Implementation Plan

Basic Information	
Title of response plan	Development of a national hydrogen strategy and action plan for accelerating Thailand's net-zero target
Technical assistance reference number	CTCN 22-013
Country/ countries	Thailand
NDE focal point and organisation	Dr. Surachai Sathitkunarat, The Office of National Higher Education Science Research and Innovation Policy Council (NXPO)
Sector(s) addressed	Renewable Energy
Technologies supported	Establishing national strategy
Implementation period and total duration	October 2022 ~ March 2024 (18 months)
Total budget for implementation	USD 260,000
Designer of the response plan	National Institute of Green Technology (previously, Green Technology Center)
Implementer of response plan	National Institute of Green Technology (previously, Green Technology Center)

1. Objectives of the TA

The main objective of the TA is to provide Thailand with a clear strategy and direction to utilize green hydrogen technologies to achieve Thailand's Net-Zero goal. This clear strategy (so-called masterplan) would be able to serve as a map for a further detailed and actionable plan for the government to develop a regulatory framework, infrastructures, and policies necessary to support and enable the development of green hydrogen technologies. The masterplan provided by the National Institute of Green Technology (NIGT) could also help relevant stakeholders understand their roles and how stakeholders can collaborate during the development stage and commercial stage in the future.

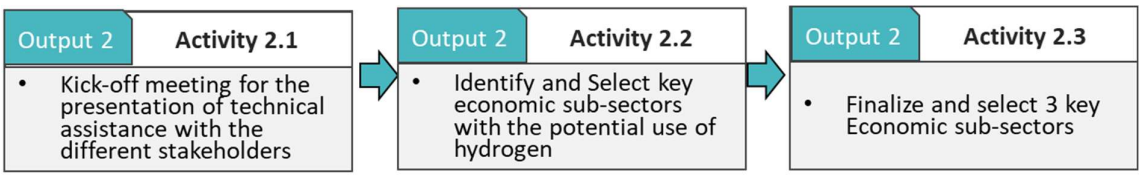
The main tasks are as follows:

- Preparing the Assessment Report on the potential use of hydrogen in three key economic sub-sectors in Thailand
- Identifying the suitable technological options to produce green hydrogen

- Drafting the National Strategy Vision Paper and the National Action Plan as well as the GCF Concept Note
- Providing capacity building for policymakers and private sector stakeholders

2. Detailed Plan of the TA

Output 2: Assessments Report on the potential use of Hydrogen in three key economic sub-sectors in Thailand



Activity 2.1: Kick-off meeting for the presentation of technical assistance with the different stakeholders

The kick-off meeting will be held in Thailand. NIGT will present the technical assistance response plan and implementation plan (Deliverables 1.1 and 1.2). NIGT will also collect relevant national policies, past and ongoing projects, and initiatives in the use of hydrogen and alternate fuel, including the activities concerning renewable energy in Thailand. The specifics such as date, venue, and presenters will be decided based on discussions between NIGT and the NDE of Thailand.

Activity 2.2: Identify and Select key economic sub-sectors with the potential use of hydrogen

In this task, NIGT will work with the NDE of Thailand and collect data and information on the energy/fuel used in key economic sub-sectors which has the potential to be replaced by hydrogen. Also, NIGT will utilize data on energy intensity (greenhouse gas emission unit) from international databases such as IEA, APEC, and World Bank. Based on analyses of data, a group of possible economic sub-sectors would be selected as the result of the 1st selection process.

For the next step, NIGT will conduct a comprehensive analysis of hydrogen applicability, compatibility with higher-level government policies, willingness to switch to the relevant industry sector, etc. This would include an analysis of any strategy which the Government of Thailand has formulated concerning its vision for a net-zero carbon economy (see Figure 1).

Table 1 provides an example of sector classification and selection processes based on two different sets of analyses.

Table 1 Example of sector classification and selection processes

Sectors*	**Sub-Sectors**		**Data Analyses Including GHG emissions (1st selection process)**	**Policy and Environment Analyses (2nd selection process)**
Energy	Electric Power Supply	For household use		
		For power generation		
	Gas Supply			
Transport	Land transport (Railways, Road transport, etc.)			
	Water transport			
	Air transport			
Commercial	Building			
Industry	Steel Industry			
	Petrochemical/ fertilizer industry			
	… etc. (will be added)			

* Sectors and Sub-sectors are subject to be changed

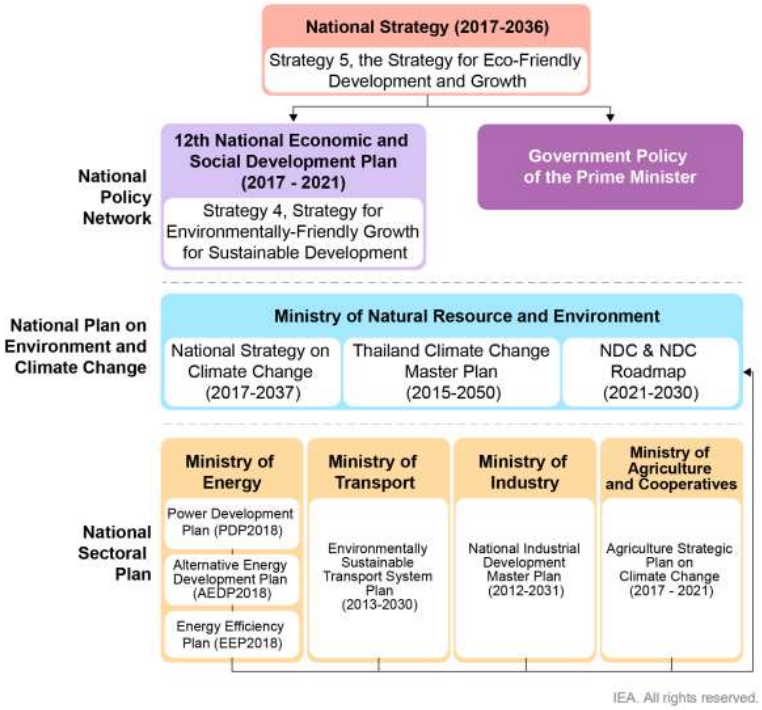


Figure 1 Example of policies and main stakeholders in Thailand

Source: IEA(2021). The Potential Role of Carbon Pricing in Thailand's Power Sector. p.17.

Activity 2.3: Finalize and Select 3 key Economic sub-sectors

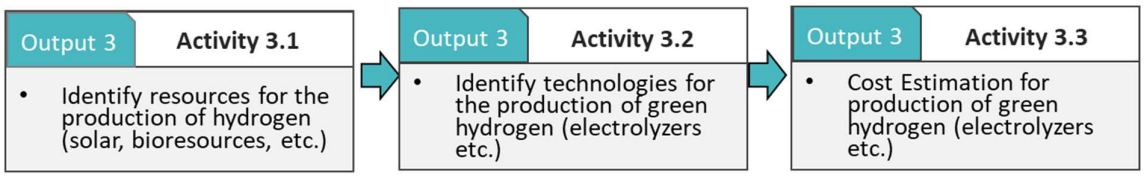
NIGT will prioritize the three selected economic sub-sectors using analyses such as SWOT analysis, multi-criteria analysis (eg. AHP), and stakeholder consultation (see an example of stakeholders in Table 2). Also, the potential benefits for each of the identified sectors would be estimated.

Table 2 Example of the stakeholders

Hydrogen Thailand	**Hydrogen Thailand Club – Group of public/private sectors** consists of PTT Plc., Bangkok Industrial Gas Co., Ltd, Toyota Motor Thailand Co., Ltd., Toyota, Daihatsu Engineering & Manufacturing Co., Ltd., Mitsui & Co., (Thailand) Ltd., Electricity Generating of Thailand (EGAT), Department of Alternative Energy Development and Efficiency, Ministry of Energy, National Energy Technology Center (ENTEC), National Science and Technology Development Agency.

Deliverables	Delivery date
2. Consolidated Assessment report on the potential use of hydrogen in three key economic sub-sectors in Thailand	30th June 2023

Output 3: Identify the suitable technological options to produce and transport hydrogen



Activity 3.1: Identify resources for the production of hydrogen (solar, bioresources, etc.)

NIGT conducts research to identify resources of hydrogen production (see Figure 2 as an example), classify them into green or blue, and estimate the potential through each of the resources. An analysis such as a SWOT analysis of the identified resources of production will be used to recommend the best option. In this activity, considering the current grey hydrogen production in Thailand, the best option might include blue hydrogen (which aligns with Thailand's Mid-century, Long-term Low Greenhouse Gas Emission Development Strategy.

Thailand				Reference Case		REmap	
			Unit	2015	2025	2036	2025	2036
Energy production and capacity	Power Sector	Total installed power generation capacity	GW	38.5	45.9	61.6	49.7	74.2
		Renewable capacity	GW	9.0	12.6	19.7	17.8	34.0
		Hydropower (excl. pumped hydro, domestic)	GW	3.5	3.1	3.3	3.2	3.4
		Wind	GW	0.2	0.9	3.0	2.3	6.0
		Biofuels (solid, liquid, gaseous)	GW	3.2	5.1	7.4	5.1	7.4
		Solar PV	GW	2.0	3.4	6.0	7.2	17.2
		CSP	GW	0.0	0.0	0.0	0.0	0.0
		Geothermal	GW	0.0	0.0	0.0	0.0	0.0
		Marine, other	GW	0.0	0.0	0.0	0.0	0.0
		Non-renewable capacity	GW	29.5	33.3	41.9	31.9	40.2
		Total electricity generation	TWh	178.9	237.5	319.3	239.4	336.8
		Renewable generation	TWh	22.7	40.2	58.3	50.0	84.2
		Hydropower	TWh	3.1	5.4	5.7	5.8	6.3
		Wind	TWh	0.4	1.8	6.3	5.3	13.9
		Biofuels (solid, liquid, gaseous)	TWh	17.1	28.3	37.9	28.3	37.9
		Solar PV	TWh	2.2	4.6	8.4	10.5	26.2
		CSP	TWh	0.0	0.0	0.0	0.0	0.0
		Geothermal	TWh	0.0	0.0	0.0	0.0	0.0
		Marine, other	TWh	0.0	0.0	0.0	0.0	0.0
		Non-renewable generation	TWh	156.2	197.3	261.0	189.4	252.6

Figure 2 (Renewable energy) Roadmap table, 2015-2036

Source: IRENA(2017). Renewable Energy Outlook: Thailand. p.52.

Activity 3.2: Identify technologies for the production of green hydrogen (electrolyzers etc.)

NIGT would estimate the energy and other requirements for the operation of the technology for the production of hydrogen. This would be undertaken through background research and looking at the future state-of-the-art technology based on Korean experts' consultation. To identify Thailand's current technology level, NIGT will closely work with local stakeholders and experts. As a result, a green hydrogen production technology pool will be established (see Table 3 for an example of electrolysis technologies).

Table 3 Example of electrolysis technologies

Types of Electrolyzers	Technological features
Alkaline Electrolyzers	Alkaline electrolyzers operate via transport of hydroxide ions (OH-) through the electrolyte from the cathode to the anode with hydrogen being generated on the cathode side. Electrolyzers using a liquid alkaline solution of sodium or potassium hydroxide as the electrolyte have been commercially available for many years. Newer approaches using solid alkaline exchange membranes (AEM) as the electrolyte are showing promise on the lab scale.
Polymer Electrolyte Membrane Electrolyzers	- Water reacts at the anode to form oxygen and positively charged hydrogen ions (protons). - The electrons flow through an external circuit and the hydrogen ions selectively move across the PEM to the cathode. - At the cathode, hydrogen ions combine with electrons from the external circuit to form hydrogen gas. Anode Reaction: $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$ Cathode Reaction: $4H^+ + 4e^- \rightarrow 2H_2$
Solid Oxide Electrolyzers	Solid oxide electrolyzers, which use a solid ceramic material as the electrolyte that selectively conducts negatively charged oxygen ions (O2-) at elevated temperatures, generate hydrogen in a slightly different way. - Steam at the cathode combines with electrons from the external circuit to form hydrogen gas and negatively charged oxygen ions. - The oxygen ions pass through the solid ceramic membrane and react at the anode to form oxygen gas and generate electrons for the external circuit.

Source: US Department of Energy Website.

For the next step, NIGT would develop a methodology for selecting suitable technologies for Thailand such as evaluation indicators or evaluation items. Examples of evaluation indicators include (future) R&D capabilities of Thailand such as the number of research papers and patents, human resources, or industry prospects. The selection of technologies will be done based on surveys of Korean and Thai experts and focus group interviews (FGI), etc. In this process, the current technology readiness level in Thailand, technology absorptive capacities, and workforce readiness will be considered to identify technologies. This aspect would also include an analysis of storage and transport system requests for the hydrogen produced.

Activity 3.3: Cost Estimation for production of green hydrogen (electrolyzers etc.)

NIGT conducts research to derive suitable regions through geographical/environmental analysis in Thailand and to estimate CAPEX and OPEX by green hydrogen production scale for selected technologies. For CAPEX, NIGT specifically utilizes previous studies and literature published by international organizations such as IRENA and IEA. As for OPEX, NIGT will collect data on the configuration items required for OPEX through local experts.

Deliverables	Delivery date
3.1: Report on resources for the production of hydrogen (solar, bioresources, etc.)	30th Aug 2023
3.2: Report on technologies for the production of green hydrogen, storage, and transport (electrolyzers, etc.)	30th Aug 2023
3.3: Report on CAPEX and OPEX costs (possibly with different size configurations and scenarios)	30th Sep 2023

Output 4: National Strategy Vision Paper and National Action Plan

Activity 4.1: National Strategy and action plan

NIGT will draft a national action plan including a vision of the national hydrogen strategy and technology roadmaps for the implementation of the best suitable application area(s) and the identified green hydrogen production technologies (see Figure 3 for an example of vision and strategies of masterplan).

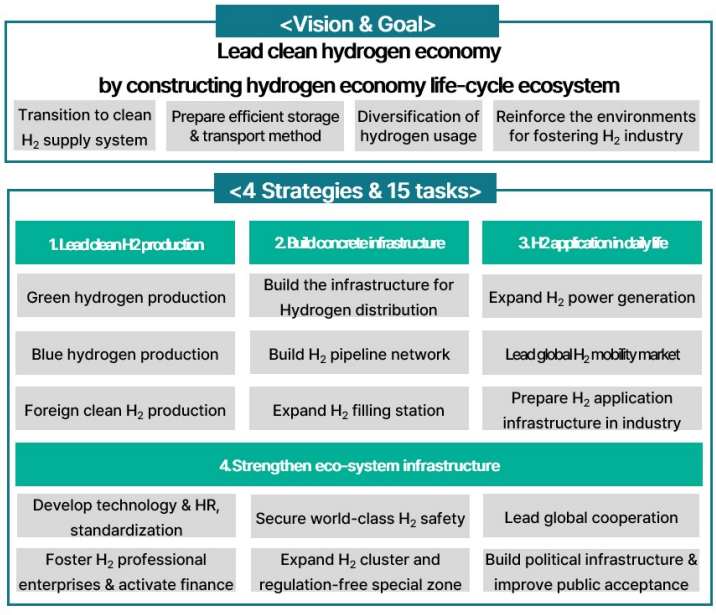


Figure 3 Example of Vision and Strategies of Masterplan

Source: Korean Government(2021). 1st Hydrogen Economy Implementation Masterplan.

In the process, Korean experts would mainly contribute to developing a national action plan and technology roadmaps. NIGT will collect opinions from Thai experts and stakeholders on the draft version by consisting of a consultative body, holding a forum, receiving written consultation, etc.

In this activity, the drafted National Action Plan will be based on a system-wide approach (including infrastructure, legal, and other non-technology issues). So, the output would include an additional section highlighting parts which directly relevant to NDE and STI policy units (e.g. NXPO itself).

Activity 4.2: GCF Concept Note

NIGT will draft a GCF concept note on the pilot demonstration project. The concept note includes a summary, information, indicative financing/cost information, and supporting documents of a proposed project/program to the GCF.

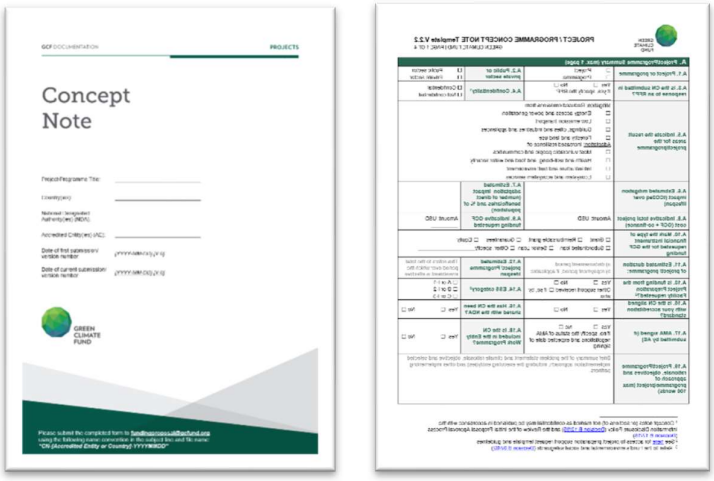


Figure 4 Template of Concept Note

Source: GCF website

Deliverables	Delivery date
4.1: National action plan and technology roadmaps	30th Dec 2023
4.2: GCF Concept Note	28th Feb 2024

Output 5: Capacity Building for Policy Makers

Activity 5.1: 2-Day workshop for Policy makers including private sector engagement

NIGT will organize a two-day workshop in Thailand for senior policymakers from the various Ministries and Departments. The objective of the workshop would be to discuss the National Roadmap and highlight investment opportunities. This two-day workshop should also invite different private-sector

players. NIGT will also arrange a three-day program in which two representatives from NXPO observe Korea's hydrogen-related facilities and share policy contents.

Table 4 Example of Workshop Agenda

Contents	Presenters	Participants
(Day 1) - Presenting the national hydrogen strategy, national action plan, and technology roadmap - Global hydrogen technology trends - Global hydrogen policy trends	NIGT researchers, Korean hydrogen experts	Policymakers
(Day 2) - Capacity Building on investment relations - Global investment trends in hydrogen projects - IR (Investor Relations) Courses (examples) ① Introduction to IR and the Financial Markets ② Understanding investors and analysts ③ Investor Targeting and Engagement	Korean hydrogen-related corporate/investment managers, Korean International Cooperation/Climate Finance experts	Private-sector players

Deliverables	Delivery date
Activity 5.1: Workshop Report	**15 March 2024**