Estimated sub-total: 10,000 persons. (iii) Outcome 3: Persons involved in the project's Outcome 3 events, including those at the project conferences, side events, and small group problem solving. Persons impacted by the project's educational materials. Persons impacted by the project platform to connect experts with companies and to connect organizations with each other. Estimated sub-total: 10,000 persons. (iv) Outcome 4: Persons receiving and reviewing disseminated documents of the project. Persons actively participating in social media groups with topics related to the green hydrogen industrial chain (as organized by the project), persons in hard-to-abate industrial sector companies impacted by project outreach to the sector, persons that become actively involved in the green hydrogen industrial chain discussion boards set up on the project website. Estimated sub-total: 7,000 persons. There may be many more persons that benefit from review of, say, a social media post or article prepared by or related to the project, but those experiencing only this more limited form of impact are not included in the overall target of 40,000 persons.

Key Risks

	Rating	Explanation of risk and mitigation measures
CONTEXT		
Climate	Low	Climatic change, including coastal storms, flooding, heat waves and other extreme weather conditions could influence the sustainability of the pilot demonstrations. Pilots will be designed with safety features to address extreme weather events.
Environmental and Social	Low	The project deploys new green hydrogen application in the chemical and transportation industries, posing the potential threat to persons of hydrogen leakage. Safety measures as proposed by the project's Environmental and Safety Specialist will be adopted, such as ensuring the green hydrogen has room to vent upwards. Low participation rates of women in respective activities is a social risk. The project will undertake active promotion of gender equality via its Gender Action Plan to address the risk. The project design incorporates specific measures to ensure that women can actively participate in various activities and play a positive role. These measures include ensuring that women make up at least 30 per cent of service providers and of participants in various capacity building events and workshops. In addition, in the design of awareness materials for social and external media, the project will aim to include content that appeals to women and children.
Political and Governance	Low	Change in government priorities away from carbon neutrality and energy transformation goals. This project, along with other projects, can continue to show government officials the multiple benefits of energy transformation and educate government on the progress and cost reductions occurring the in the green hydrogen field. There is residual risk that government priorities change, but it is considered unlikely.
INNOVATION		
Institutional and Policy	Low	The project has strong elements of design to support innovation in policy aspects. Risks to this innovation is lack of acceptance by national and local level policy makers. This risk will be reduced by education of the policy makers to understand benefits of proposed policies. There is residual risk that national and local level policy makers do not move quickly to take up proposed draft policies.
Technological	Low	The project has a strong design element to support technological innovation through its Green Hydrogen Industrial Innovation Grant Fund and other support of addressing technological barriers (such as GHIC Technology

		Roadmap). A risk is that companies and innovators lose interest in this field. There is already some good interest in the field and the project activities as described above should help to sustain that. There is some residual risk that technology innovations needed are not developed during the project lifetime.
Financial and Business Model	Low	There is a strong need for financial and business model innovation to support development of the GHIC. The project adopts specific activities such as review of innovative business models to date and demonstration of innovative business models. Yet there is some residual risk that desirable business models cannot be found in some links of the chain.
EXECUTION		
Capacity	Moderate	The PEE, while a relatively new organization has persons with many years of experience in implementing donor projects. To mitigate risks in implementation capacity, UNIDO is taking on an M&E role for this project which will include carefully and continuous monitoring of project activities to ensure that they are done in a way that targets meaningful results.
Fiduciary	Moderate	During the PPG phase, a HACT assessment of the PEE was conducted. Risk mitigation will involve implementing the recommendations in the HACT. Furthermore, UNIDO as GEF Implementing Agency will carry out quality control review of procurement and expenditures.
Stakeholder	Low	The project will secure the participation of public and private stakeholders by maintaining constant communications with relevant governmental institutions, private developers and/or members of the civil society through remote means of communication and when possible, executing face-to-face stakeholder engagements through workshops, event, webinars, etc.

Other	Low	CARBON LEAKAGE RISKS Because some of the project activities may generally support the scale-up of hydrogen use, there is some risk that the project could stimulate increases in production of coal-based hydrogen, the production of which has high emissions such that coal-based hydrogen is not considered low carbon. The project, however, has taken strong efforts to avoid stimulating increased coal-based hydrogen production. All activities that address the GHIC will aim to put emphasis on green hydrogen. Finally, the project will strongly leverage the Government of China's aims to reach net zero by 2060 and the positive response that is now being seen in industry to prepare for net zero requirements. As seen in Exhibit 2, after 2023 or so, a reduction in coal-based hydrogen in China (made up for by increasing production of green hydrogen) is forecast, reflecting net zero targets, and suggesting that, in conjunction with the aforementioned project measures the risk of substantial carbon leakage of this type from the project is low. REPUTATIONAL RISKS Individuals or articles in the press may criticize the project for links with coal industry and petrochemical industry partners. Yet, in some cases it can be important for green initiatives to engage the fossil fuel sector as one of the greatest leverage points for carbon emission reductions. In

		terms of green hydrogen, such engagement is particularly critical, because the top end use worldwide of hydrogen is petrochemicals. In fact, one of the most important players so far in green hydrogen in China is Sinopec, one of China's largest petrochemical companies. Companies using a lot of fossil fuels are cognizant of net zero targets of the nation and are working to address these targets. In order to mitigate the reputation risk associated with fossil fuel industry partners, the project in it is communications should continually send the message of how green hydrogen is a means of lowering the carbon footprint of these major carbon emitters, a major leverage point for lowering national emissions overall, and of helping them gradually transition to green production. The project's regular and transparent communications will be important in mitigating the risk in this way and will include links to reports available to stakeholders, which will, in turn, include results of field checks of demo sites. MIS-ALIGNED INTERESTS Partners from the fossil fuels sector and coal sector, in particular, may have interests that conflict with those of the project, such as a preference for coal-based hydrogen over green hydrogen. In terms of risk mitigation, the project will require clear contracts with involved companies that will require commitment to production and use of green hydrogen. The agreements will include penalties for non-compliance. Financial support will be provided to partners only if they meet green hydrogen targets. Ongoing engagement with stakeholders will also help all parties remain aligned with regard to the project objective. Further, the nation's net zero targets and policy direction are already aligning interests of the fossil fuels sector with those of the China Green Hydrogen Project.

Overall Risk Rating	Moderate	The project Implementing and Executing entities shall ensure to apply all risks mitigations and risks redress methods to for the smooth execution of the project; and develop a robust mitigation strategy that depicts the project does not encounter longer delays, environmental or policy bottlenecks.

C. ALIGNMENT WITH GEF-8 PROGRAMMING STRATEGIES AND COUNTRY/REGIONAL PRIORITIES

Explain how the proposed interventions are aligned with GEF- 8 programming strategies and country and regional priorities, including how these country strategies and plans relate to the multilateral environmental agreements.

For projects aiming to generate biodiversity benefits (regardless of what the source of the resources is - i.e., BD, CC or LD), please identify which of the 23 targets of the Kunming-Montreal Global Biodiversity Framework the project contributes to and explain how.

Confirm if any country policies that might contradict with intended outcomes of the project have been identified, and how the project will address this. (max. 500 words, approximately 1 page)

Alignment with GEF Programming Strategies: The project is aligned with GEF-8 programming strategies under the Climate Change Mitigation (CCM) Area. It addresses one of the two pillars in this area: "Promote innovation, technology development and transfer, and enabling policies for mitigation options with systemic impacts." And, it addresses three of the four objectives under the pillar: 1.1 - Accelerate the efficient use of energy and materials, 1.2 – Enable transition to decarbonized power systems, and 1.3 - Scale up zero-emission mobility of people and goods. Under objective 1.2, the GEF 8 Programming Document states, "The GEF may also provide early support for green hydrogen—produced with renewable electricity through electrolysis—as an additional option for energy storage and potential to help decarbonize hard-to-abate sectors.” The project design is highly aligned with this statement. Green hydrogen in the project is exclusively produced via use of isolated grid renewable electricity in electrolysis. And, end-uses focus solely on high priority hard-to-abate sectors, namely (a) heavy duty vehicles in the transport sector and (b) hard-to-abate industrial sectors, especially chemicals.

For the aforementioned pillar, the GEF Programming Document states that, “The GEF-8 climate change investments will focus on opportunities with a potential to trigger the transformation of key economic systems, including energy, transport, and land use.” The *China Green Hydrogen Project* is in line with this focus, as setting up the enabling environment for a rapid scale-up of green hydrogen, as the project aims to do, indeed does have the potential for transformation of China’s economic systems – towards a green hydrogen based economy. Transport is one sector, in particular, that may be transformed by the complete green hydrogen industrial chain work of the project. Others are hard-to-abate industrial sectors, particularly chemicals. The project also adopts some of the key areas for interventions highlighted with regard to this pillar including technology, policy and regulatory support, and best practices.

Alignment with Country Priorities:

Alignment on a general level with China’s decarbonization aims and its national priorities: The project supports the Chinese government in moving towards decarbonization of its industrial sector and transportation systems. The project and proposed interventions are aligned with China’s national strategies and plans under the UNFCCC. The project directly contributes to China’s goals on combatting climate change, reaching a carbon peak by 2030, and achieving carbon neutrality by 2060. As for China's national priorities, advanced energy (including fuel cell technologies and renewable energy technologies such as hydrogen, wind power), new energy vehicles (including fuel cell vehicles), environmental protection, and comprehensive utilization of resources are all priority areas identified by the Chinese Government and congruent with the project.

Alignment with China’s hydrogen plans and priorities overall: The Chinese government places high importance on the development of the hydrogen industry, viewing it as a crucial means to promote energy structure transformation and achieve the national dual carbon goals. At the national level, the hydrogen industry has been incorporated into the 'Energy Production and Consumption Revolution Strategy (2016-2030)' and 'Made in China 2025.' These policy documents clearly outline long-term goals for developing green and low-carbon energy, designating hydrogen technology as a key area for innovation and thus showing that the project is well-aligned in its focus on both green hydrogen and innovation.

China’s 'Medium and Long-Term Plan for the Development of the Hydrogen Energy Industry (2021-2035)' provides a concrete roadmap and policy support framework for the development of China’s hydrogen industry. This plan not only emphasizes the application of hydrogen energy in the transportation sector, but also highlights its potential uses in the industrial sector, including the chemical industry, and thus directly aligns with the target green hydrogen end use markets of this project. The measures outlined in the plan, such as technological innovation, infrastructure development, and application promotion, offer a solid policy foundation for the implementation of our project and align with the areas of work of the project.

Alignment with China’s vehicle sector plans and priorities: As noted, China gives priority to the development of new energy vehicles, including FCVs. Research on FCVs in China began during 'the Tenth Five Year Plan' period (2001-2005). In 2010, China’s National '863 Plan' began to support the development of FCVs. In 2012, the Ministry of Science and Technology issued the Special Project of '12th Five Year Plan' for Development of Electric Vehicle Technology, which determined 'the Three Vertical and Three Horizontal' research and development layout, of which FCVs became one of the key fields to be supported. In September 2020, the Ministry of Finance and five other departments jointly issued the *Notice on Developing the Demonstration Application of Fuel Cell Vehicles*, which adjusted the original purchase subsidies to some selected qualified urban agglomerations (the aforementioned "City Clusters"), called for the carrying out of industrialization research and demonstration of core technologies, and provided subsidies for the foregoing. In November 2020, the State Council issued the *New Energy Vehicle Industry Development Plan (2021–2035*), which defined the development goals and key tasks vis-a-vis hydrogen FCVs, and promoted high-quality development of the hydrogen FCV industry in the nation.

Alignment with chemical/ petrochemical sector plans and priorities: In April 2022, the Ministry of Industry and Information Technology (MIIT), together with six other ministries and commissions, issued the 'Guiding Opinions on Promoting High-Quality Development of the Petrochemical Industry in the 14th Five-Year Plan.' This document encourages petrochemical and chemical enterprises to develop 'green hydrogen' in a reasonable and orderly manner according to local conditions and promotes the cooperation of and demonstration in industries such as refining, the coal chemical industry, 'green electricity,' and 'green hydrogen.' In March 2022, the National Development and Reform Commission and the National Energy Administration issued the 'Medium- and Long-Term Plan for the Development of the Hydrogen Energy Industry (2021-2035)," proposing to explore the demonstration of the use renewable energy based green hydrogen in the synthetic ammonia, methanol, refining, and coal-to-oil and gas industries, as a replacement for fossil fuel use. In June 2023, the 'Notice on Promoting the Healthy Development of the Modern Coal Chemical Industry,' issued by the National Development and Reform Commission and other departments, clearly stated that in regions with favorable resource endowments and industrial foundations, the development of the modern coal chemical industry should be promoted through innovative coupling with renewable energy, green hydrogen, and carbon dioxide capture, utilization, and storage (CCUS). The release of these policies provides clear development directions and supportive measures for green hydrogen in the chemical industry and also shows alignment of the project's chemical industry work with national chemical sector plans and priorities.

D. POLICY REQUIREMENTS

Gender Equality and Women's Empowerment

We confirm that gender dimensions relevant to the project have been addressed during Project Preparation as per GEF Policy and are clearly articulated in the Project Description (Section B).

Yes

1) Does the project expect to include any gender-responsive-measures to address gender gaps or promote gender equality and women's empowerment?

Yes

If the project expects to include any gender-responsive measures to address gender gaps or promote gender equality and women empowerment, please indicate in which results area(s) the project is expected to contribute to gender equality:

Closing gender gaps in access to and control over natural resources;

Improving women's participation and decision-making; and/or

Yes

Generating socio-economic benefits or services for women.

Yes

2) Does the project's results framework or logical framework include gender-sensitive indicators?

Yes

Stakeholder Engagement

We confirm that key stakeholders were consulted during Project Preparation as required per GEF policy, their relevant roles to project outcomes has been clearly articulated in the Project Description (Section B) and that a Stakeholder Engagement Plan has been developed before CEO endorsement.

Yes

Select what role civil society will play in the Project

Consulted only; Yes

Member of Advisory Body; Contractor;

Co-financier;

Member of project steering committee or equivalent decision-making body ;

Executor or co-executor; Yes

Other (Please explain)

Private Sector

Will there be private sector engagement in the project?

Yes

And if so, has its role been described and justified in section B project description?

Environmental and Social Safeguards

We confirm that we have provided information regarding Environmental and Social risks associated with the proposed project or program, including risk screenings/ assessments and, if applicable, management plans or other measures to address identified risks and impacts (this information should be presented in Annex E).

Yes

Please provide overall Project/Program Risk Classification

Overall Project/Program Risk Classification

PIF	CEO Endorsement/Approval	MTR	TE
Medium/Moderate	Low		

E. OTHER REQUIREMENTS

Knowledge management

We confirm that an approach to Knowledge Management and Learning has been clearly described during Project Preparation in the Project Description and that these activities have been budgeted and an anticipated timeline for delivery of relevant outputs has been provided.

Yes

Socio-economic Benefits

We confirm that the project design has considered socio-economic benefits to be delivered by the project and these have been clearly described in the Project Description and will be monitored and reported on during project implementation (at MTR and TER).

√ Yes

ANNEX A: FINANCING TABLES

GEF Financing Table

Trust Fund Resources Requested by Agency(ies), Country(ies), Focal Area and the Programming of Funds

GEF Agency	Trust Fund	Country/ Regional/ Global	Focal Area	Programming of Funds	Grant / Non-Grant	GEF Project Grant($)	Agency Fee($)	Total GEF Financing ($)
UNIDO	GET	China	Climate Change	CC STAR Allocation: CCM-1-1	Grant	6,300,000.00	567,000.00	6,867,000.00
UNIDO	GET	China	Climate Change	CC STAR Allocation: CCM-1-2	Grant	6,300,000.00	567,000.00	6,867,000.00
UNIDO	GET	China	Climate Change	CC STAR Allocation: CCM-1-3	Grant	3,400,000.00	306,000.00	3,706,000.00
Total GEF Resources ($)						**16,000,000.00**	**1,440,000.00**	**17,440,000.00**

Project Preparation Grant (PPG)

Was a Project Preparation Grant requested?

true

PPG Amount ($)

300000

PPG Agency Fee ($)

27000

GEF Agency	Trust Fund	Country/ Regional/ Global	Focal Area	Programming of Funds	PPG($)	Agency Fee($)	Total PPG Funding($)
UNIDO	GET	China	Climate Change	CC STAR Allocation: CCM-1-1	120,000.00	10,800.00	130,800.00
UNIDO	GET	China	Climate Change	CC STAR Allocation: CCM-1-2	120,000.00	10,800.00	130,800.00
UNIDO	GET	China	Climate Change	CC STAR Allocation: CCM-1-3	60,000.00	5,400.00	65,400.00
Total PPG Amount ($)					**300,000.00**	**27,000.00**	**327,000.00**

Please provide Justification

Sources of Funds for Country Star Allocation

GEF Agency	Trust Fund	Country/ Regional/ Global	Focal Area	Sources of Funds	Total($)
UNIDO	GET	China	Climate Change	CC STAR Allocation	17,440,000.00
Total GEF Resources					**17,440,000.00**

Focal Area Elements

Programming Directions	Trust Fund	GEF Project Financing($)	Co-financing($)
CCM-1-1	GET	6,300,000.00	55000000
CCM-1-2	GET	6,300,000.00	55000000
CCM-1-3	GET	3,400,000.00	29704000
Total Project Cost		**16,000,000.00**	**139,704,000.00**

Confirmed Co-financing for the project, by name and type

Please include evidence for each co-financing source for this project in the tab of the portal

Sources of Co-financing	Name of Co-financier	Type of Co-financing	Investment Mobilized	Amount($)
GEF Agency	United Nations Industrial Development Organization	In-kind	Recurrent expenditures	400000
GEF Agency	United Nations Industrial Development Organization	Grant	Investment mobilized	100000
Beneficiaries	International Hydrogen Fuel Cell Association (IHFCA)	In-kind	Recurrent expenditures	470000
Private Sector	Dalian- Guochuang Hydrogen Technology Co., Ltd.	Equity	Investment mobilized	67334000
Private Sector	Dalian- Guochuang Hydrogen Technology Co., Ltd.	In-kind	Recurrent expenditures	1400000
Private Sector	Shenyang -Huadian Liaoning Energy Development Co., Ltd.	Equity	Investment mobilized	68600000
Private Sector	Shenyang -Huadian Liaoning Energy Development Co., Ltd.	In-kind	Recurrent expenditures	1400000
Total Co-financing				**139,704,000.00**

Please describe the investment mobilized portion of the co-financing

The investment mobilized as part of the co-financing consists primarily of cash contributions from the main implementing companies in the demonstration cities, such as for equipment, construction, and operational infrastructure. The in-kind contributions largely support recurrent expenditures at the demonstration sites - covering operational support, maintenance costs, staffing and funding experts with some allocated towards technical assistance (TA) activities.

It is worth noting that that specifically for Ningdong Guoneng's co-financing letter will be provided during project implementation stage. As a result, the Ningdong co-financing is not included in the current co-financing table. We have an "in principle" commitment from Ningdong for a minimum of fifty million (50,000,000) dollars.

The co-financing letters from the main implementing companies, Shenyang Huadian Liaoning Energy Development Co., Ltd. and Dalian Guochuang Hydrogen Technology Co., Ltd., confirm their commitments and indicate significant investment in the demonstration projects. Specifically, Shenyang Huadian Liaoning Energy Development Co., Ltd. has committed USD 70 million, with USD 68.59 million in cash and USD 1.41 million in-kind. This funding will be utilized for critical components of the demonstration such as the 50 MW wind power installation, green hydrogen production facilities, and heavy-duty FCVs. The investment also covers broader initiatives including the hydrogen industrial park, hydrogen exhibition hall, and local policy development to support the green hydrogen industrial chain. More details on the expected expenditures can be found in the Shenyang Demo Annex.

Dalian Guochuang Hydrogen Technology Co., Ltd. has committed USD 68.734 million, including USD 67.334 million in cash and USD 1.4 million in-kind, focusing on projects like green hydrogen production, FCVs, hydrogen refueling stations (HRSs), and a microgrid power generation demo. Additionally, the company will support the development of local standards and product certification, and implement safety and environmental programs. Details of these expenditures are outlined in the Dalian Demo Annex.

ANNEX B: ENDORSEMENTS

GEF Agency(ies) Certification

GEF Agency Type	Date	Project Contact Person	Phone	Email
GEF Agency Coordinator	5/30/2024	Ms. Ganna ONYSKO	+43 1 26026 3647	G.ONYSKO@unido.org
Project Coordinator	5/30/2024	Mr. Heng LIU	+43 1 26026 3779	H.LIU@unido.org
Project Coordinator	5/30/2024	Mr. Alvin Tepo TOGBA	+43 1 26026 3652	A.TOGBA@unido.org

Record of Endorsement of GEF Operational Focal Point (s) on Behalf of the Government(s):

Please attach the Operational Focal Point endorsement letter(s) with this template.

Name of GEF OFP	Position	Ministry	Date (MM/DD/YYYY)
Mr. Xiang PENG	Director	Ministry of Finance	4/28/2023

ANNEX C: PROJECT RESULTS FRAMEWORK

Please indicate the page number in the Project Document where the project results and M&E frameworks can be found. Please also paste below the Project Results Framework from the Agency document.

Note: UNIDO uses the CER as its ProDoc, so the PRF can be found below. Two versions are included: (1) The first version directly below includes only the high level indicators (objective and outcome level indicators) to be used in evaluations and by project management to ensure the project is on its way to having the intended impact and meaningful results. (2) The second includes the same high level indicators but also adds output indicators to support day-to-day management in ensuring the necessary basic tasks of the project (e.g. holding meetings, preparing reports) are completed.

ANNEX C: PROJECT RESULTS FRAMEWORK

Project Strategy	KPI/ Indicator	Baseline	Target at End of Project	Means of Verification (Sources/ Methods)	Assumptions
Project Objective: To facilitate the development and replication of comprehensive and	Direct lifetime GHG emission reductions from the three project demos	0 tons CO_2	11,416,389 tons CO_2	Demo project monitoring reports; info on expected lifetime of equipment	Demo cities and demo city company partners maintain strong commitment to follow through with demos.

integrated green hydrogen industrial value chains in China, with demand pull from hard-to-abate industrial and heavy duty vehicle sectors and with stimulus and support across the value chain from policy, strategic planning, standards, successful demonstration in Ningdong, Dalian, and Shenyang using renewable energy, technical innovation, new business models, improved technical and cost viability, capacity building, information dissemination, capacity building, and human networks.	Number of cities or locales and potential annual green hydrogen production represented by strong replications in pipeline with strong likelihood of realization that are largely attributable to the project (tons H_2 in China, tons H_2 abroad)	0 cities China, 0 cities abroad; 0 tons per year H_2 China, 0 tons per year H_2 abroad	12 cities China, 12 cities abroad; 24,000 tons per year H_2 China, 24,000 tons per year H_2 abroad	Project list of cities and locales to which the project has promoted replication, such as via replication plan support; follow up survey of these locales	China's net zero target and favorable policies related to the green hydrogen industrial chain continue and expand to create added incentives. Policies in other replication countries are or become favorable to the developing of green hydrogen industrial chains.
	Total persons (and %, number of women) with new or substantially increased involvement in the green hydrogen sector via involvement in the project's demos, its capacity building, and/ or its talent development platform and programs.	0 persons	40,000 persons (30% or 12,000 women)	Project logs of attendees at all conferences and training events (with double counting removed); project talent platform; demo city provided listing of persons involved in demos; removal of other double counting by project	Policy conditions in China remain favorable to the development of green hydrogen industrial chain. Demo cities and demo city company partners maintain strong commitment to follow through with demos.
Outcome 1: China's pipeline policies, plans, and standards, as well as information, innovation, and financing related to green hydrogen and its value chain increase from a very limited baseline to a significant level that raises the motivation and confidence of industry and other players to participate in the green hydrogen industrial chain.	Green Hydrogen Roadmap that comprehensively covers technology options at different links in the chain and for different time periods achieves formal endorsement by target number of companies and of research/ academia experts; MIIT issues a letter of recognition regarding roadmap and several elements of roadmap incorporated into government issuances	0 companies, 0 experts No MIIT letter of recognition, 0 elements of roadmap into issuances	60 companies, 60 experts MIIT letter of recognition of roadmap, 5 or more differentiated elements of roadmap incorporated into government issuances	Endorsement signature list indicating support for the Roadmap (as provided by project); MIIT letter of recognition; Government issuances that contain elements of roadmap (verified by comparison to roadmap)	Policy and economic conditions in China remain favorable to the development of green hydrogen industrial chain.
	At national level: number of draft policies prepared by project that are approved and/or achieve letters of recognition as being in pipeline, and number that are endorsed by at least 20 experts from at least 10 different institutions (including industry, research institutions, and universities) [Note: The second sub-indicator may also include some or all of the approved and pipeline policies]	National: 0 approved and/or achieved letter of recognition, 0 endorsed by experts	National: 3 approved and/or achieved letter of recognition by government, 12 endorsed by at least 20 experts from 10 institutions (*including some or all of the prior 3 achieving approval and/or letters of recognition*) Local: 15 approved and/or achieved letter of recognition by local government and/or received	Issuance of new policies by government at national and local levels; Government letters of recognition of submitted policies at national and local levels; expert endorsement of national and local level policies drafted (as obtained by project)	National government continues to prioritize low carbon development and diversification of energy sources

	At the local level: Number of draft policies prepared by project that are approved and/ or achieve letters of recognition from government at local level and/or are endorsement by 10 experts from multiple institutions (*approval at more than one locality results in multiple points equal to number of localities for the policy*), number of draft policies prepared by project that have received letters of recognition (*approval at more than one locality results in multiple points equal to number of localities for the policy*) [Note: The second sub-indicator will also include all approved policies] [Overall note: This indicator will include both incentive policies and safety and management policies.]	Local: 0 approved and/or achieve letter of recognition and/or receive endorsements from experts	endorsement from at least 10 experts from multiple institutions (*includes more than one point if multiple provinces, cities, or districts involved per policy*)		
	Standards drafted by the project per needs identified by project standards tree: National level: number approved or in the pipeline for adoption At association level: Number issued or in pipeline for adoption	National: 0 approved or in pipeline Group: 0 issued or in pipeline	National: 5 approved or in the pipeline for adoption Association: 8 issued or in pipeline for adoption	Issuances of new standards at national or association level; evidence standard has entered formal adoption process at national or group level, respectively, per standard procedure	Hydrogen economy continues to receive national government support, so that national standards committees remain active on items relevant to the green hydrogen industrial chain
	Monitoring data from the demos and other project info products provides quality, comprehensive cost and technical performance data for the public at	0	18, as verified by expert review	Expert review of demo monitoring data and analysis thereof to confirm that reliable and insightful information on costs	Demo cities and their partners are willing to share enough data to provide reliable information on cost viability and technical

	each of the following links in the value chain: renewable energy power generation, hydrogen production, transport and storage, use in chemical industry, HRS, use in heavy duty vehicles (one point for each city/ link pair for total of 18 possible and one point for each link considered to be covered reliably in other info products for total of 6 possible, so total possibility of 24 points)			and technical performance is provided at each link in value chain; Similar expert review of project info product reports on cost and technical viability across the value chain	viability at various links in the value chain. Researchers for other project info products dealing with cost and technical performance are able to gather reliable/ quality data that reflects current best achievements or best potential achievements in the industry.
	Increased support of national level plans for green hydrogen industrial chain attributable to project: (a) national hydrogen highway network plan adopted, (b) number of hard- to-abate industrial sector plans newly incorporating green hydrogen or expanding related content, (c) inclusion of green hydrogen and application in hard-to-abate industrial sectors in national hydrogen energy city cluster plan	(a) no national hydrogen highway network plan (b) 0 hard-to-abate industrial sectors (c) green hydrogen production and application in hard-to-abate industrial sectors not included	(a) national hydrogen highway network plan adopted (b) at least 3 hard-to-abate industrial sectors (c) green hydrogen production and application in hard-to-abate industrial sectors included in national city cluster expansion plan	National issuance regarding national hydrogen highway network plan; Updated sector plans for hard-to-abate sectors as issued by their industry associations or relevant government departments; Reports on cluster city activity	National government continues to prioritize low carbon development and diversification of energy sources Economic situation continues to make it realistic for hard-to-abate industrial sectors to get involved in green hydrogen production and utilization
	Number of technical innovations, number of business plan innovations, and number of policy innovations newly identified in project info products, via fund outreach, or via entrepreneur training that are deemed by experts to be viable cost-wise and technically (if relevant) and that have not been deployed to significant scale prior to project and that were not raised/ described in this project document.	0 technical 0 business plan 0 policy	10 technical innovations/ advances 5 business plan innovations 5 policy innovations	Project commissioned reports on such innovations; project reports on start-ups identified via fund outreach activities and follow up with promising start-ups; project reports on entities involved in entrepreneur training; analysis of experts in assessment of this indicator	Policy and economic conditions in China remain favorable to the development of green hydrogen industrial chain. Technical and business plan innovators are willing to share reliable information on costs and technical performance.
Outcome 2: Demonstration of complete green hydrogen value chains successfully realized, featuring innovative technologies and approaches and showing improved technical and cost viability as compared	Number of green hydrogen industrial chain related meaningful/ industry advancing technical innovations or substantial cost reductions or performance improvements (from baseline) successfully	0	7	Demo monitoring data and reports; Criteria developed by experts; Project site visit consultations and reports.	Demo cities and demo city company partners maintain strong commitment to follow through with demos.

to baseline, including green hydrogen production, its storage and transport, and its use in hard-to-abate industrial sectors and in various heavy duty vehicle types and scenarios (supported by hydrogen refueling stations).	demonstrated. Achievements counted may include, but not be limited to the following: (i) system that enables alkaline electrolyzers to better deal with RE power variability, (ii) lower cost/ higher efficiency alkaline electrolyzers, (iii) lower cost/ higher efficiency PEM electrolyzers, (iv) use of O2 byproduct from electrolytic H2 production, (v) domestication of certain fuel cell stack parts (membrane, catalyst, carbon paper), thus lowering heavy duty FCV cost, (vi) increased power density and reliability of fuel cell stack, (vii) lower cost of fuel cell stacks, (viii) stable supply of H2 to chemical customers with significant green hydrogen uptake, utilizing buffer tanks and grey hydrogen as needed, (ix) low ex-factory cost of green hydrogen (11 RMB/ kg), (x) extensive use of higher pressure tubes (e.g. 50 Pa) on H2 transport trucks and associated cost reduction, (x) extensive use of 70 mPa HRS equipment, (xi) lower cost desalinization using process heat from hydrogen production. [*Experts will define success criteria for each innovation/ cost-reduction/ performance improvement from baseline and these criteria will be referenced in assessing this indicator*]				
	Number of green hydrogen industrial chain related meaningful/ industry-advancing (a) business model innovations or (b) local policy innovations successfully demonstrated. Achievements counted may include, but not be limited to the following:	0	8 (4 business model + 4 policy)	Demo monitoring data and reports; Criteria developed by experts; Project site visit consultations and reports.	Demo cities and demo city company partners maintain strong commitment to follow through with demos.

	(i) integration of fisheries with tidal flat PV power production increases economic viability, (ii) use of heavy duty FCV trucks for cold storage fleets with HRSs near overnight parking locations reduces lifetime costs as compared to other vehicle types (i.e. ICEVs, EVs), (iii) use of FCV buses on long-distance public bus routes reduces lifetime costs as compared to other vehicle options (i.e. ICEVs, EVs), (iv) use of heavy duty FCVs on fixed long-distance logistics routes reduces lifetime costs as compared to other vehicle options (i.e. ICEVs, EVs), (v) use of green hydrogen in chemicals production increases profitability vis-à-vis green chemicals demand of certain export markets, (vi) toll free passage and/or right of way on hydrogen highway increases heavy duty FCV uptake, (vii) allowing hydrogen production outside chemical parks results in increased viability of projects, (viii) allowing HRSs on industrial land and/ or allowing HRSs to lease land improves economic viability, (ix) offering "5 in 1" HRSs large quotas for selling petrol improves economic viability, (x) subsidies for green hydrogen production increase upstream investments in the green hydrogen industrial chain [*Experts will define success criteria for each innovation and these criteria will be referenced in assessing this indicator.*]				
	Green hydrogen being produced annually that is attributable to the project demos and utilized in the transport and hard-to-abate	0 tons	At least 26,141 tons (at least 21,000 tpy Shenyang (at least 2,000 Phase 1 plus 19,000 Phase 2), 600 tpy Dalian,	Demo monitoring data and reports; Project reports from site visits and consultations.	Demo cities and demo city company partners maintain strong commitment to follow through with demos.

	industrial sectors of the project's integrated industrial value chains		4,541 tpy Ningdong)		
	End use of green hydrogen in project demos: Tons of ammonia (or other products) produced annually; number of active heavy duty vehicles fueled by green hydrogen; and total demo vehicle km driven with green hydrogen by EOP	0 tons 0 vehicles 0 km	415,000 tons (100,000 tpy methanol Shenyang Phase 2 + 300,000 tpy ammonia Dalian associated project + 15,000 tpy ammonia Ningdong main demo[1]) 500 vehicles 79.43 M km (35.63 M Shenyang + 23.8 M Dalian + 20 M Ningdong[2])	Demo monitoring data and reports; Project reports from site visits and consultations.	Demo cities and demo city company partners maintain strong commitment to follow through with demos.
	Isolated grid installed RE power generation capacity associated with the project demos and used exclusively for the production of green hydrogen	0 MW	720 MW (120 MW PV Ningdong, 100 MW PV Dalian, 50 MW wind +450 MW wind Shenyang)	Demo monitoring data and reports	Demo cities and demo city company partners maintain strong commitment to follow through with demos.
Outcome 3: Increased knowledge and capacity of government, industry, experts, technical personnel, engineers, and students regarding green hydrogen and its industrial chain, along with improved mode of connecting human talent to needs/ projects, leads to increased availability of qualified persons across domains to ensure success of the industry.	Number of attendees at large project conferences that improve their scores on content tests by 25% or more (%, and number of women) Number of cases of key lessons from cluster cities or international cities presented at Project conferences that are confirmed as adopted (via policy or planning documents) by Project demo cities or other cities due to Project capacity building	0 (0%, 0) 0	400 (30%, 120) 20	Results of content tests administered at conferences; Follow up of project with project demo cities, other cities attending conferences, and other sources to confirm uptake of lessons; Planning or policy documents that confirm uptake of lessons	Attendees have strong interest in content Continued strong national support for low-carbon development
	Number of major green hydrogen industrial chain problems presented and newly solved at Project meetings that are acted	0 points for problems newly solved and acted upon or in pipeline for action	10 points for problems newly solved and acted upon or in pipeline for action	Minutes of meetings to identify problems solved; Project follow up with potential implementers to	Potential implementers of solutions are receptive to recommendations and have the resources to implement them

	upon or in clear pipeline for action (*Note: Experts will come up with a scoring system as to whether the problem solved counts as "major" and "newly solved"*) (major problem gets 1 point if newly solved, average problem ½ point if newly solved, or small problem 1/4 point if newly solved)			assess implementation of solutions or likelihood thereof; Assessment of experts on magnitude of each problem, whether newly solved, and whether implemented or likely to be implemented	
	Number of universities newly offering courses based on project prepared textbooks/ training materials and total number of different courses offered across universities (each course at a university with different content from the others courses will be counted, as will be same courses but offered at different universities)	0 universities 0 courses	1 university 4 courses	Project prepared textbook/ training materials; Information from universities on past and current courses	Universities perceive market demand for students having the type of training supported by project textbooks/ training materials. Students have interest in hydrogen related coursework.
	Number of researchers or research institutes/ universities successfully reaching out to companies via connection on the platform with either the talents' confirmed involvement in projects they heard about via the platform or confirmed deals for the companies to deploy/ test technologies developed in the research institute	0 outreach to companies via platform resulting in project involvement or cooperation	20 outreaches to companies via platform resulting in project involvement or other cooperation	Platform monitoring logs if there is tracking of interactions via platform; Follow up with persons and entities listed on platform to determine results	Policy and economic conditions in China remain favorable to the development of green hydrogen industrial chain. IPR concerns do not hinder short-term recruitment of talent or cooperation between talent/ research institutes and companies on projects.
Outcome 4: Knowledge dissemination, awareness raising, international exchange, and information sharing on the green hydrogen industrial chain results in active engagement of companies in upstream and downstream links of the value chain, increased confidence in hydrogen (particularly green hydrogen) and support thereof from government officials, and increased interest	Total unique hits of landing pages on project website associated with project demo results reports and project information reports prepared under Outcome 1	0	10,000	Results of website analytics for landing page set up for each relevant report, respectively; Project website discussion boards, cluster city-demo city exchange board, technology info exchange board, and other project experience board	Policy and economic conditions in China remain favorable to the development of green hydrogen industrial chain.
	Number of hits of Project-related articles and videos (not including KOL videos) posted on social media domestically. (Articles, Videos)	0 (0, 0)	30,000 (=15,000 article hits and 15,000 video views) (*domestic*)	Analytics of hits/ views of articles and videos posted on social media; Project follow up with KOLs approached by project; Project follow up with external news	Domestic and international media in the green hydrogen industrial chain continues and grows

of the public in green hydrogen and its applications.	Number of KOLs promoting Project content and green hydrogen as a result of relationships with the Project; Number of hits of KOL video clips promoting the Project	0, 0	10 KOLs, 10,000 hits of KOL videos	organizations and analytics of hits/ views of articles posted; Internet search for articles about project	KOLs assess the green hydrogen industrial chain as a high potential topic for them to promote to their audiences
	Number of domestic external news organizations or news wires that publish articles on Project; Number of domestic external articles published on Project, Number of hits of external domestic articles published on Project	0, 0, 0	10 news organizations, 20 articles, 10,000 hits of external media (*domestic*)		
	Number hits of brochure/ presentation addressing hydrogen safety misconceptions and truths and number of articles in external media coverage re misconception research findings	0	5,000 hits of hydrogen safety brochure/ presentation, 5 articles (*domestic or international*)		
	Number of hits of articles and videos on foreign/ international social media (articles, videos)	0	30,000 (=15,000 article hits and 15,000 video views) (*international*)		
	Number of international external news organizations or news wires that publish articles on the project, Number of international articles published on the project, Number of hits of external international articles published on the project	0, 0, 0	10 news organizations, 20 articles, 10,000 hits of external media (*international*)		
	Number of "active" relationships or ongoing discussions between Chinese and international firms achieved with substantial attribution to project (comprised of	0 (0, 0, 0)	10 (4, 3, 3)	Project follow up with companies involved in Project activities fostering international cooperation; Articles in the media and on company websites.	Policy and economic environment in other countries conducive to green hydrogen industrial chain projects

	number for sourcing of international products, number for technological cooperation for R&D or manufacturing, number for Chinese supply of equipment to demo projects abroad)				IPR concerns do not inhibit foreign firms from technological cooperation with Chinese firms and vice versa
	Number of companies in hard-to-abate industrial sectors that are confirmed to have developed either plans for green hydrogen projects or roadmaps for a path to green hydrogen as a result of Project capacity building and dissemination (comprised of number that have developed green hydrogen project, number that have developed roadmaps)	0 (0,0)	5 (1 with plans for specific projects, 4 with roadmaps)	Project follow up with companies involved in Project's hard-to-abate industrial sector capacity building; Documentation of company plans for green hydrogen projects or related roadmaps, as available	Economic situation of companies in hard-to-abate industrial sectors is strong enough to pursue new areas Policy environment in China continues to push hard-to-abate industrial sectors to reduce carbon emissions

[1] Ningdong's demo feasibility study did not offer a target for annual green chemicals output, so a low end figure as compared to the other two cities and proportionally considering hydrogen output directed to chemical production is used.

[2] Ningdong's demo feasibility study did not offer a target for km driven, so a low end figure as compared to the other two cities is used.

ANNEX D: STATUS OF UTILIZATION OF PROJECT PREPARATION GRANT (PPG)

Provide detailed funding amount of the PPG activities financing status in the table below:

Project Preparation Activities Implemented	GETF/LDCF/SCCF Amount ($)		
	Budgeted Amount	Amount Spent To date	Amount Committed
Inception workshop	10,000.00	10,000.00	0.00
Stakeholder engagement activities	10,000.00	10,000.00	0.00
Preparation of Stakeholder Engagement Plan	10,000.00	10,000.00	0.00
Baseline data collection and Demo cities feasibility studies	70,000.00	70,000.00	0.00
Provision of info on situational analysis, baseline projects, and barriers. Included Hiring of three(3) National Senior Experts*: Hydrogen Production National Expert, Policy & FCV Expert, and Fuel Cell Technology Applications Expert	40,000.00	40,000.00	0.00
ESMP development	10,000.00	10,000.00	0.00
Gender assessment preparation	10,000.00	10,000.00	0.00
Follow-up on co-financing letters (including from Companies)	10,000.00	5,000.00	5,000.00

PEE Assessment (HACT of PEE)	20,000.00	20,000.00	0.00
Validation workshop	10,000.00	0.00	10,000.00
TOR for Execution Preparation	10,000.00	10,000.00	0.00
Stakeholders' consultation and development of detailed activities	20,000.00	20,000.00	0.00
Travels (Int'l and National)	40,000.00	20,000.00	20,000.00
Preparation (including revision) of project results framework, budget, work plan, and preparation of demo annexes	30,000.00	30,000.00	0.00
Total	**300,000.00**	**265,000.00**	**35,000.00**

ANNEX E: PROJECT MAP AND COORDINATES

Please provide geo-referenced information and map where the project interventions will take place

Location Name	Latitude	Longitude	GeoName ID
Ningdong	38.1644	106.5862	11,426,204

Location Description:

Activity Description:

Location Name	Latitude	Longitude	GeoName ID
Dalian	38.9140	121.6147	1,814,087

Location Description:

Activity Description:

Location Name	Latitude	Longitude	GeoName ID
Shenyang	41.8048	123.4330	2,034,937

Location Description:

Activity Description:

Please provide any further geo-referenced information and map where project interventions are taking place as appropriate.

The Project will take place in three demo cities: Ningdong in Ningxia Province of Western China, and Shenyang and Dalian of Liaoning Province in Northeastern China.
NB: More detailed geo-spatial viewing of project sites are found in respective EIAs (see ESMP of project).

Location Name	Latitude	Longitude	Location/Activity Description
Ningdong	38.1644000°	106.5862000°	Ningxia Province, Demo site
Dalian	38.9140000°	121.6147000°	Liaoning Province, Demo site
Shenyang	41.8048000°	123.4330000°	Liaoning Province, Demo site

ANNEX F: ENVIRONMENTAL AND SOCIAL SAFEGUARDS SCREEN AND RATING

Attach agency safeguard datasheet/assessment report(s), including ratings of risk types and overall project/program risk classification as well as any management plans or measures to address identified risks and impacts (as applicable).

Title
Annex T Stakeholders Consulted in PPG
Annex R_ Technology Assessment and Review
Annex I_J_K Demonstration Cities in Dalian Ningdong Shenyang
Shenyang EIA Report-Liaoning Huadian Tieling Off-grid Energy Storage & Hydrogen Production
EIA Ningdong National Renewable Hydrogen Energy & Carbon Emission Reduction Demonstration – Zone
Annex S - ESMP Green Hydrogen China 20240528
UNIDO Environmental and Social (E&S) Screening Template

ANNEX G: BUDGET TABLE

Please upload the budget table here.

Please explain any aspects of the budget as needed here

SUMMARY BUDGET TABLE: Compressed Format Showing Totals of Components 1-4 (Filled Out to Improve Readability) detailed Content Uploaded Annexes-Documents Upload Section. NOTE: NSB=National Standards Bureaus, PRE= Policy Research

SUMMARY BUDGET TABLE: Compressed Format Showing Totals of Components 1-4 (Filled Out to Improve Readability) detailed Content Uploaded in Excel Annexes-->Documents Upload Section. NOTE: NSB=National Standards Bureaus, PRE =Policy Research Entities

Overview					Component (USD)												
Cost Categories	Detailed Description	Unit	No. of units	Unit cost	Component 1		Component 2		Component 3		Component 4		Sub-total	M&E	PMC	Total GEF	Responsible Entity
					Outcome 1 Output 1.1	Total Component 1	Outcome 2 Output 2.4	Total Component 2	Outcome 3 Output 3.1	Total Component 3	Outcome 4 Output 4.1	Total Component 4					
Event Organization (Workshops Training, Conf.)	3.1.1 Five large (estimated 100 attendees each) experience sharing and training GHIC "comprehensive" conferences focusing on green hydrogen industrial chain.					0		0	250,000	250,000		0	250,000			250,000	PEE & Subcontractor
	3.2.1 GHIC side event sessions at China's annual FCV conference focused on specific issues (5 side events, 20 persons each, certain gender proportion)					0		0		62,050		0	62,050			62,050	PEE & Subcontractor
	3.2.2 GHIC side events at int'l H2 conferences, low Carbon regional mtgs to promote demo replication (5 side events, 20 persons each, certain gender proportion)					0		0		87,750		0	87,750			87,750	PEE & Subcontractor
	3.3.1 Small, results oriented GHIC problem solving meetings on specific topics (at least 3 meetings x 20 persons at each, certain gender proportion)					0		0		28,300		0	28,300			28,300	PEE
	3.3.2 Follow up to 3.3.1 problem solving meetings to ensure recommendations are acted upon/ implemented					0		0		13,500		0	13,500			13,500	PEE
	1.2b.3 Outreach and presentation to policy makers re real risks of hydrogen and proposed safety policies/ policy revisions					10,950		0		0		0	10,950			10,950	PEE & PRE
	1.3.2 Consultation re recommended methods for computing carbon emission reductions for green hydrogen					26,075		0		0		0	26,075			26,075	Policy Research Entity
	1.3.3 Promotion to provincial/ national authorities of carbon emission reduction computation methods/ support of pilot					12,775		0		0		0	12,775			12,775	PREs
	1.4c.6 Outreach to industry re needed product standards and preparation of selected product standards (national or group)					16,850		0		0		0	16,850			16,850	PEE
	1.7b.2 Consultations as input to plans for developing National Hydrogen Energy Highway Network					24,150		0		0		0	24,150			24,150	PEE & PRE
	1.7b.3 Promotion of plans for National Hydrogen Energy Highway Netowrk to relevant decision-makers and their advisors					13,800		0		0		0	13,800			13,800	PEE & Various PRE

	1.4c.8 Promotion of product standards developed to international standards organizations, as relelvant					10,300		0		0		0	10,300			**10,300**	PEE
	1.1.4 Outreach to gov't and industry for endorsing GHIC Technology Roadmap, incorporating it into their strategies				10,300	10,300		0		0		0	10,300			**10,300**	PEE
	1.2a.8 Periodic consultation with industry to collect input on needs for GHIC incentive policies - drafting/promotion of policies					10,375		0		0		0	10,375			**10,375**	PEE
	1.2b.3 Outreach and presentation to policy makers re real risks of hydrogen and proposed safety policies/ policy revisions					9,525		0		0		0	9,525			**9,525**	PEE & PRE
	1.4a.2 Consultations for preparation of comprehensive GHIC standards tree					59,150		0		0		0	59,150			**59,150**	PEE
	1.4b.4 Promotion as appropriate standards of 1.6.1 to 1.6.3 to relevant international standards organizations					42,250		0		0		0	42,250			**42,250**	PEE
	1.4c.6 Outreach to industry re needed product standards and preparation of selected product standards (national or group)					11,850		0		0		0	11,850			**11,850**	PEE
	1.5.1 Outreach to planners and regulators in hard-to-abate sectors, support in incorporating GCIC in their sector plans					15,000		0		0		0	15,000			**15,000**	PEE
	1.7a.1 Outreach to other Chinese cities re demo replication; support to these cities in developing GHIC demo plans					52,050		0		0		0	52,050			**52,050**	PEE
	1.7a.2 Outreach to cities/companies in developing countries re demo replication; support to them in developing GHIC demo plans					64,225		0		0		0	64,225			**64,225**	PEE
	1.7b.2 Consultations as input to plans for developing National Hyrogen Energy Highway Network					24,150		0		0		0	24,150			**24,150**	PEE & PRE
	1.7b.3 Promotion of plans for National Hyrogen Energy Highway Netowrk to relevant decision-makers and their advisors					13,800		0		0		0	13,800			**13,800**	PEE & PRE
	1.7c.2 Liaison with cities, experts, policy makers etc. for input on City Cluster expansion plan and selection of proposed cities					45,700		0		0		0	45,700			**45,700**	PEE
	1.8a.1 Identification of promising GHIC innovative business models; summary listing and elaboration of them					22,900		0		0		0	22,900			**22,900**	PEE
	1.8a.2 Promotion of promising innovative business models of 1.17.1 to enterprises and organizations that may adopt them					58,475		0		0		0	58,475			**58,475**	PEE
	1.8b.2 Identification of suitable candidates for GHIC entrepreneur training course of 1.18.1					39,100		0		0		0	39,100			**39,100**	PEE

	2.4.3 Innovation grant fund: outreach and search for good candidates to fund					0	101,200	101,200		0		0	101,200			**101,200**	PEE
	2.4.5 Innovation grant fund: Following up with winning candidates/ other strong candidates to track progress; dissemination via media					0	40,900	40,900		0		0	40,900			**40,900**	PEE
	3.4.2 Promotion of training materials of 3.4.1 to universities (aim is to get them to offer courses and majors with them)					0		0		13,100		0	13,100			**13,100**	PEE
	4.1.1 General promotion of demo city experience.					0		0		0	8,750	8,750	8,750			**8,750**	PEE
	4.3.1 Exchange between Chinese and foreign entities involved in the GHIC that may have cooperation potential					0		0		0		16,500	16,500			**16,500**	PEE
	4.4.1 Tailor-made GHIC outreach and awareness program for the hard-to-abate sectors, including one-on-one outreach					0		0		0		13,000	13,000			**13,000**	PEE
	Sub-total Events Organization				**10,300**	**593,750**	**142,100**	**142,100**	**250,000**	**454,700**	**8,750**	**38,250**	**1,228,800**	**0**	**0**	**1,228,800**	
Knowledgement Management (Web portal related, Database, Social Media)	2.1.6 Ningdong: Monitoring platform and collection of Ningdong demo data					0		50,000		0		0	50,000			**50,000**	Demo Cities
	2.2.7 Shenyang: Monitoring platform and collection of Shenyang demo data					0		50,000		0		0	50,000			**50,000**	Demo Cities
	4.2.2 Promotion of project via external media in China					0		0		0		16,000	16,000			**16,000**	Subcontractor
	2.3.7 Dalian: Monitoring platform and collection of Dalian demo data					0		50,000		0		0	50,000			**50,000**	Demo Cities
	4.5.1 Design, development, promotion of Project's GHIC website (sub-website of IHFCA's website), uploadingof docs, promotion of docs					0		0		0		13,000	13,000			**13,000**	Subcontractor
	4.5.2 Facilitation of info exchange for (a) cluster cities/ demo cities (b) technology aspects so as not to reinvent the wheel					0		0		0		10,000	10,000			**10,000**	Subcontractor
	4.5.3 Encouraging other China-based GHIC projects to share project information, results, an learnings					0		0		0		10,000	10,000			**10,000**	Subcontractor
	1.6a.1 Collection of monitoring data from project demos, including cost and technical performance data					51,950		0		0		0	51,950			**51,950**	PEE
	1.8b.3 Delivery of GHIC entrepreneur training course					148,075		0		0		0	148,075			**148,075**	PEE
	3.5.1 Establishment of GHIC platform to connect indiviual talent and research institutes to companies and projects					0		0		22,200		0	22,200			**22,200**	PEE
	4.1.1 General promotion of demo city experience.					0		0		0	6,500	6,500	6,500			**6,500**	Subcontractor
	4.1.2 Dissemination of detailed technical and cost results of Project demons and of the project's other information products					0		0		0	21,750	21,750	21,750			**21,750**	PEE
	4.2.1 Social media outreach both tohe general public and to more specific groups					0		0		0		28,500	28,500			**28,500**	PEE

	4.2.2 Promotion of project via external media in China					0		0		0		21,000	21,000			**21,000**	PEE
	4.2.4 Simple, fact based brochures that address misconceptions regarding hydrogen safety; widespread dissemination thereof					0		0		0		10,500	10,500			**10,500**	PEE
	4.5.1 Design, development, promotion of Project's GHIC website (sub-website of IHFCA's website), uploadingof docs, promotion of docs					0		0		0		2,500	2,500			**2,500**	PEE
	4.5.2 Facilitation of info exchange for (a) cluster cities/ demo cities (b) technology aspects so as not to reinvent the wheel					0		0		0		10,000	10,000			**10,000**	PEE
	4.5.3 Encouraging other China-based GHIC projects to share project information, results, an learnings					0		0		0		21,000	21,000			**21,000**	PEE
	Sub-total KM, Web, Media				**0**	**200,025**	**0**	**150,000**	**0**	**22,200**	**28,250**	**170,750**	**542,975**	**0**	**0**	**542,975**	
Contractual Services - with Companies	1.2b.1 Research, assessment of GHIC safety aspects, drafting of recommendations and related policies/ revisions (national or local)					36,850		0		0		0	36,850			**36,850**	PEE & Policy Research Entity
	1.2b.2 Preparation of policy briefs and presentations regarding recommended/ drafted GHIC safety policies					27,650		0		0		0	27,650			**27,650**	PEE & PRE
	1.2b.4 Identification of additional GHIC policy needs and drafting/promotion of policies (industry, review of local policies, etc.)					8,550		0		0		0	8,550			**8,550**	PEE & PRE
	1.3.1 Reseach, analysis, drafting of recommended methods for computing carbon emission reductions for green hydrogen					27,150		0		0		0	27,150			**27,150**	PRE
	1.4c.1 Product standards for both PEMS and alkaline electrolyzers (national or group)					52,000		0		0		0	52,000			**52,000**	PEE & NSBs
	1.4c.2 Product standards for H2 storage/transport: higher pressure cntrs, H2 liquid state cntrs, H2 solid state cntrs, H2 pipeline					52,000		0		0		0	52,000			**52,000**	PEE & local or NSBs
	1.4c.3 Product standards for fuel cells (national or group)					51,350		0		0		0	51,350			**51,350**	PEE & NSBs
	1.4c.4 Product standards for HRS equipment (national or group)					51,350		0		0		0	51,350			**51,350**	PEE & NSBs
	1.4c.5 Product standards for key parts of systems of FCVs (national or group)					51,350		0		0		0	51,350			**51,350**	PEE & NSBs
	1.4c.7 Identification of needs via review of local pilots of product standards, needs assessment in Years 2,3,4,5; prep of standards					14,800		0		0		0	14,800			**14,800**	PEE
	1.7b.1 Assessment and plans for National Hydrogen Energy Highway Network					12,050		0		0		0	12,050			**12,050**	PEE & IHFCA& NSBs
	2.1.1 Ningdong main demo: Converting generated 500 MW + 120 MW PV RE to GH2 in two hydrogen production sites					0		600,000		0		0	600,000			**600,000**	Demo Cities

	2.1.2 Ningdong main demo: Transport of green H2 to chemical customer (piping), first HRS (piping), second HRS (tube truck)					0		50,000		0		0	50,000			**50,000**	Demo Cities
	2.1.3 Ningdong main demo: use of green H2 in chemical industry and managing intermittent supply of green H2					0		100,000		0		0	100,000			**100,000**	Demo Cities
	2.1.4 Ningdong main demo: establishment of 2 HRSs (one with green H2 production next door) using green hydrogen					0		100,000		0		0	100,000			**100,000**	Demo Cities
	2.1.5 Ningdong main demo: 200 heavy-duty fuel cell vehicles powered by green hydrogen					0		1,000,000		0		0	1,000,000			**1,000,000**	Demo Cities
	2.1.7 Ningdong: Design, adoption, and implementation of local policy incentives					0		150,000		0		0	150,000			**150,000**	Demo Cities
	2.1.8 Ningdong: Safety measures for demos					0		50,000		0		0	50,000			**50,000**	Demo Cities
	2.1.9 Ningdong: Possible additional demos (Phase 2 and Ningdong green hydrogen projects of other companies)					0		100,000		0		0	100,000			**100,000**	Demo Cities
	2.2.1 Shenyang main demo: Generating 2,000 tpy green hydrogen from 50 MW wind station (PEM)					0		1,000,000		0		0	1,000,000			**1,000,000**	Demo Cities
	2.2.2 Shenyang main demo: green H2 transport/ storage, holding tank, piping, and tube trucks (using higher pressure equipment)					0		50,000		0		0	50,000			**50,000**	Demo Cities
	2.2.3 Shenyang main demo: Use of green hydrogen in chemical industry					0		80,000		0		0	80,000			**80,000**	Demo Cities
	2.2.4 Shenyang main demo: 4 HRSs (3 in Shenyang and 1 on ShenDa Hydrogen Highway) providing green H2					0		100,000		0		0	100,000			**100,000**	Demo Cities
	2.2.5 Shenyang main demo: 200 FCVs using green hydrogen					0		900,000		0		0	900,000			**900,000**	Demo Cities
	2.2.6 Shenyang Phase 2 demo: 450 MW wind, 19,000 tpy hydrogen and 100,000 per year green chemicals					0		100,000		0		0	100,000			**100,000**	Demo Cities
	2.2.8 Shenyang: Hydrogen industrail park					0		20,000		0		0	20,000			**20,000**	Demo Cities
	2.2.9 Shenyang: Local policy incentives					0		150,000		0		0	150,000			**150,000**	Demo Cities
	2.2.10 Shenyang: Hydrogen Exhibition Hall					0		70,000		0		0	70,000			**70,000**	Demo Cities
	2.2.11 Shenyang: Safety measures for demos					0		30,000		0		0	30,000			**30,000**	Demo Cities
	2.3.1 Dalian main demo: Producing 600 tpy GH2 from 100 MW PV using low temp desalinization(tidal flats, PV with sea cucumber production)					0		2,400,000		0		0	2,400,000			**2,400,000**	Demo Cities
	2.3.2 Dalian main demo: Storage & Transport - demo of extensive use of Type 4 cylinders					0		300,000		0		0	300,000			**300,000**	Demo Cities

	2.3.3: Dalian main demo: 6 HRSs in Dalian and 1 on ShenDa hydrogen highway, all using green hydrogen					0		300,000		0		0	300,000			**300,000**	Demo Cities
	2.3.4 Dalian main demo: 200 Heavy duty FCVs powered by green hydrogen					0		900,000		0		0	900,000			**900,000**	Demo Cities
	2.3.5 Dalian: small-scale rooftop PV (less than 3 MW) and distributed power generation with green H2 (100 kW x 10 generators)					0		100,000		0		0	100,000			**100,000**	Demo Cities
	2.3.6 Dalian large-scale green hydrogen associated project: help build GW-scale GHIC producing 50,000 tpy GH2, for the production of 50,000 tpy green hydrogen, 300,000 tpy green ammonia					0		200,000		0		0	200,000			**200,000**	Demo Cities
	2.3.8 Dalian: Local policy incentives, systems and regulations					0		150,000		0		0	150,000			**150,000**	Demo Cities
	2.3.9 Dalian: Demonstration of progress in fuel cell stack technology					0		300,000		0		0	300,000			**300,000**	Demo Cities
	2.3.10 Dalian: Testing of high-power hydrogen fuel cells under different environmental conditions					0		250,000		0		0	250,000			**250,000**	Demo Cities
	2.3.11 Dalian: Demonstration of standards and product certification (green H2 production, H2 safety, high pressure transport/storage					0		50,000		0		0	50,000			**50,000**	Demo Cities
	2.3.12 Dalian: Safety measures for demos					0		50,000		0		0	50,000			**50,000**	Demo Cities
	3.4.1 Training materials or textbooks for 4-6 different GHIC courses					0		0		8,250		0	8,250			**8,250**	Subcontractor
	4.2.3 Series of project highlight videos for global-scale promotion					0		0		0		15,000	15,000			**15,000**	Subcontractor
	Sub-total Contractual Services – Company				**0**	**385,100**	**0**	**9,650,000**	**0**	**8,250**	**0**	**15,000**	**358,250**	**0**		**10,058,350**	
Contractual Services - PEE	1.1.1 Research, consultation, outreach and assessment for GHIC Technology Roadmap				51,150	51,150		0		0		0	51,150			**51,150**	PEE
	1.1.2 Series of workshops for GHIC Technology Roadmap				45,050	45,050		0		0		0	45,050			**45,050**	PEE
	1.1.3 Drafting and finalizing of GHIC Technology Roadmap (*by end of Year 2*)				33,500	33,500		0		0		0	33,500			**33,500**	PEE
	1.2a.1 Incentive policy(ies) to lower cost of green hydrogen (national or local level)					45,900		0		0		0	45,900			**45,900**	PEE
	1.2a.2 Incentive policy for use of green hydrogen in hard-to-abate sectors (national or local level)					45,900		0		0		0	45,900			**45,900**	PEE
	1.2a.3 Incentive policy for use/purchase of FCVs for commercial vehicle fleets (national or local level)					32,400		0		0		0	32,400			**32,400**	PEE
	1.2a.4 Incentive policy(ies) to establish HRSs (national or local level)					30,400		0		0		0	30,400			**30,400**	PEE
	1.2a.5 Incentive policy(ies) for localization of GHIC parts (national or local level)					30,400		0		0		0	30,400			**30,400**	PEE

	1.2a.6 Incentive policy(ies) for advanced methods of hyrogen transport (national or local level)					32,400		0		0		0	32,400			**32,400**	PEE
	1.2a.7 Incentive policy(ies) for financing of and investmetn in GHIC (national or local level)					52,575		0		0		0	52,575			**52,575**	PEE
	1.2a.9 Review of experience with local GHIC incentive policies - drafting/promotion of ones appropriate to national level					7,575		0		0		0	7,575			**7,575**	PEE
	1.2a.10 Identification of further needs for incentive policies in years 2,3,4, and 5 - drafting/promotion of policies					12,075		0		0		0	12,075			**12,075**	PEE
	1.2b.1 Research, assessment of GHIC safety aspects, drafting of recommendations and related policies/ revisions (national or local)					17,300		0		0		0	17,300			**17,300**	PEE & Policy Research Entity
	1.2b.2 Preparation of policy briefs and presenations regarding recommended/ drafted GHIC safety policies					15,400		0		0		0	15,400			**15,400**	PEE & Policy Research Entity
	1.2b.4 Identification of additional GHIC policy needs and drafting/promotion of policies (industry, review of local policies, etc.)					7,775		0		0		0	7,775			**7,775**	PEE
	1.4a.1 Research for, assessment for, and preparation of comprehensive national standards tree for GHIC					80,850		0		0		0	80,850			**80,850**	PEE
	1.4b.1 Management, operational, and safety standards for green hydrogen production (group level)					75,000		0		0		0	75,000			**75,000**	PEE
	1.4b.2 Management, operational, and safety standards for HRSs (national level)					54,350		0		0		0	54,350			**54,350**	PEE
	1.4b.3 Management, operational, and safety standards for FCs and FCVs (gorup level)					78,400		0		0		0	78,400			**78,400**	PEE
	1.4c.1 Product standards for both PEMS and alkaline electrolyzers (national or group)					47,000		0		0		0	47,000			**47,000**	PEE & NSBs
	1.4c.2 Product standards for H2 storage/transport: higher pressure cntrs, H2 liquid state cntrs, H2 solid state cntrs, H2 pipeline					52,000		0		0		0	52,000			**52,000**	PEE & NSBs
	1.4c.3 Product standards for fuel cells (national or group)					51,350		0		0		0	51,350			**51,350**	PEE & NSBs
	1.4c.4 Product standards for HRS equipment (national or group)					51,350		0		0		0	51,350			**51,350**	PEE & NSB Entity
	1.4c.5 Product standards for key parts of systems of FCVs (national or group)					51,350		0		0		0	51,350			**51,350**	PEE & NSB Entity
	1.4c.7 Identification of needs via review of local pilots of product standards, needs assessment in Years 2,3,4,5; prep of standards					14,800		0		0		0	14,800			**14,800**	PEE

	1.4c.8 Promotion of product standards developed to international standards organizations, as relelvant					10,300		0		0		0	10,300			**10,300**	PEE
	1.6a.2 Project demo monitoring/ results reports, including cost and technical viability					98,050		0		0		0	98,050			**98,050**	PEE
	1.6b.1 Study on cost viaility and technical issues asociated with green hydrogen production					42,450		0		0		0	42,450			**42,450**	PEE
	1.6b.2 Study assessment on potential use of green hydrogen in hard to abate sectors, including cost viability and technical issues					49,950		0		0		0	49,950			**49,950**	PEE
	1.6b.3 Study on use of green hydrogen in FCs and FCVs including cost and technical anslysis and future trends					43,600		0		0		0	43,600			**43,600**	PEE
	1.6b.4 Study on novel business models, technical innovations, and policy innovations in the GHIC including recommendations					40,450		0		0		0	40,450			**40,450**	PEE
	1.6b.5 Case study of other GHIC projects (outside of the project demos)					23,550		0		0		0	23,550			**23,550**	PEE
	1.6c.1 Identification of target audience and assessment re content for *Annual Global Green Hydrogen Development Review*					66,100		0		0		0	66,100			**66,100**	PEE
	1.6c.2 Three annual editions of *Annual Global Green Hydrogen Development Review*					107,850		0		0		0	107,850			**107,850**	PEE
	1.6c.3 Development of mechanism for ensuring future editions post-project of *Annual Global Green Hydrogen Development Review*					31,050		0		0		0	31,050			**31,050**	PEE
	1.7a.3 Plans for scale-up of GHIC demos in demo cities of Ningdong, Shenyang, and Dalian					44,075		0		0		0	44,075			**44,075**	PEE
	1.7a.4 Plans for cross-region GHIC scaled-up project with eastern city demand enough to justify H2 pipeline from western area					39,650		0		0		0	39,650			**39,650**	PEE
	1.7b.1 Assessment and plans for National Hydrogen Energy Highway Network					12,050		0		0		0	12,050			**12,050**	PEE & NSBs
	1.7c.1 Assessment and recommendations for expansion of China's Hydrogen Energy City Cluster Program					17,500		0		0		0	17,500			**17,500**	PEE
	1.7c.3 Refinement and promotion of expansion plan for China's Hydrogen Energy City Cluster Program					36,800		0		0		0	36,800			**36,800**	PEE
	1.8a.3 Implementation of promising innovative business models of 1.17.1					18,625		0		0		0	18,625			**18,625**	PEE
	1.8b.1 Preparation of content for entrepreneur training course for those pursing innovative GHIC tech or biz model ventures					102,825		0		0		0	102,825			**102,825**	PEE
	2.4.1 Innovation grant fund: methodologies to find and select companies					0	19,550	19,550		0		0	19,550			**19,550**	PEE

	2.4.2 Innovation grant fund: setting up and operating fund					0	38,350	38,350		0		0	38,350			38,350	PEE
	2.4.4 Innovation grant fund: selection of winning candidates and disbursement of funds					0	750,000	750,000		0		0	750,000			750,000	PEE
	3.4.1 Training materials or textbooks for 4-6 different GHIC courses					0		0		4,850		0	4,850			4,850	PEE
	4.2.3 Series of project highlight videos for global-scale promotion					0		0		0		33,000	33,000			33,000	PEE
	4.6.1 Additional awareness raising programs to address needs identified in Years 2,3,4,5					0		0		0		18,000	18,000			18,000	PEE
	Sub-total Contractual Services – PEE				**129,700**	**1,801,125**	**807,900**	**807,900**	**0**	**4,850**	**0**	**51,000**	**2,664,875**	**0**	**0**	**2,664,875**	
Travel																	
	Travel to meeting project site, workshops etc.					100000		0				0	100,000			100,000	
	Sub-total Travel				**0**	**100,000**	**0**	**0**	**50,000**	**50,000**	**0**	**0**	**100,000**	**0**	**0**	**100,000**	
Office supplies																	
	Office supplies, rent, equipment, etc.					0		0	50,000	50,000		0	50,000			50,000	
						0		0		0		0	0			0	
	Sub-total Office supplies				**0**	**0**	**0**	**0**	**50,000**	**50,000**	**0**	**0**	**50,000**	**0**	**0**	**50,000**	
M&E																	
	5.1.1 Carrying out all periodic M&E assessment and reporting, including assessment of PRF indicators													50,000		50,000	UNIDO
	5.1.2 Ongoing project monitoring of timely, efficient, and effective implementation of all activities, PEE...													50,000		50,000	UNIDO
	5.2.1 Mid-Term Review													150,000		150,000	UNIDO
	5.2.2 Terminal Evaluation													150,000		150,000	UNIDO
	Sub-total M&E													400,000		400,000	
Staffing (Consultants), Audit and Miscellaneous	Project Manager	1	40,000	40,000		0		0	0	0		0			40,000	**40,000**	PEE
	Industry Specialists & Experts	7	20,000	140,000	0	0		0		0		0			140,000	**140,000**	PEE
	Communications and Gender Specialists & Experts	2	20,000	40,000		0		0	0	0		0			40,000	**40,000**	PEE
	Standards Expert	2	10,000	20,000		0		0		0		0			20,000	**20,000**	PEE
	Chief Technical Advisor	1	400,000	400,000		0		0		0		0			400,000	**400,000**	PEE
	International Commutation Expert	1	30,000	30,000		0		0		0		0			30,000	**30,000**	PEE
	Environmental and Safety Specialist	1	30,000	30,000		0		0		0		0			30,000	**30,000**	PEE
	Project Audit Costs			30,000											30,000	**30,000**	PEE/ UNIDO
	Miscellaneous			30,000											30,000	**30,000**	PEE
	Sub-total Consultants (PMC)						**0**	**0**		**0**					**760,000**	**760,000**	
	TOTAL YEARS 1-5				**140,000**	**3,190,000**	**950,000**	**10,750,000**	**350,000**	**600,000**	**37,000**	**300,000**	**5,133,400**	**400,000**	**760,000**	**16,000,000**	
				Outcome	3,190,000		10,750,000		600,000		300,000						

ANNEX I: RESPONSES TO PROJECT REVIEWS

From GEF Secretariat and GEF Agencies, and Responses to Comments from Council at work program inclusion and the Convention Secretariat and STAP at PIF.

Review comments to be considered are those review comments not yet responded to from the GEF Secretariat and GEF Agencies, from the GEF Council at work program inclusion, and comments from the Convention Secretariat and STAP made at the time of the PIF. In this case, the comments not yet responded to and thus included here are from GE Council members and from the STAP

Comments from the GEF Council

Comments	Response	Reference in Documents
✓ ***Canada Comments*** With regards to green hydrogen, it would also be important to take into consideration the energy efficiency of green hydrogen production, recognizing that it is a typically inefficient process for generation usable energy when the renewable energy can be used directly with additional energy loss in most cases, including possibly for the transportation sector.	This comment makes an important point: The project aims to use green hydrogen where direct use of electricity (so not including battery use) is not an option. In the chemical industry initiatives supported by the Project, hydrogen is a raw material rather than energy source, so the conversion efficiency is not relevant. For vehicles, however, sources indicate fuel cell vehicles have roughly 60% conversion efficiency compared to 80% for EVs and 20% for ICEs. There is also a need to look at efficiency of green hydrogen production which has been proposed as an area of standards work under the project. For heavy duty vehicles, FCVs have advantages over electric vehicles that may outweigh the standard conversion efficiency numbers given above. Heavy duty EVs must carry a very heavy load of batteries, which reduces the payload that the vehicle can carry to fulfill its economic purpose. Further, FCVs typically have a longer range and can refuel more quickly.	Page 13, end of paragraph on FCV as application of hydrogen
✓ ***Germany Comments*** - <u>Germany welcomes the proposal. Germany approves the following PIF in the work program but asks that the following comments are taken into account:</u> Germany welcomes the proposal, which aims to catalyze green hydrogen production and application in Ningdong, Dalian and Shenyang, China, with the aim to decarbonize and support the energy transition. At the same time, Germany		

has the following comments that it suggests be addressed in the next phase of finalizing the project proposal: Suggestions for improvements to be made during the drafting of the final project proposal: - ***Germany Comment 1*** Germany appreciates the description of the outcomes. Nevertheless, a stronger focus should be placed on the sustainability of the entire process chain. In this context, especially in mobile applications of hydrogen, it should always be questioned whether more efficient solutions are available that could avoid the conversion step from green electricity to hydrogen. ***Germany Comment 2*** In the production of green hydrogen, greater consideration should be given to the aspect of additionality in the production of the green electricity. If this aspect is neglected, there is a risk in an energy system still largely based on fossil power generation, as in China, that other consumers will be supplied with additionally generated fossil power and the positive climate effect of the application of green hydrogen will fizzle out. ***Germany Comment 3*** Outcome 2.1 focuses on green hydrogen technology in production, heavy	This is a good point and has some synergies with the comment from Canada above. In the case of the chemical industry, Project demo green hydrogen is being used as a raw material, so conversion efficiency is not an issue. Yet, in the vehicle industry, it is being used as a fuel so thus it may need to compete with electric cars (80% conversion efficiency) and ICEs (20%) conversion efficiency. FCEs are reported to have 60% conversion efficiency, but this does not include the efficiency of the hydrogen production process, which is something the project looks into both from the policy angle and the industry angle	Page 13, end of paragraph on FCV as application of hydrogen Activities 1.1.1 to 1.1.3 (Technology Roadmap), pages 26-27.

transportation and hard-to-abate industry sector. While the measures in the transport sector are already presented quite precisely, the explanations for applications in the industrial sector remain quite vague. It would be welcome if this could be fleshed out a little more.	This is also a good point. All of the project's renewable energy power resources (wind, solar PV, and biogas) are isolated renewable energy power grids built specifically to produce hydrogen. While the owners could have made more money selling to the grid, (1) there are many reports that it is difficult to get approval to sell to the grid and (2) they see long-term prospects in becoming experienced in the green hydrogen economy. Because of (1), the grid's inability or at least unwillingness to accept much more renewable energy based power generation at present, it does not seem like these isolated grid installations mean there is less renewable energy in the power grid than there would have been otherwise. In fact, we argue that developing green hydrogen with renewable energy allows for more large solar PV, wind, and possibly biogas installations than there would be if grid connection /selling to the grid were the only option for such large installations. This, in turn, contributes to the development of the renewable energy based power generation sector (especially PV and wind) and the continuation of cost reductions. During the course of the PPG more information has been gathered on the use of green hydrogen in hard-to-abate industrial sectors in the demos. The additional information is now provided in the relevant activity descriptions in the main text of the ProDoc as well as in the demo annexes. At the same time, certain activities have been designed to focus on the hard-to-abate industrial sectors. It is thus expected that, in the process of implementation, more information on these sectors (such as ultimate end uses) will be gathered.	Page 17, second paragraph (dedicated to response to this comment) Annexes J, K, and L (demo annexes). Activity 1.6b.2 re planned work on ultimate end uses in hard-to-abate industrial sectors (page 38), Output 1.5 re outreach for policy /planning in those sectors and Output 4.4 (page 60) re outreach to companies in those sectors
✓ ***Japan Comments*** ***Japan Comment 1*** We recognize that the 1:7.5 overall co-financing metric cited may have been inflated by a few private-sector/corporate- related	During the PPG stage, co-financing has been reviewed and double checked. There is an issue that some of the project partners are very enthusiastic about green hydrogen and the co-financed parts of the Project have moved ahead before the GEF-funded portions of the Project were ready to begin. Those investments already made and contracts already signed prior to the PPG mission in March 2024 will not be counted as co-	Pages 20 re progress of demo installations, page 76 re co-financing, and Demo

projects. Of the regular projects, we observe the very large co-financing ratios in industry-related projects in sectors such as power generation and construction, and suspect these may have contributed to this overall boost. We hope that these risks are taken into account in project designs, and recommend careful review to back check these figures assessed, which may also affect the value of the grants proposed.	financing, but some additional work planned in the future will be incorporated into the work plan.	Annexes (Annexes J, K, an L) re demo projects
Japan Comment 2 Furthermore, since some of these industry projects relate to the sectors (hydrogen in particular) that could be easily financed by risk-tolerant private capital, we may want to consider additionality issues much more carefully (for example, by prioritizing/ prompting re-allocation of capital in other themes/areas that can't have such easy access to markets for funding, even if it may have less co-financing ratios, or considering NGI path as an option).	While it is true that there is large investment from energy companies investing in hydrogen, the nature of hydrogen investments to "move the needle" are that they generally need to be large	Please see Exhibit 4, page 14 (this is a list of green hydrogen projects including those by the energy companies)
Japan Comment 3 We should be leaving these initiatives to the handling of the private sector, to avoid unnecessary politicization and other reputation-related risks for the GEF. We therefore recommend projects with these characteristics to be subject to a second review by Council with more information before CEO endorsement.	The GEF project is partnering with local governments in China and the companies that they work with. More of the companies are SOEs rather than private companies, but this is because local governments have more confidence SOEs will deliver on their commitments. In China, local governments play a role in stimulating investment and organizing projects that involve multiple companies. In the green hydrogen projects that have been left to the private sector in China, what is typical is a major energy	

	company doing the project all by themselves (RE power production, green hydrogen production, use of green hydrogen to make chemicals). So, while we acknowledge the risk in working with government, in order to achieve multi-stakeholder involvement and a more comprehensive value chain (with heavy duty vehicles), coordination with local governments appears a good method.	Regarding private sector involvement versus commercial sector more generally: page 76

Comments from STAP		
Comments	**Response**	**Reference in Documents**
Summary of STAP's views of the project This project aims to catalyze green hydrogen production and application to decarbonize and support the energy transition in hard-to-abate sectors in three regions in China. The proposal seeks to build on past GEF investment supporting China in the green hydrogen sector. While the project has good merit because it can help catalyze and scale up an emerging energy technology that can lead to significant GEBs, the project document in its current form requires substantial improvement before the project can proceed. Some issues with the proposal include: • Lack of system-based analysis of the issues and consideration of how drivers can affect the project.	The project document has been extensively redrafted based on a reassessment of barriers with a systematic approach that considers barriers along two axes – the value chain axis (renewable energy based power generation->green hydrogen production->storage and transport->end use in hard-to-abate industrial sectors and end use in heavy duty vehicles, after refueling at HRSs) and the "functional" axis (policy/ regulatory/ planning; cost/ economics; technology; information; capacity; financing). Based on a systems approach along these two axes, the assessment on which the project is based	

	is now more comprehensive and considers interactions among the different elements of the two axes. In fact, the systems approach is considered to be a key aspect of the need for this project which addresses the full green hydrogen value chain to a greater extend as compared to some of the green hydrogen projects in the pipeline.	Please see Exhibit 3 on page 13-14 and text following, pages 14-17, especially sub-section on systems approach starting on page 16.
• Lack of clarity on the project's niche, given some of China's recent advancements in green hydrogen.	This is a very important point and much appreciated. As a part of the PPG exercise the team did extensive research on pipeline and already launched green hydrogen projects, as well as the status of technology, and also probed in what areas the barriers suggested a need for the project. One finding is that although there are many green hydrogen projects in the pipeline, many have stagnated. Of those that have advanced, it is typical that they are carried out by a single company as both producer and user of the green hydrogen and, in addition to lacking a diversity of players represented in the green hydrogen value chain as a result, these projects also tend to lack a fuel cell vehicle component. Another issue is the lack of data on technical and financial viability from such projects, as the data is not publicly shared. Those in the industry are anxious to get a hold of data to understand the viability of the green hydrogen value chain. Finally, there is a need for demonstration of new technical advances, new business models, and new policies to address the technical and cost challenges of green hydrogen (which is currently much more expensive to produce than grey hydrogen). The project aims to address these issues by demonstrating multi-company value chains of green hydrogen and its applications, monitoring the demos and sharing the data, including heavy duty fuel cell vehicles in its value chain, and demonstrating and sharing with the public results of use of innovative or improved technologies, business models, and policies. Currently, there is a higher return on grid connecting a renewable energy based power installation in China and selling power to the grid than keeping such installations isolated from the grid to produce green hydrogen. In fact, the PPG team more than once learned of companies planning to establish two RE based power installations: one to connect to the grid to make a good profit that could in a sense make up for the low or negative returns of the other one that would be producing hydrogen. Yet, the PPG team also found that it is getting more difficult for companies to ensure they get an opportunity to connect a new RE installation to the grid. And, all installations we heard about that are producing green hydrogen in isolated grids are new, specifically built to produce green hydrogen. Thus, it is concluded that there is enough renewable energy resources to address both grid needs and the nascent green hydrogen industry. That is, large isolated RE (PV and wind) installations for hydrogen production are not taking away from installations that might be connected to and sell to the grid as the grid is either unable or unwilling to take on too much more intermittent RE. Thus, in fact, the opportunity to build large-scale RE power generation (PV and wind) for another purpose (hydrogen production contributes to the total installation activity and thus to continuing to drive down the cost of such large-scale installations	Please see Exhibit 4 of pipeline projects pages 18 to 20 and text prior on baseline projects pages 17 to 18

• Lack of adequate analysis of benefits and trade-off of diverting renewable energy from other uses to green hydrogen	– exactly what is needed for green hydrogen to reach parity with grey hydrogen and, in the case of heavy duty vehicles, with other heavy duty vehicle "fuel" types (i.e. gasoline and electricity from battery without fuel cell) The PPG team has carried out extensive consultations with experts and industry players. The barriers, as discussed above, have been comprehensively assessed leading to refinement of the theory of change. None of the original outcomes has been deleted (except that 2.2 has been merged with 2.1), but the wording of the outcomes now makes their purpose in the overall logical framework more clear. And the activities of the project components are now elaborated in detail. GHG emission reduction (GHG ER) methodology has been clarified. As there are two main applications, the methodology addresses each of those. Industrial applications where the green hydrogen replaces grey hydrogen as an industrial raw material reduce GHG emissions by the amount of CO_2 used in production of the grey hydrogen. This requires determination of the production method of the grey hydrogen, which is most often coal-based in China. As for heavy duty vehicles, the assumption is made that each heavy duty FCV replaces an ICE (diesel) vehicle of the same type and is driven the same mileage. The PIF GHG ER computations focus on GHG ERs achieved by EOP. The ProDoc's method puts the most emphasis on GHG ERs over the lifetime of the equipment installed. The process of preparing the ProDoc revisited project risks. At the same time, findings suggest that the cost of renewables, particularly PV, continues to drop. One source at a demo site in Ningxia indicated a PV panel cost of 0.1 Chinese yuan per watt and, when balance of system is also included, 0.2 Chinese yuan per watt, the latter being USD0.027 per watt. It is believed that further drops in PV costs will play a key role in improving the competitiveness of green hydrogen when compared to grey hydrogen, although green hydrogen is currently much more costly to produce. We did find some keen interest in green hydrogen and its applications, particularly FCVs. Some investors look at the trends with electric vehicles in China (huge reduction in cost and huge growth in EVs on the road in recent years) and expect a similar scenario going forward for FCVs.	Please see dedicated paragraph to address this issue on page 17, paragraph 2 and Ningdong Demo Annex (Annex J)
• Need to improve the theory of change and provide more information on project components.	As explained above, the project design has now incorporated a systems approach, looking at barriers to the development of green hydrogen across the green hydrogen and applications value chain and across functional areas, such as policy, costs, technology, information dissemination, capacity, etc. There is more focus on cost and incentives to make up for the high cost, as stakeholders pointed out cost of production as their top pick barrier to the development of green hydrogen. As noted, with rapid drops in PV	Revised theory of change Exhibit 6 (page 37); Extensive description of

• Need to provide clarity on the estimation of expected GEBs. The project proponents also need to reflect on possible scenarios related to changes in the price of renewables, demand and markets for renewables, and investor interest in green hydrogen over other renewable energy sources. STAP has provided specific recommendations on how to improve the proposal. **Project rationale, and project description – are they sound?** The proposal focuses on demonstrating green hydrogen production and utilization in three regions in China. While the project has good merit because it can help catalyze and possibly scale up an emerging energy technology, the	prices and with electric power costs being a main component of green hydrogen costs, some stakeholders are optimistic there will be declining trends in green hydrogen production costs. The other lever of hydrogen production costs is said to be related to electrolyzer efficiency – a more efficient electrolyzer will use less of the power, which is, in turn, seen to be the limiting factor. There is now more attention in the ProDoc to these underlying drivers. Sociocultural acceptance among officials is important. We have reviewed the articles referenced by the STAP in that regard. Now the project addresses heavily safety concerns of policy makers with regard to hydrogen. In China, hydrogen is regulated like a toxic chemical rather than energy source. As such, it can only be produced in chemical industry parts. Experts in China challenge this position. The project, in turn, aims to take a balanced look at the evidence and provide materials to help separate fact from fiction and provide advice on the aforementioned treatment of hydrogen in China's policy framework. As noted, the trend in renewable power prices is now looking favorable and Chinese policy supports diversification of energy sources and domestic supply. At the same, in its risk assessment the design is cognizant about the possibility of political change impacting project progress.	component outputs and activities (pages 26-62). Brief explanation after Core Indicators table: page 67-68; Annex V on GHG ER calculations Second paragraph, page 17. Ningdong Demo Annex (Annex K). Please see list of barriers in Exhibit 3 and accompanying text on barriers that follows, pages 13-

project document in its current form is poorly prepared. Great effort went into telling (with repetition across the proposal) the story of green hydrogen in China, including past GEF investments (which GEF evaluations seem to have concerns about their success – as noted on p18 of the PIF). But little was done to analyze the issues from a systems perspective or discuss the drivers of change that could influence project success.		16 and paragraph on systems approach, page 16, as well as Theory of Change, Exhibit 6, on page 37.
Further to the above, while the proposal discussed some barriers, it fails to address the underlying drivers influencing green hydrogen outside of the project influence, which could determine how the future could unfold. Drivers and challenges such as the price of renewable energy, growth of industries, new technologies, change in political priorities, the Chinese economy, sociocultural acceptance among critical actors, etc., will influence how green hydrogen technology plays out in the future (e.g., Hoyland et al., 2023; Eljack and Kazi, 2021; IEA, 2022, PWC, and Kane and Gil, 2022) and need to be considered in project design. Hence, the project needs to consider some plausible narratives of how these drivers may unfold as part of the baseline scenario and test proposed interventions against these futures to ensure the interventions will work (i.e., are robust to future changes).	As noted above, many pipeline green hydrogen projects have not come to fruition. At the same time, it is true that a good number are moving forward. Yet, there is still a need for this GEF Project as designed. As noted above, the Project and its design takes a systems approach and involves multiple companies where many of the pipeline projects involve only a single company (such as Sinopec) merely making green hydrogen with its own renewable energy installation and then making industrial chemicals with the hydrogen. And, the data that the demo Projects can provide will be something new and helpful to companies. The project will aim to connect with companies in hard-to-abate industrial sectors where green hydrogen could be used and this will include Sinopec. And the project will also connect with the city clusters that represent the nation's previous efforts in FCVs (though green hydrogen is not the main focus of these clusters – instead, FCVs are).	Please see list of barriers in Exhibit 3 and accompanying text on barriers that follows, pages 13-16. Please see Activities 1.26.1 (page 31) and 4.2.4 (page 59), which will address information gaps and perception issues with regard to hydrogen safety
It is good that the proposal will build on previous GEF projects on hydrogen technology in China and is incorporating lessons from these projects. The proposal noted on p18 that issues were raised during the GEF evaluation of these projects but did not provide details of these issues, their relevance to		

this project, or how the concerns will be prevented, if relevant. Further on lessons that could apply to this project, China is already building significant capacity on green hydrogen, including over 120 green projects underway1 and the world's largest green hydrogen project by Sinopec;2 what lessons can be learned from these efforts that can benefit this project? How will this project connect with these efforts? And what is the niche and added benefits of GEF investments? (The PIF indicates that the project will be the first to apply green hydrogen in hard-to-abate coal chemical industry. However, Sinopec's green hydrogen project will already use green hydrogen for making chemicals from coal, so this project will not be the first).	As noted, all the installations for producing hydrogen under this project will be isolated renewable energy grids mainly built for the purpose of the project. As also noted, Chinese companies hoping to build grid connected renewable projects are facing some challenges in getting their projects approved. Thus, there seems room to pursue new, isolated grid renewable power installations for hydrogen production, with the main challenge being getting sufficient returns on the investment. Most of those investing in green hydrogen and using renewable energy to produce it are doing so for strategic reasons. They forecast that the Chinese Government will institute carbon emission limitations for enterprises in China in the coming few to handful of years and are anxious to be ready. There is strong enthusiasm for the potential of the sector. Overall, findings strongly imply that these large-scale renewable energy (wind and solar PV) power installations in isolated grids dedicated to hydrogen production are not taking away renewable energy from the main power grid as the grid is either unable or unwilling to accept that much more renewable energy. As such, having a second application (i.e. hydrogen) for such large installations (wind and PV) is actually advantageous as it provides that much more experience with these technologies helping to drive their price down which is exactly what is needed to make green hydrogen production economically viable.	Please see Exhibit 4 (on pipeline projects), from bottom of page 17 to end of page 20.
While supporting the scaling of green hydrogen could be essential in the fight against climate change, the proposal seems not to consider other relevant factors to justify the project. For example, the proposal narrowly focuses on comparing green and grey hydrogen but not the cost-benefit (or opportunity cost) of whether renewable energy will be diverted from other needs to green hydrogen. For example, the proposal indicated that Dalian (one of the project demonstration regions) has 58.6% non-fossil fuel power capacity (16.6% of this being renewable and the rest nuclear). Hence, 41.4% of its energy is fossil fuel-based. Would the project divert the limited renewable energy in this region to green hydrogen? Would it build new renewable capacities? These details were not clear in the proposal. Even if new renewables are installed for this project, what are the benefits and trade-offs of diverting new renewable energy from other uses to green hydrogen? As the proposal is further developed, these questions and others need to be asked.	The proposal has been reviewed for accuracy. We agree that the item you indicate is confusing. It says RE installation will increase from 14 million to 30 million kW and that RE will increase 16 million kW. It does add up but this is a confusing way to say it. The sentence	

It will be good to review the proposal to ensure accuracy as some sections of the PIF need clarification; for example, p13 indicated that Liaoning province will install 30 million kW by 2025, and among the newly installed, renewable will be 16 million kW. This is unclear. Is there part of the new installations that would not be renewable?	is only referring to renewable installations. Sections such as these if not removed have been clarified.	
The proponent needs to clarify if the green hydrogen demonstration component of the project will be mainly research or demonstration of technological solutions already available. The table on barriers and solutions (p11-12) seems to suggest that the proposal will focus on "developing" innovative technologies working with national and international research institutions.	The current ProDoc aims to clarify this issue. While the project is demo focused (so demonstrating already available technological solutions), at the same time, it does aim to demonstrate some latest technology among these existing solutions, so as to push the envelope on performance and cost as well as look at innovative business models and polices.	See page 17, second paragraph
The project is aligned with current government policy and emission reduction targets and intends to address imperfect policies and regulatory frameworks to support the green hydrogen economy. The proposal, however, falls short of discussing the imperfections, gaps, or what needs to be improved in current policies and regulations. Also, policy and regulatory interventions should go beyond addressing gaps to address any incoherencies across the energy sector and any form of antagonistic policies or laws in other economic sectors that can hinder the project objective –ensuring policy coherence. Doing this may help accelerate the decline in the cost of green hydrogen production. There is a need to benchmark the current production cost of all energy sources in the targeted sectors to enable transparent monitoring of the competitiveness of green hydrogen compared to other energy sources.	The ProDoc now extensively addresses policy and regulatory gaps. Component 1/ Outcome 1 includes extensive work on policy and standards. One important policy incoherency in China is that hydrogen is treated as a hazardous chemical rather than fuel. The project aims to address this issue via policy work as well. The project now puts more emphasis on the cost of green hydrogen and what level needs to be achieved to become competitive with grey hydrogen in industry and what level needs to be achieved to be competitive with EVs and ICEs.	

A theory of change showing the planned activities, outputs, outcomes, and impact was provided. It also includes two underlying assumptions related to implementing central and local government policies on green hydrogen and the share of green hydrogen in China's energy profile increasing to 10% by 2050. However, the theory of change is deficient as follows: o The two assumptions are insufficient. There should be assumptions underlying the different pathways to the project impact. For example, what is the assumption or basis for expecting that establishing a business model will reduce GHG emissions? Or that building capacity leads to an improved enabling environment? o The assumptions need to acknowledge the uncertainties associated with green hydrogen technology, including technical, economic, and sociocultural acceptance among key actors. Hence, the assumptions must be strengthened to acknowledge these challenges and include measures to address them. o Doing the above will help strengthen the causal pathway and the logical chain. o While the solutions indicated in the barriers/solutions table (p11-12) suggest that the project will involve research, the theory of change does not reflect this and seem to suggest that green hydrogen solution are already mature, and the project would demonstrate this. o The current "impact" in the theory of change is phrased as an assumption between the outcomes and impact. The impact box should only contain the expected overarching impact of the project, and the assumption should be between the outcomes and impact. o Consider splitting outcomes into intermediate and long-term outcomes; that way improved	Assumptions in theory of change have been adjusted. Critically important is the high price of green hydrogen, so a critical assumption is that the price of renewable energy based power generation will keep going down so that in a few years or in at most five years, green hydrogen price will reach parity with grey hydrogen price.	This confusing text has been removed. For specific information on the Liaoning Demos, see Demo Annexes J and L See Demo Annexes J, K, and L

enabling environment will not be at the same level as some of the outcomes because it is the enabling environment that leads to them, e.g., GHG emissions reduction. o The co-benefits should acknowledge other possible ones (the paragraph on SDGs on p25 can serve as a guide). The proposal provides some details of the project components but could also be improved: o Outcome 1.1: add some narratives on what the key outputs are supposed to achieve. Currently just a long list of outputs. Provided narrative to understand the causal pathway. o Clarify what energy source will be used for demonstration in Ningdong. This information was provided for Dalian and Shenyang. o Provide narratives for Outcome 2.2 on green hydrogen production, storage, and fuel cell application to understand what will be done. Storage was raised as an important issue pertinent to green hydrogen, so it would be helpful to provide information on what the project intends to do about it. o Component 4. Who is the targeted audience for social media activities? Provide some information on the logic. o Be explicit on actions to promote and foster the acceptance of green hydrogen as an energy source among key actors and stakeholders. The proposal noted key strategies to help promote green hydrogen with central and local	The new version of the ProDoc makes it clearer how assumptions are being addressed and mitigated. Particularly in the first component, the policy and standards work is more clearly explained. As noted above, the project is more of a demo than research, but some of the technologies in the demo are "latest versions," such as latest models of fuel cell stacks or using PEM electrolyzers instead of alkaline ones. The aim of using the improved technology is to show improved efficiency of hydrogen production, achieve lower costs/ higher returns, etc. The theory of change has been revised accordingly to have intermediate and long-term outcomes. The wording of the "impact" has been changed. Our outcomes are divided functionally (policy/ planning/ information versus demos versus capacity building versus awareness raising/ outreach). Thus, they are not amenable to division based on timeline. GHG emissions is not an outcome in our Theory of Change now, it is the overall goal/ aim which is at a higher level. Enabling environment is an intermediate state. A new paragraph has been added under project justification. Co-benefits mentioned include economic development and jobs,	See Outcome 1 activities (pages 26-43).

governments, including government offering financial incentives (e.g., subsidies, tax credits), government investing in infrastructure, and government requiring a certain percentage of fuel be derived from green hydrogen. It is, however, unclear if these are strategies the government has already agreed to implement (or is already implementing) or if this will be part of the policy interventions of the project. The main GEBs from the project is GHG emission reduction linked to the switch from grey to green hydrogen. The proposal also identified local environmental and socioeconomic co-benefits, including air pollution reduction, improved health, enhanced resilience, improved energy access, etc. However, the calculation of the GEB is unclear: o What is the basis for the assumption that "the synergy of the project will increase the share of green hydrogen in industry and transport to 2%"? (p32) o How was the 17 million tCO_2 in 5 years estimated? What were the assumptions? o The indirect GHG reduction of 130 million tCO_2 was based on the 2% share for green hydrogen in industry and transport. But 1% of this already exists (first two sentences on p32); hence the project will only be responsible for 1%. Thus, only 1% can be attributed to the project. Please clarify. o Provide the basis (and assumptions, if applicable) for the methodology used in calculating the number of people benefiting. Some of the risks identified in the risk table (e.g., change in government priorities and economic risks) are risks to the	improved local air quality and therefore human health, increased energy independence for China, and increased opportunities and input for women in the new hydrogen economy. For each outcome, "rationale" for the outcome has been added. In some cases, outputs are elaborated as well. And some of the activities offer narrative explanation when needed. Ningdong's energy source for hydrogen being a PV isolated grid is now clarified. The activities for the demos now include more narrative. In a few cases, higher pressure containers ("Type 4 cylinders", which could lower transport costs) will be tested and this is now noted in the activity description The component now clarifies that both the general public (whose buy-in will be needed for extensive green hydrogen scale up) and professionals in the industry may be targets of different social media campaigns of the project.	Exhibit 6 – Theory of Change, page 25 See Outcome 1 description beginning on page 26

durability of GEBs and ought to be dealt with in the fundamental design of the response to the problem by the project rather than in a post hoc risk assessment about implementation. This further emphasizes the need for developing a simple narrative of the future.	The output and activity to develop a packaged presentation of the facts on hydrogen safety as well as workshops/ conferences with officials should help. The text is now more explicit in this regard.	See Demo Annexes (Annexes J, K, and L)
Specific points to be addressed, and suggestions This proposal requires significant revision and improvements in line with STAP's recommendations below. (see Section 2 above for the basis for the recommendations) 1. The summary is supposed to capture the whole essence of the project. Currently, it does not include information on the specific components and activities through which the objectives will be achieved. Kindly add that. 2. Analyze the issues from a systems perspective or consider the drivers of change that could influence project success based on the expectations of the new GEF PIF template. See GEF PIF training and associated materials for guidance. 3, Develop a narrative of plausible futures that considers the potential effects drivers of change and their associated uncertainties on achieving the project's goal and use this to inform intervention options. See STAP's primer on future narratives for more guidance. 4. Consider past projects and other ongoing efforts on green hydrogen in China in further developing the project, ensuring to incorporate	The design now states more clearly which activities will be undertaken in the policy and standards area under Outcome 1. For applications in the chemical industry the shift from grey to green hydrogen is used to calculate GHG ERs. For the heavy duty fuel cell vehicles, since they replace ICEs for the most part, the GHG ERs are based on the shift from diesel powered heavy duty vehicles to fuel cell powered ones. The GHG ER calculations have been redone and the two points mentioned in the comment to the left are no longer included. The earlier calculations were for GHG ERs by EOP (rather than direct emissions reductions during lifetime of equipment installed, which is the approach now taken).	Exhibit 6, Theory of Change, page 25 Exhibit 6, Theory of Change, page 25 See page 24, 3rd paragraph See description of Outcomes, Outputs and Activities, pages 26-62

lessons, reflecting on how to connect with these efforts, and ensuring there is a niche for, and added benefits from, GEF's investments.	The GHG ER calculations have been redone and these points/ amounts are no longer included. Responses to new GEFSec comments (after full ProDoc review) on the GHG ER calculations have been provided.	See Annex K on Ningdong Demo Please see description of Outcome 2 beginning on page 43
5. Undertake an analysis of the benefits and trade-offs of diverting renewable energy from other uses to green hydrogen?	The target number of persons benefiting from the project has been adjusted to 40,000. The text after the core indicators table explains the breakdown in estimated number of beneficiaries by outcome and explains the main ways these persons benefit for each outcome. Capacity building with government, and especially the government technology road map and policy and standards are the way the Project design deals with the risk of change in government priorities. Yet, it seems that despite being addressed in the design, these risks could still come to play despite the Project's best efforts.	Please see Outcome 4, Output 4.1, pages 58-59 See Activity 4.2.4, pages 59-60
6. Review the proposal for the accuracy of the information provided. 7. Clarify if demonstration activities would be research or the implementation of tested and tried green hydrogen solutions.		See Outcome ,1 beginning on page 26

8. Provide information on policies and regulatory imperfections, gaps, or needed improvements, and undertake a policy coherence analysis to understand where conflicting policies can hinder the achievement of the expected outcomes and ensure these are addressed appropriately. See STAP's paper on policy coherence for more guidance.		
9. Address issues raised in Section 2 regarding the theory of change.	The summary now clearly explains the four components of the project and some of their content.	Please see page 67-68, brief notes on GHG core indicator and also Annex V, which shows methodology of GHG ER calculations.
10. Address issues raised in Section 2 regarding the project components.	Project design now takes a systems approach from two angles. First, it looks at the entire value chain for green hydrogen, recognizing that the full chain needs to be completed and addressed in order to have a successful green hydrogen project. The design also looks at the functional angle of policy, costs, technology, dissemination and capacity building. The revised design also plays closer attention to drivers The narrative is now in place and highlights the uncertainty of whether the cost of renewable energy will go down far enough to make green hydrogen competitive, suggesting that (given the magnitude of that issue) the project work concurrently on other cost levers, such as raising the efficiency with which the electricity is used to produce hydrogen. Continued government support is another uncertainty, but the project addresses that by	

	engaging the government in development of the technology roadmap, relevant policies, and standards.	
	As noted, the niche of the project as compared to other ongoing green hydrogen projects is that the project takes a systems approach to address all links in the green hydrogen value chain and all policy, regulatory, planning, cost, technical, and financing problems. Compared to some of the realized green hydrogen projects (many have not been realized), which typically have a single large energy company as renewable energy producer, hydrogen producer and hydrogen consumer to make chemicals, the project demos have many companies involved. Further, unlike the other green hydrogen projects to date, the GEF project will share its data so that those involved in the industry can better understand costs and technical performance. Lastly, to greater leverage those commercial green hydrogen projects that have been realized (e.g. Sinopec Kuqa), the project will hold separate capacity building workshops for hard-to-abate industrial sectors and invite the proponents of realized projects to share their experience.	Page 68 (last paragraph, continuing on to page 69)
	This has been done. As noted, consultations showed that it is not that easy for all players to be given permission to sell renewable energy based power generation to the grid. All project installations for green hydrogen production are isolated grids. It may be concluded that officials feel China's absorptive capacity for green energy is not unlimited. Thus, in light of this, it seems renewable energy is not being diverted to make hydrogen as it is just not that easy to get a contract to supply the grid. The grid either cannot handle more intermittent RE power (e.g. wind and PV) or, at least, is not willing to accept it. In a sense, then, large-scale installations of wind and PV in isolated grids for hydrogen production benefit the PV and wind industry, giving them more experience with which to get the costs down – exactly what is needed to make green hydrogen viable.	See Outcome 1, starting on Page 26
	ProDoc reviewed for accuracy. The confusing reference made in the text and explained in an earlier comment above is no longer there.	
11. Provide information on the basis and assumptions for the GEB estimates and recalculate the GEBs if appropriate.	The demo activities fall on a spectrum that leans towards tested and tried green hydrogen solutions, but there is encouragement to use latest models for cost reduction or efficiency improvements and there is encouragement to present new business models and policies.	
12. Put provisions to track, measure and report these and the socioeconomic co-benefits in place. Please see STAP's recent paper on incorporating co-benefits in GEF's investments for guidance.	The revised version of the ProDoc provides more information on policy/ regulatory needs and gaps and these are addressed directly in Outcome 1. Coherence problems are identified in the Government's treatment of hydrogen as a toxic chemical rather than an energy source, thus requiring hydrogen to be produced in	

	chemical parks. Overall, the project puts tremendous efforts and resources in the policy area.	
		Please see Summary starting on page 3
	As noted, the theory of change has been revised accordingly to have intermediate and long-term outcomes. The wording of the “impact” has been changed. Also, the wording of the outcomes and objective have been revised to more clearly reflect the logic of the theory of change. Assumptions in theory of change have been adjusted. Critically important is the high cost of producing green hydrogen, so a critical assumption is that the price of renewable energy priced power generation will keep going down so that in a few years or in at most five years, green hydrogen cost of production will reach parity with grey hydrogen cost of production.	Please see barrier table in Exhibit 3 starting on page 13 and full activity design starting on page 26-62
	Responses to those Section 2 listed issues are given above, but repeated here for convenience:	See Exhibit 3 starting on page 13 and text on barriers following
	For each outcome, “rationale” for the outcome has been added. In some cases, outputs are elaborated as well. And even some of the activities have a bit of explanation.	
	Ningdong’s energy source being a PV isolated grid is now clarified.	
	The activities for the demos now include more narrative. In a few cases, higher pressure containers (“Type 4 cylinders,” which could lower transport costs) will be tested and this is now noted in the text.	
	Outcome 4 now clarifies that both the general public (whose buy-in is needed) and professionals in the industry may be targets of different social media campaigns of the project.	Please see project activities, pages 26-62 and Demo Annexes, J, K, and L

	Activity 4.2.4, which is to develop a packaged presentation of the facts on hydrogen safety as well as workshops/ conferences with officials, should help. The text is now more explicit in that regard.	
	These comments are included above, but restated here for convenience: For applications in the chemical industry there is a shift from grey to green hydrogen used to calculate GHG ERs. For the heavy duty fuel cell vehicles, since they replace ICEs for the most part, the GHG ERs are based on the shift from diesel powered heavy duty vehicles to heavy duty fuel cell powered ones.	
		Please see page 17, second paragraph
	The GHG ER calculations have been redone. The earlier calculations were for GHG ERs by EOP, rather than direct emissions reductions during lifetime of equipment installed, which is the approach now taken.	
	The project results framework has a GHG ER indicator which will be tracked annually and a new, more specific "persons benefiting" indicator ("Total persons (and %, number of women) with new or substantially increased involvement in the green hydrogen sector via involvement in the project's demos, its capacity building, its talent development platform and programs, its policy and planning work, etc.") that will also be tracked annually.	
		Confusing comment deleted
		See demo annexes, Annexes J, K, and L
		See Outcome 1 starting on pages 26-43

		See new Theory of Change, Exhibit 6, page 25 See listing of outcomes and outputs and activities. pages 26-43 See Outcome 2 beginning on page 43 and Ningdong Annex (Annex K)

		Output 4.2 and Activity 4.2.1 (Pages 57-58) See Activity 4.2.4 on pages 59-60 Pages 67-68, brief notes on core indicators and Annex V on GHG ER calculations Pages 67-68, brief notes on core indicators and Annex V on GHG ER calculations Text on scope and calculation of number of beneficiaries (last paragraph on page 68, continuing on to page 69). See relevant objective-level indicator in PRF, Annex C, page 78