CONSULTING ENGINEERS

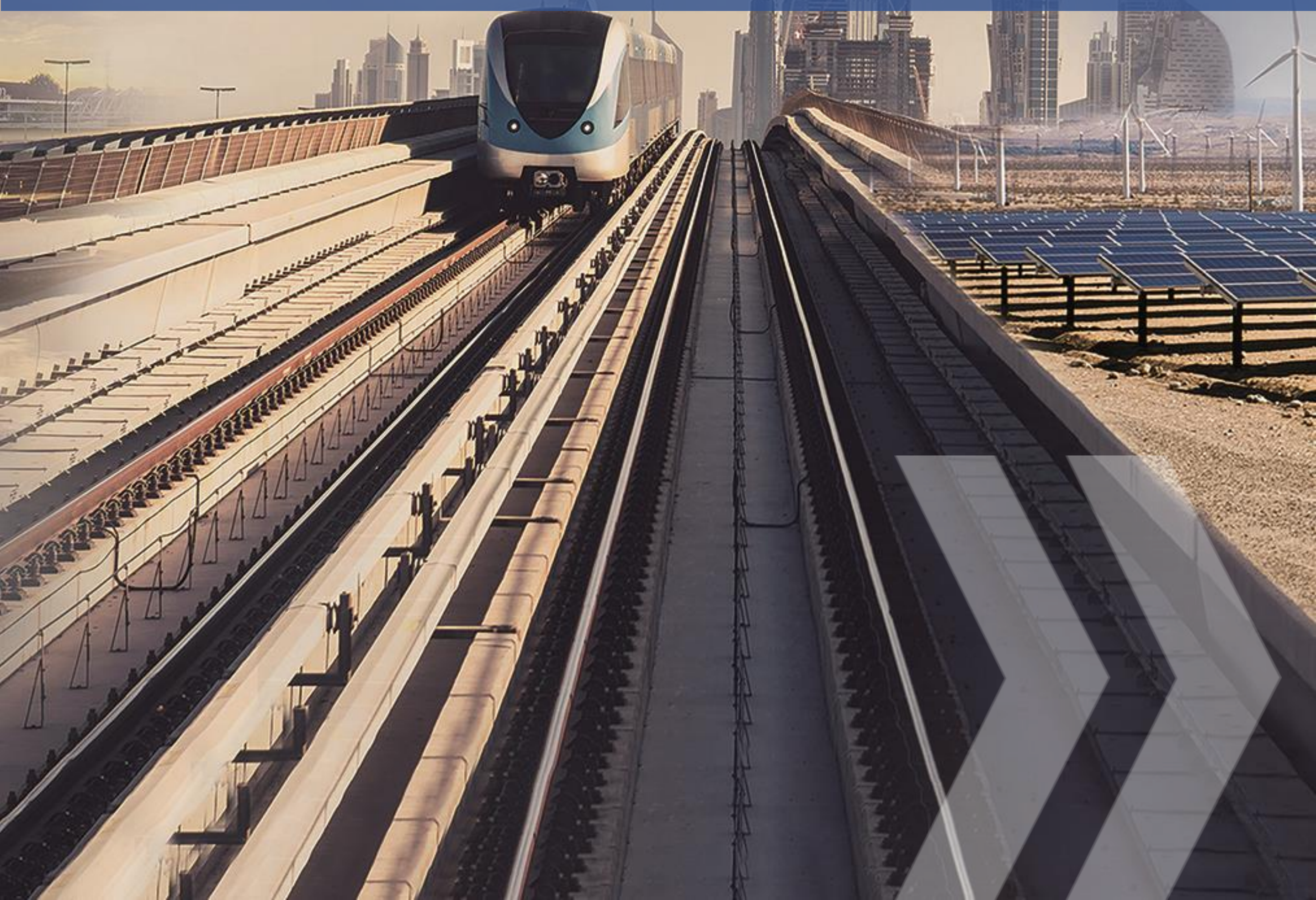
Project Excerpt

Green Hydrogen Common Infrastructure Development in Jordan

May 2025

European Bank for Reconstruction and Development

Ministry of Energy and Mineral Resources
The Hashemite Kingdom Of Jordan



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European Bank
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EBRD In Jordan

The European Bank for Reconstruction and Development (EBRD) is an international financial institution that works across three continents to support the transition to successful market economies. As a multi-lateral developmental investment bank, the EBRD funds various infrastructure projects to promote growth by fostering the private sector in a sustainable form. It combines business models, with financial and policy-based advisory. The Bank is currently active in thirty-six countries.

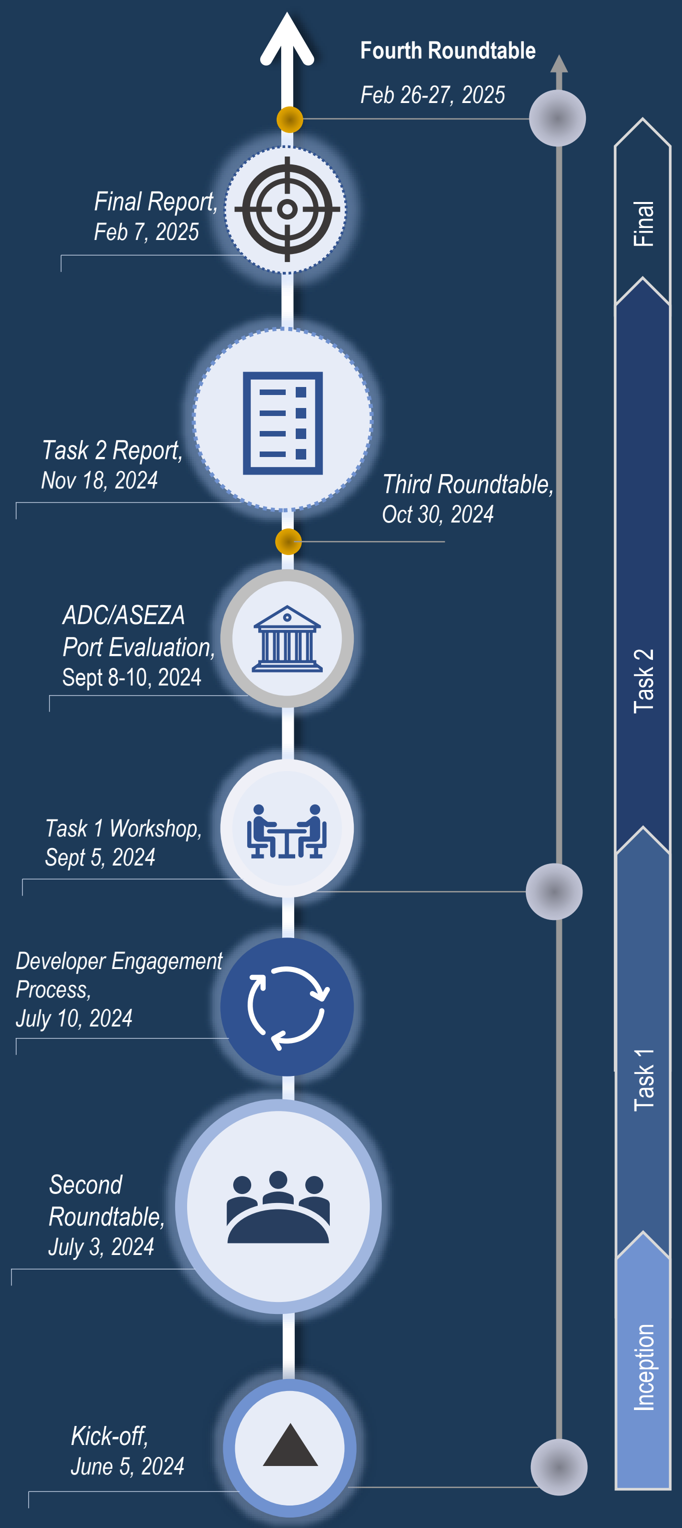
In a bid to develop the Green hydrogen sector in Jordan, EBRD has funded multiple Roundtables and a key assignment on an infrastructure masterplan to develop a common infrastructure that augments Green hydrogen production. So far, EBRD has hosted four Roundtables that have involved discussions from Ministry of Energy and Mineral Resources, who are spearheading the sector development planning, along with active participation of investors, developers, international financiers, policy advisors and consultants. The discussions have been instrumental in shaping the implementation planning and supporting various decisions and initiatives.

The assignment, which is highlighted in this excerpt, forms that largest share of investments by the EBRD. The objectives of the project were to:

» Provide advisory to MEMR and the Technical Committee responsible for Green hydrogen project development addressing techno-economic arrangements for Common-Use Infrastructure (CUI); and,

» Elaborate a strategy and implementation plan based on the evaluation of developer plans, governmental possibilities.

Timeline of Major Milestones



GH_2 COMMON INFRASTRUCTURE PLAN

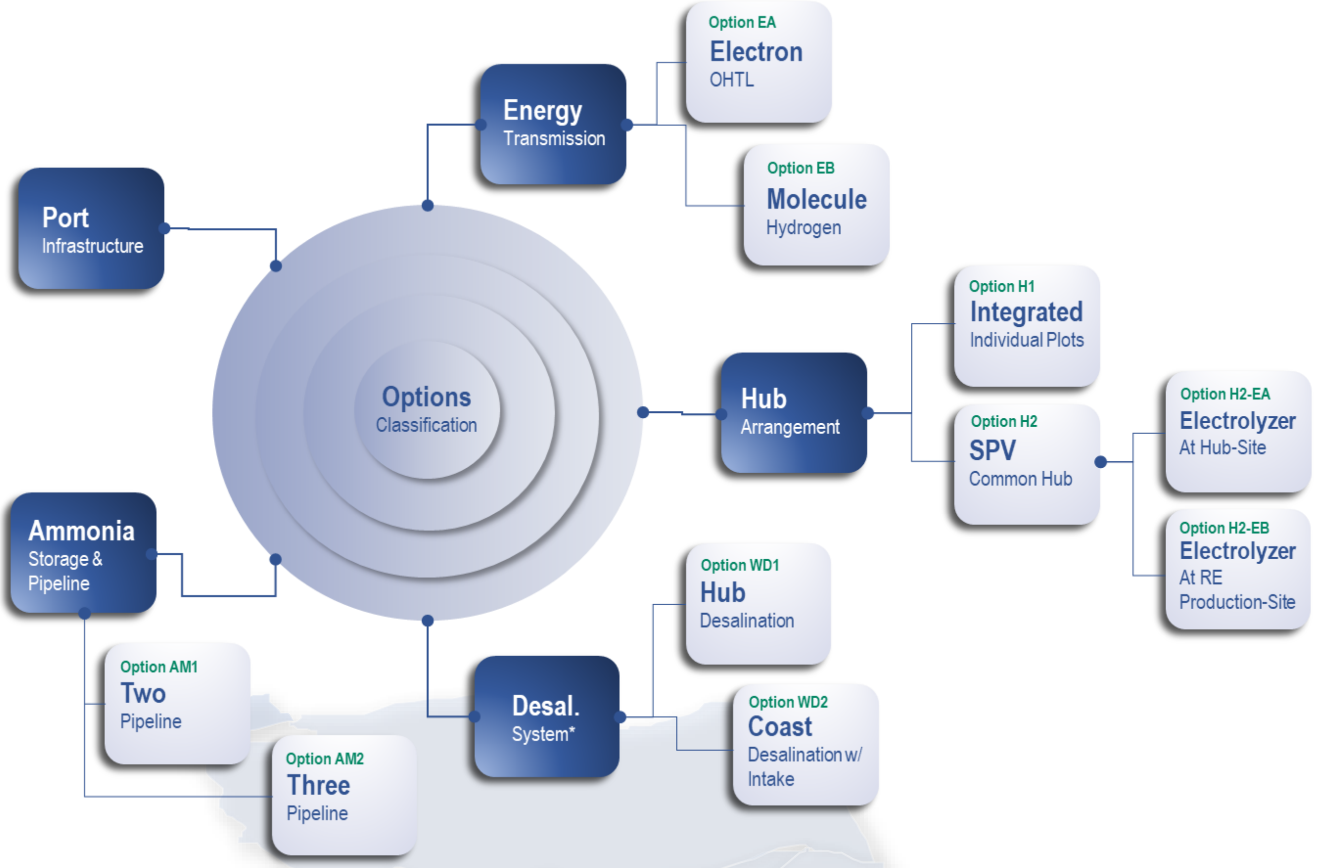
Jordan has devised its draft National Hydrogen Strategy to propel itself as a major Power-to-X (PtX) player in the region. The long-term strategic plan aims to meet its internal demand for low-carbon fuels and generating exports to increase energy trade of green hydrogen in the form of green ammonia and methanol. With abundance of renewable resources, especially solar, Jordan is well poised to harness and sell clean energy. The country already has seen progressive development with 27% of the total installed power capacity being supplied by renewables and transmitted within its power system to meet a growing national power demand.

The MEMR, chairing the Technical Committee for Green Hydrogen (GH_2) projects, has been coordinating the process of managing and guiding developers, who plan to invest and develop Green hydrogen and ammonia production facilities for the purposes of export. As of date, a dedicated plot of land in the Aqaba Special Economic Zone has been identified for allotment to developers. As per an initial survey of developer plans, the projected timeline for completion of the projects is 2030.

The EBRD in 2024, had orchestrated a procurement process to invite proposals for the developmental planning of the common infrastructure. ILF Consulting Engineers GmbH was selected, upon due evaluation, to plan the development of a Green Hydrogen Hub and its associated common infrastructure in Aqaba Special Economic Zone.

The assignment covered the basic design of the entire value chain for project development, starting from the understanding of energy supply profiles from solar PV system and onshore wind turbines, energy transmission modalities, production process, hub development approach, water desalination system with transmission pipeline and ammonia storage, handling and export via port facilities at Aqaba.

Moreover, the assignment entailed supporting the Technical committee to make informed decisions on the planning and implementation of the selected options. This involved discussions with officials from MEMR and Aqaba Development Company (ADC) as well as the national transmission system operator National Electric Power Company (NEPCO). In stakeholder engagement process, all interested developers were interviewed as well.



Over sixteen options had been assessed to check for optimal configuration of the Green Hydrogen hub and the various arrangements possible for the CUI.

The site layout plan and the chosen transmission system both influence the design and scale of facilities required at the hub that forms the primary determinant of the implementation plan.

In case electrolysis and ammonia synthesis plants are installed in Aqaba, energy transmission in the form of Overhead Transmission Lines (OHTL) is envisaged. Whereas, in case electrolysis is situated along with renewable energy production, a gas pipeline conveys the hydrogen gas for ammonia synthesis, from the energy production sites to Aqaba. Both modes have their own set of advantages and disadvantages linked to scalability, cost and technical nuances.

The site layout concept had been assessed for multiple approaches. The base case considers a common hub development approach, while an alternative would foresee an individual approach by the project developers. The common hub development plan would provide an optimal utilization of land resources and provide substantial scaling benefits for both electrolysis and ammonia synthesis. The individual or integrated project development approach by every developer, on the other hand, would simplify commercial structuring and ownership issues.

Desalination plant could be located within hub premises or on the coastline. Ammonia pipeline and storage systems have been assessed on the need of a new berth at the port, already identified for expansion by the Aqaba Development Company (ADC).

Jordan Hydrogen Strategy

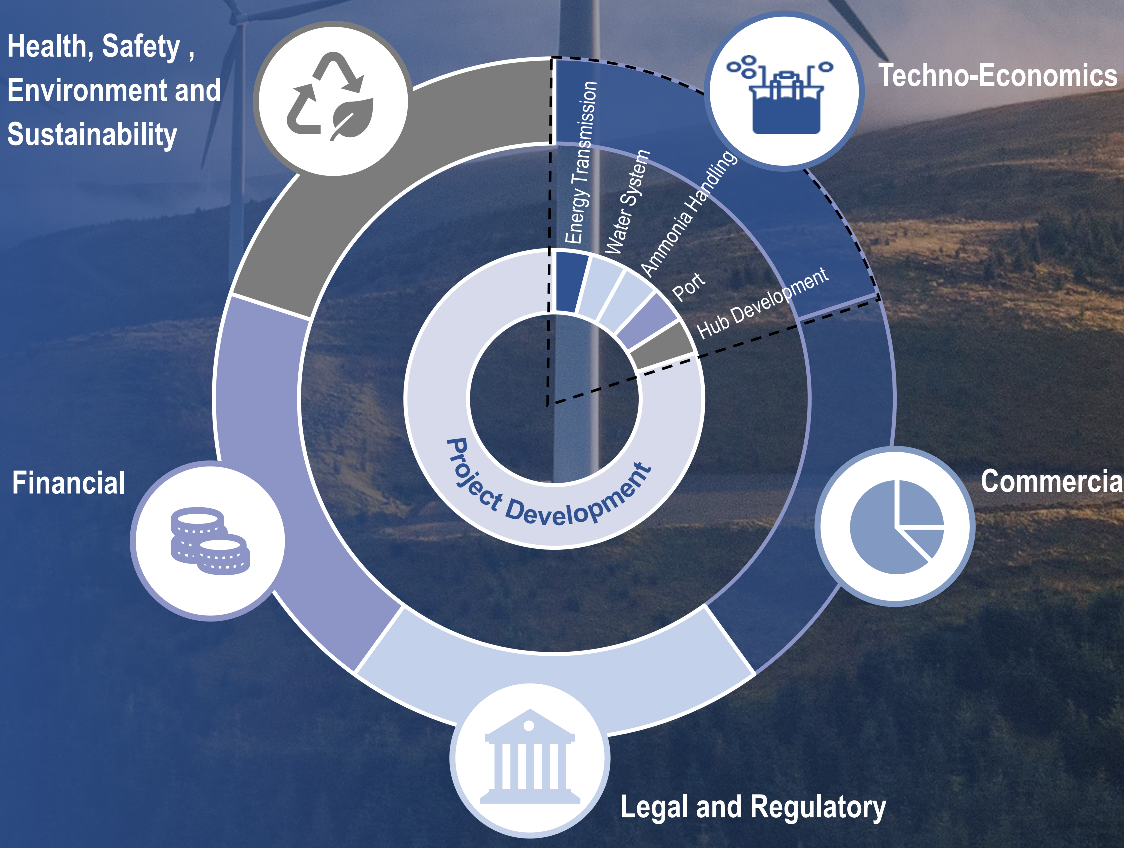
Annual Green Ammonia Export Target

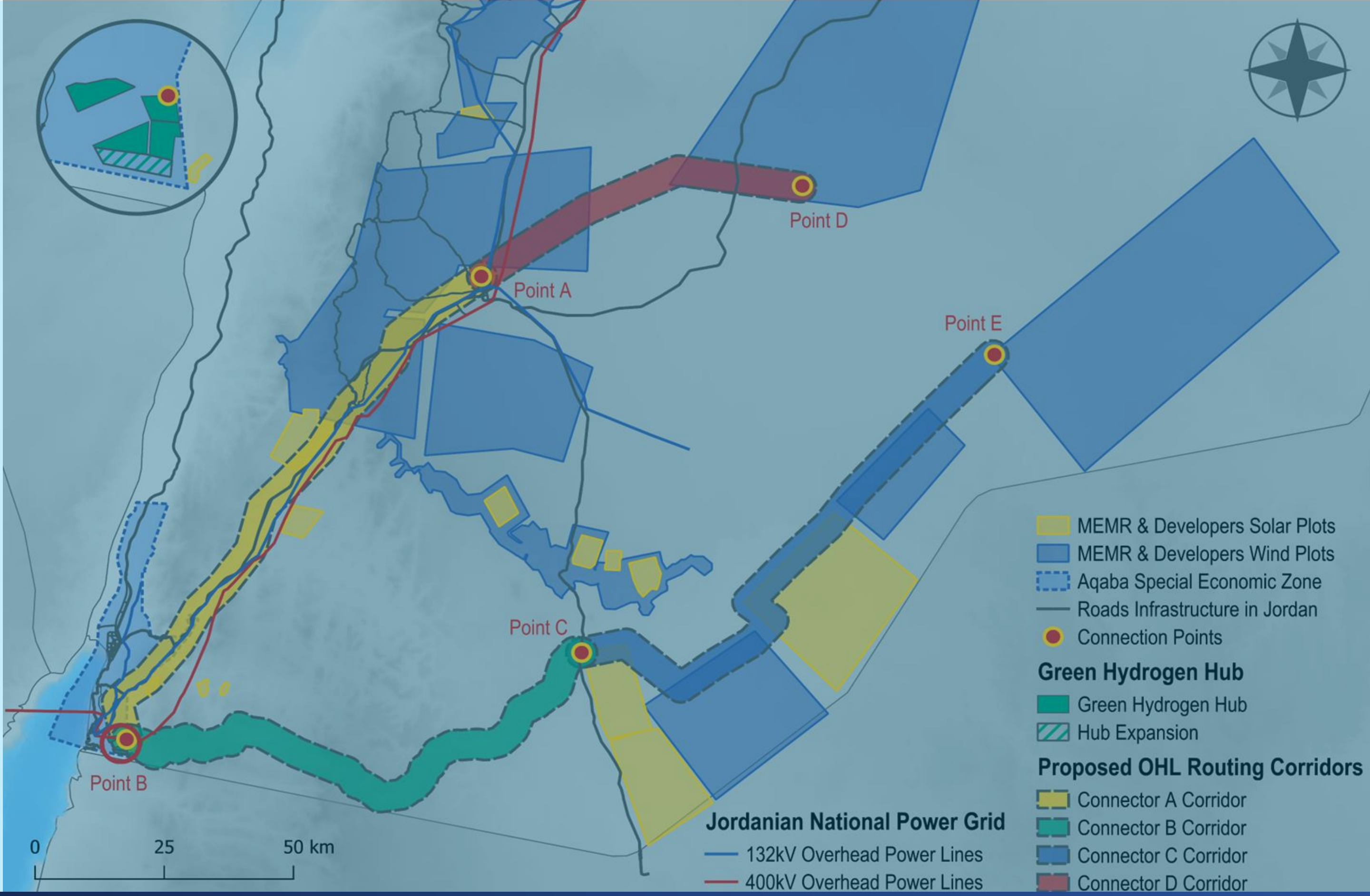
[forms the basis for quantitative evaluation]

2030	2040	2050
3 Million tonnes per annum	6 Million tonnes per annum	13 Million tonnes per annum

Structure of the Assignment

Green hydrogen project development in Jordan necessitated a new insight into a complex interlay of topics.





DESIGN OF ENERGY TRANSMISSION

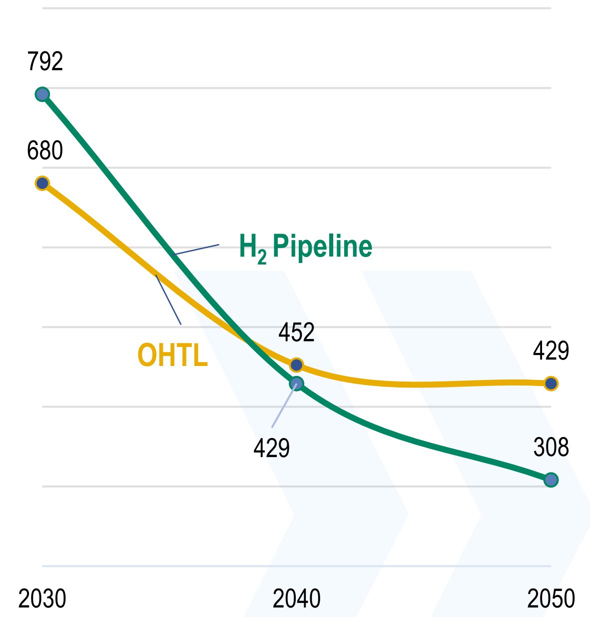
Energy transmission formed the largest share of the CAPEX requirements in the CUI assessment. The proposed system comprised of a network of transmission lines, with generation transformers and pooling hub substation for a 400-KV AC transmission grid. The network followed the corridors (shown in the map above) with a total length of 420 km. The same corridor had also been utilized for assessment of 100-bar hydrogen pipeline system with compression and storage duration of 8 hours.

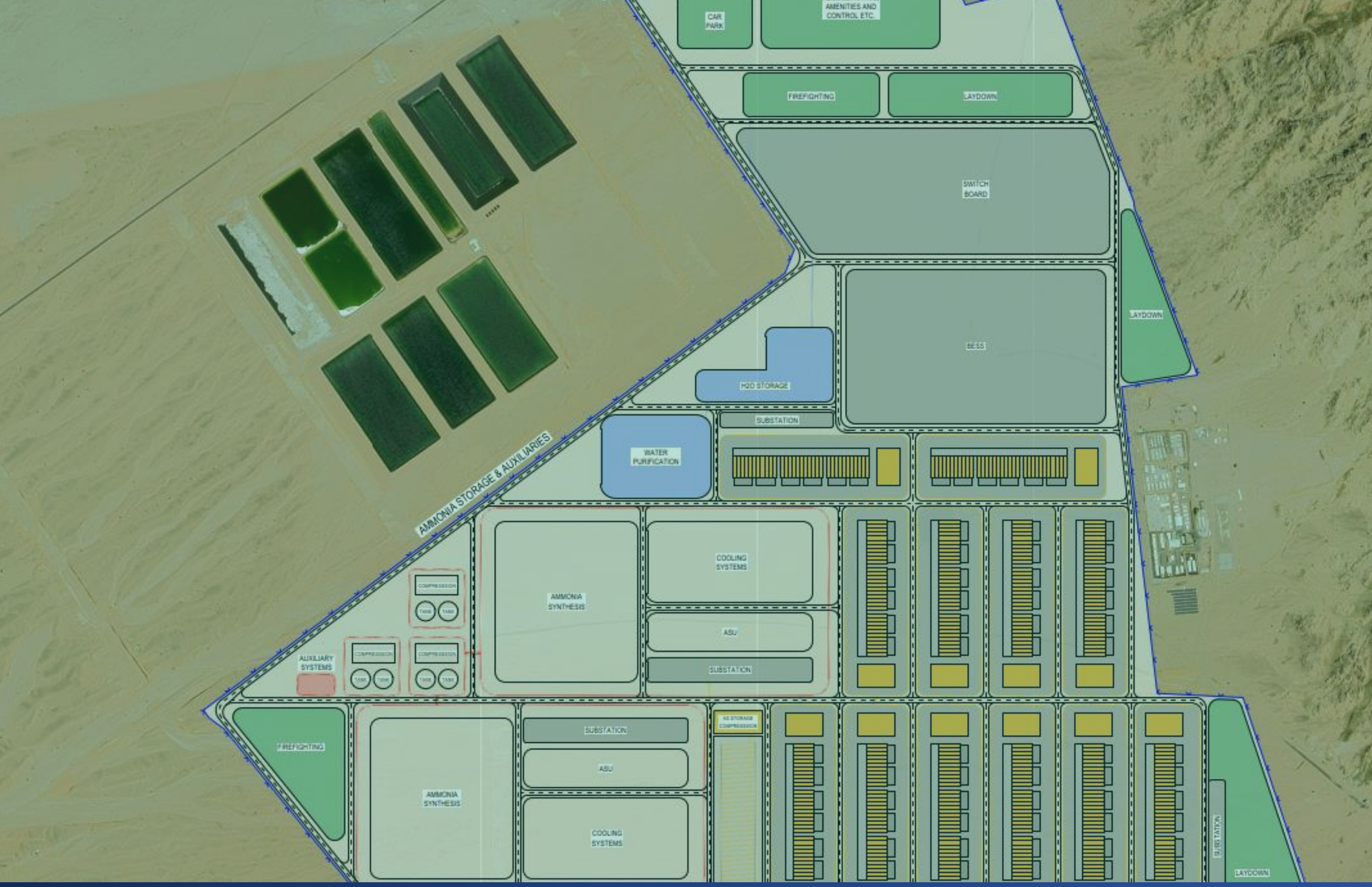
The evaluation considered a basic plan to connect the energy generation sites to Aqaba in both instances.

The CUI specific-CAPEX is used as a means to measure the total capital costs incurred for entire CUI against the annual ammonia production target. To compare the apparent benefits of hydrogen pipeline over OHTL, it is noteworthy to highlight that as the scale increases, the specific CAPEX of CUI with hydrogen pipeline is 28% lower than specific CAPEX for CUI with OHTL systems by year 2050. Evidently, the hydrogen transmission system becomes cost-effective at higher capacities.

CUI Specific CAPEX with OHTL and H2 Pipeline 2030 - 2050

In US Dollar per Tonne-Green Ammonia





LAYOUT PLANNING OF GH_2 HUB

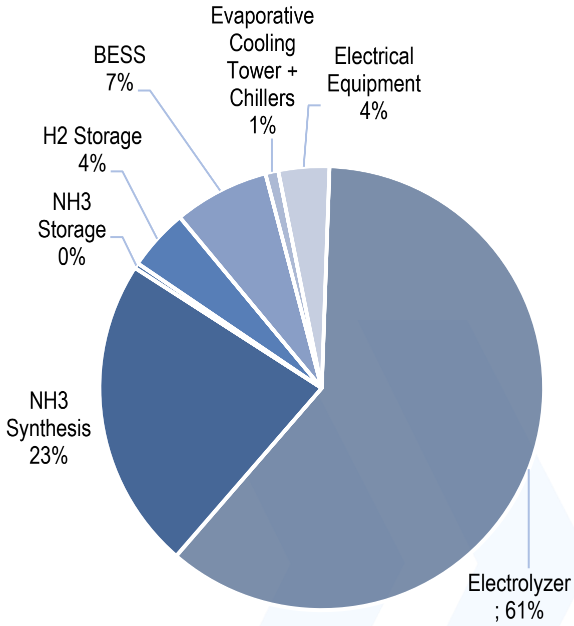
The Green hydrogen hub is being planned in the Aqaba Special Economic Zone for development. It is at a distance of 8 to 10 Km from an operating port that handles both solid and liquid bulk cargo. The land is maintained and controlled by ADC.

The land parcel identified is 5.5 square Km in area and within the vicinity of fertilizer production plants, defence camp and evaporation ponds of the fertilizer plants. An analysis had been conducted for the total production capacity of green ammonia varies based on the multiple archetypes. A common hub approach, under a joint Special Purpose Vehicle (SPV) of developers and with electrolyzer and ammonia synthesis on the hub would yield 6.4 Million tonnes per annum (Mtpa) of Green ammonia production. Whereas a joint SPV with only green ammonia production on the plot, the production could reach values of up to 15.6 Mtpa.

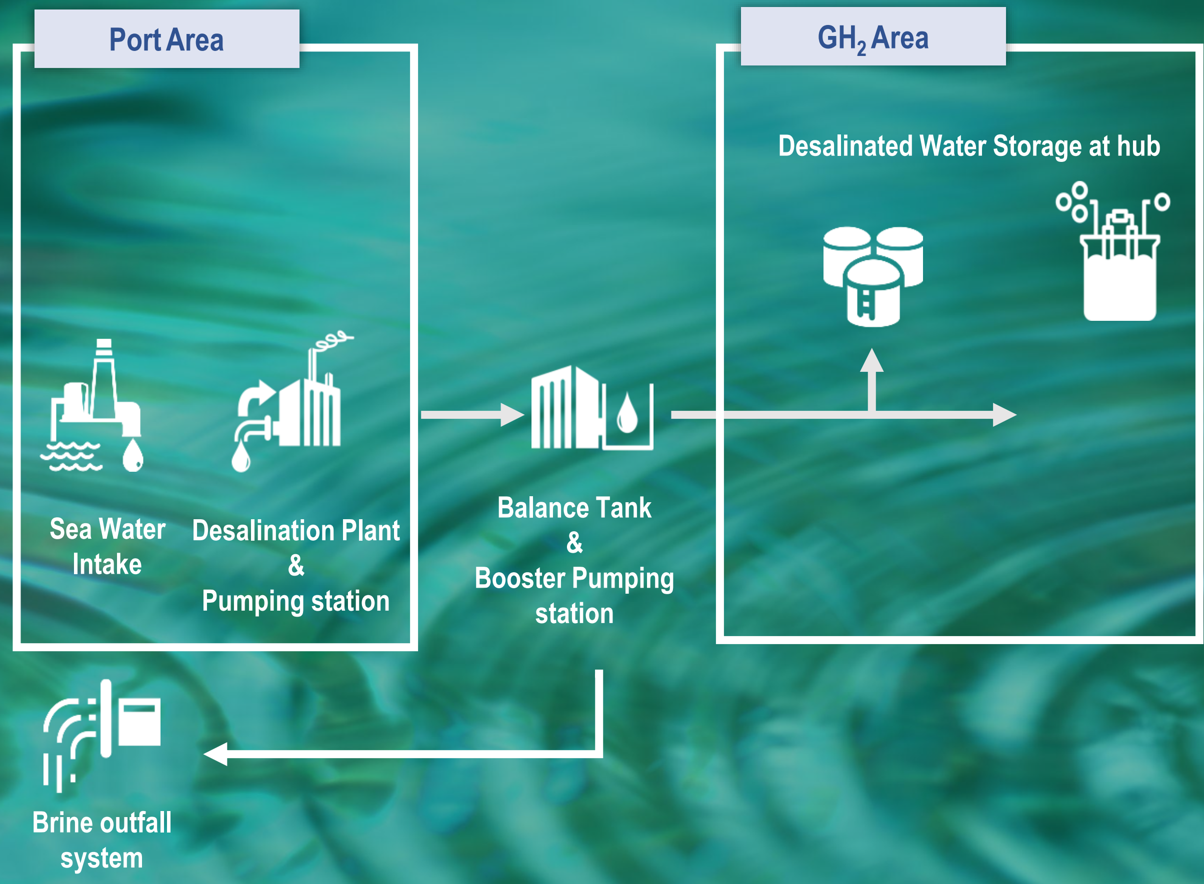
If the developers would prefer to set integrated production facilities, the production of green ammonia under "electrolyzer & ammonia synthesis" combination is restricted to 6 Mtpa of Green ammonia. This meets that export target capacity of 2040, as set in the Jordan Hydrogen Strategy.

Share of CAPEX* by System and Equipment for Production of Green Ammonia

In US Dollar Million



*Total CAPEX is USD ~ 11 billion for hub arrangement to meet production target of the year 2030, i.e. 3 Mtpa



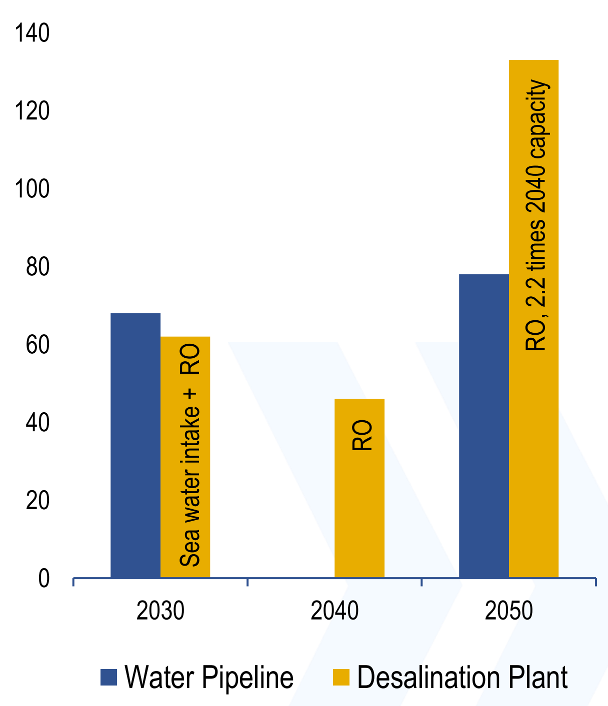
DESIGN OF WATER TREATMENT SYSTEM

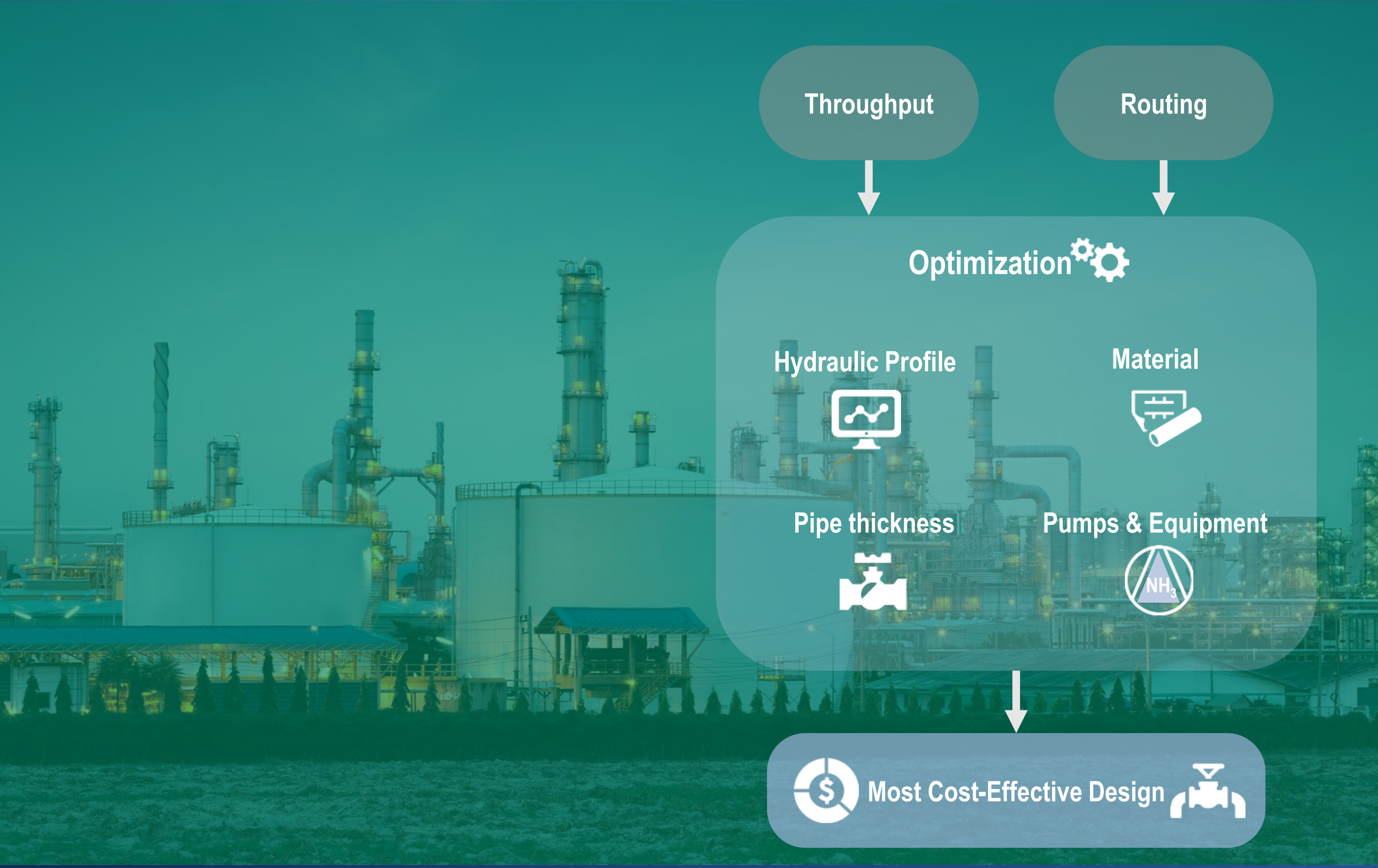
The basic design had been proposed to supply daily raw seawater requirements through the intake pumping station through a transmission pipeline, extending from the intake structure in the sea. The transmission system would also require a balance tank, and a booster pumping station located roughly halfway along the transmission pipeline, as well as a storage raw water tank within the hub area. The desalination plant's nominal capacity corresponded to average GH_2 generation with 24/7 production. A 4-hour storage of produced desalinated water is foreseen at the plant. The product water is permeated as output of the Reverse Osmosis (RO) treatment.

The water pipeline system comprises of a two-pipeline archetype, with first pipeline set for capacities needed till 2040, would be constructed in 2030 and the second pipeline constructed for 2050 requirements. The CAPEX requirements for desalination plant in 2030 encompasses the construction costs for sea water intake that catered to water requirement till 2050. From 2040, consideration of new RO modules had been made. The total capacity of RO water estimated is 29 000 cubic meters per day in 2030 to 133 000 cubic meters per day in 2050.

CAPEX Estimation for Water Pipeline and Desalination Plant at Port

In US Dollar Million





DESIGN OF AMMONIA STORAGE AND HANDLING

Pipelines had been considered for transporting liquid ammonia to its destination and typically operated in two ways: as pressurized liquid at ambient temperature or as cooled liquid at approximately -33°C and ambient pressure.

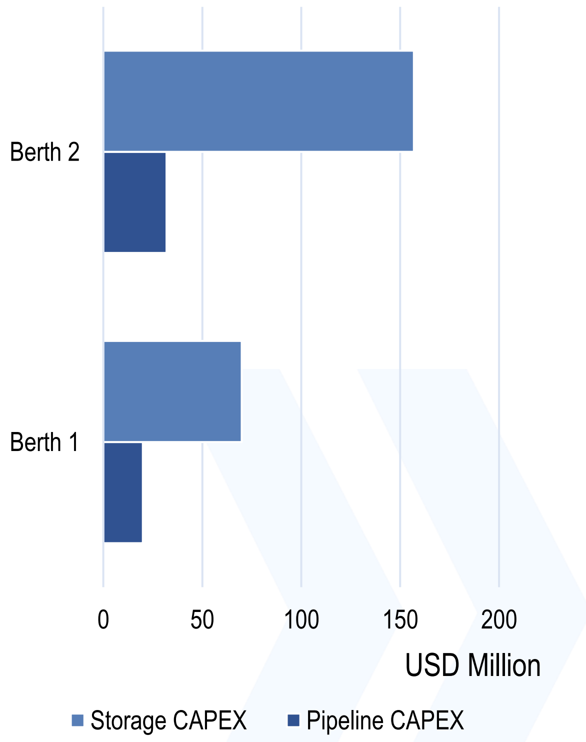
Pressurized pipelines are generally preferred for longer distances, as the insulation required for cooled pipelines can add significant costs. However, this method may require facilities to warm the ammonia at the supply point and cool it again at the destination.

For shorter distances, cooled liquid ammonia pipelines are more common, as the costs and operational complexity of warming and re-cooling ammonia are more detrimental than using an insulated pipeline and the impact of a leak is much smaller for refrigerated ammonia.

A two-pipeline systems had been assessed for the CUI requirements. A nominal pipe size of 500 mm for the Berth 1 system, and 750 mm for Berth 2 system is proposed, with associated total CAPEX in the order of magnitude of US Dollar (USD) 280 million and OPEX of USD 8 million.

CAPEX for Pipeline and Storage for Berth 1 and Berth 2

In US Dollar Million

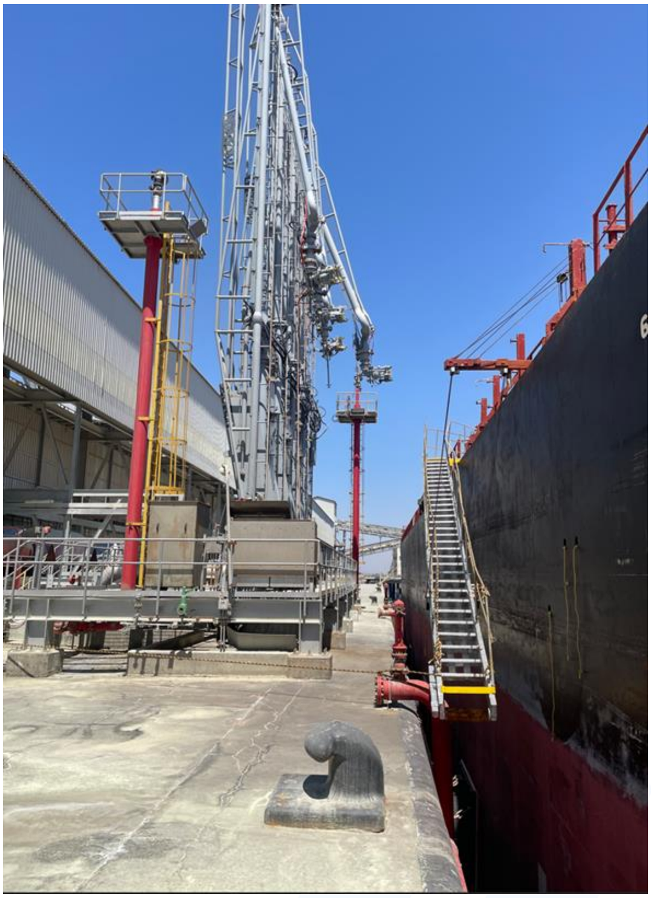


ASSESSMENT OF PORT FACILITIES

A maximum of 75 vessels, each with 30,000 DWT, could handle a capacity 2 Mtpa of Green ammonia. The existing berth's capacity had been determined to be insufficient for 2030, with a shortfall of 0.8 Mtpa. This insufficiency also applies to the 2040 and 2050 scenarios. Therefore, a new berth had been proposed which complements ADC's plan for berth expansion per their strategic vision.

The timeline for the installation of this new berth includes a 2-year design and approval phase, followed by a minimum of 1 year for construction. The investigations performed indicate the need for a new berth for handling oil products and chemicals. However, this new berth could also be used for ammonia export. It is designed for tankers with a max. 80,000 DWT (which corresponds to the LR 1 tanker category).

The cost estimate for the new berth is estimated to be USD 65 Million.



Commercial Structuring Assessment

Common Infrastructure Development

ILF had prepared a commercial structuring framework for implementation of CUI.

Structure

SPVs

Separate SPVs for each CUI. Holding SPV can also be considered.

Shareholding

Shareholding shall be based on capacity allocation of developer for their production plans and could follow structures in Oil and Gas projects.

Models

Government to create support environment. BOO(T) models for water, ammonia handling and port.

Common Infrastructure Development

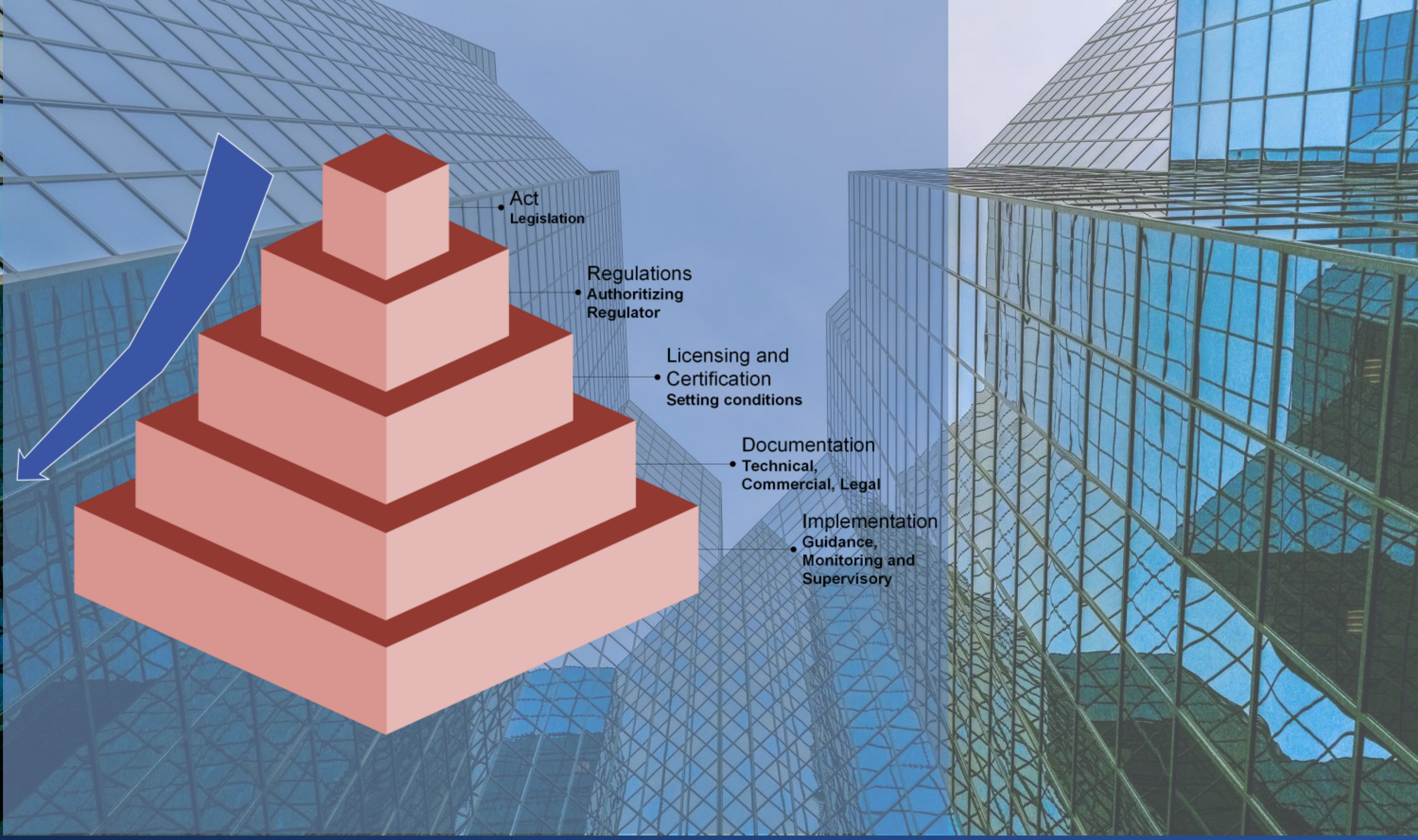
Environmental and Social Assessment

Energy Transmission
The pathways require additional studies and authorization as the proposed corridors pass through critical areas of environmental, commercial and archaeological significance.

Desalination System
Reject from reverse osmosis could pose threat to the marine preserve in the Red Sea. Aqaba also serves as an important tourist destination that showcases its marine biosphere, forcing further caution.

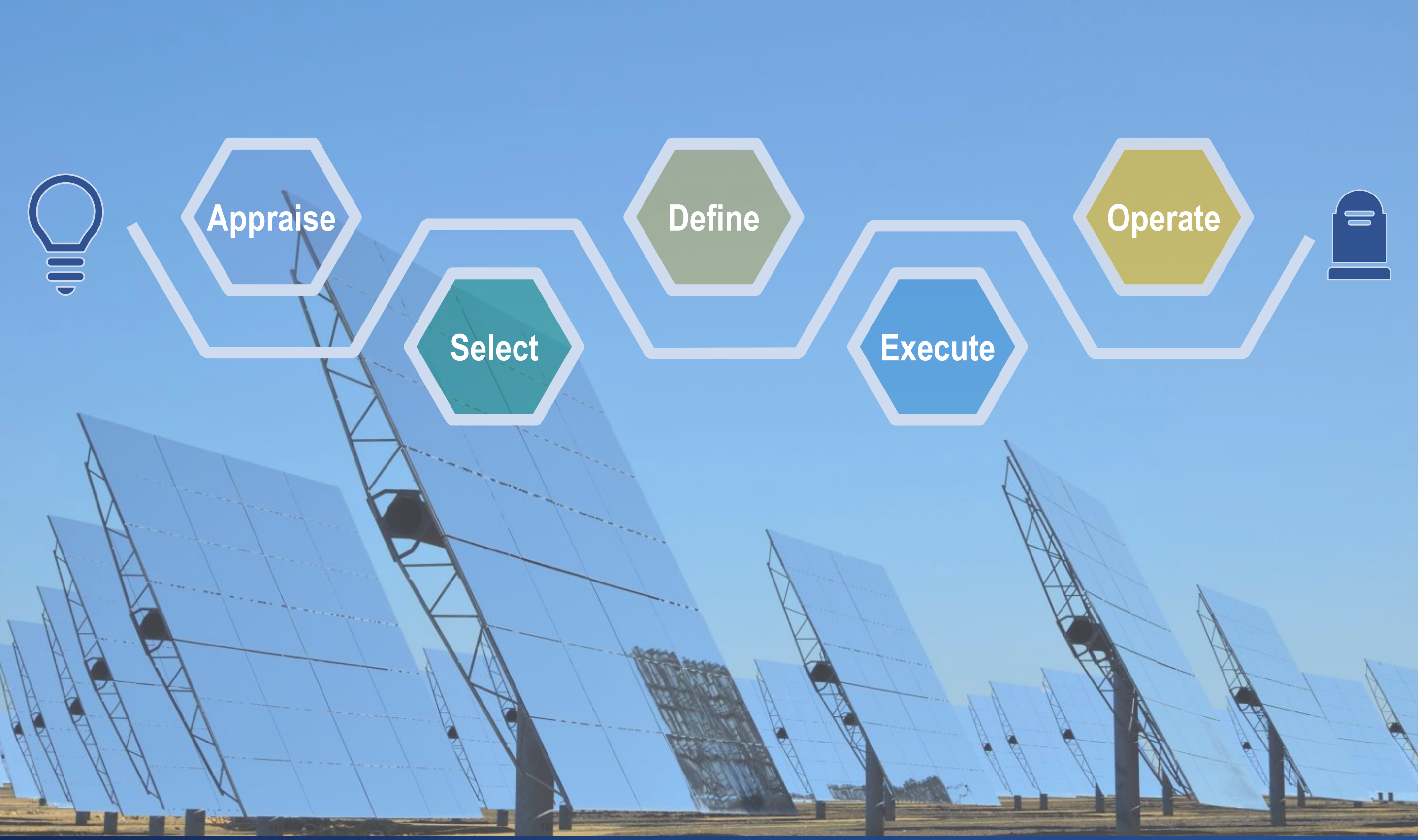
Ammonia Handling and Storage
Comprehensive safety studies are required for the storage and transportation of ammonia within the industrial zone.

Port Infrastructure
Extant port operations reflect elevated safety standards and a commitment to environmental protection.



REGULATORY AND INSTITUTIONAL SCREENING

Regulations & Policies	Strategic Planning	Permits and Licenses	Project Financing	Hub Development	CUI Development
Formulate & implement the necessary regulations and policies for the emerging hydrogen sector.	Designate land plots for renewable energy generation and the GH_2 Hub. Establish a defined procedure to oversee the entire life cycle of projects, from conception to implementation.	Linearizing permit and license issuances under as a single umbrella entity. Issue the necessary permit for the development and operation of the GH_2 Hub & CUI.	Provide the necessary financial support for the development of GH_2 projects and CUI. Coordinate with Donors & Early Interest Parties.	Development & operation of GH_2 projects, including RE generation, green hydrogen production, and ammonia synthesis.	Development & operation of common-use infrastructure, including OHTL or hydrogen pipelines, product export terminal, water and ammonia pipelines, and water desalination facilities.
National Green Hydrogen Committee	National Green Hydrogen Committee	Regulator	International Financial Institutions (IFIs) Project Financiers Bank Syndicate	Project Developers	Dedicated SPVs NEPCO ADC



IMPLEMENTATION PLANNING

CUI development in Jordan remains in the "Appraise Phase." The studies that had been pursued so far are expected to present a preliminary design of the CUI, identify potential routing corridors, provide a high-level cost estimate (AACE Class V), and compile a list of identified stakeholders, including the project developers leading to viable execution strategy.

One of the foremost considerations is the establishment of a comprehensive legal and regulatory framework to govern the emerging green hydrogen sector in the Kingdom.

As per a tentative investment plan, approximately, two billion dollars would be required by 2030, USD 1.75 billion by 2040, and USD 5.1 billion by 2050 to establish the components of the CUI based on the OHTL network as the baseline energy transmission option. For the hydrogen pipeline option, the implementation plan envisages a CAPEX requirement of approximately USD 4.5 billion by 2030, USD 280 million by 2040, and USD 580 million by 2050. The costs considered in this estimates do not include the renewable energy generation equipment, land, taxes, customs duties, fees etc. and are based on CAPEX considerations of CUI evaluated.

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