Study on possibilities and implications of desalination for the production of Green Hydrogen in India

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Abbreviations

Shortened Form	Phrase
AP	Andhra Pradesh
APIIC	Andhra Pradesh Industrial Infrastructure Corporation Limited
APSMA	Andhra Pradesh State Disaster Management Authority
BESS	Battery Energy Storage System
BOOT	Built Own Operate and Transfer
CAPEX	Capital Expenditure
CE	Central Excise
CER	Corporate Environmental Responsibility
CMWSSB	Chennai Metropolitan Water Supply and Drainage Board
CO_2	Carbon dioxide
CPCB	Central Pollution Control Board
CRZ	Coastal Regulation Zone
CZMA	Coastal Zone Management Act
dB	decibels
DBFOT	Design Built Finance Operate and Transfer
DBOT	Design Built Operate and Transfer
DRE	Decentralized Renewable Energy
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EOT	Electric Overhead Travel
EPC	Engineering Procurement and Construction
ESIA	Environmental Social Impact Assessment

Shortened Form	Phrase
FGD	Focus Group Discussion
FI	Fichtner India
FRP	Fiber Reinforced Plastic
GH2	Green Hydrogen
GIDC	Gujarat Industrial Development Corporation
GIZ	German Development Cooperation
GoI	Government of India
GRP	Glass fiber reinforced plastics
GW	Government of India
GWIL	Gujarat Water Infrastructure Limited
HDPE	High Density Polyethylene
HTL	High Tide Level
LSI	Langelier Saturation Index
LSTK	Lump Sum Turnkey Contract
LTL	Low Tide Level
ML	Million Liter
MLD	Million Liter per Day
MMT	Million Metric Tons
MoC	Material of Construction
MOEF&CC	Ministry of Environment, Forest and Climate Change
MRPL	Mangalore Refineries and Petrochemical Ltd
MW	Mega Watt
NABL	National Accreditation Board for Laboratory
NGEL	NTPC Green Energy Limited
NSPC	Navigational Safety in Ports Committee
NTPC	National Thermal Power Corporation
NWP	National Water Policy

Shortened Form	Phrase
O&M	Operation and Maintenance
OPEX	Operational Expenditure
PG	Performance Guarantee
PMC	Project Management Consultant
PPM	Parts Per Million
PPP	Public Private Partnership
PRA	Participatory Rural Appraisal
PtX	Power to X (derivates of hydrogen)
PUC	Pollution Under control Certificate
RCC	Reinforced Concrete Cement
RE	Operational Cost
RF	Reserved Forest
RO	Reverse Osmosis
RRP	Rapid Rural Appraisal
SMBS	Sodium Meta bi-Sulphite
SPCB	State Pollution Control Board
SWRO	Sea Water Reverse Osmosis
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UOM	Unit of Measurement
UPW	Utra-Pure Water
VGF	Viability Gap Funding
3 R's"	Reduce, Reuse, Recycle

1 Executive Summary

1.1 General

The Republic of India and the Federal Republic of Germany share a robust and enduring partnership in tackling critical issues about green and sustainable development, climate change, and environmental conservation. This collaboration is marked by active and mutually beneficial engagement. Both nations are committed to fostering cooperation in areas such as technological innovation, regulatory standards, capacity building, and private investments, all aimed at cultivating a green economy.

In line with this commitment, GIZ-New Delhi has been tasked with providing a comprehensive study on the possibilities and implications of utilizing desalination to produce Green Hydrogen in India. In response to this service requirement, FI has meticulously crafted a report on "Study on possibility and implications of desalination to produce green hydrogen in India." This report delves into the key policies and regulatory frameworks in India that are pertinent to the utilization of desalinated water in industrial processes. It serves as a valuable resource to guide and inform future endeavors in the realm of sustainable water use and green hydrogen production in the country.

1.2 Introduction

In recent years, there has been a heightened global awareness regarding the need for coordinated efforts to mitigate the adverse impacts of global warming. A substantial number of major economies, India included, have pledged to achieve net-zero carbon emissions as part of their commitment to this crucial cause. India has undertaken several initiative-taking measures to reduce its carbon footprint to attain net-zero emissions by the year 2070.

The government is actively prioritizing the adoption of green hydrogen as a key strategy to achieve this objective, particularly in the decarbonization of critical sectors such as ammonia production, refineries, iron and steel manufacturing, methanol production, and heavy-duty trucking. This strategic focus reflects a concerted effort to align economic growth with environmental sustainability, signaling India's commitment to playing a pivotal role in the global fight against climate change.

India has developed the National Green Hydrogen Mission (NGHM) with a target to produce 5 MMT (Million Metric Tons) of Green Hydrogen per annum by 2030 to achieve net zero emission by 2070.

To produce green hydrogen water and energy are two main inputs to produce Green Hydrogen. Water is a scarce commodity in most parts of India, particularly along the coast zone. Hence it is essential to identify a perennial source of water to produce Green Hydrogen. The desalinated water will be one of the dependent sources of water for the production of Green Hydrogen. This study mainly focuses on the pros and cons of the production of Desalinated water in India for the ultimate production of Green Hydrogen.

To bolster and strengthen collaboration in the energy sector between India and Germany, the Indo-German Energy Forum (IGEF) was established by the German Chancellor and the Indian Prime Minister at the Hannover Fair in April 2006. The primary focus of this initiative is to advance private sector involvement while creating a conducive environment to further develop the market for power plant technologies, energy efficiency, and renewable energies in India.

1.3 Overview of Policies and Regulations in India relevant to desalinated water.

Applicable national and state-level government policies and regulations designed to promote the utilization of desalinated water in industries are discussed. This document mentions specific incentives and concessions available, pinpointing the essential requirements for establishing a captive desalination plant geared towards supplying desalinated water to GH2/PtX plants. The procedural framework for developing greenfield desalination plants is explained in a step-by-step manner, outlining the intricacies involved.

Furthermore, the discussion meticulously outlines the requisite clearances mandated by both state and central governments, including but not limited to Environmental Impact Assessment (EIA) and Coastal Regulation Zone (CRZ) clearances. The document also highlights the permits and other essential clearances required during the pre-establishment and pre-operation stages, providing a comprehensive guide for navigating the regulatory landscape.

1.4 Desalination Plant Specification

In collaboration with GIZ, the Electrolysers capacity has been categorized into Small (100 MW), Medium (1000 MW), and Large (5000 MW) for GH2/PtX plants. Consequently, the water needs to encompass Ultra-Pure Water (UPW) for electrolyser, Cooling makeup water, water for air separation, and service water. The specific water requirements for small, medium, and large plants have been determined.

Table 1-1 - GH2/PtX Plant water requirement

Description	UOM	GH2/PtX Plant water requirement		
		Value Small	Value Medium	Value Large
Electrolyser size	MW	100	1,000	5,000
UPW treated (Ref. - Chapter 3.2.1 a)	LPH	20,000	200,000	100,0000
Cooling water (Ref. - Chapter 3.2.1 b)	LPH	100,000	100,0000	500,0000
Green Hydrogen Generation (Ref. – Chapter3.2.1 a)	Kg/hr	2,000	20,000	100,000
Total Desalinated water requirement per kg of GH2/PtX production.	Liters	~65	~64	~63
Total Ultra Pure Water requirement per kg of GH2/PtX production.	Liters	~10	~10	~10

Note: The desalinated water and UPW quantities can be extrapolated from the above table based on the GH2/PtX production.

Typical seawater characteristics along with intake and brine discharge methods are addressed in detail in chapter 6. Typical sea water TDS is 38000 ppm and brine (with TDS of about 63000 ppm) is discharged into sea through diffusers for effective dispersion and dilution. About 1.5 m3 of brine is discharged to sea for every m3 of desalinated water produced.

The general specifications for a typical desalination plant commence with the Sea Water Intake System, Pre-Treatment, Reverse Osmosis (RO), Post-Treatment, and brine outfall system, among other components. Comprehensive discussions on the green energy prerequisites for the desalination plant, including the possibility of Decentralised Renewable Energy (DRE), have been undertaken.

1.5 Assess the characteristics of establishing and operating a seawater desalination plant.

Extensive deliberation has been undertaken with NTPC officials to elucidate the crucial characteristics pivotal for the establishment of both offshore and onshore facilities, particularly in the context of selecting an optimal location for a greenfield desalination plant at Pudimadaka, Andhra Pradesh, and the present site conditions, etc.

Based on previous experiences in the preparation of Feasibility reports & DPRs for various Seawater Desalination Projects, a comprehensive criteria matrix has been developed to guide the site selection process. Detailed discussions were held with NTPC officials.

Any Seawater Desalination Project consists of two major parts the offshore facilities and the onshore facilities.

A. Related to the SWRO desalination plants the major offshore facilities required are:
    a. Offshore intake arrangement
    b. Offshore intake seawater pipeline
    c. Offshore outfall rejects water pipeline
    d. Offshore Outfall arrangements

B. The onshore facilities of a typical desalination plant will be:
    a. Onshore intake pumphouse (if required separately)
    b. Raw water conveying main (if required)
    c. Desalination Plant
    d. Product water conveying main till the supply point (here it may be GH2 plant)

For evaluation, both facilities are considered under four major characteristics as

I. Technical
II. Environmental
III. Economical
IV. Social

A total 100 score is considered with a major allocation of 50 for offshore facilities and a balance 50 for onshore facilities. The 50 score is subdivided equally for the above four characteristics.

The Criteria Matrix a rapid, preliminary assessment is developed as given below:

	Basic assessment criteria			Site Specific evaluation – Location		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50			
	Total score for Technical		**12.5**			
	Total score of Environmental		**12.5**			
	Total score for Economical		**12.5**			
	Total score for Social		**12.5**			
II	Onshore – (Land related)		50			
	Total Score for Technical		12.5			
	Total Score for environmental		12.5			
	Total Score for Economic		12.5			
	Total Score for Social		12.5			
	Overall scoring		100			

Under each factor like Technical, Environmental, Economic and Social, there are multiple selection criteria and their scoring . The same is given in detail in chapter 4.

To further refine and validate the criteria, four states in India have been strategically chosen due to their initiative-taking plans to embrace more GH2/PtX plants. The following states and their designated sites have been earmarked for thorough desktop criteria evaluation:

1. Gujarat – Mandvi
2. Tamil Nadu – Tuticorin
3. Andhra Pradesh – Pudimadaka
4. Odisha – Konark

Each of these selected sites has undergone a technical analysis to discern and comprehend the variations that may exist. This scrutiny ensures that the chosen location aligns seamlessly with the specific requirements for the establishment of a greenfield desalination plant.

1.6 Preliminary environment and social scoping

Among the four chosen sites for criteria evaluation, the Andhra Pradesh – Pudimadaka site has been identified as the focal point for the development of an environmental and social scoping model. The comprehensive assessment considers both on-site visits and available secondary data, aligning with various National and State regulations, including Coastal Regulation Zone (CRZ) notifications issued by the Government of India. It is important to note that this is not an Environmental and Social Impact Assessment (ESIA) report, as it is not exclusively based on primary site data. Instead, it serves as a prototype framework that can guide the future preparation of an ESIA report for the selected site.

1.7 Suitability of Brine treatment and upcycling Technologies

In this discussion, we explore brine treatment and upcycling technologies. It is important to acknowledge that a sizeable portion of brine treatment technologies is currently in the developmental stage, and even the more established ones may not yet be economically feasible. Nevertheless, there are a few promising reuse and recycling technologies that merit future consideration. The applicability and effectiveness of these brine treatment/upcycling technologies are assessed in the context of four specific sites.

Regardless of whether brine undergoes further treatment or is recycled, the development of a responsible outfall arrangement is crucial for any desalination plant. Brine, with a TDS of about 63,000 ppm and PH of about 8.5 harms marine life and this requires suitable mitigation. Proper selection of the outfall location, considering factors such as brine quantity, quality, sea depth, tide currents, and hydrodynamic modeling, is essential for the quick dilution of brine within a small radius to minimize environmental impact. The design of outfall diffusers, coupled with necessary measures and monitoring, ensures that the discharge process into the sea is effective.

2 Policies on Desalinated water use in industries

2.1 India’s Green Hydrogen Mission

To become self-reliant in energy by 2047 and achieve net zero by 2070, the Government of India (GoI) is implementing the Green Hydrogen mission with the following objectives:

The Mission will result in the following likely outcomes by 2030:

- Development of green hydrogen production capacity of at least 5 MMT (Million Metric Tons) per annum by 2030 with an associated renewable energy capacity addition of about 125 GW in the country.
- Over eight lakh crores of Indian Rupees as total investments
- Creation of over six lakh jobs
- Cumulative reduction in fossil fuel imports by over Rupees one lakh crore
- Abatement of nearly 50 MMT of annual greenhouse gas emissions

In a pivotal development to advance the National Green Hydrogen Mission, the government has officially introduced the Green Hydrogen Standard for India, establishing a critical emission threshold of 2 kg CO_2 equivalent per kg of hydrogen over a 12-month average. This standard signifies a crucial benchmark in steering the country towards sustainable practices.

The substitution of current hydrogen usage with production derived from renewable sources, especially within the industrial and transportation sectors, stands as a significant stride in India's transition towards a greener future. This strategic shift underscores the nation's commitment to reducing carbon emissions and embracing environmentally friendly alternatives in key sectors, marking a noteworthy step forward in its sustainability journey.

2.2 Indo-German Cooperation in Green Hydrogen

To bolster and strengthen collaboration in the energy sector between India and Germany, the Indo-German Energy Forum (IGEF) was established by the German Chancellor and the Indian Prime Minister at the Hannover Fair in April 2006. The primary focus of this initiative is to advance private sector involvement while creating a conducive environment to further develop the market for power plant technologies, energy efficiency, and renewable energies in India.

Since its inception in 2006, the Indo-German Energy Forum has significantly enhanced cooperation in energy security, energy efficiency, renewable energies, and investment in energy projects. Additionally, collaborative efforts in research and development have contributed to the success of the forum.

In May 2022, a significant step was taken as the Union Minister for Power and New and Renewable Energy (MNRE) and the German Minister for Economic Affairs and Climate Change signed a Joint Declaration of Intent on the Indo-German Hydrogen Task Force. This agreement establishes the Indo-German Green Hydrogen Task Force, aimed at fostering cooperation in the production, utilization, storage, and distribution of Green Hydrogen. The task force will work towards creating enabling frameworks for projects, regulations, standards, trade, and collaborative research and development (R&D) projects.

Recognizing the challenge of water scarcity for green hydrogen production, the Indo-German cooperation in green hydrogen, led by GIZ and their Power-to-X Hub (PtX Hub), commissioned a study. This study will provide crucial information on the economic, technical, legal, environmental, and social aspects of using desalination plants as a water source for green hydrogen projects in India. It serves as a foundation for planning green hydrogen facilities and aligns with the ongoing efforts to ensure sustainable and innovative solutions in the energy sector.

2.3 Water Policies in India

As part of Task 2 of this project to understand the 'Policies on Desalinated water use in industries', data related to various policies & Guidelines of GoI and state governments were collected and reviewed.

It may be noted that specific clear guidelines and policies are not made available either by GoI or by state governments regarding the use of Desalinated water in industries. However, it has been seen that the Governments encourage the use of desalinated water in industries in the coastal areas by not allocating fresh water.

2.3.1 National Levels

At present the 'National Water Policy 2012' (NWP-2012) is in effect. To review this and bring a new 'National Water Policy' a drafting committee was constituted by the Ministry of Jal Shakti, GoI in December 2021.

While discussing the NWP it is mentioned by GoI that "Water being a state subject, steps for augmentation, conservation and efficient management of water resources are primarily undertaken by the respective State Governments. To supplement the efforts of the State Governments, the Central Government provides technical and financial assistance to them through various schemes and programs."

From the above, it is clear that water management is a state subject and concerned states are responsible for the management of water.

In the National Water Policy 2012 under 'chapter 5. ENHANCING WATER AVAILABLE FOR USE' it is mentioned as:

"The availability of water is limited but the water demand is increasing rapidly due to growing population, rapid urbanization, rapid industrialization, and economic development. Therefore, the availability of water for utilization needs to be augmented to meet the increasing demands of water. Direct use of rainfall, desalination, and avoidance of inadvertent evapo-transpiration is the new additional strategies for augmenting utilizable water resources."

From the above, it is understood that NWP considers desalination as one of the water-enhancing measures.

2.3.2 State Levels

As water is a state subject, the state governments have more responsibility in managing, augmenting, and allotting water to various sectors. Hence, the data related to 'State Water Policy' and 'State Industrial Policy' are collected from the government websites & public domain. These policies have been reviewed for the following states.

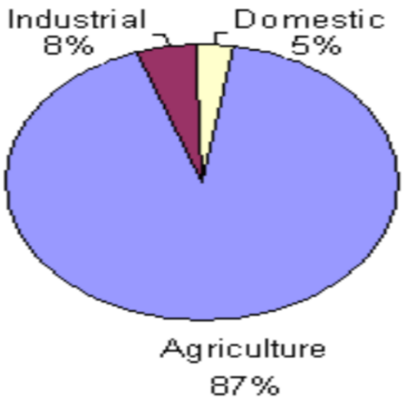
- Gujarat
- Maharashtra
- Karnataka
- Kerala
- Tamil Nadu
- Andhra Pradesh
- Orissa

On review of these documents, it is observed that the use of desalinated water in Industries is not addressed directly. These policies consider desalination as one of the sources of water particularly in the coastal areas where the groundwater is brackish / saline. No specific guidelines or concessions are indicated for the use of desalinated water for industries. However, the Environmental ministries encourage industries in the coastal region to generate their water through desalination by not allocating adequate surface water for the industries.

2.3.3 Scenario of water availability for the GH2/PtX plants in general

An analysis has been done on the water availability for use in Industries.

The general water usage pattern in India is given below:



(Source: Industrial water supply – Incentive for conservation by Senior Environmental Engineer, Central Pollution Control board – uploaded on 2023)

In India for water use the priorities are domestic, agriculture, and then industries. In the water-stressed states, the availability of water for usage in industries is less than demand. It is also to be noted that in many states during the drought period, the availability of water for the industries is minimal or zero.

Hence, desalinated water will be a sustainable source of water for industries including GH2/PtX, particularly in the coastal regions.

2.3.4 Exemption from Customs and Central Excise Duty to Water Treatment Plant

As per Notification 91/2002-Cus, 92/2002-Cus, 93/2002-Cus, and 47/2002-CE, all dated 6th September 2002 issued by the Government of India, Ministry of Finance & Company Affairs, Department of Revenue (attached as Annexure – 1) exemption have been given from Customs and Central Excise duties in respect of water treatment projects (including desalination plants) for the supply of drinking water for human and animal consumption. This benefit would be available to all items of machinery, including instruments, apparatus and appliances, auxiliary equipment, and their components/ parts required for the initial setting up of the project as well as for substantial expansion of any such project.

The above concessions would be subject to certification by the Collector / District Magistrate / Deputy Commissioner of the district in which the water treatment plant is to be set up.

However, as such this exemption does not apply to desalination plants that supply water to industries.

2.3.5 Special concessions for the RE power supply to the Captive Desalination plant for GH2/PtX

It is to be noted that the power cost is a major component in the OPEX of desalination plants and the unit cost of desalinated water is influenced by the cost of power.

In the 'Green Hydrogen Policy' issued by GoI, specific guidelines are given regarding the green energy to be provided to GH2 / PtX production in para numbered 3 to 7 of the policy document (as listed in Annexure-2) and these can be extended to the captive desalination plant which supply water to GH2/PtX plant. This concession will help to get green power to desalination plants at a lesser cost which in turn will reduce the cost of desalinated water. GoI may be approached in this regard. The policy gaps and interventions are listed in Annexure – 3.

2.4 Process for the Development of Greenfield Desalination projects.

Demand Assessment & Fixing the capacity of Desalination Plant

↓

Site Selection

Conducting onshore & offshore field studies

Data collection for EIA study etc

↓

Preparation of Detailed Project Report

Fixing Intake & Outfall system

Finalizing Desalination Plant location & Processing

Preparation of supporting drawings & documents

Block cost estimate conclude va

Techno – Economic Analysis to conclude the project

↓

EIA / CRZ Clearance

Preparation of EIA report

Preparation of CRZ map incorporating project components

Submission of application to get CRZ clearance to MoEFCC through state CZMA.

↓

Procurement Process

Preparation of Tender Document and floating of Tenders

Fixing of contractor for execution of the work

↓

Construction & Commissioning of Plant

Getting necessary statuary clearances & approvals by Contractor

Construction of onshore & offshore facilities

Trail run & Commissioning of the Plant

Process for the Development of Greenfield Desalination Plant

Demand assessment: Calculation of required water quantity based on the capacity of proposed GH2/PtX plant.

Site selection: Selection of area for the proposed desalination plant based on the various site selection criteria including the location of GH2/PtX plant, Proximity of sea shore etc.

Onshore field studies: Topographical survey, Geo-technical investigation, pipe route survey for raw water, product water and reject water pipelines.

Offshore field Studies: Sea water sampling & testing, Bathymetric survey, Tide & Current measurement, Sea bed sampling & testing and other studies based on the site condition

Formulation of Desalinattion Scheme: Based on the sea water quality and requirement of permeate water quality the Intake water requirement, the pre-treatment, R.O. process, Post RO treatment, storage and conveying of product water to GH2/PtX plant.

Fixing of Intake & Outfall Systems

Intake System: Fixing of intake location type of intake etc. based on the offshore field study data, considering the Techno-Economic and Environmental aspects and pipe upto on shore pump house.

Outfall system: Outfall location shall be fixed based on the dispersion model study such that the brine is dispersed quickly and within the minimum area considering the Techno-Economic and Environmental aspects.

EIA / CRZ clearance: On finalization of complete scheme including Intake and outfall system, necessary data collection and studies shall be carried out for the preparation of EIA report. An application shall be submitted through the project proponent by the approved EIA consultant to the concerned authority) to get EIA-CRZ clearance.

Techno Economic Analysis: Basic Engineering shall be done and project cost shall be arrived based on the current market rates / Schedule of rate provided by the respective agencies. Detailed Project Report shall be prepared. Based on the Project cost the Techno-Economic analysis shall be done to conclude the financial viability of the Project

Procurement Process: Various procurement models shall be analysed and based on the finance and project requirement the suitable procurement model shall be finalized and the Tender documents shall be prepared accordingly.

Contractor selection: Based on the selected contract model the tendering shall be done and shall be fixed for both construction of plant and for maintenance of plant.

Construction & Commissioning of plant: All statutory permits and approvals shall be obtained by the contractor through the owner and the plant shall be constructed and commissioned as per the contract period. The water from the desalination plant shall be conveyed to GH2/PtX plant as input water.

2.5 EIA and CRZ clearance

2.5.1 Coastal Regulation Zone (CRZ)

The coastal areas of seas, bays, creeks, rivers, and backwaters which get influenced by tides up to 500 m from the high tide line (HTL), and the land between the low tide line (LTL) and the high tide line have been declared as coastal regulation zone (CRZ).

High Tide Line: HTL means the line on the land up to which the highest water line reaches during the spring tide.

Low Tide Line: Similarly, it means the line on the land up to which the lowest water line reaches during the spring tide.

Spring tides: The position of both the sun and the moon in relation to the earth has direct bearing on tide height. When the sun, the moon, and the earth are in a straight line, the height of the tide will be higher. These are called spring tides, and they occur twice a month, one during the full moon period and another during the new moon period.

2.5.1.1 Importance of Regulation of Coastal Zones

- Protection of ecologically Sensitive Areas like mangroves, and coral reefs which act as a shield against tsunamis and cyclones.
- Improving the lives of coastal communities like fishing communities
- Resilient measures for mitigating impacts of Climate Change and high-intensity Cyclones
- To balance development with conservation of the coastal environment

2.5.1.2 Environmental and Social Impact Assessment Study (ESIA)

Environmental and Social Impact Assessment (ESIA) is a process aimed at improving environmental protection by preventing, reducing, or offsetting negative environmental effects and enhancing positive effects.

2.5.1.3 Objective of ESIA

- Identifying, predicting, and evaluating economic, environmental, and social impacts of development activities.
- Providing information on the environmental consequences of decision-making.
- Promoting environmentally sound and suitable development by identifying appropriate alternatives and mitigation measures.
- The Ministry of Environment and Forests is the only major government authority responsible for approving the EIA Study report in India.

2.5.2 Authority for providing EIA/CRZ clearance.

The EIA/CRZ clearance is to be obtained from State CZMA and finally CZMA of MoEF&CC, GoI.

2.6 Permits and clearances to be obtained.

The following clearances will have to be obtained by the contractor. Required documentation support wherever applicable will be provided by the owner.

2.6.1 Clearances Required during Pre-establishment Stage.

- Planning permission from Town planning/Development Authority

- Building permit from local body (Village Panchayat/ Municipality/ Municipal Corporation)
- Factory Plan Approval under the Factories Act, 1948 from Directorate of Industrial Safety and Health (DISH)
- No Objection Certificate for Multi Storied Building (MSB)/ Non-MSB from the Fire & Rescue Services Department
- High Tension Electricity connection from State Electricity Board
- Consent to Establish from the State Pollution Control Board
- Registration of establishments deploying building and other construction workers under The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 with the Directorate of Industrial Safety and Health
- Permission for Change of land use for industrial purposes in unplanned areas from Town planning/Development Authority if applicable
- Industrial Building License from Rural Development and Panchayat Raj Department
- CRZ clearance from the Ministry of Forest and Environment (As per CRZ Notification 2011 and as amended from time to time – Attached Annexure - 4)
- CZMA zone clearance at the state level
- Site clearance for Intake and Outfall from Local Marine Board
- NSPC clearance from Navigational Safety in Ports Committee
- Coastal Guard clearance from the Coast Guard Department
- Pre and Post construction surveys from the Naval Hydrographers office at Dehradun
- In principle clearance for storage of hazardous material
    - Clearances Required during the Pre-operation Stage.
- Approval from the State Electrical Inspectorate
- Factory Registration and Licensing under The Factories Act, 1948
- Consent to Operate from the State Pollution Control Board
- Authorization under the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 from the State Pollution Control Board

- Registration of establishments deploying contractual workers under the provision of The Contracts Labor (Regulation and Abolition) Act, 1970 with the Directorate of Industrial Safety and Health
- Registration of establishments deploying inter-state migrant workers under the Inter-State Migrant Workmen (RE&CS) Act,1979 with the Directorate of Industrial Safety and Health

Note: Most of the above permits to be obtained are from the state government and this may vary slightly from state to state.

3 Specification for a Desalination Plant for small / medium / large Green Hydrogen Plants

Overview of legally permissible operating and ownership modes

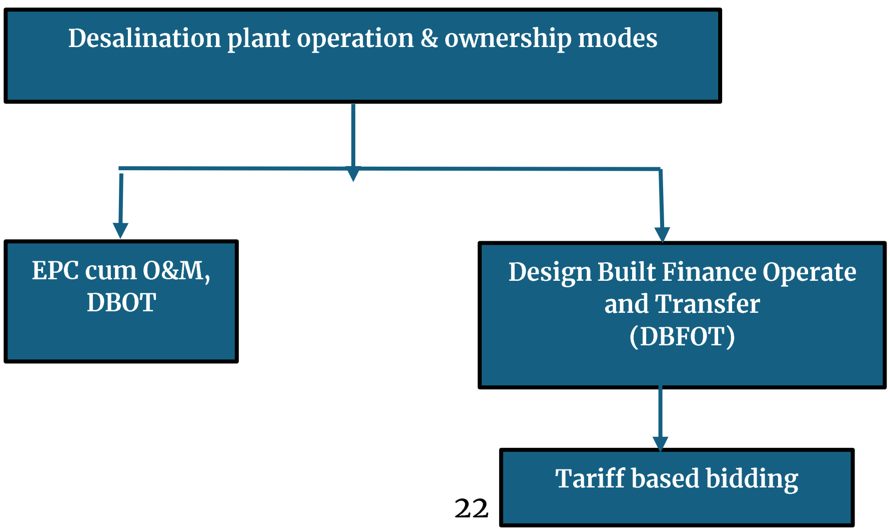
In India Desalination plants are being developed mainly for the following purposes:

- Captive Desalination plants supply desalinated water to main plants like power plants, refineries, Petrochemical industries, etc.
- Supply of desalinated water to Municipalities.
- Supply desalinated water to Industries.

Depending on the various conditions the operation and ownership modes of contracts are finalized and the same is discussed below in detail.

3.1.1 Various operating and ownership modes practiced in India.

Figure 3-1 -Various Operation and Ownership modes



In general, the widely adopted implementation methods (operating & ownership modes) for desalination plants are as follows:

- Engineering Procurement and Construction with O&M for a specific period (EPC cum O&M)
- Design Built Finance Operate and Transfer (DBFOT)
    1. Tariff-Based Bidding – No VGF
    2. Viability Gap Funding (VGF)
    3. Hybrid Model – Design, Built, Operate and Transfer (Hybrid-DBOT)
- It is envisaged that out of the above implementation methods only the EPC cum O&M and the Tariff Based – DBFOT methods will be applicable for these captive Desalination plants for GH2/PtX plants and the same are discussed in detail below:

3.1.1.1 EPC cum O&M Model

In an EPC cum O&M model the entire investment will be made and the plant will be fully owned by the owner/developer. The construction of desalination plants along with allied onshore & offshore works shall be given as a single Lump Sum Turnkey Contract (LSTK) with specific performance guarantees. Responsibility of O&M of the constructed plant for a period of 10 to 20 years with guaranteed performance is also included as a part of the contract. The duration of the O&M period is fixed based on the size of the desalination plant and the capacity of the owner to take over the O&M.

Generally, such LSTK contract will cover Developing, Designing, Engineering, Procurement, Factory Testing, Transporting to Site, Supply, Erection, Construction, Commissioning and Performance Testing including Site Investigation, site Development, and all related Civil, Mechanical, Electrical, and Control & Instrumentation works for Desalination including, complete intake and outfall systems, Cross country pipeline with allied works and specified years of O&M with all spares and consumables including membranes and with or without power cost.

In general, the advantages & disadvantages of EPC contracts are discussed in the table below.

Table 3-1 – Advantages & Disadvantages of LSTK / EPC contract

Advantage	Disadvantage
EPC contractor will be the single point responsible.	Owner's participation is limited and hence the control over the project is also limited.
The contractor will take the responsibility of Engineering, different procurements, quality testing, system integration, commissioning, PG tests, etc.	The owner transfers the risk to the EPC company. So, it is important to choose the right EPC company. In the event, the EPC company has serious financing problems and setbacks in technical knowhow the project will be at risk
The total price and duration of the contract are fixed.	EPC contractor takes the risk and hence Risk cost will be passed on to the owner through the tender cost.
The owner's responsibilities are limited to general project monitoring and funding.	As it is an EPC contract it is difficult to issue variation order/changes in scope etc.
Contractor takes the risk during construction.	The owner needs to invest the full CAPEX. May also need to appoint PMC if in-house technical knowledge is not there.

EPC cum O&M contract is a successful model in the desalination sector and the following projects have adopted the above model.

- Chennai Metropolitan Water Supply and Drainage Board (CMWSSB), Tamil Nadu has completed the 100 MLD desalination plant at Nemmeli and has been in Operation since 2013.
- CMWSSB is also executing another 150 MLD Desalination plant at Nemmeli which is in the commissioning stage.
- Gujarat Industrial Development Corporation (GIDC), Gujarat has completed a 100 MLD desalination plant and has been in operation since June 2022.
- Mangalore Refineries and Petrochemical Ltd (MRPL), Mangalore has completed a 30 MLD (expandable to 70 MLD) and has been in operation since March 2022.
- CMWSSB has just awarded another 400 MLD desalination plant at Perur in July 2023.

3.1.1.2 Design Built Finance Operate and Transfer (DBFOT)

DBFOT is an ideal fit for an infrastructure project. A most optimal method focuses simultaneously on minimizing whole-life costs while ensuring that incentives and protections are in place for the responsible long-term upkeep of the infrastructure.

Under DBFOT, the selected private party (concessioner) will be responsible for designing and building the infrastructure, financing, owning, and operating it for the concession period (maybe 25 to 30 years) and at the end of the concession period transferring it to the owner/developer.

The key responsibilities of the owner will be to provide suitable land for infrastructure, supporting the concessionaire in getting statutory clearances like EIA / CRZ clearance, etc., connectivity with the distribution network/supply point, and assure payment mechanism linked with the availability factor of the plant. The other roles and responsibilities of each party are discussed in the 'Risk identification, allocation and mitigation strategy' section below.

3.1.1.3 Owner's commitment to payment

In general, the owner must buy the entire water quantity as per the water purchase agreement and pay at the agreed tariff. However, due to some reason if the owner does not require the full quantity of water committed, then the owner can purchase the required quantity under an arrangement where the owner commits to pay the fixed component of tariff for the entire committed / water produced and the variable component of tariff for the actual purchase of the treated water.

This kind of arrangement ensures that the concessionaire gets the tariff to cover his fixed expenses like Debt servicing costs, Insurance, Equity returns, and other fixed components of Operations and Maintenance (O&M) costs. Hence, the developer carries no demand risk.

Generally, the tariff structure in the DBFOT mode is detailed below:

3.1.1.4 Tariff Structure

In the simplest form, any tariff structure has two components, Fixed and Variable. Fixed Cost covers the fixed expenses like finance cost and fixed part of the Operations and Maintenance (O&M) expenses, regardless of the actual production, whereas Variable Cost covers the variable part of the O&M expenses and is directly proportional to the actual production.

The biggest component in the O&M expenses is power cost. The overall tariff can be reduced substantially by controlling and reducing the power cost. Hence, the Tariff shall be divided into three parts as under:

(i) Fixed Expenses – No change regardless of the actual production

(ii) Variable Expenses (Rs./Cum) – directly proportional to the actual production

(iii) Power Cost – In general, concessionaire will have no control on the variations in actual power tariff. Hence, it will be better that owner takes the responsibility of bearing the actual power cost subject to the maximum consumption of guaranteed units/cum, i.e., maximum power consumption per cum. of water should be guaranteed units X Actual Power Rate.

The concessionaire may implement energy efficiency measures to reduce power consumption, or have a very efficient plant, or have captive solar power. All these measures will entail capital investments. To incentivize the reduction in power consumption by undertaking various energy efficiency measures, any savings in the power consumption could be shared between the concessionaire and the owner.

The division of various O&M expenses into fixed and variable is given in the table below:

Table 3-2 – OPEX – Fixed & Variable costs

Operation & Maintenance Cost	Fixed	Variable
Chemical cost	0%	100%
Other O&M costs including regular consumables, spares and replacements	25%	75%
Membrane replacement cost	0%	100%
Admin, Insurance, Manpower etc.	100%	0%

Power consumption (kwh/cum)	10%	90%

Note: Above table arrived based on the Indian conditions and best Industrial practices.

3.1.1.4.1 DBFOT Structure– Tariff-based bidding

Bid Parameter: The bid parameter for this option can be, the minimum fixed tariff at the time of commissioning & the supply of water to the owner, and the escalation of tariff till the concession period.

The other key components will be the power cost.

In the case of power cost there are two scenarios:

- Power cost will be reimbursed on the actual basis by the owner subject to the maximum power consumption of guaranteed units/cum
- However, in case power cost is clubbed with the tariff, then above will not be applicable. This model was successfully implemented by CMWSSB for its first 100 MLD desalination plant at Minjur, which is in operation since June 2010 with a concession period of 25 years.

3.1.2 Assessment for the suitable mode of a desalination plant for GH2/PtX

The adoption of a particular mode of procurement model depends on the size of the desalination capacity, CAPEX and O&M period, etc

Table 3-3 - GH2/PtX plant scenario with Desalinated water requirement

The GH2/PtX plants likely to come in the future India are categorized into follows scenarios:

Plant category	GH2/PtX plant capacity in MW	Desalinated water required in MLD	Sea water intake in MLD	Brine Discharge In MLD
Scenario 1 - Small	100	3.28	9.36	6.08
Scenario 2 - Medium	1,000	32.13	91.79	59.66
Scenario 3 - Large	5,000	160.25	457.86	297.61

Note: The desalination water requirement is discussed in detail in the chapter 3.2.3

3.1.2.1 Suitable operating & ownership mode for Scenario 1:

From the above table, it is seen that the ultimate water requirement itself is only 3.28 MLD, hence it may not be financially viable for any concessionaire to execute the project in the PPP mode as the CAPEX is very low.

Hence, here the best procurement mode is EPC cum O&M. As this is a small desalination plant, the O&M period shall be 2 to 5 years and during this period the operator can train the owner personnel so that they can take up the O&M once the contract O&M period is over. Alternatively, after the contractor's O&M period necessary experienced service provider may also be engaged to operate the plant by the owner.

3.1.2.2 Suitable operating & ownership mode for Scenario 2:

In the medium category, the ultimate water requirement is about 32.13 MLD. In this scenario also the best is EPC cum O&M mode. The O&M period may be 15 to 20 years.

3.1.2.3 Suitable operating and Ownership mode for Scenario 3:

In the high category, the desalination plant capacity becomes about 160.25 MLD which attracts reasonably high CAPEX and hence this can be procured either by EPC cum O&M mode or through DBFOT mode.

If the owner is having enough CAPEX to develop the desalination plant, it can be procured through EPC cum O&M with an O&M period of 20 to 25 years.

If the owner has limited CAPEX, then it can be procured through DBFOT – a tariff-based model. Here it is enough for the owner to sign a water purchase agreement with the concessionaire and necessary land shall be provided to the concessionaire. Here the necessary statuary clearance will be the responsibility of the concessionaire with the support of the owner.

Table 3-4- GH2/PtX plant scenario with operating & ownership modes

Plant category	GH2/PtX plant capacity in MW - @	Desalinated water required in MLD - #	Recommended Operation & Ownership mode
Scenario 1 - Small	100	3.28	EPC cum O&M
Scenario 2 - Medium	1,000	32.13	EPC cum O&M DBFOT
Scenario 3 - Large	5,000	160.25	EPC cum O&M DBFOT

Note: The above recommendation arrived based on the current scenario of procurement in the desalination sector in India. However, it is necessary to analyse the project specifically considering owner – Govt. or private, availability of CAPEX, GH2/PtX plant life, etc.

@ - Refer to clause 3.2.2

- Refer Table 3.5

3.2 Water demand assessment of desalinated water for three GH2/PtX production scenarios.

For any green hydrogen & hydrogen-based products plant (GH2/PtX) the major input requirements are green power & water. India is a water-stressed country and many states do not have the required fresh water to supply for industries. Hence, considering the long coastal line of India, desalinated seawater can be used for GH2/PtX plants.

To arrive at the quantity of desalinated water requirement for the GH2/PtX plants, it is necessary to estimate various quality & quantity of water required for the major processing units.

3.2.1 Typical water demand for GH2/PtX plant.

In general, for a typical GH2/PtX plant the major water requirement is as follows:

Based on the various national & international articles and with an in-house database the following water estimations are made. However, there may be variations in the water requirement based on the location of the plant, type of electrolyser, and downstream processing units for the hydrogen-based products.

a) Ultra-Pure Water (UPW) for the electrolyser:

Even though there are some variations in the requirement of UPW depending on the electrolyser brand, it is conservative to consider $10m^3/hr$[1] to produce 1 tonne of Hydrogen or 10 L for 1kg of GH2.

[1] It is a functional requirement based on the electrolyser. Here given is an indicative.

1 MW of electrolyser produces about 20 kg/hr[1]. of hydrogen.

1 MW of electrolyser requires UPW = (10/1000) x 20 = 0.2 m^3/hr or 200 L/hr.

It is assumed that the recovery of UPW from the desalinated water is 75%.

b) Cooling water requirement:

The cooling water is required to cool the electrolyser and the downstream production unit of the Ammonia and air separator unit etc. A common cooling system is considered to provide cooling water to the electrolyser, ammonia plant, and air separator. From FI in-house knowledge and expertise, it is estimated that the makeup water required for a 1000 MW GH2/PtX plant is about 1000 m^3/hr.

Hence for 1 MW GH2/PtX plant, the cooling makeup water requirement shall be considered as = (1000/1000) = 1 m^3/hr. or 1000L/hr. ((1000/20)=50 L/kg of hydrogen.)

c) Service and utilities water requirement: In addition to the above any plant requires water for cleaning and for toilets, canteen, office and for other utilities. This requirement is very minimal compared to the requirement of UPW and cooling water requirement. This water requirement may vary depending on the manpower utilized in a plant.

d) However, it is appropriate to assume that for the medium plant of 1000 MW the service and utility water requirement can be considered as 5 m^3/hr.

3.2.2 Analysis and three scenarios of GH2/PtX plants.

As per the Terms of Reference the water demand assessment, desalination plant capacities, and the subsequent estimations are to be done for three scenarios of small, medium, and large plants.

In India, the development of GH2/PtX plants is in the initial planning stage.

Many state governments are yet to announce their green hydrogen policy. The same was discussed during the meeting with GIZ on 10.08.2023 and it was decided to consider the scenario as detailed below:

Small - 100 MW

Medium - 1,000 MW

Large - 5,000 MW

[1] It is a functional requirement based on the electrolizer. Here given is an indicative.

3.2.3 Water demand assessment for the three scenarios.

Based on the water demand discussed in Chapter 3.2.1 & the three scenarios arrived in Chapter 3.2.2 the water demand is calculated as follows:

Table 3-5 – Desalinated water demand assessment for three scenarios

Description	UOM	GH2/PtX Plant water requirement		
		Value Small	Value Medium	Value Large
Electrolyser size	MW	100	1,000	5,000
UPW treated (Ref. - Chapter 3.2.1 a)	LPH	20,000	200,000	100,0000
Cooling water (Ref. - Chapter 3.2.1 b)	LPH	100,000	100,0000	500,0000
Green Hydrogen Generation (Ref. - Chapter 3.2.1 a)	Kg/hr	2,000	20,000	100,000
Desalinated water is required for the process [((UPW water/0.75)+Cooling water)/1000]	m3/hr	127	1,267	6,333
Desalination water required for non-process - Service water, drinking, bathing, canteen, etc. (Assumed)	m3/hr	3	5	5
Total Desalinated water requirement	m3/hr	130	1,272	6,338
Total Desalinated water requirement per day considering 24 hrs. operation	**MLD**	**3.11**	**30.52**	**152.24**
Desalination plant capacity with 95% plant availability	**MLD**	**3.28**	**32.13**	**160.25**

Generally, desalination plants will be designed for 95% of product water availability for the quality of TDS < 500ppm. Hence in the above table, 95% of the water availability is also considered to arrive at the total desalination plant capacity.

3.2.4 Water quality with 10%, 20% and 30% oversize.

Besides the GH2/PtX plant water requirement there may be some need for desalinated water to meet other statuary requirements / social commitments. Hence as per the ToR, it is decided to analyse desalination plant requirements with 10% oversize, 20% oversize, and 30% oversize for all three scenarios of small, medium, and large plants. Accordingly, the water demand and the proposed desalinated water plant capacities are arrived and are tabulated below:

Table 3-6 - Desalination plant capacity with oversize scenarios

Desalination plant capacity with oversizing scenarios				
Description	UOM	Small Value	Medium Value	Large Value
Total desalination plant capacity arrived	MLD	3.28	32.13	160.25
10% oversize	MLD	3.60	35.34	176.28
20% oversize	MLD	3.93	38.55	192.30
30% oversize	MLD	4.26	41.76	208.33

3.2.5 Assessment of saline water quantity for the above scenarios

Mostly the raw saline water for the desalination plant will be sea water as India is having very long seacoast. However, the quantity of seawater required various depending on the quality of seawater available near the project location. The availability of TDS, TSS, and other parameters will decide the actual seawater requirement to produce the targeted desalinated water.

The R.O. membrane, pretreatment method will also influence the seawater requirement.

However, considering the general seawater quality near the Indian seacoast, 35% recovery of treated desalination water is considered for the purpose of arriving the sea water requirement.

The seawater requirement is calculated for all three scenarios for the three oversizing options and tabulated below:

Table 3-7- Quantity of seawater requirement for three scenarios for oversizing

Quantity of seawater requirement with oversizing scenarios				
Description	UOM	Small Value	Medium Value	Large Value
Total Sea water Requirement per Day	MLD	9.36	91.79	457.86
10% oversize	MLD	10.30	100.97	503.65
20% oversize	MLD	11.23	110.15	549.44
30% oversize	MLD	12.17	119.33	595.22

3.2.6 Disaggregation of estimated water uses by use required quality.

In general, the desalinated water can meet the IS: 10500:2012 standard which is suitable for potable use. However, it is possible to produce a higher quality of water by adding a second pass R.O. system, etc. as required.

Here let us understand the water quality based on the usage. Here the water is generally used for three major purposes.

1. For electrolyser – Ultra-Pure Water
2. For Cooling Tower makeup water – As per IS10500:2012
3. For service water, office, canteen, etc - As per IS 10500:2012.

Ultra- Pure Water (UPW) the general quality of Ultra-pure water is given below:

Table 3-8 - Table showing the UPW quality parameters.

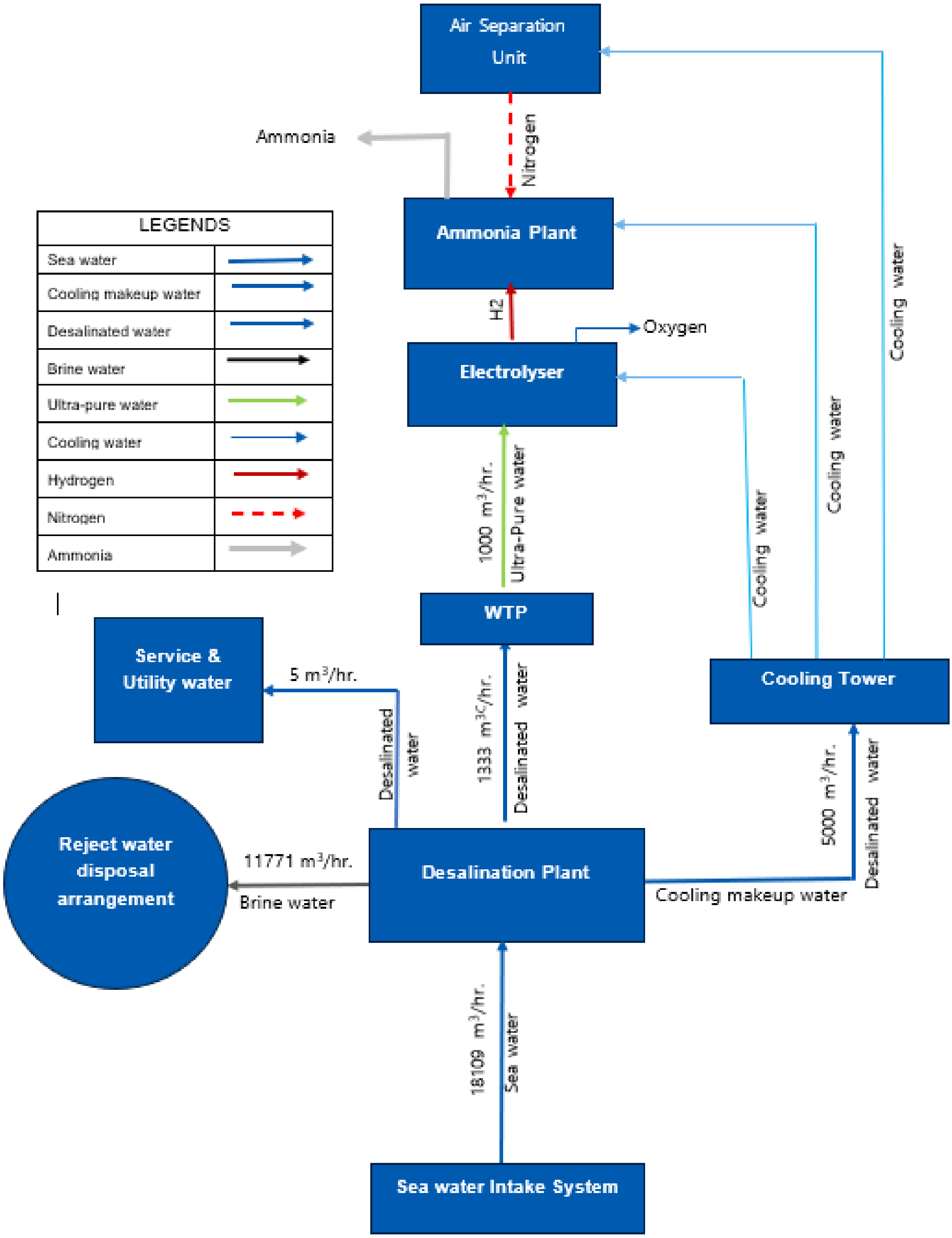
Description	Value
Characteristic	Requirement
Conductivity	<0.055 uS/cm at 25°C
Hardness	11 d°H
Resistivity	<18.2 MΩ
TOC content	< 5 ppb
Micro-organism content	< 1 CFU/1000 ml
Particle content	(>0.2µm) < 1/ml

It is to be noted that the quantity of UPW required is about 15% of the overall desalinated water requirement. Hence, a separate WTP shall be provided within the GH2/PtX plant to treat the desalinated water to UPW which will be economical. It is also advisable to locate the UPW treatment plant close to the electrolyser to prevent any contamination.

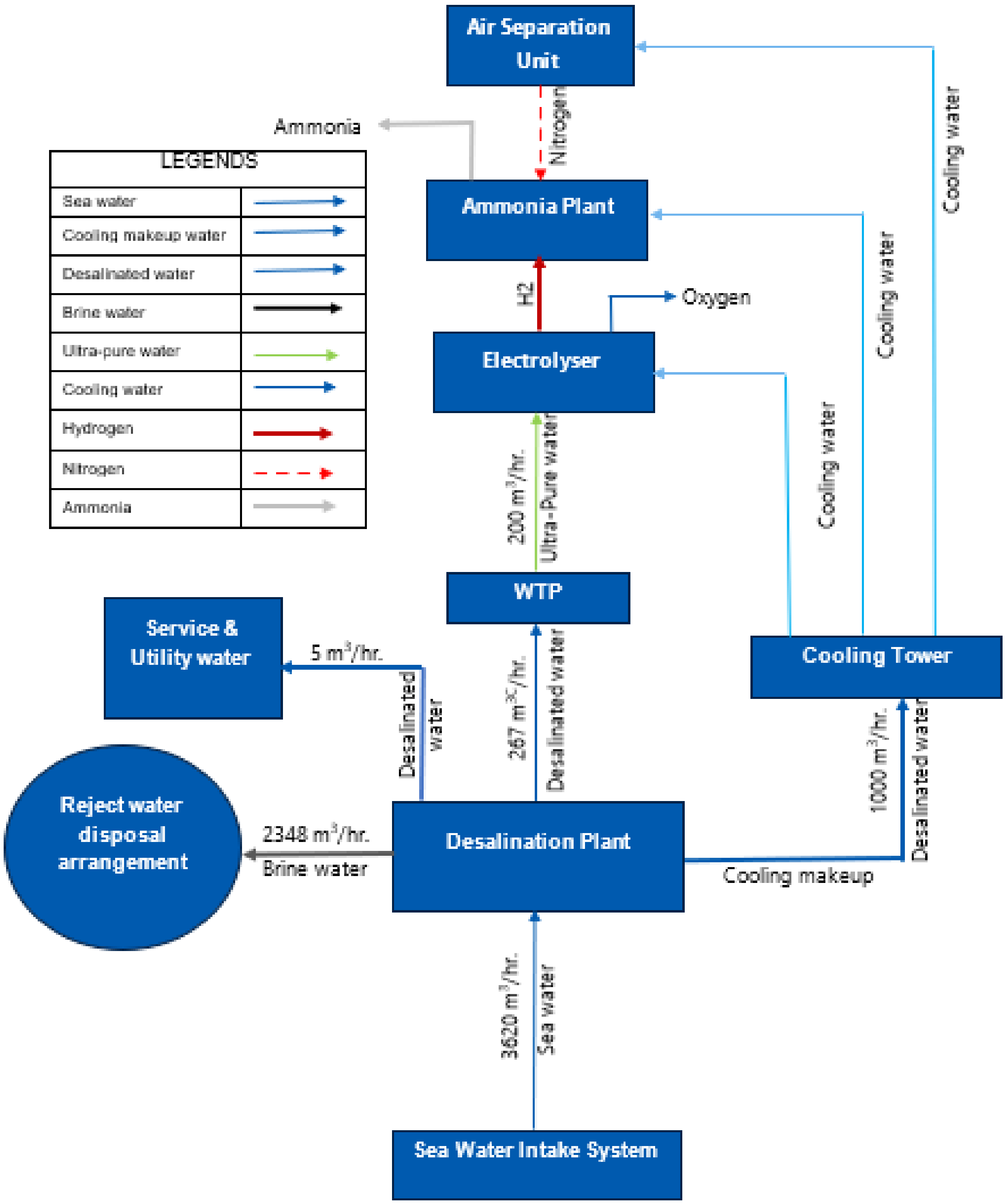
The desalinated water shall be produced with less than 500 ppm TDS directly used for cooling make-up water and for other services, office, and utilities requirements.

The Water balance diagram for the GH2/PtX plants of large, medium, and small plants is given below:

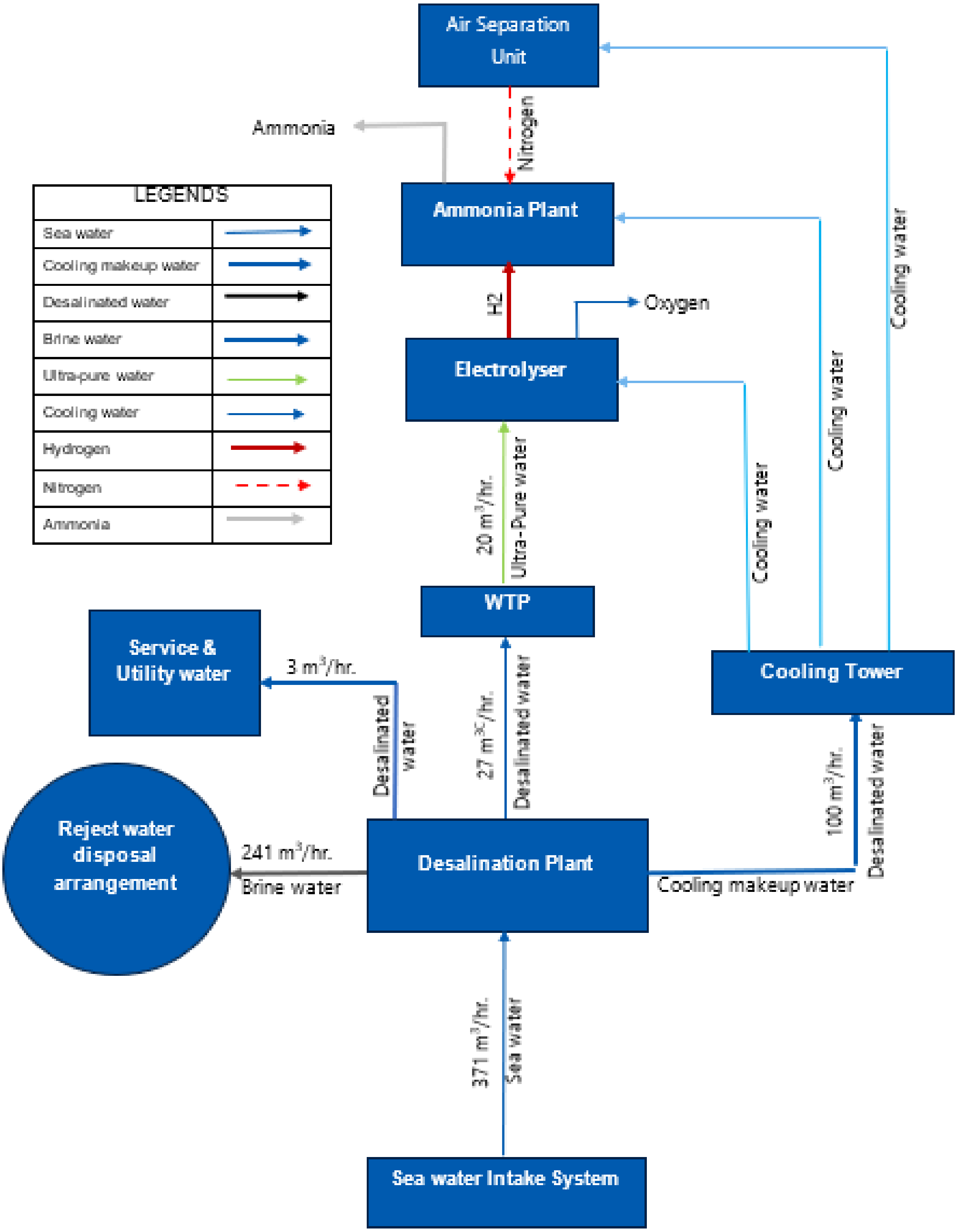
Typical Water Balance Diagram for a 5000 MW GH2/PtX plant with Desalinated Water (Large Plant)



Typical Water Balance Diagram for a 1000 MW GH2/PtX plant with Desalinated Water (Medium Plant)



Typical Water Balance Diagram for a 100 MW GH2/PtX plant with Desalinated Water (Small Plant)



3.3 General technical specifications of the desalination plant.

A typical Sea Water Reverse Osmosis Desalination (SWRO) plant will have the following major parts:

- Offshore seawater intake system
- Onshore Intake pumphouse and raw water conveying main (if required)
- Desalination plants have the following major parts:
    i. Pre-treatment process units
    ii. Reverse Osmosis (RO) process plant
    iii. Post-treatment process units
    iv. Storage & distribution of product water
- Offshore outfall system for disposal of reject water

The above stages will be discussed in detail in the subsequent chapters.

3.3.1 Desalination plant blueprint – specification and setup

3.3.1.1 Offshore Sea Water Intake System

The offshore seawater intake arrangement depends on the following factors:

- Seabed levels and formation
- Tide variations
- Current condition
- Possibility of cyclone / Tsunami / Seismic etc.
- Various parameters of seawater
- Length of intertidal zone from landfall point
- Environmental impact factors

- Socio-economic conditions in the offshore & onshore
- Quantity of seawater to be drawn etc.

There are various types of offshore intake systems being adopted in India to suit the above factors. The mostly used intake systems are:

a) Intake through an offshore pump house and pumping with discharge pipeline on trestles.

b) Intake through an offshore intake structure (such as Velocity Cap, passive screen, etc) with a gravity pipeline below the seabed and pump house in onshore.

c) Intake channel with pump house on onshore.

d) Beach wells.

e) Offshore intake arrangement of infiltration type with media replacement and pump house on shore.

a) Intake through an offshore pump house and pumping with discharge pipeline on trestles.

This type of intake arrangement consists of an offshore pump house located where a seawater depth of about 6-8 m during low tide is available. The pumps are located inside the pump house with associated traveling screens and gates. The seawater will be conveyed through Pipelines routed on trestles as shown in the below figure

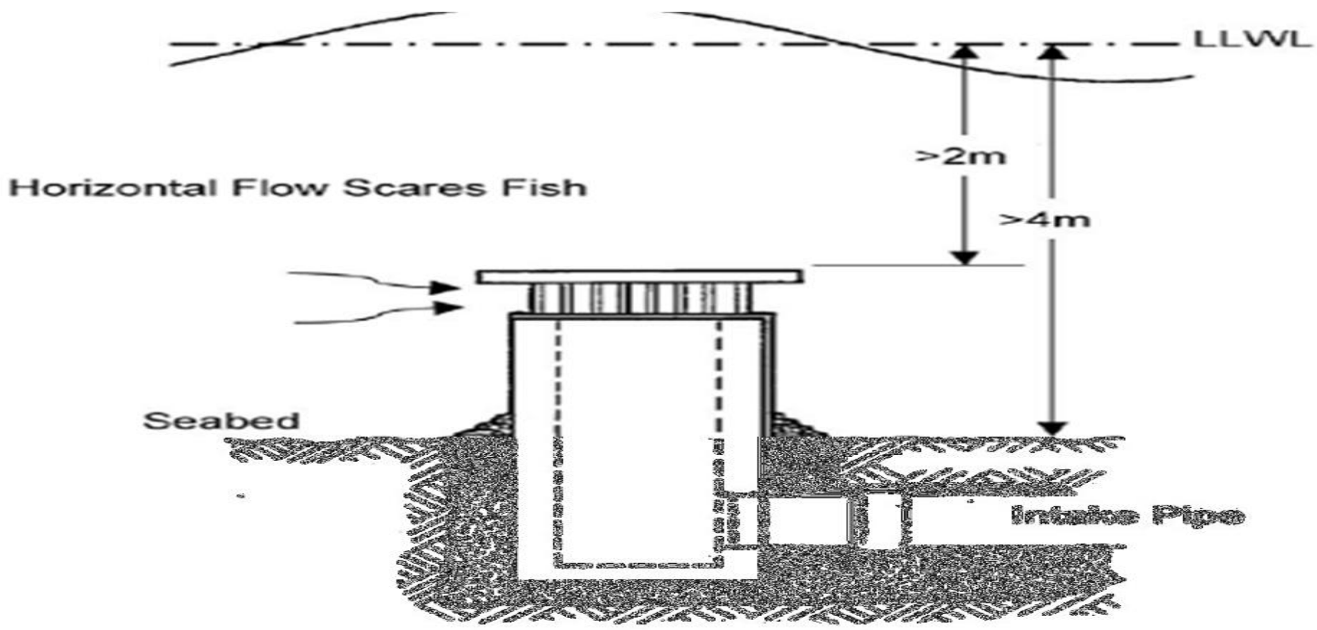
Figure 3-2 – Offshore Intake arrangement for 10 MIGD Desalination Plant at CPCL, Chennai

This type of intake is possible only in the sea area where the ship movement/boat movements are not there. This is suitable for drawl of large quantity of water for bigger desalination plants.

b) **Intake through an offshore intake structure (such as Velocity Cap, passive screen, etc) with gravity pipeline below the seabed and pump house in the onshore**

In this type of intake arrangement, an offshore structure is provided for intake, and the water is drawn by gravity from this structure through a pipeline buried below the bed. The pump house is located on shore with the pump sump at the required depth to receive the water. The water is then pumped to the point of utility by a pump and pipes.

Figure 3-3 - Typical Velocity Cap arrangement



(Source: Figure 3 of An Overview of Seawater Intake Facilities for Seawater Desalination – Tom Pankratz)

Figure 3-4 – Screen Intake

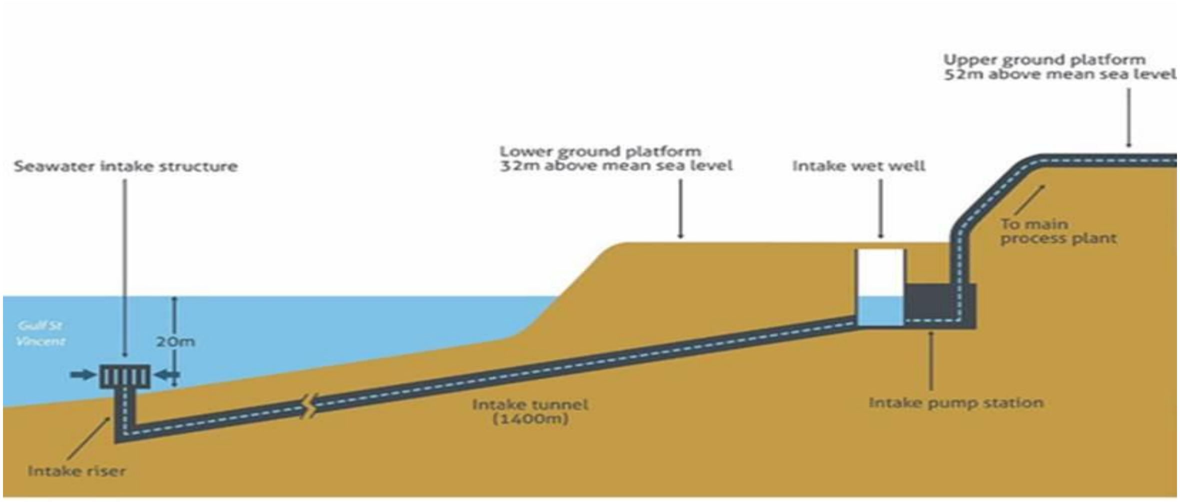


Figure 2. Seawater intake system

(Source: Desalination Plants Seawater Intakes Considerations – Evangelos Kantilaftis, MANAGING DIRECTOR at OSMO SISTEMI S.r.l. – June 10, 2019)

This is a very common system for drawing water from the deep sea to the pump house located on the shore. Since the turbulence is minimal at such depths, the water is usually low in sand content and seaweed. The intake structure is usually located beyond the surf zone to avoid any hostile wave or current from acting on the intake structure. The intake pipes will typically be of HDPE as the same is flexible and will accommodate any deflection.

The intake arrangement is planned such that the intake is at-least two meter above the seabed and three meters below the sea surface. This will ensure that seabed disturbances and the floating matter will not be affecting the intake water quality and reasonably clear water with limited TSS will be drawn for the desalination plant.

Depending on the sea water and sea environment instead of Intake structure prefabricated screen (coarse / passive) shall be used.

c) Intake channel with pump house on onshore

Channel intakes are common methods for intake of water from a flowing water body. When water is drawn from an open sea having waves in the surf zone, the same is difficult as the waves breaking can damage the channel. In such conditions, breakwaters are constructed to ensure that the waves are not present and then a channel is dredged to the point of receipt of water on shore.

Channel-type intake arrangements are generally preferred when a large quantity of water is to be drawn and when the water has a large number of suspended solids that can settle in case of gravity pipe intake such as velocity cap arrangement. In case of channels, any settlement of suspended solids can be taken out by dredging and pumping.

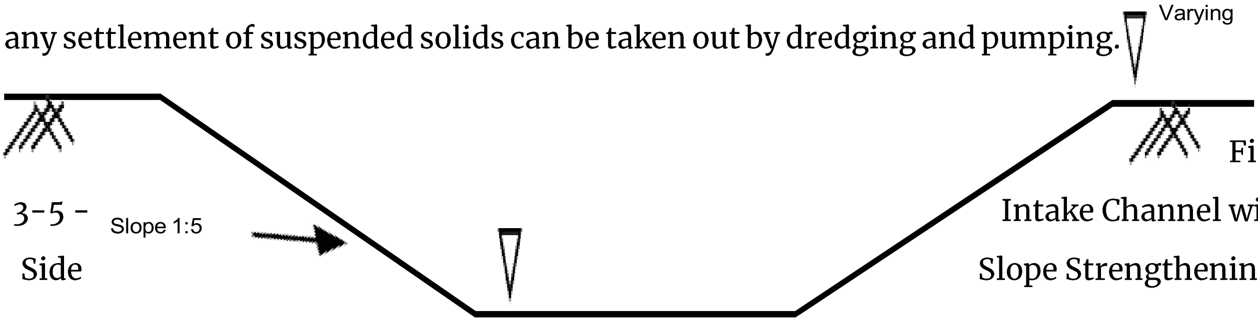


Figure 3-5 - Side Intake Channel without Slope Strengthening

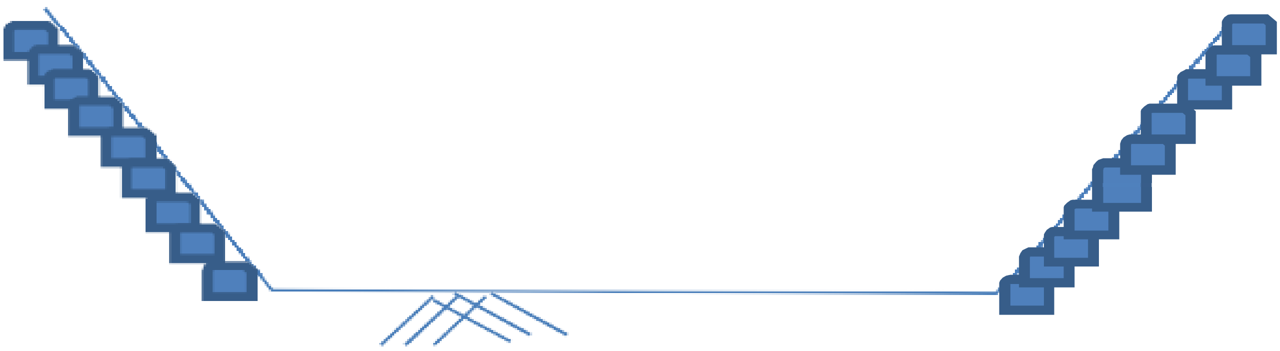
(Source: Fichtner India own source)

The intake channel can be either RCC, earthen with stone pitching, or simply earthen. The walls of RCC channels can be vertical. The earthen channel with stone pitching can have a limited slope and the earthen channels without any pitching or RCC will have a slope of 1:4 to 1: 5 for the sides. This will to some extent reduce the chances of collapse of the walls due to tide-induced flows.

Channel with sheet pile or stone pitching will involve large offshore construction and maintenance dredging.

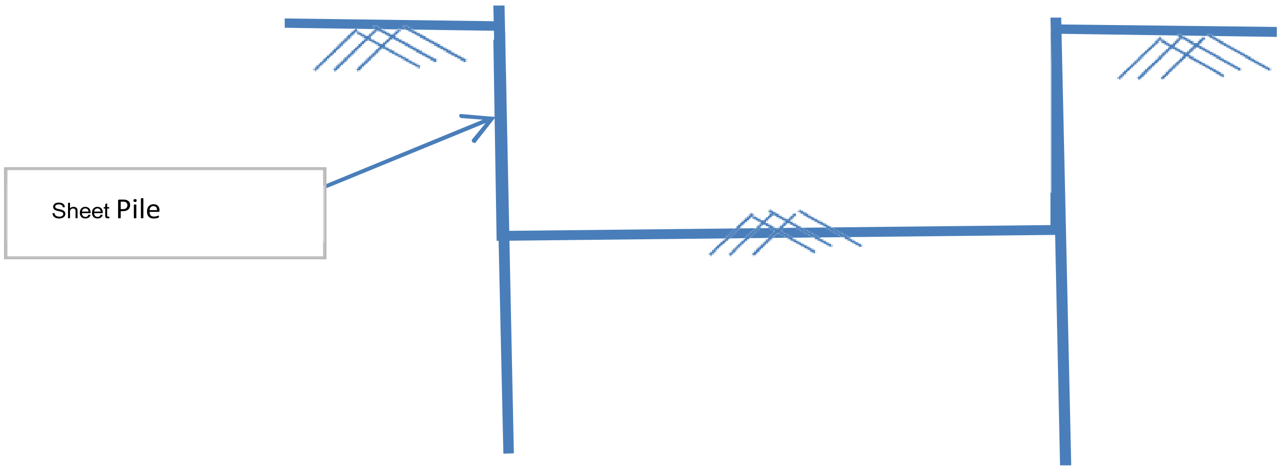
.

Figure 3-6 - Intake Channel with Stone Pitched side slopes



(Source: Fichtner India own source)

Figure 3-7 - Intake Channel with Sheet Piling for sides



(Source: Fichtner India own source)

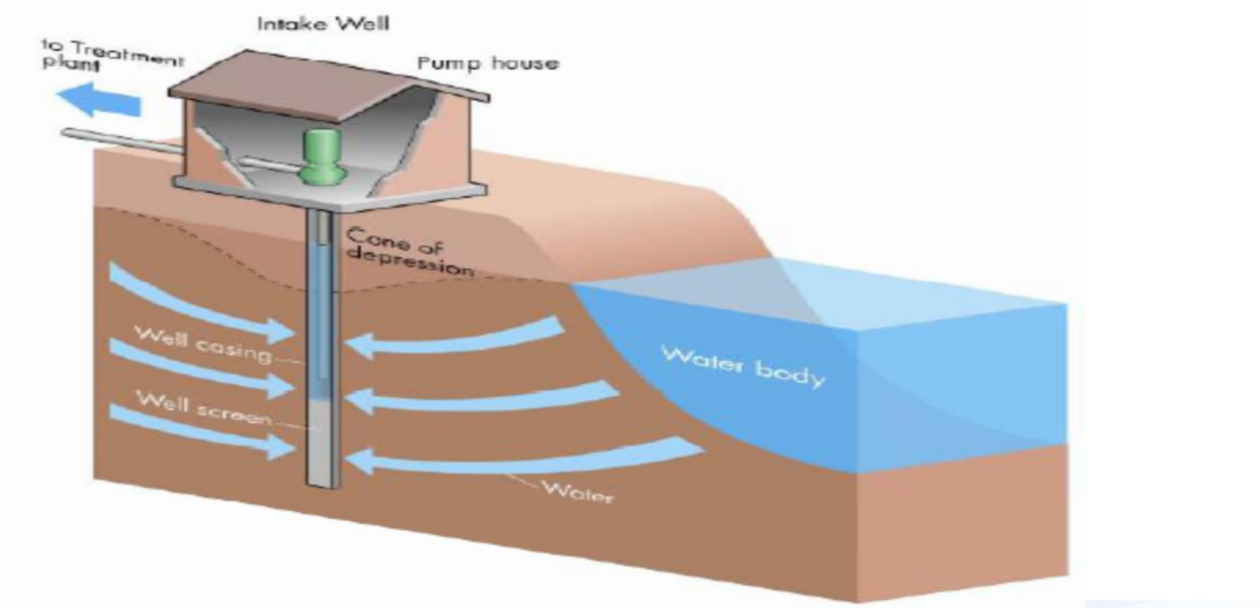
d) Beach Wells.

Beach wells are commonly used as an option for intake for sea water especially in case of small desalination plants. Typically, beach wells provide "pre-filtered" water have very low levels of suspended solids and obviate the need for extensive pre-treatment systems like clarifiers.

Taking raw water through beach bore wells will have advantages compared to other intake systems as the water taken from this system will be of better quality and hence the pre-treatment cost will reduce considerably in addition to the advantage of low capital cost.

It must be noted that the yields from beach wells are dependent on the type of soil/sand where they are located. The beach wells are best suited in locations having granular sand having good permeability and when the requirement is low, where several beach wells are connected in parallel to provide the required quantity of water. Typically, the yield of beach wells under good sand permeability conditions is limited to a maximum of 4 MLD.

Figure 3-8 – Vertical Beach Well



(Source: Overview of Desalination plant Intake alternatives – White Paper – 2011 – Water Reuse Association)

It is also to be noted using such beach wells may lead to seawater/ saline water intrusion to the nearby sub-surface and may spoil the groundwater quality and hence not recommended by statutory bodies such as MoEF / PCB.

The most suitable intake arrangement is selected depending on the site conditions.

Table 3-9 – Comparison of various intake options and their suitability

Characteristics of proposed intake location	Offshore Pump house & Trestle	Offshore Piped Intake	Beach well	Infiltration gallery	Channel	Channel with Sheet pile
High Current & Tide variation	S	S	NA	X	X	S
Large Intertidal Zone	S	S	NA	X	S	S
Received water quality	S	S	S	S	X	X
High Intake Flow Rate	S	S	X	X	S	S
Requirement of Offshore structures	Yes	Limited	NA	Yes	Limited	Yes
Low permeability of soil	S	S	X	S	S	S
Possibility of sea water intrusion with onshore ground water	NA	NA	Possible	NA	NA	NA
Construction cost	High	Med	Low	High	Low	High
Maintenance Dredging cost	NA	NA	NA	NA	High	Medium

S = Suitable, **X** = Not Suitable, **NA** = Not Applicable,

3.3.1.2 Onshore Intake pumphouse and raw water conveying main

For the offshore Intake, the Intake pumphouse shall be onshore mostly near the landfall point. The water from the offshore intake structure will be drawn by gravity and the depth of the pumphouse will be provided accordingly. A typical onshore pumphouse will consist of:

- Inlet chamber
- Suitable pigging arrangement (if required).
- Stop log gate
- Trash bar screen
- Travelling waterscreen
- Forebay
- Pump sump with pump floor
- Pumps with associated electro-mechanical items
- EOT crane
- Maintenance area
- Electrolyser house/chlorine storage area with dosage pumps
- Suitable air burst arrangement.
- Electrical room
- Control room

If the suspended solids are more in the seawater necessary settling pond arrangements can be provided to reduce the suspended solids in the water supplied to the pre-treatment system.

If the desalination plant is located away from the onshore intake pumphouse then the necessary raw water pumping main will be provided to supply the seawater from the intake pumphouse to the desalination plant. The MoC of the cross-country pipeline will be selected based on the soil condition and the seawater parameters. Generally, this kind of raw water pipeline can be of HDPE or GRP pipe.

3.3.1.3 SWRO desalination plant

a) Pre-treatment process

This system pre-conditions the seawater and makes it suitable for the Reverse Osmosis (RO) membranes as per membrane manufacturer's guidelines. The various sub-process components in the pre-treatment process largely vary depending on the seawater quality, availability of land, O&M cost, etc.

Typically, the pre-treatment process consists of the following sub-systems and equipment.

- Stilling chamber
- Flash mixers
- Flocculator
- Lamella clarifiers
- Dissolved Air Floatation units (if required)
- Rapid Gravity Filters (if required)
- Pressure Filters / UF (as may be required.

At the intake pumphouse, seawater is screened using a traveling water screen for floating and larger matter. This water, after initial screening, is transferred to the stilling chamber through Intake pumps.

Chlorine dosing is considered in the stilling chamber. The chlorinated seawater from the stilling chamber shall flow to the Lamella Clarifiers via Flash Mixers. The coagulant shall be dosed in the Flash Mixer the upstream of the clarifier/s. Ferric Chloride shall be used as a coagulant. Flocculent shall be dosed in the Flocculator. A suitable polyelectrolyte shall be used as Flocculent.

Each of the Lamella clarifier units shall generally contain two (2) Streams and Two Flash Mixers, two flocculation chambers, and two inclined plate settlers that are located suitable to Hydraulics. This unit shall consist of multiple compartments/ zones- viz-flash mixers, flocculation, pre-settling cum clarifier compartment, and underflow compartment/zone.

The underflow chamber of the clarifier shall receive the sludge-laden water. Sludge gets settled and is collected in a sludge pit from which it can be easily discharged.

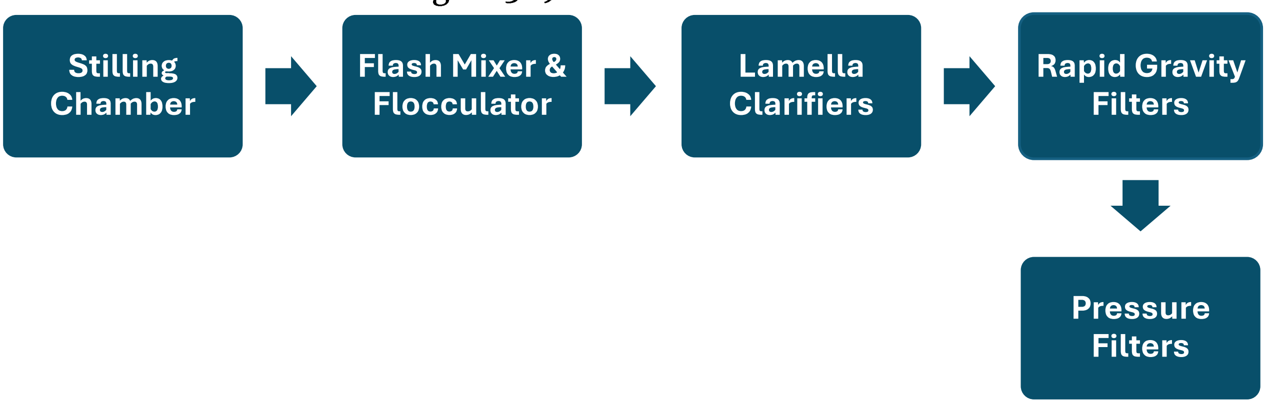
The sludge generated is non-hazardous and non-toxic. The sludge from the bottom of the seawater clarifier is discharged to a sludge pit and then transferred to an outfall tank for further disposal.

The clarified water from the clarifier shall be led to DAF units (if required) by gravity for handling light-suspended solids, organics and oil and then to the Rapid Gravity filters where further suspended particles are removed and led to the Clarified water Storage tank. From the clarified water storage tank water is pumped to pressure filters for further treatment of suspended solids removal. Alternatively, an Ultrafiltration system may be provided.

The product water from this filter system will be led to the SWRO system.

The above pre-treatment discussed is indicative and this may vary depending on the raw water quality, availability of space and many other factors.

Figure 3-9 - Pre-Treatment Process



b) Reverse Osmosis (RO) process plant

The RO system is generally designed with modular type. The independent trains of Sea Water Reverse Osmosis (SWRO) units will be decided based on the overall desalination plant capacity and the possible variations in the product water demand. This is further discussed in the subsequent chapter.

The RO plant shall consist of the following sub-equipment:

- Antiscalant and SMBS dosing systems
- Cartridge filters
- High-pressure pumps and PX booster pump (as applicable)
- Membrane element assembly unit
- Energy recovery unit
- Auto dumping system
- Remineralising system
- Clean in-place system
- Flushing water system

Pretreated and filtered seawater is fed to the RO plant, at the suction of the High-pressure feed pump. The high-pressure pump pressurizes and feeds it to the membrane assembly unit. Cartridge filters shall be provided at the upstream side of the HP pumps for final protection. Each train of SWRO consists of a dedicated High-pressure pump, an energy recovery unit, and the Membrane element assembly unit.

Each HP pump with its drive motor shall be mounted on a single base frame. The energy recovery unit shall be able to discharge brine against back pressure without the need for additional pumping equipment. The HP feed pump shall be VFD-driven to regulate the feed flow to the membrane assembly. The pump shall be designed to operate in the entire range of operation of the feed system.

The pressurized seawater is sent to the polyamide semi-permeable membranes which separate the permeate (less salty water) and brine (highly concentrated salt water).

Membranes are loaded in the high-pressure FRP vessels which are mounted on steel frames. The brine is disposed of back to the sea through an outfall tank after recovering the pressure energy in the brine, by passing through the energy recovery device.

The energy recovery device recovers a substantial part of the energy consumed by the high-pressure pump, resulting in reduction in energy consumption. State-of-the-art high-efficiency energy recovery devices and energy-efficient high-pressure pumps shall be used in these RO units, to optimize the energy used for the RO system. In case of pressure exchanger being used for energy recovery, a PX booster pump shall be installed in parallel with main HP pump and the PX booster pump shall be VFD driven.

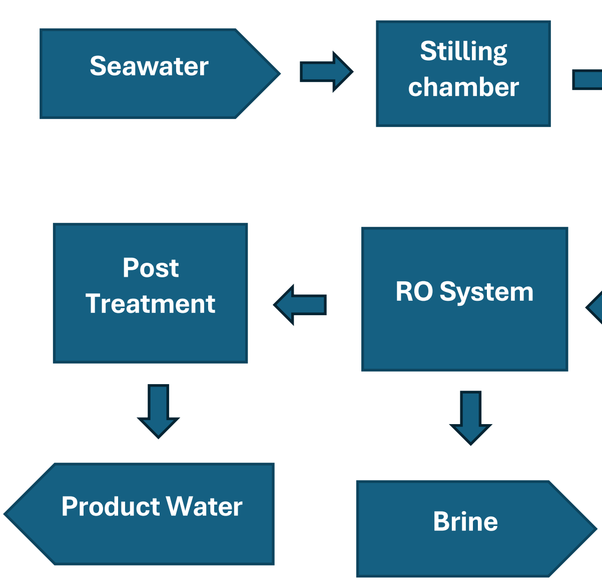
The materials coming in contact with seawater shall be either non-metallic or superior or Super Duplex SS to avoid corrosion. Equipment not meeting the above requirement is protected by Cathodic protection.

PVC/CPVC/FRP/GRP/HDPE pipe materials are used for low-pressure piping and super duplex stainless steel is used for high-pressure seawater feed and brine piping.

The permeate water is discharged to the product water storage tank located in the desalination area where the permeate water is treated to correct the pH and LSI, the product water is then transported to the product water Storage tank in the desalination area for further transmission to GH2/PtX plant. A disinfection dosage facility will be provided for potable water application.

Cleaning and Flushing systems are provided to protect the membrane from fouling and scaling. The cleaning system facilitates cleaning of the fouled membranes and the flushing system flushes the membranes off High TDS water with low TDS water during shutdown operation.

Figure 3-10 - *Typical Desalination plant scheme*



c) Post-treatment process units

The SWRO permeate flows to an above-ground storage tank located in the desalination area. the pH and LSI of the product water will be corrected to the desired product water quality limits. Correction will be affected by dosing Lime (Ca $(OH)_2$) and CO_2 to improve the LSI. Alternately, limestone filters may be provided.

Lime and CO_2 are dosed online at the outlet transfer pump discharge before transferring into the final storage tank.

The post-treatment system is common for the entire plant and shall be provided with chemical tanks, mixers, dosing system to dose the correct quantity of chemical automatically.

d) Chemical dosing system

The following chemical dosing systems are envisaged for a typical project.

- Pre-chlorination system

- Coagulation and flocculent dosing system
- Antiscalant and De-chlorination (SMBS) dosing system
- Limestone filter and CO_2 dosing system
- Post chlorination dosing system

All the chemical systems will be automatic control system based on the flow rate as well as the dosage rate.

e) Chlorination System

Bio-fouling control or chlorination is effected to kill and prevent the biological growths, so as to keep the water clear of biological growths. Gas chlorination dosing system shall be considered the in the Pre-Treatment Plant. Gas chlorination system will be considered and shall be in the Intake pumphouse area. Shock Chlorination shall also be done at the offshore intake head.

In the Pre-Treatment Plant, Chlorine will be dosed in the Stilling Chamber. A continuous dosing of 1 ppm will be considered in the stilling chamber to maintain a residual chlorine level as 0.5 ppm.

The seawater will be de-chlorinated prior to RO system, as per membrane manufacturer's recommendation by dosing sodium meta bi-sulphite (SMBS).

The chlorination and SMBS systems shall be provided with chemical tanks, mixers (as applicable), dosing system to dose the desired quantity of chemicals automatically.

f) Storage & distribution of product water

The product water will be stored in a storage reservoir within the Desalination plant boundary. The size of the storage tank shall be decided based on the water requirement of the GH2/PtX plant and its working hours etc. Generally, for small and medium size desalination plants the storage tank can be for one day storage. Along with storage tank necessary pumping system will be provided to pump the product water to GH2/PtX plant.

3.3.1.4 Offshore outfall system for disposal of reject water

The purpose of the outfall brine water (reject water) disposal system is to discharge brine and other process reject water to the identified outfall location. Generally, in SWRO the total reject water will be about 2/3 of seawater intake. All the brine from the SWRO shall be collected in an outfall water storage tank. This tank will be connected through pumps to the disposal point in the sea through GRP / HDPE / equivalent pipes. Sludge collected from the pretreatment section will be dewatered and the supernatant water will be transferred to the outfall tank.

All other effluents as below are also pumped to the outfall tank.

- Filter Backwash water
- Ultra filtration wastewater (if applicable)
- Supernatant water from the sludge thickener and sludge dewatering arrangement
- Neutralized effluent.

The location of the brine outfall shall be identified based on a detailed modeling study conducted to prevent brine recirculation into the intake and to disperse the excess salinity to the ambient condition within a specified area.

Figure 3-11 - *Typical Multiport Diffuser Arrangement*

(Source: Environmental issues in seawater reverse osmosis desalination: Intakes and Outfalls – by Thomas M. Missimera,⁎, Robert G. Malivab)

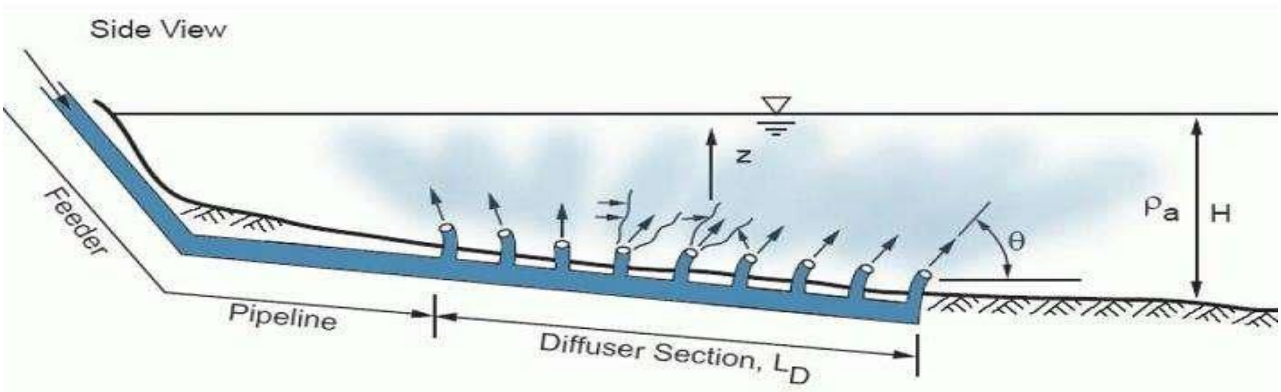
Generally, the outfall will be provided with a proper dispersion arrangement by providing diffusers. The design of diffusers will be based on the quality of reject water, salinity, depth of sea and current at the disposal location, and the outcome of dispersion modeling, etc.

3.3.2 Modular desalination plant design options and overview of common module sizes

While discussing the modular desalination plant it is to be noted that certain components/units of the desalination plant will be designed for ultimate capacity and certain units can be developed in modular mode.

If the GH2/PtX plant is developed for its full ultimate capacity at the beginning itself then all components of the desalination plant can also be developed for the ultimate requirement and the RO skids can be designed as modular to take care of the variation in the capacity 10%, 20%, 30%.

However, if the GH2/PtX plant itself is planned to develop in a phased manner then some components of the desalination plant can be developed for ultimate capacity and some



components can be developed in a phased manner in modules. The same is discussed below.

- The **Intake, Outfall, and certain common facilities** shall be sized for ultimate capacity at the beginning itself and will be executed accordingly.
- Some of the pre-treatment units like Clarifiers, Rapid sand filters, and Pressure filters can be designed in modules to suit the GH2/PtX plant requirements during development phases.
- The **RO skids shall be of modular type** and will be installed as per the demand requirement and the same discussed below:

As mentioned in Chapter 3.2.4 the desalination plant capacity for the scenario of small, medium, and large capacity GH2/PtX plants are given as:

Table 3-10 – Desalination plant capacity with oversizing scenarios

Desalination plant capacity with oversizing scenarios				
Description	UOM	Small Value	Medium Value	Large Value
Total desalination plant capacity arrived	MLD	3.28	32.13	160.25
10% oversize	MLD	3.60	35.34	176.28
20% oversize	MLD	3.93	38.55	192.30
30% oversize	MLD	4.26	41.76	208.33

Typically, the desalination plants will be designed with about 10% margin on the above capacities duly rounded off.

3.3.2.1 Small plant requirement:

In this case, the capacity of the desalination plant is from 3.28 MLD to 4.26 MLD.

Hence, in this case, the overall desalination plant capacity is less than 5 MLD in the Intake & Outfall system, the complete pre-treatment and post-treatment units shall be for the ultimate plant capacity.

The RO skids shall be in the modular type of 3 numbers of 2 MLD skids.

3.3.2.2 Medium Plant Requirement:

In this case, the capacity of the desalination plant is from 32.13 MLD to 41.76 MLD.

Here the overall desalination plant capacity is medium size and more than 30 MLD the plant can be designed as modular as discussed below:

The RO skids shall be in the modular type of 5 numbers of 10 MLD skids.

3.3.2.3 Large Plant Requirement:

In this case, the capacity of the desalination plant is from 160.25 MLD to 208.33 MLD.

Here the overall desalination plant capacity is large and more than 150 MLD The plant can be designed as modular as discussed below:

The RO skids shall be in the modular type of 11 numbers of 20 MLD skids:

The above is an example that can be decided based on the actual project requirement.

3.3.3 Input energy required for the mentioned scenarios.

In the desalination plant, the major consumable is electric power and it mainly depends on the seawater quality, type of RO membrane, pre-treatment process, energy recovery system, etc.

Generally, the power consumption will be expressed in kwh/KLD of desalinated water.

Currently, the power consumption for a desalination plant varies from 3.0 kWh/m^3 to 4.25 kWh/m^3 depends on various factors discussed above.

However, for the purpose of calculation of power requirement for the mentioned scenarios electrical power of 3.5 kWh/m^3 of desalinated water will be considered. This power requirement includes the entire power consumption of the desalination plant including common area lighting, HVAC

Table 3-11 – Energy requirement for three scenarios of Desalination plant

Energy requirement for three scenarios of Desalination plant				
Description	UOM	Small Value	Medium Value	Large Value
Desalination Capacity for three scenarios	MLD	3.28	32.13	160.25
Energy requirement @ 3.5 kWh/m^3 of desalinated water	kWh	11,480	1,12,455	5,60,875

3.3.4 Readiness level with respect to completely powered by DRE

The DRE (Decentralized Renewable Energy) in India is mainly of Wind energy & Solar Energy. However, the wind energy will be available only during a limited period and can be installed only in the places where required wind flow is there.

However, solar energy is available more than 300 days in a year in India in many places. But, on the other hand solar power production will be only in the daytime for a maximum of 8 to 9 hours. It is to be noted even during this period the production of electric power will not be uniform. The full capacity of power production will be only for 3 to 4 hours.

The GH2 plant can be operated for 8 hours in order to use DRE power directly. Even for that as the power production will not be uniform in the 8 hours some kind of power storage is required.

It is not advisable to operate the desalination plant only for 8 hours in a day and keep the plant idle for rest of period in a day. This will affect the function and life of the RO membrane. Hence, it is advisable to operate the desalination plant for all the 24 hours. The desalination plant capacity shall be fixed such that the water requirement for the GH2/PtX plant for 8 hours shall be produced in 24 hours by the desalination plant and with desalinated water storage arrangement for a minimum one day demand.

Hence, while using DRE for the desalination plant the power shall be stored and used for the desalination plant with the following options:

Option – 1: Compared to the requirement for power for the GH2/PtX plant the power required for a captive desalination plant is very minimum (i.e. less than 0.5% of GH2/PtX plant power requirement). Hence, a Battery Energy Storage System (BESS) shall be thought of for power storage during the non-supply period of Renewable Energy. GoI has also announced Budgetary support (up to 40% of cost) for the development of BESS.

The provision of BESS will increase the cost of power due to its additional CAPEX & OPEX. However, the GOI, ‘cabinet approved Rs.3,760 crore Viability Gap Funding (VGF) for development of battery energy storage system. The scheme envisaged the development of 4,000 MWh of BESS project by 2030-31, with the financial support of up to 40% of capital cost as budgetary support. This shall be considered for the DRE to minimize the renewable energy tariff.

Option – 2: Power banking is another good option for getting green power from the grid for 24 hours. The GoI, Ministry of Power No. 23/02/2022-R&R - Green Hydrogen Policy addresses the following:

“4. Banking shall be permitted for a period of 30 days for Renewable Energy used for making Green Hydrogen / Green Ammonia.

5. The charges for banking shall be as fixed by the State Commission which shall not be more than the cost of the differential between the average tariff of renewable energy bought by the distribution licensee during the previous year and the average market clearing price (MCP) in the Day-Ahead Market (DAM) during the month in which the Renewable Energy has been banked"

Considering the above the Renewable Energy required for the captive desalination plant for the three scenarios is given in the below table.

Table 3-12 – Renewable Energy requirement for three scenarios of Desalination plant

Renewable Energy requirement for three scenarios of Desalination plant				
Description	UOM	Small	Medium	Large
		Value	Value	Value
Desalination Capacity for three scenarios	MLD	3.28	32.13	160.25
Power requirement assumed @ 3.5 kWh/m³ of desalinated water	MWH	0.50	4.7	23.5
The tentative capacity of the solar plant to be installed to get the required power for the desalination plant. (Considering 1 MW of solar plant will produce 4000 units per day)	MW	2.87	28	140
The tentative area of land required for the solar plants	Ha	5.74	56	280

Hence for a Typical Medium GH2/PtX plant of 1000 MW the total land required:

Table 3-13 – Area Requirement for a 1000MW GH2/PtX plant including DRE

S.No.	Description	Land required in acres
1.	1,000 MW GH2/PtX plant	85

2.	Captive Desalination Plant of about 32 MLD	15
3.	Land required for 1000 MW solar plant for GH2/PtX plant	4942
4.	Land required for 28 MW solar plant for desalination plant	139
	Total Land required	5181

The total land bank of 5150 acres getting at a place may not be possible in many cases. Even such land available should be favorable to produce Renewable Energy. Under these circumstances, it is to be noted that GoI, Ministry of Power No. 23/02/2022-R&R - Green Hydrogen Policy also addresses the following:

"3. Green Hydrogen / Green Ammonia can be manufactured by a developer by using Renewable Energy from a co-located Renewable Energy plant, or sourced from remotely located Renewable Energy plants, whether set up by the same developer, or a third party or procured renewable energy from Power Exchange. Green Hydrogen / Green Ammonia plants will be granted Open Access for sourcing of Renewable Energy within 15 days of receipt of application complete in all respects, The open Access charges shall be in accordance with Rules as laid down"

List of Attachments

Drawings

1. FCE-20723126-DWG-6101-001-R0 PFD for SWRO Desalination Plant – Annexure - 5
2. FCE-20723126-DWG-6101-002-R0 SWRO Desalination Plant Layout - Annexure – 6.

4 Assess characteristics of establishing and operating a seawater desalination plant.

To establish and operate any SWRO desalination plant it is very important to select a suitable site. The site for SWRO desalination plant has two major components one is the offshore site and the other onshore site.

Besides the above as this desalination plant is for the GH2/PtX plant, the site selection criteria for the GH2/PtX shall also be considered during the onshore site selection.

4.1 General Characteristics

Criteria for the selection of a suitable site shall meet the technical, environmental, economic, and social requirements.

- The site selection for the desalination plant shall also have enough land for GH2/PtX plant at a reasonable distance which meets the site selection criteria for GH2/PtX.
- The site selected shall be such that there needs to be connectivity by road from the desalination plant to the GH2/PtX plant.
- The site shall also have the necessary pipeline corridor (right of way) to convey the desalinated water from the Desalination plant.
- Both the desalination plant & GH2/PtX plant shall have connectivity with the power grid and/or required additional land for developing green energy plants (Solar plant, Windmill, etc.)

The site selection characteristics for the SWRO desalination plant shall be considered in two segments one for offshore facilities and another for onshore facilities.

4.2 Characteristics to be considered for the offshore facilities.

Related to the SWRO desalination plants the major offshore facilities required are:

- Offshore intake arrangement
- Offshore intake seawater pipeline
- Offshore outfall reject water pipeline
- Offshore Outfall arrangements

4.2.1 Technical characteristics:

A. Availability of enough water:

The offshore should be such that the sea water is available at all times. It is to be noted in some parts sea during the low tide there will be no water. That means water can't be drawn from the sea during the low tide this will seriously affect the operation of the desalination plant for which continuous seawater supply is needed for 24 hrs.

To identify the availability of water the tide measurements which provide the Highest Astronomical Tide (HAT), Mean High Water Spring (MHWS), Mean High Water Neap (MHWN), Mean Sea Level (MSL), Mean Low Water Neap (MLWN), Mean Low Water Spring (MLWS) etc along with bathymetry map (Seabed levels) shall be examined coherently.

Generally, the intake point will be selected such that even during the Lowest Tidal Level adequate sea water is available to draw.

For a typical 'velocity cap intake' system the minimum depth required is about 6m. This is only indicative, and the depth required for the proposed intake point shall be finalized considering the following factors:

- Type of Intake system
- Quality of Seawater
- Sea bed soil type
- Sediment transport / littoral drift
- Quantity of seawater to be drawn

B. Location of Intake:

- The intake point shall preferably be away from the estuary/river mouth meeting the sea as this can create silting during the rainy season and there can be variations in the water quality like TDS, TSS, etc. This will result in the possible blocking of intake by silt deposits and the huge variation in the seawater quality may lead to problems in the effective function of a desalination plant.
- The Intake shall not be very close to or in the ship movement corridor (Passageway) as there is a possibility of damaging the intake structure by ships and because of turbulence, the seawater may contain more TSS / oil, etc.

C. Intake pipeline:

- The intake to be selected such that the intake pipeline is not very long offshore to reduce problems in the design, execution, and maintenance of the intake pipeline. This will also optimize the cost of both CAPEX & OPEX.
- If the invert level of the Intake pipeline at the Intake point is much deeper than the Finished Ground Level of the proposed onshore Intake pumphouse then the depth cutting for laying

the intake pipeline near shore will be very deep which will create higher costs in the pipelaying and in maintenance.

- If the seabed is hard rock, then the offshore construction cost will be very high which needs to be avoided as much as possible.

D. Outfall Arrangement:

- To select the outfall location for the disposal of reject water necessary 'dispersion model study' to be conducted considering the various parameters like Tide levels, current, depth of water, ambient sea water quality, characteristics of reject water coming from desalination plant, etc.
- In addition to the above considering the distance between the intake & outfall location necessary recirculation study shall also be carried out.
- Outfall location shall be selected such that it meets the following characteristics:

I. As near to the shore as possible

II. The outfall location shall have enough depth of water and sufficient current so that the dispersion of reject water happens with a minimum area and attains the salinity to the ambient condition.

III. The subsoil condition of the outfall location shall be verified such that the diffuser arrangements shall be placed properly and firmly.

IV. This location shall be away from intake such that reject water should not have any recirculation effect in the intake water.

E. Outfall Pipeline:

- The length of the outfall pipeline is depending on the distance of the outfall location from the desalination plant.
- Generally, the outfall pipeline will be of pressurized conveying main.

4.2.2 Environmental characteristics:

The onshore & offshore facilities proposed should not have any impact on the Environment. Necessary Environmental Impact Assessment (EIA) study to be done by the accredited EIA consultant.

The preparation of Local level CRZ Map for the project and superimposing on approved CZMP as per CRZ Notification 2011 to be done through Ministry of Environment, Forest, and Climate Change (MoEF&CC) approved agencies.

The EIA / CRZ clearance needs to be obtained from the State Coastal Zone Management Authority (SCZMA) and the Ministry of Environment, Forest, and Climate Change (MoEF&CC), GoI.

- The Intake structure and the outfall location shall not be in CRZ 1A – an ecologically sensitive area.
- However, the laying of a buried pipeline may be allowed in the CRZ 1A when it crosses the mangrove buffer as a special case. However necessary EMP with required cost allocation in the budget to be done for the same.
- CRZ – IB – In the inter-tidal area the offshore facilities for the desalination plant are allowed.
- The Intake system, particularly for the velocity cap arrangement the screen shall designed such that the entry horizontal velocity near the screen shall be about 0.15m/sec. so that the fish will get the necessary warning and take a diversion from the intake system this will avoid the Impingement of marine organisms into intake well.
- A necessary dispersion model study is to be done and it is to be ascertained by the result of a model study that the higher salinity in the reject water will get diluted to ambient level within the short area near the outfall point.

- It is also to be proved by conducting a necessary recirculation study such that the reject water will not be recirculated into the intake water.
- Necessary Budget allocations to be made for the execution of EMP.

The following criteria/ considerations are to be made for the selection:

I. Water depth
II. Geological composition of seabed
III. Region influenced by littoral drift
IV. Width of surf zone in monsoon
V. Bed load and suspended load of sediments.
VI. Wave climate
VII. Current speed and directions
VIII. Coastal morphology
IX. Presence of other intakes/ Outfalls in the vicinity
X. Presence of coastal structures if any
XI. Occurrences of cyclones and tsunamis
XII. Quantity of effluent discharge and
XIII. Difference between discharge water quality & ambient seawater quality

4.2.3 Economic characteristics:

The success of any project lies in the economic viability of the project. If the project cost of offshore facilities is too high the project may not be viable for execution.

Some of the characteristics that affect the economy of the project are:

- High TSS and TDS in the seawater will lead to an increase in the pre-treatment & R.O. treatment cost.

- In the selected marine area if the intertidal zone is very high then it will increase the length of the Intake & Outfall pipeline which in turn increases both the CAPEX and OPEX.
- If the seabed is rock or clay, then offshore construction costs will increase.
- The type of intake system will also have an impact on the cost of offshore facilities. Generally, the channel intake may be of less CAPEX and more OPEX, and the offshore intake with pumphouse will be of high CAPEX. The offshore intake with onshore pumphouse with buried intake & outfall pipeline may be moderate CAPEX & OPEX. However, the type of intake system many times decided based on the offshore & onshore conditions.

4.2.4 Social characteristics:

- The selected site for offshore facilities shall be away from the fishing area.
- Necessary social assessment should be done before finalizing the site to avoid any social issues in the future.

4.3 Characteristics to be considered for onshore facilities.

The onshore facilities of a typical desalination plant will be:

I. Onshore intake pumphouse (if required separately)
II. Raw water conveying main (if required)
III. Desalination Plant
IV. Product water conveying main till the supply point (here it may be GH2 plant)

The desalination plant typically comprises the following:

I. Intake System
II. Pre-treatment System
III. RO System
IV. Post Treatment System

V. Membrane Cleaning System

VI. Flushing System

VII. Wastewater Neutralization System

VIII. Outfall / Reject disposal system

IX. Product water conveying system

X. Electrical System

XI. Instrumentation and Controls System

4.3.1 Technical characteristics:

The various technical characteristics to be considered for the selection of onshore facilities are as follows:

- The land for the onshore intake pumphouse and desalination plant shall be approachable in all seasons from the nearby main road or town.
- The land shall be close to the grid sub-station of adequate capacity. However, if the GH2/PtX plant is proposed to be located close to the desalination plant, then a separate substation may not be required as the power can be tapped from the GH2/PtX plant.
- If DRE is considered, then enough land shall be available for the renewable power plants.
- The desalination plant shall be as near as the seashore and near to the GH2/PtX plant.
- The topography of the desalination plant level shall be preferably above the Highest Astronomical Tide (HAT).
- The land may have a suitable soil condition for construction so that the foundation cost is minimal.
- Minimal Georisk.

4.3.2 Environmental characteristics:

Generally, the operation of the Desalination plant does not have much environmental impact as it does not have air pollution and may have only a little noise pollution.

However proper EIA study to be done by the accredited EIA agency and necessary pollution control board clearance to be obtained as per state / Central government rules and norms.

The proposed land shall meet the required CRZ regulations as per the CRZ notification 2019.

Table 4-1 - Summary of CRZ Regulations

CRZ	Description of CRZ
CRZ I	Areas are environmentally most critical
CRZ IA	Shall constitute the following Ecologically Sensitive areas (ESAs) and the geomorphological features that play a role in maintaining the integrity of the coast: Mangroves, Coral reefs, Reserve Forest, Sand Dunes, Salt Marsh, Nesting Ground of Birds, archaeologically important and Heritage sites, Seagrass, Mudflats, Turtle nesting grounds, Inter-Tidal zone, Salt pan / Aquaculture Pond and Eco-Sensitivity zone.
CRZ 1B	The intertidal zone (area between the Low tide line and High tide line)
CRZ II	Shall constitute the developed land areas up to or close to the shoreline, within the existing municipal limits or in other existing legally designated urban areas, which are substantially built-up with a ratio of built-up plots to that of total plots being more than 50 percent and have been provided with drainage and approach roads and other infrastructural facilities, such as water supply, sewerage mains, etc
CRZ III	Relatively undisturbed land areas (viz. rural areas, etc.) and those that do not fall under CRZ-II, shall constitute CRZ–III
CRZ IIIA	Such densely populated CRZ-III areas, where the population density is more than 2161 per square kilometer as per the 2011 census base, shall be designated as CRZ–

CRZ	Description of CRZ
	III A, and in CRZ-III A, area up to 50 meters from the HTL on the landward side shall be earmarked as the 'No Development Zone (NDZ)',
CRZ IIIB	All other CRZ-III areas with a population density of less than 2161 per square kilometer, as per the 2011 census base, shall be designated as CRZ-III B, and in CRZ-III B, the area up to 200 meters from the HTL on the landward side shall be earmarked as the 'No Development Zone (NDZ)'.
CRZ IV	The CRZ-IV shall constitute the water area
CRZ IVA	The water area and the seabed area between the Low Tide Line up to twelve nautical miles on the seaward side shall constitute CRZ-IV A
CRZ IVB	CRZ-IV B areas shall include the water area and the bed area between LTL at the bank of the tidal-influenced water body to the LTL on the opposite side of the bank, extending from the mouth of the water body at the sea up to the influence of

Table 4-2 - Permissible activities in CRZ in respect of Desalination plant

CRZ	Permissible activities in respect of Desalination plant
CRZ I	
CRZ IA	These areas are ecologically most sensitive and generally no activities shall be permitted to be carried out in the CRZ-I A area, with the following exception: In the mangrove buffer, only such activities shall be permitted like laying of pipelines, transmission lines, and conveyance systems.
CRZ 1B	Pipelines, conveying systems including transmission lines. Desalination plants and associated facilities
CRZ II	Activities as permitted in CRZ-I B shall also be permissible in CRZ-II,
CRZ III	Activities as permitted in CRZ-I B shall also be permissible in CRZ-III, in so far as applicable
CRZ IV	Intake & Outfall structures, Pipelines, and conveying systems including transmission lines

4.3.3 Economic characteristics:

- The cost of the land for intake offshore pumphouse and desalination plant shall be reasonable. If the cost of the land is high, then it will increase the project cost directly.
- The finished ground level of the desalination plant should be above the HAT or High Flood level of the zone. If the natural ground level is low then site grading and filling costs will increase.
- If the subsoil of the selected land is very poor, then it may require a pile / heavy foundation which may increase the civil cost of the plant.

4.3.4 Social characteristics:

The site for the proposed desalination plant and allied structures shall not have any impact on the existing habitats nearby.

- The project area shall not have any existing settlement so there will be no Rehabilitation & Resettlement (RR) issues.
- The approach roads and pipeline corridors which are away from the desalination plant shall also be settlement-free areas.
- However, if unavoidable circumstances any existing settlement there then a necessary social impact assessment should be done by the social expert, and as required public hearing also be done to convince the existing habitats. Necessary Rehabilitation & Resettlement plant to be prepared and approved by the concerned state government agency.
- The desalination plant shall have the social acceptance of the neighbouring communities and other authorities.

4.4 Selection of four potential hydrogen production locations

The potential states that are likely to plan large GH2/PtX plants and are of coastal regions are:

- Gujarat
- Karnataka
- Maharashtra
- Kerala
- Tamil Nadu
- Andhra Pradesh
- Odisha.

From the above, 4 states are selected as potential areas for the development of GH2/PtX plants and which also have the favour to develop captive Desalination plants to supply required water to GH2/PtX.

This selection was made based on various factors like state Green Hydrogen policy, Proposed investment, or production of GH2/PtX, availability of Coastal zone, Availability of Land near coastal zone, proposed Hydrogen hubs announced by GoI etc.

Table 4-3 - Potential Selection Criteria

S. No.	State	Reasons for selection of this potential hydrogen production location
1.	Gujarat	▪ Govt. of Gujarat (GoG) about to release the state Green Hydrogen Policy ▪ GoG already issued the Policy on Land Allotment for Green Hydrogen Production and it earmarked huge land for leasing to GH2 production. ▪ Gujarat has a large coastal boundary (about 1214 km) ▪ In Gujarat total renewable energy installed capacity is more than 19,000 MW. Hence green energy is already available for GH2 plants. ▪ Gujarat also has a huge land parcel along the seashore which shall be used not only for the GH2/PtX plant and desalination plant it also to produce green power (Solar / Wind) ▪ Gujarat aims to produce 8 lakh tonnes per annum of green hydrogen by 2035. ▪ State expects about Rs.10 lakhs Cr. The worth of investment in the next 15 years in the GH2 sector. ▪ The government of India has proposed to develop a hydrogen hub in Kandla Port, Gujarat.
2.	Tamil Nadu	▪ Govt. of Tamil Nadu (GoTN) is in the process of issuing of state Green Hydrogen policy. ▪ Tamil Nadu has a large coastal boundary of about 1076 km. ▪ In Tamil Nadu total renewable energy installed capacity is about 16,000 MW. ▪ Tamil Nadu also has a huge land parcel along the seashore which shall be used not only for the GH2/PtX plant and desalination plant it also to produce green power (Solar / Wind) ▪ The Government of India has proposed to develop a hydrogen hub in the VOC Port, Tuticorin, Tamil Nadu which may attract an investment of Rs.50,000 Cr. to Rs.80,000 Cr.
3.	Andhra Pradesh	▪ Andhra Pradesh has already issued the 'Andhra Pradesh Green Hydrogen & Green Ammonia Policy – 2023'. ▪ Andhra Pradesh has a coastal boundary of about 975 km.

S. No.	State	Reasons for selection of this potential hydrogen production location
		▪ In Andhra Pradesh total renewable energy installed capacity is more than 10,000 MW. ▪ Govt. of AP target to produce 0.5 MTPA of Green Hydrogen in the next five years. ▪ Govt. of AP has announced a provision for land leasing at a concessional rate for the GH2/PtX plant. ▪ NGEL has acquired about 1200 acres of land in Pudimadaka, Andhra Pradesh to develop GH2/PtX plants and allied supporting industries including captive desalination plants.
4.	Odisha	▪ Govt. of Odisha has issued the 'Renewable Energy Policy 2022' in which it talks about Green Hydrogen and Green Ammonia. ▪ Govt. of Odisha already approved the investment of more than 1,50,000 Cr. By private sector in the Green Hydrogen sector. ▪ Odisha is having a coastal length of 450 km. ▪ Government of India has proposed to develop a hydrogen hub in the Paradip port, Odisha.

The above four states will be considered for developing the criteria matrix at each location.

4.5 Information format for the rapid assessment

Table 4-4 - Rapid Assessment

S. No.	Data to be collected
I	**Sea Related Data**
1.	Tidal levels which may include Highest Astronomical Tide (HAT) Mean High Water Spring (MHWS) Mean High Water Neap (MHWN) Mean Sea Level (MSL) Mean Low Water Neap (MLWN) Mean Low Water Spring (MLWS)
2.	Bathymetry map / data
3.	Tide & Current data
4.	Sea water quality
5.	CRZ map
6.	Sensitivity area in the sea near the project location like breeding place for various sea species, Important Monuments, Reserved Forest or mangroves, Flora, and Fauna etc.
7.	Marine habitat and fishing details Local economic.
8.	If any port is available near the proposed project site, the following details may be collected: • Existing port facilities and their operation. Any negative impact of port / ship passageway with the proposed desalination plant offshore / onshore facilities.
II	**Land related data**
1.	Area of Land available near seashore and its ownership
2.	Topography of the available land

3.	Hydrology, Geology and georisks (like flooding, tectonic movement, earthquakes, landslides, coastal erosion, land stability, liquefaction, rock falls etc.)
4.	Nearby Grid power station from where power shall be drawn.
5.	Accessibility of land from the nearby Town / Highway.

4.6 Criteria Matrix and Site Selection

4.6.1 Criteria matrix for a rapid, preliminary assessment

4.6.1.1 For offshore facilities

Table 4-5 – Offshore Facilities

	Basic assessment criteria			Site Specific evaluation – Location		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50			
Technical	**Total score for Technical**		**12.5**			
	Approximate distance of intertidal zone	< 1000 m	2.0			
	Proposed intake location is away from estuary / river mouth meeting the sea	> 2000 m	1.0			
	Proposed intake location is away from passageway & boating corridors.	Yes	2.5			
	Approximate length of Intake pipeline length	< 2000 m	2.5			
	Is the outfall location having enough depth of water	> 6.5m	2.0			

	Basic assessment criteria			Site Specific evaluation – Location		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50			
	Approximate length of outfall pipeline	< 2000 m	2.5			
Environmental	**Total score of Environmental**		**12.5**			
	Is intake location being in the CRZ 1A	No	2.5			
	Do intake & outfall pipeline cross CRZ 1A	No	2.0			
	Region influenced by high littoral drift	No	2.0			
	Width of wave breaking zone in monsoon	< 450 m	0.5			
	Presence of other intakes/ Outfalls in the vicinity	Case to case	0.5			
	Presence of coastal structures if any	Subjective	1.0			
	Occurrences of cyclones and tsunamis	Historical	2.0			
	Are the Offshore facilities being away from the marine national reserves etc	> 10 km	2.0			
Economical	**Total score for Economical**		**12.5**			
	Is the seabed being rocky or clay	No	4.5			
	Possible type of Intake and its impact on project economic	Channel Intake/ /offshore Intake onshore pumphouse/ Offshore	8.0 / 6.0 / 4.0			

	Basic assessment criteria			Site Specific evaluation – Location		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50			
		pumphouse with trestle				
Social	**Total score for Social**		**12.5**			
	Will offshore facilities affect nearby fishing and other communities?	No	6.0			
	Are there any objections expected from the local communities for the proposed projects.	No	6.5			

4.6.1.2 For onshore facilities

Table 4-6 – Onshore Facilities

	Basic assessment criteria			Site Specific evaluation – Location		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
II	Onshore – (Land related)		50			
Technical	**Total Score for Technical**		**12.5**			
	Land – Area availability	Adequate	2.5			
	Land availability of GH2/PtX plant nearby.	Adequate	2.0			
	Accessibility - Distance from nearby town / Highway	Available / shall be created / Not possible	2.0 / 1.0 / 0.0			
	Is the topography of plant site being above Highest Astronomical Tide HAT	Yes	1.5			
	Is the Sub-soil condition being suitable for normal foundation	Yes	1.5			
	Access to the power grid sub-station	Yes	1.0			

	Basic assessment criteria			Site Specific evaluation – Location		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
II	Onshore – (Land related)		50			
	What is the Seismic zone of the project area	Zone 2 / 3 / 4 / 5	1.0 / 0.75 / 0.5 /0.0			
	Is there any possibility of geo risk in the proposed site	No	1.0			
Environmental	**Total Score for Environmental**		**12.5**			
	Is the project site (onshore pumphouse, desalination plant conveying mains) being in the CRZ IA	No	6.5			
	Is there any Monuments within 10 km radius from the project boundary.	No	4.0			
	Accessibility to Highway	Subjective	2.0			
Economical	**Total Score for Economic**		**12.5**			
	Water Quality: Does the sea water require any special pre-treatment such as oil removal etc.	No	2.0			
	Is the TDS being above the normal range	< 45000 ppm	3.0			

	Basic assessment criteria			Site Specific evaluation – Location		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
II	Onshore – (Land related)		50			
	Is the TSS being above the normal range	< 500 ppm	2.0			
	Is any site filling is required to raise the FGL	No	1.5			
	Distance of proposed GH2/PtX plant from the desalination plant	Reasonable	1.0			
	Is the sub-soil being poor requires special foundations.	No	1.0			
	Land cost	Reasonable	2.0			
Social	**Total Score for Social**		**12.5**			
	Are there any existing settlements in the project site.	No	4.0			
	Are there any existing settlements in the proposed pipeline corridors.	No	3.0			
	Are there any existing settlements in the proposed approach road Right of Way.	No	3.0			
	Any other R & R issues	Resolvable	2.5			
	Overall scoring					

4.6.2 Site Selection

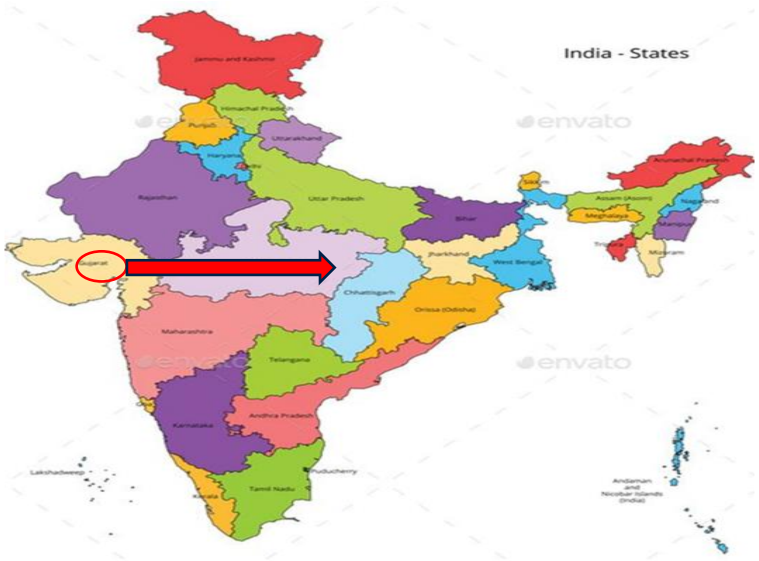
4.6.2.1 Gujarat - Mandvi

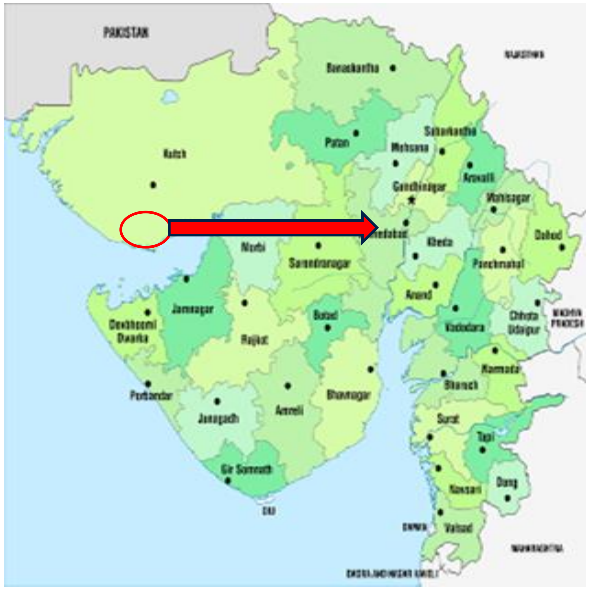
Gujarat has been selected as one of the four locations considered for the Ripid, preliminary assessment as already discussed in Chapter 1.4.

Within Gujarat, the Mandvi has been selected as it has a favourable seashore for the construction of desalination plants and also has enough land for industries in the vicinity for the development of GH2/PtX plants. There are already desalination plants under construction nearby. GoI has planned to develop Deenthayal Port (Kutch) as a green hydrogen / Ammonia hub.

It is also to be noted that many Fertilizers and chemical industries are in Gujarat, so there is a demand for green Hydrogen / Ammonia. The land in the vicinity of Gundiyali Village at Mandvi Taluka, Kutch District is taken for a site evaluation.

India – Gujarat – Mandvi





PROJECT SITE - MANDVI, GUJARAT, INDIA

Table 4-7 – Offshore Assessment Criteria for Gujarat State

	Basic assessment criteria			Site Specific evaluation – Mandvi, Gujarat.		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50		44.5	
Technical	**Total score for Technical**		**12.5**		**11.0**	
	Approximate distance of intertidal zone	< 1000 m	2.0	< 1000	2.0	
	The proposed intake location is away from the estuary/river mouth meeting the sea	> 2000 m	1.0	2000 m >	1.0	
	The proposed intake location is away from the passageway & boating corridors.	Yes	2.5	Yes	2.5	
	Approximate length of Intake pipeline length	< 2000 m	2.5	2100 m	2.0	
	Is the outfall location having enough depth of water	>6.5m	2.0	> 4.5 m	1.5	
	Approximate length of outfall pipeline	< 2000 m	2.5	2600 m	2.0	
Environmental	**The total score of Environmental**		**12.5**		**11.0**	
	Is the intake location in the CRZ 1A	No	2.5	No	2.5	
	Is intake & outfall pipeline cross CRZ 1A –	No	2.0	Yes	1.0	
	Region influenced by high littoral drift	No	2.0	No	2.0	
	Width of wave breaking zone in monsoon	< 450 m	0.5	Yes	0.5	

	Basic assessment criteria			Site Specific evaluation – Mandvi, Gujarat.		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50		44.5	
	Presence of other intakes/ Outfalls in the vicinity	Case to case	0.5	Under construction	0.5	
	Presence of coastal structures if any	Subjective	1.0	No	1.0	
	Occurrences of cyclones and tsunamis	Historical	2.0	Not much	1.5	Only one cyclone occurs within 25 km radius from 1918 to 2017.
	Are the Offshore facilities away from the marine national reserves etc	>10 km	2.0	No	2.0	No marine national park available within 25 km
Economical	**Total score for Economical**		**12.5**		**10.5**	
	Is the seabed being rocky or clay	No	4.5	No	4.5	
	Possible type of Intake and its impact on project economic	Channel Intake/ /offshore Intake onshore pumphouse/ Offshore pumphouse with trestle	8.0 / 6.0 / 4.0	offshore Intake onshore	6.0	
Social	**Total score for Social**		**12.5**		**12.0**	
	Will offshore facilities affect nearby fishing and other communities?	No	6.0	No	6.0	

	Basic assessment criteria			Site Specific evaluation – Mandvi, Gujarat.		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50		44.5	
	Are there any objections expected from the local communities for the proposed projects.	No	6.5	No	6.0	

Table 4-8 – Onshore Assessment Criteria for Gujarat State

	Basic assessment criteria			Site Specific evaluation – Mandvi, Gujarat		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
II	Onshore – (Land related)		50		46.5	
Technical	**Total Score for Technical**		**12.5**		**11.0**	
	Land – Area availability	Adequate	2.5	Adequate	2.5	
	Land availability of GH2/PtX plant nearby.	Adequate	2.0	Adequate	2.0	Industrial Park land available - In Mandvi
	Accessibility - Distance from nearby town / Highway	Available / shall be created / Not possible	2.0 / 1.0 / 0.0	Available	1.5	
	Is the topography of the plant site being above the Highest Astronomical Tide HAT	Yes	1.5	Yes	1.5	
	Is the Sub-soil condition suitable for a normal foundation	Yes	1.5	Yes	1.5	
	Access to the power grid sub-station	Yes	1.0	Yes	1.0	
	What is the Seismic zone of the project area	Zone 2 / 3 / 4 / 5	1.0 / 0.75 / 0.5 /0.0	5	0.0	

	Basic assessment criteria			Site Specific evaluation – Mandvi, Gujarat		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
II	Onshore – (Land related)		50		46.5	
	Is there any possibility of geo risk in the proposed site	No	1.0	No	1.0	
	Total Score for Environmental		**12.5**		**12.0**	
Environmental	Is the project site (onshore pumphouse, desalination plant conveying mains) being in the CRZ IA	No	6.5	No	6.5	
	Are there any Monuments within 10 km radius of the project boundary?	No	4.0	No	4.0	
	Accessibility to Highway	Subjective	2.0	Yes available	1.5	
	Total Score for Economic		**12.5**		**11.5**	
Economical	Water Quality: Does the seawater require any special pre-treatment such as oil removal etc?	No.	2.0	No	2.0	No oil, Grease, heavy metals etc.
	Is the TDS being above the normal range	< 45000 ppm	3.0	In the range of 45,500 ppm to 46,500 ppm	2.5	
	Is the TSS being above the normal range	< 500 ppm	2.0	< 500 ppm	2.0	

	Basic assessment criteria			Site Specific evaluation – Mandvi, Gujarat		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
II	Onshore – (Land related)		50		46.5	
	Is any site filling is required to raise the FGL	No	1.5	No	1.5	
	Distance of the proposed GH2/PtX plant from the desalination plant	Reasonable	1.0	Available in the Kutch	0.5	Land available nearby for small to medium size GH2/PtX plant.
	Is the sub-soil being poor requires special foundations.	No	1.0	No	1.0	
	Land cost	Reasonable	2.0	Reasonable	2.0	
Social	**Total Score for Social**		**12.5**		**12.0**	
	Are there any existing settlements on the project site?	No	4.0	No	4.0	
	Are there any existing settlements in the proposed pipeline corridors?	No	3.0	No	3.0	
	Are there any existing settlements in the proposed approach road Right of Way.	No	3.0	No	3.0	
	Any other R & R issues	Resolvable	2.5	Resolvable	2.0	May not be much
	Overall scoring					

Observation / Conclusion:

- By the above criteria evaluation, the total score is 91.50 out of 100.
- For offshore facilities, the score is 44.5 out of 50.0. The major variations are in the environmental & economical. The offshore intake and onshore pumphouse. The Intake & outfall pipeline may need to cross the sand dune which is classified as CRZ 1A.
- For onshore facilities, the score is 46.5 out of 50.0. Here the little concern is the Mandvi is in Seismic zone 5 and the availability of land for GH2/PtX may not be very near.
- Govt. of Gujarat has already issued a policy for the allotment of land for GH2/PtX plants and this will help to develop GH2/PtX plants in the Kutch district.
- Already Gujarat is producing about 19,000 MW of green energy.
- There are many Steel plants, Fertilizers, and chemical industries in Gujarat and hence the demand for Greeh Hydrogen and ammonia is there.

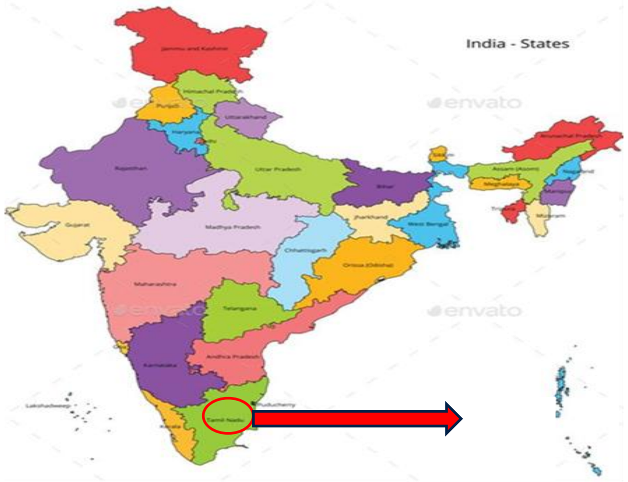
4.6.2.2 Tamil Nadu - Tuticorin

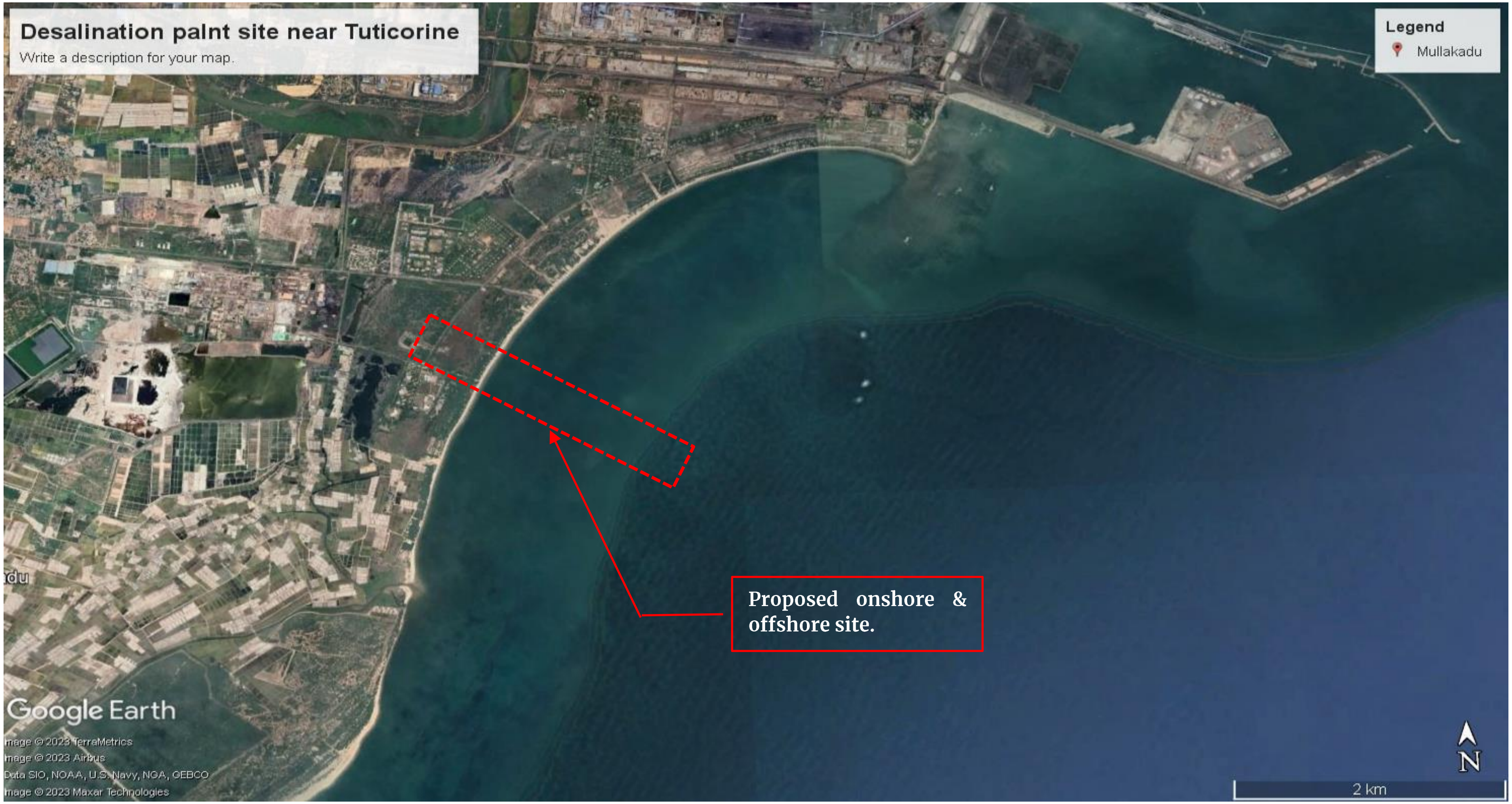
Tamil Nadu has been selected as one of the four locations considered for the Ripid, preliminary assessment as already discussed in Chapter 1.4.

Within Tamil Nadu, Tuticorin has been selected as it has a favourable seashore for the construction of desalination plants and also has enough land for industries in the vicinity for the development of GH2/PtX plants. It is also to be noted that GoI has proposed to develop a Green Hydrogen hub at VOC Port, Tuticorin.

It is also to be noted there are Fertilizers and chemical industries in Tuticorin and hence the requirement of Hydrogen / Ammonia is there. The land in the vicinity of Tuticorin is taken for a site evaluation.

India – Tamil Nadu – Tuticorin





PROJECT SITE - TUTICORIN, TAMIL NADU - INDIA

Table 4-9 – Offshore Assessment Criteria for Tamil Nadu State

	Basic assessment criteria			Site Specific evaluation – Tuticorin, Tamil Nadu		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50		41.5	
Technical	**Total score for Technical**		**12.5**		**11.0**	
	Approximate distance of intertidal zone	< 1000 m	2.0	<100 m	2.0	The intertidal zone is minimal
	The proposed intake location is away from the estuary/river mouth meeting the sea.	> 2000 m	1.0	Yes	1.0	There is no river mouth near the project site.
	The proposed intake location is away from the passageway & boating corridors.	Yes	2.5	Yes	2.5	
	Approximate length of Intake pipeline length	< 2000 m	2.5	< 2000 m	2.5	
	Is the outfall location having enough depth of water	>6.5m	2.0	> 8.0 m	2.0	
	Approximate length of outfall pipeline	< 2000 m	2.5	> 2000 m	1.0	.
Environmental	**The total score of Environmental**		**12.5**		**10.5**	
	Is the intake location in the CRZ 1A	No	2.5	No	2.5	
	Do intake & outfall pipeline cross CRZ 1A	No	2.0	Yes	1.0	
	Region influenced by high littoral drift	No	2.0	No	2.0	
	Width of wave breaking zone in monsoon	< 450 m	0.5	<450	0.5	
	Presence of other intakes/ Outfalls in the vicinity	Case to case	0.5	No	0.5	No intake/outfall near the proposed location

	Basic assessment criteria			Site Specific evaluation – Tuticorin, Tamil Nadu		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50		41.5	
	Presence of coastal structures if any	Subjective	1.0	Port	1.0	The Tuticorin port is at about 4.5km from the intake location.
	Occurrences of cyclones and tsunamis	Historical	2.0	Occurrences are there	1.0	Tuticorin is also on the list of tsunami-prone areas.
	Are the Offshore facilities away from the marine national reserves etc.,	>10 km	2.0	Yes	2.0	
Economical	**Total score for Economical**		**12.5**		**9.5**	
	Is the seabed being rocky or clay	No	4.5	Yes	3.5	Rocky outcrops are found in patches. However, some corridors can avoid the rocky zone.
	Possible type of Intake and its impact on project economic	Channel Intake/ /offshore Intake onshore pumphouse/ Offshore pumphouse with trestle	8.0 / 6.0 / 4.0	Offshore intake onshore pumphouse.	6.0	
Social	**Total score for Social**		**12.5**		**10.5**	
	Will offshore facilities affect nearby fishing and other communities?	No	6.0	No	5.0	Temporary impact during construction. No impact during operation period of the plant.

	Basic assessment criteria			Site Specific evaluation – Tuticorin, Tamil Nadu		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50		41.5	
	Are there any objections expected from the local communities for the proposed projects?	No	6.5	No	5.5	Not expected as the project is expected to generate employment both during construction and during the O&M period.

Table 4-10 – Onshore Assessment Criteria for Tamil Nadu State

	Basic assessment criteria			Site Specific evaluation – Tuticorin, Tamil Nadu		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
II	Onshore – (Land related)		50		47.5	
Technical	**Total Score for Technical**		**12.5**		**11.5**	
	Land – Area availability	Adequate	2.5	Adequate	2.5	
	Land availability of GH2/PtX plant nearby.	Adequate	2.0	Adequate	2.0	1000 acres of Industrial lands are available for sale by SPICOT
	Accessibility - Distance from nearby town / Highway	Available / shall be created / Not possible	2.0 / 1.0 / 0.0	Available	2.0	
	Is the topography of the plant site being above the Highest Astronomical Tide HAT	Yes	1.5	Yes	1.5	
	Is the Sub-soil condition suitable for a normal foundation	Yes	1.5	No	0.5	Shallow depth soil is weak hence special foundations may be required.
	Access to the power grid sub-station	Yes	1.0	Yes	1.0	
	What is the Seismic zone of the project area	Zone 2 / 3 / 4 / 5	1.0 / 0.75 / 0.5 /0.0	2	1.0	

	Basic assessment criteria			Site Specific evaluation – Tuticorin, Tamil Nadu		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
II	Onshore – (Land related)		50		47.5	
	Is there any possibility of geo risk in the proposed site	No	1.0	No	1.0	
Environmental	**Total Score for Environmental**		**12.5**		**12.5**	
	Is the project site (onshore pumphouse, desalination plant conveying mains) being in the CRZ IA	No	6.5	No	6.5	
	Are there any Monuments within a 10 km radius of the project boundary?	No	4.0	No	4.0	
	Accessibility to Highway	Subjective	2.0	Available	2.0	
Economical	**Total Score for Economic**		**12.5**		**12.0**	
	Water Quality: Does the seawater require any special pre-treatment such as oil removal etc?	No	2.0	No	2.0	No oil, Grease, heavy metals etc.
	Is the TDS being above the normal range	< 45000 ppm	3.0	About 35000 ppm	3.0	
	Is the TSS being above the normal range	< 500 ppm	2.0	34 ppm	2.0	
	Is any site filling is required to raise the FGL	No	1.5	No	1.5	

	Basic assessment criteria			Site Specific evaluation – Tuticorin, Tamil Nadu		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
II	Onshore – (Land related)		50		47.5	
	Distance of the proposed GH2/PtX plant from the desalination plant	Reasonable	1.0	Reasonable	1.0	
	Does the subsoil be poor and require special foundations?	No	1.0	Yes	0.5	
	Land cost	Reasonable	2.0	Reasonable	2.0	
Social	**Total Score for Social**		**12.5**		**11.5**	
	Are there any existing settlements on the project site?	No	4.0	No	4.0	
	Are there any existing settlements in the proposed pipeline corridors?	No	3.0	No	3.0	
	Are there any existing settlements in the proposed approach road Right of Way?	No	3.0	No	2.5	Approach roads are available nearby
	Any other R & R issues	Resolvable	2.5	Yes	2.0	
	Overall scoring				**89.0**	

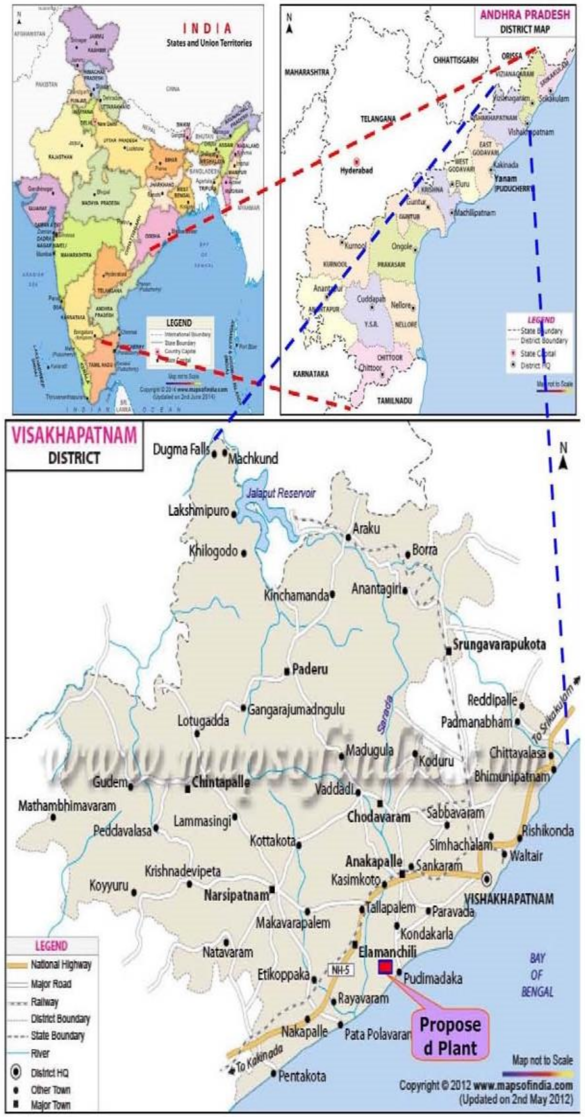
Observation / Conclusion:

- By the above criteria evaluation, the total score is 89.0 out of 100.
- For `offshore facilities, the score is 41.5 out of 50.0. The major variations are in the economical as the sea bed has rock outcrops and the offshore site is not suitable for channel intake. The Tuticorin area has having large fishing community and even though the offshore facilities does not affect the fishing community much, there may be some objections that can be resolved through proper public hearing.
- For onshore facilities, the score is 47.5 out of 50.0. Here the little concern is the sub-soil condition at shallow depth is weak and a special/deep foundation may be needed for major plant components which may increase the plant cost to some extent.
- There are about 1000 acres of industrial land available for sale by SIPCOT and hence the GH2/PtX plant can be established nearby. The desalinated water can be conveyed through the pipeline from the desalination plant to the GH2/PtX plant.
- It may not be possible to establish Renewable Energy plants (Solar / Wind) near the desalination plant. However, such green energy shall be drawn from the power grid.
- The government of India has proposed to develop a hydrogen hub in the VOC port as a hub for Green Hydrogen / Ammonia.
- There are Fertilizer and chemical industries available in the Tuticorin which also will be a major consumer of Green Hydrogen / Green Ammonia.
- Therefore, the site near Tuticorin is considered suitable for a medium-sized GH2/PtX plant of 1000 MW.

4.6.2.3 Andra Pradesh - Pudimadaka

Adhara Pradesh has been selected as one of the four locations considered for the Rapid, preliminary assessment. Further for detailed criteria evaluation for one site Pudimadaka in Andhara Pradesh is selected.

As NTPC Green Energy Limited (NGEL) a subsidiary of National Thermal Power Corporation (NTPC) is proposed to develop a Green Hydrogen hub in Pudimadaka. NGEL has already acquired about 1200 acres near Pudi village next to APIIC Multiple Product SEZ, Atchutapuram. This GH2/PtX hub requires a 60 MLD desalination plant.



The highlights of this Project site are:

- The site is located in Pudimadaka, in the Anakapalle Taluk of Visakhapatnam.
- It is near to AP state Highway 154 and is 42 km from Visakhapatnam
- The nearest Airport & Seaport is at Visakhapatnam.
- The total area of the Project site is about 1200 acres
- The project site is protected with a compound wall of a total length of about 12 km.
- The nearby sea fronts from the Project site are Chippada Beach, Pudimadaka Beach, and Lovapalem Beach.
- The Road leading to Pudimadaka Beach passes through thickly populated villages and Pudimadaka Beach is also having a lot of settlements.
- The road leading to Lovapalem Beach passes through a few small habitations.
- The road leading to Chippada Beach is not cross any settlements.
- This Project site has provisions for various integrated facilities for the production of GH2/PtX production and covers the following:
    - Solar Module manufacturing Units
    - Electrolyzer Manufacturing Units
    - BESS Manufacturing Units
    - Green Ammonia Production plants
    - Central Business District (CBD) with Administration Building
    - Two Sub-stations of 2500 MW each
    - 60 MLD desalination plant
    - Water Treatment plants & storage reservoirs
    - Common effluent treatment plant
    - Space for other small industries

- Space for Green Belt etc.

Figure – Showing Project Location

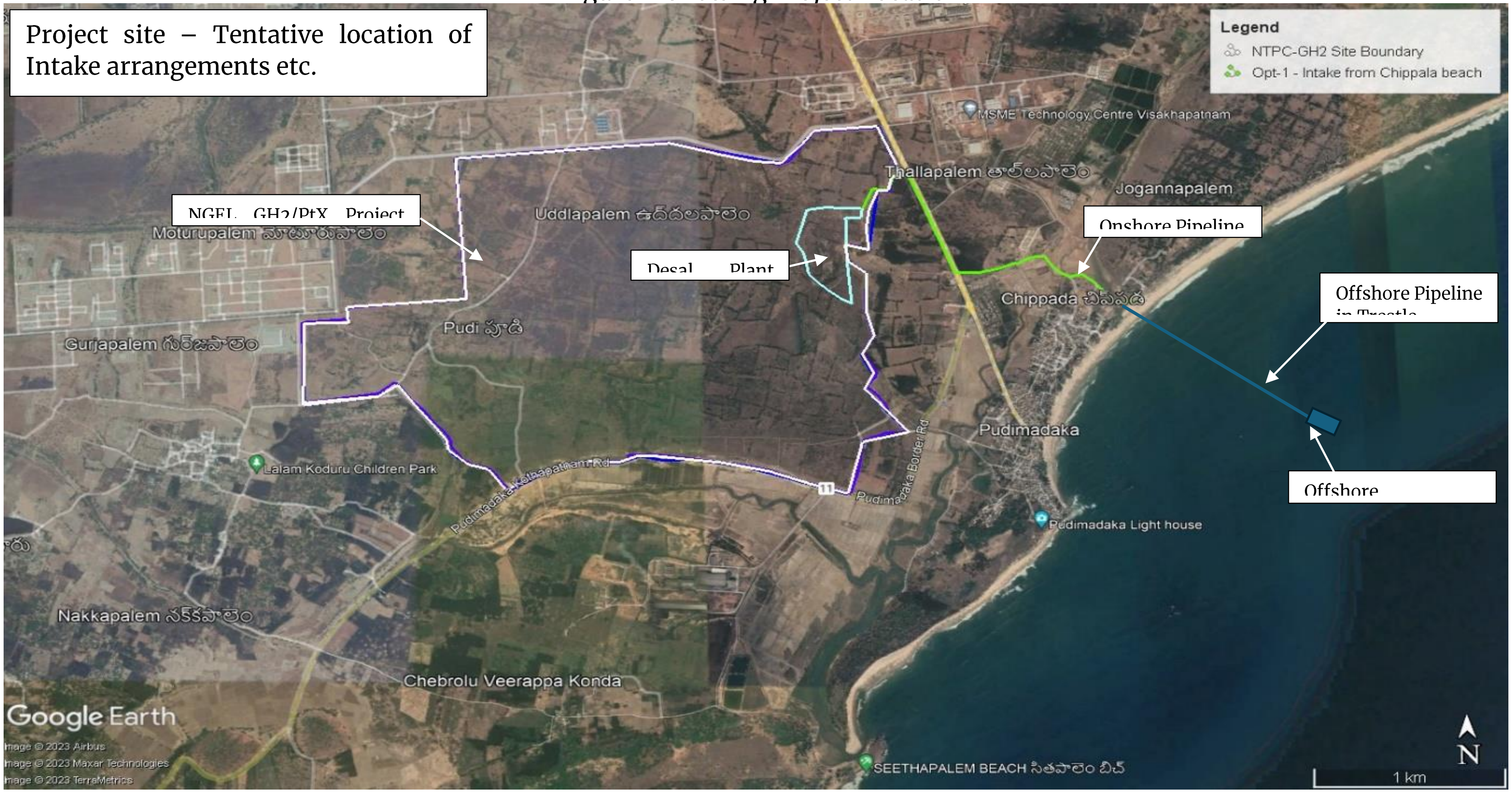
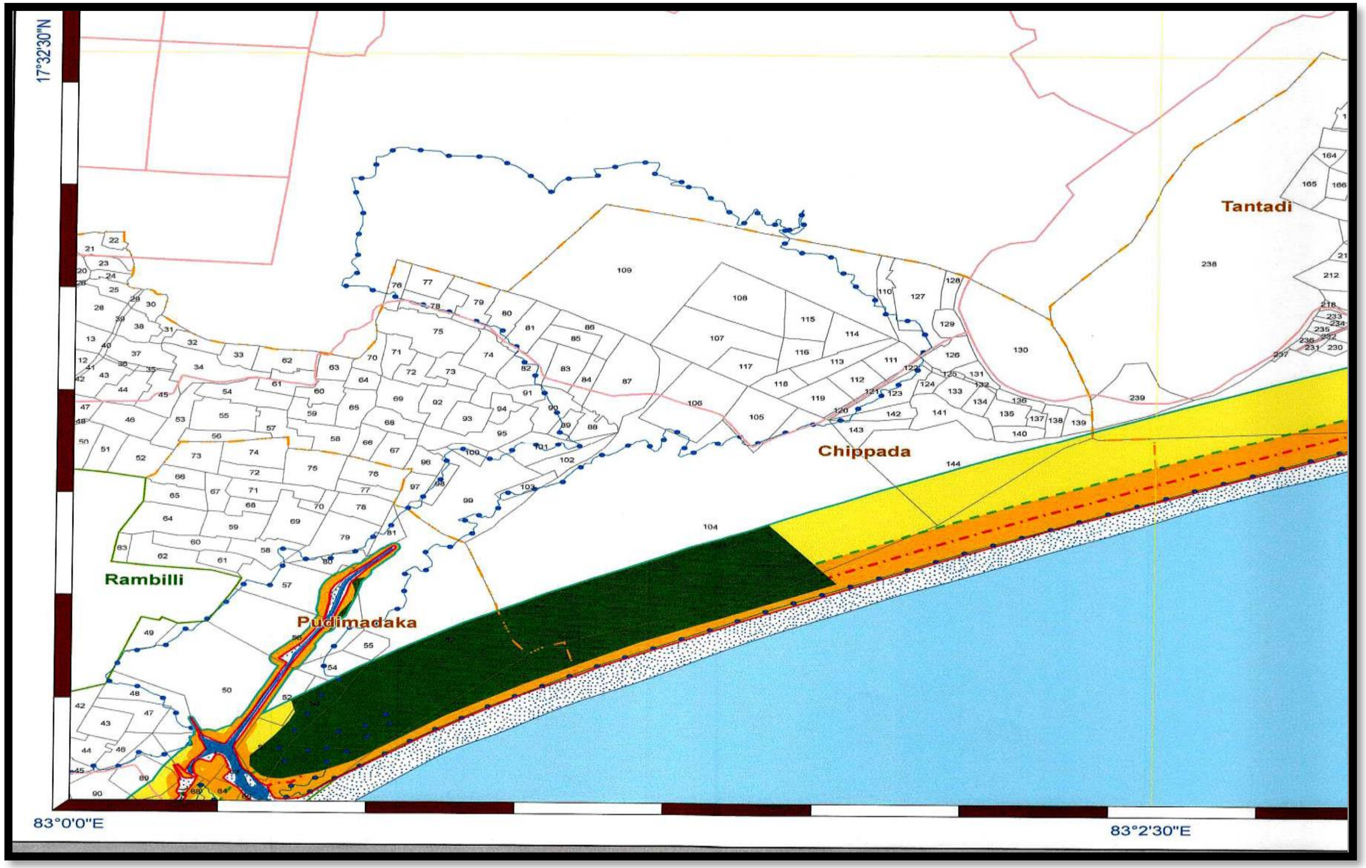
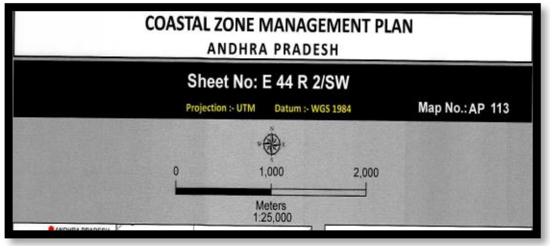
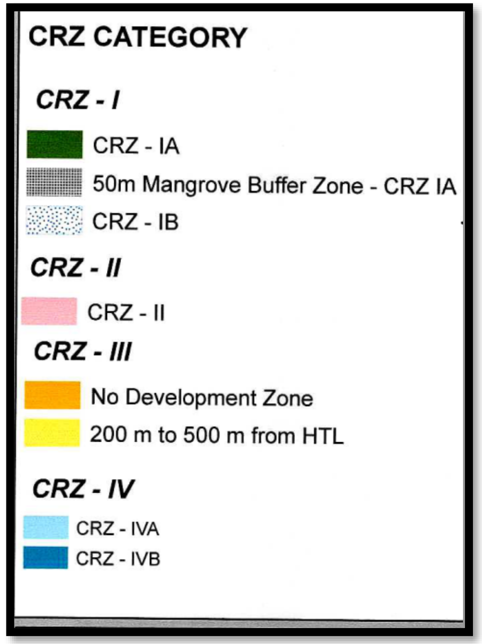


Figure - showing the tentative location of Project site, Offshore Intake Pumphouse, Onshore & Offshore pipelines.

Note: The above figure is only an indicative. All the above components need to be finalized based on the detailed onshore & offshore field studies and Front-End Engineering and Design (FEED). Detailed EIA & CRZ studies to be done by Authorized agencies.


17°32'30"N
Tantadi
Chippada
Rambilli
Pudimadaka
83°0'0"E
83°2'30"E





Extract from Coastal Zone Management Plan, Andhra Pradesh Sheet No. E44 R 2/SW, Map No. 113

Table 4-11– Offshore Assessment Criteria for Andhra Pradesh

Basic assessment criteria				Site Specific evaluation – Pudimadaka, Andhra Pradesh		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50		41.5	
Tec hnic	**Total score for Technical**		12.5		11.5	

	Basic assessment criteria			Site Specific evaluation – Pudimadaka, Andhra Pradesh		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50		41.5	
	Approximate distance of intertidal zone	< 1000 m	2.0	< 1000 m	2.0	
	Proposed intake location is away from estuary / river mouth meeting the sea	> 2000 m	1.0	> 2000 m	1.0	
	Proposed intake location is away from passageway & boating corridors.	Yes	2.5	Yes	2.0	
	Approximate length of Intake pipeline length	< 2000 m	2.5	< 2000 m	2.5	Offshore intake pumphouse
	Is the outfall location having enough depth of water	> 6.5m	2.0	> 6.5 m	2.0	
	Approximate length of outfall pipeline	< 2000 m	2.5	> 2000 m	2.0	
Environmental	**Total score of Environmental**		**12.5**		**11.5**	
	Is intake location being in the CRZ 1A	No	2.5	No	2.5	
	Do intake & outfall pipeline cross CRZ 1A	No	2.0	No	2.0	

	Basic assessment criteria			Site Specific evaluation – Pudimadaka, Andhra Pradesh		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50		41.5	
	Region influenced by high littoral drift	No	2.0	No	2.0	An offshore intake pumphouse is suitable
	Width of wave breaking zone in monsoon	< 450 m	0.5	< 450	0.5	To be confirmed
	Presence of other intakes/ Outfalls in the vicinity	Case to case	0.5	There are few intake & outfall	0.5	Existing intake & outfall may not have any influence on the new intake.
	Presence of coastal structures if any	Subjective	1.0	No	1.0	
	Occurrences of cyclones and tsunamis	Historical	2.0	Cyclone prone area	1.0	
	Are the Offshore facilities being away from the marine national reserves etc	> 10 km	2.0	> 10 km	2.0	
Economical	**Total score for Economical**		**12.5**		**7.5**	
	Is the seabed being rocky or clay	No	4.5	rocky exposures & promontories are conspicuous	3.5	Open cutting and pipelaying may be difficult. But offshore intake pumphouse with pipeline on trestle is O.K.

	Basic assessment criteria			Site Specific evaluation – Pudimadaka, Andhra Pradesh		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50		41.5	
	Type of Intake and its impact on project economic	Channel Intake/ /offshore Intake onshore pumphouse/ Offshore pumphouse with trestle	8.0 / 6.0 / 4.0	offshore Intake onshore pumphouse	4.0	
Social	**Total score for Social**		**12.5**		**11.0**	
	Will offshore facilities affect nearby fishing and other communities?	No	6.0	No	5.5	Need detailed social impact assessment
	Are there any objections expected from the local communities for the proposed projects.	No	6.5	No	5.5	Need detailed social impact assessment

Table 4-12 – Offshore Assessment Criteria for Andhra Pradesh

	Basic assessment criteria			Site Specific evaluation – Pudimadaka, Andhra Pradesh		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
II	Onshore – (Land related)		50		48.5	
Technical	**Total Score for Technical**		**12.5**		**12.0**	
	Land – Area availability	Adequate	2.5	Adequate	2.5	
	Land availability of GH2/PtX plant nearby.	Adequate	2.0	Adequate	2.0	
	Accessibility - Distance from nearby town / Highway	Available / shall be created / Not possible	2.0 / 1.0 / 0.0	Available	2.0	
	Is the topography of plant site being above Highest Astronomical Tide HAT	Yes	1.5	Yes	1.5	
	Is the Sub-soil condition being suitable for normal foundation	Yes	1.5	No	1.0	Detailed Geotechnical investigation to be done
	Access to the power grid sub-station	Yes	1.0	Yes	1.0	
	What is the Seismic zone of the project area	Zone 2 / 3 / 4 / 5	1.0 / 0.75 / 0.5 /0.0	2	1.0	

	Basic assessment criteria			Site Specific evaluation – Pudimadaka, Andhra Pradesh		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
II	Onshore – (Land related)		50		48.5	
	Is there any possibility of geo risk on the proposed site?	No	1.0	No	1.0	Need detailed investigation.
Environmental	**Total Score for Environmental**		**12.5**		**12.5**	
	Is the project site (onshore pumphouse, desalination plant conveying mains) being in the CRZ IA	No	6.5	No	6.5	
	Is there any Monuments within 10 km radius from the project boundary.	No	4.0	No	4.0	
	Accessibility to Highway	Subjective	2.0	Available	2.0	Nearby SH 154
Economical	**Total Score for Economic**		**12.5**		**11.5**	
	Water Quality: Does the sea water require any special pre-treatment such as oil removal etc.	No.	2.0	No	2.0	Detailed water quality test to be done
	Is the TDS being above the normal range	< 45000 ppm	3.0	<52000 ppm	2.0	
	Is the TSS being above the normal range	< 500 ppm	2.0	< 500 ppm	2.0	

	Basic assessment criteria			Site Specific evaluation – Pudimadaka, Andhra Pradesh		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
II	Onshore – (Land related)		50		48.5	
	Is any site filling is required to raise the FGL	No	1.5	Site grading may be required	1.5	
	Distance of proposed GH2/PtX plant from the desalination plant	Reasonable	1.0	Inside the project area	1.0	
	Is the sub-soil being poor requires special foundations.	No	1.0	No	1.0	Detailed Geo-Technical investigation required
	Land cost	Reasonable	2.0	Already acquired	2.0	
Social	**Total Score for Social**		**12.5**		**12.5**	
	Are there any existing settlements in the project site.	No	4.0	No	4.0	
	Are there any existing settlements in the proposed pipeline corridors.	No	3.0	No	3.0	
	Are there any existing settlements in the proposed approach road Right of Way.	No	3.0	Site is near to Ap SH 154	3.0	
	Any other R & R issues	Resolvable	2.5	No. Site is already protected with compound wall	2.5	
	Overall scoring					

Observation / Conclusion:

- By the above criteria evaluation, the total score is 90 out of 100.

- For offshore facilities, the score is 41.5 out of 50.0. The major variations is in the economy, as offshore has rock exposures and here the offshore intake pump house is recommended.
- For onshore facilities, the score is 48.5 out of 50.0. Here the little concern is the higher TDS of sea water which may increase the CPAEX & OPEX to some extent.
- There are about 1200 acres of land is already acquired and GH2/PtX plants along with the manufacturing of Electrolyzer and BESS units are also proposed. The proposed 60 MLD desalination plant will be within the NGEL project site.
- It may not be possible to establish renewable energy plants (Solar / Wind) near desalination plants. However, such green energy should be drawn from the power grid. The promotor of this project, NTPC, has already had production of more than 5000 MW of RE and it targets 60 GW of RE production in 2032.
- The nearby Vizag port should be developed and used for the export of Green Ammonia.
- There are Fertilizers and steel plants in the Visakhapatnam district and hence the demand for Green Hydrogen & Ammonia is there.

Hence, it is concluded that this NGEL GH2/PtX Project site at Pudimadaka, Andhra Pradesh is suitable to produce GH2/PtX production and desalinated water shall be produced through the SWRO captive desalination plant.

4.6.2.4 Odisha-Konark

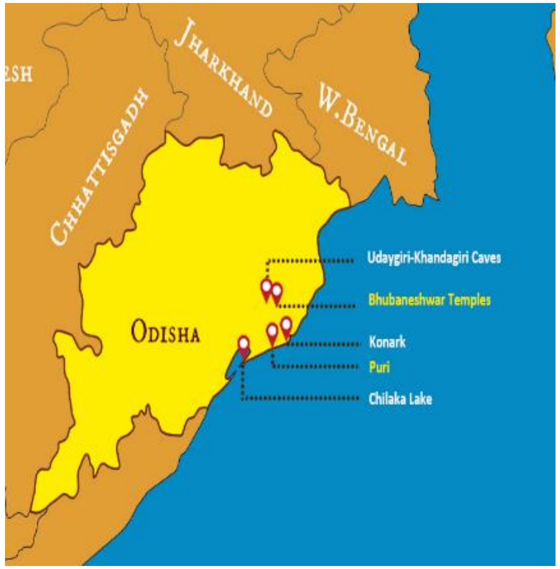
Odisha has been selected as one of the four locations considered for the Rapid, preliminary assessment as already discussed in Chapter 1.4.

GoI has proposed to develop a Green Hydrogen hub at Paradip Port.

Within Odisha, the Konark Village has been selected as it has about 90 acres of land that can be used for a Desalination plant. There are about 1056 acres of land available near Jatni village that can be used for GH2/PtX plant.

It is also to be noted there are Steel and aluminium plants and Fertilizers in Odisha and hence there is demand for Green Hydrogen / Ammonia.

India – Odisha – Konark (Puri district)



Proposed Desalination Plant near Konark Village and onshore Intake pumphouse near beach.

Table 4-13 – Offshore Assessment Criteria for Odisha State

	Basic assessment criteria			Site Specific evaluation – Konark, Odisha		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50		38.0	
Technical	**Total score for Technical**		**12.5**		**10.5**	
	Approximate distance of intertidal zone	< 1000 m	2.0	<1000 m	2.0	
	The proposed intake location is away from the estuary/river mouth meeting the sea	> 2000 m	1.0	Yes	1.0	
	The proposed intake location is away from the passageway & boating corridors.	Yes	2.5	Yes	2.5	
	Approximate length of Intake pipeline length	< 2000 m	2.5	> 2000 m	1.5	
	Is the outfall location having enough depth of water	>6.5m	2.0	> 6.5 m	2.0	
	Approximate length of outfall pipeline	< 2000 m	2.5	> 2000 m	1.5	
Environ mental	**The total score of Environmental**		**12.5**		**9.5**	
	Is the intake location in the CRZ 1A	No	2.5	No	2.5	

	Basic assessment criteria			Site Specific evaluation – Konark, Odisha		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50		38.0	
	Do intake & outfall pipeline cross CRZ 1A	No	2.0	Yes	1.0	May cross CRZ 1A. However, by detailed site survey, this can be minimized.
	Region influenced by high littoral drift	No	2.0	Moderate	1.0	Can be checked and located the Intake suitably.
	Width of wave breaking zone in monsoon	< 450 m	0.5	< 450	0.5	
	Presence of other intakes/ Outfalls in the vicinity	Case to case	0.5	No	0.5	
	Presence of coastal structures if any	Subjective	1.0	No	1.0	
	Occurrences of cyclones and tsunamis	Historical	2.0	Subjective	1.0	Odisha is prone to cyclone
	Are the Offshore facilities away from the marine national reserves etc	> 10 km	2.0	> 10 km	2.0	
Economical	**Total score for Economical**		**12.5**		**10.0**	
	Is the seabed being rocky or clay	No	4.5	No	4.0	Seabed is mostly dense silty sand
	Possible type of Intake and its impact on project economic	Channel Intake/ /offshore Intake onshore pumphouse/ Offshore pumphouse with trestle	8.0 / 6.0 / 4.0	Offshore Intake onshore pumphouse	6.0	

	Basic assessment criteria			Site Specific evaluation – Konark, Odisha		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
I	Offshore - (Sea related)		50		38.0	
Social	**Total score for Social**		**12.5**		**8.0**	
	Will offshore facilities affect nearby fishing and other communities?	No	6.0	May be	4.0	This is both a fishing and tourist area
	Are there any objections expected from the local communities for the proposed projects?	No	6.5	Yes	4.0	

Table 4-14 – Onshore Assessment Criteria for Odisha State

	Basic assessment criteria			Site Specific evaluation – Paradip, Odisha		
	Factors / Characteristics	**Selection Criteria**	**Scoring**	**Value / Info**	**Score**	**Remarks**
II	**Onshore – (Land related)**		**50**		**37.25**	
Technical	**Total Score for Technical**		**12.5**		**10.25**	
	Land – Area availability	Adequate	2.5	Adequate	2.0	90 acres available in Konark village at about 2.5 km from the seafront.
	Land availability of GH2/PtX plant nearby.	Adequate	2.0	Adequate	1.0	1056 acres available in Jatin.
	Accessibility - Distance from nearby town / Highway	Available / shall be created / Not possible	2.0 / 1.0 / 0.0	Available	2.0	
	Is the topography of the plant site above the Highest Astronomical Tide HAT	Yes	1.5	Yes	1.5	
	Is the Sub-soil condition suitable for a normal foundation	Yes	1.5	Yes	1.0	Enough data is not available for the site.
	Access to the power grid sub-station	Yes	1.0	Yes	1.0	
	What is the Seismic zone of the project area	Zone II / III / IV / V	1.0 / 0.75 / 0.5 /0.0	Zone III	0.75	
	Is there any possibility of geo risk in the proposed site	No	1.0	No	1.0	No specific data is available
Envi ron	**Total Score for Environmental**		**12.5**		**9.0**	

Basic assessment criteria				Site Specific evaluation – Paradip, Odisha		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
II	Onshore – (Land related)		50		37.25	
	Is the project site (onshore pumphouse, desalination plant conveying mains) being in the CRZ IA	No	6.5	No	6.0	
	Are there any Monuments within a 10 km radius of the project boundary?	No	4.0	Yes	1.0	
	Accessibility to Highway	Subjective	2.0	Yes	2.0	
Economical	**Total Score for Economic**		**12.5**		**11.5**	
	Water Quality: Does the seawater require any special pre-treatment such as oil removal etc?	No	2.0	No	2.0	No oil, Grease, heavy metals etc.
	Is the TDS being above the normal range	< 45000 ppm	3.0	<42000 ppm	3.0	
	Is the TSS being above the normal range	< 500 ppm	2.0	Very less	2.0	
	Is any site filling required to raise the FGL	No	1.5	No	1.5	
	Distance of the proposed GH2/PtX plant from the desalination plant	Reasonable	1.0	Land available away from desalination plant site	0	The site available for GH2/PtX plant is about 50 km from proposed desalination plant

	Basic assessment criteria			Site Specific evaluation – Paradip, Odisha		
	Factors / Characteristics	Selection Criteria	Scoring	Value / Info	Score	Remarks
II	Onshore – (Land related)		50		37.25	
	Is the sub-soil being poor requires special foundations.	No	1.0	No	1.0	
	Land cost	Reasonable	2.0	Reasonable	2.0	
Social	**Total Score for Social**		**12.5**		**6.5**	
	Are there any existing settlements on the project site?	No	4.0	Possible	2.0	
	Are there any existing settlements in the proposed pipeline corridors?	No	3.0	Possible	1.5	Does not have clarity with available data.
	Are there any existing settlements in the proposed approach road Right of Way?	No	3.0	Possible	2.0	
	Any other R & R issues	Resolvable	2.5	Possible	1.0	
	Overall scoring				**86.0**	

Location: Konark Village, Puri District, Odisha.

Observation / Conclusion:

- By the above criteria evaluation, the total score is 75.25 out of 100.
- For offshore facilities, the score is 38 out of 50.0. The major variations are in all criteria. There is a need to pump Raw water from the onshore pump house to the desalination plant which is about 2.5 km away.
- For onshore facilities, the score is 37.25 out of 50.0. Here, land is a concern as the land available for the GH2/PtX plant is about 50 km from the desalination plant site.
- It may not be possible to establish Renewable Energy plants (Solar / Wind) near desalination plants. However, such green energy shall be drawn from the power grid.
- GoI has proposed to develop a Green Hydrogen hub at Paradip Port from where GH2/PtX products can be exported.
- Odisha state has Steel, Aluminium, and Fertiliser plants. Hence the demand for green hydrogen / Ammonia will be considerable.

4.7 Technical variations for some of the sites are deemed suitable.

1. The evaluation of the four locations reveals that there are no major technical variations between the four locations. The Type of Intake - Offshore intake with an onshore pumphouse is envisaged in three locations and in Andhra Pradesh offshore pump house is envisaged.
2. The technical variations between the sites will be the length of intake & outfall pipelines as it will depend on the water depth available at each location.
3. At the Odisha – Konark site, the onshore pumphouse will be near shore and the seawater will be pumped to a Desalination plant which may be about 2.5 km from the pumphouse, whereas in Gujarat – Mandivi and Tamil Nadu – Tuticorin sites, the onshore pumphouse will be within the desalination plant site.

Out of 4 locations, the Pudimadaka site in Andhra Pradesh has been identified to conduct preliminary environmental and social

5 ENVIRONMENTAL SOCIAL IMPACT ASSESSEMNT

In Chapter 4 the Criteria Evaluation was carried out for four sites in four states and based on further discussion with GIZ the Pudimadaka site in Andhra Pradesh was selected for the preparation of the EIA scoping report. This chapter covers the Environment & Social Impact Assessment scoping requirements.

A team from Fichtner India visited the identified site at Pudimadaka, Andhra Pradesh, and observed the site conditions. However, this report is prepared based on both visual assessment and various secondary data and will be a template/reference for the preparation of the ESIA report and not a complete ESIA report as such.

As per the CRZ Notification, issued by MOEF&CC, for obtaining necessary CRZ clearance certain documents are to be prepared and submitted and one such important document is the Environment Impact Assessment (EIA) report including marine and terrestrial components as applicable.

The report shall address mainly the following:

i) Guidelines for Environmental baseline data: Primary baseline data collection through field surveys and monitoring of terrestrial (air, noise, water, soil) and marine environment (seawater, seabed sediment, subtidal and intertidal benthos, ecology and biodiversity) and socio-economics in the study area. This data collection needs to be conducted through an authorized EIA consultant at the time of EIA study.

ii) Identification and prediction of environmental impacts and their mitigation measures.

iii) Disaster Management Plan, Risk Assessment, and Mathematical dispersion modeling studies.

iv) Preparation of an Environment Management Plan (EMP) and identify monitoring requirements for EMP.

5.1 ESIA Scoping Report

Environment Impact Assessment is a process used to identify the potential impact of the proposed project or its function on the environment, social and cultural values, and health. Scoping in Environmental Impact Assessment helps to identify the key issues and the potential impact that should be considered during the assessment process.

The purpose of ESIA studies is to verify the suitability of the location (both marine & terrestrial) for implementing the project with minimal adverse impact to the environment and recommend suitable mitigation measures to minimize the implications during the construction and operation phases. All the required studies shall be conducted to achieve the above and present to the statutory authority to obtain the EIA / CRZ clearance.

The study shall also include the social impact on neighboring villages, fishermen, etc on account of implementation of the project. This will include a temporary or permanent impact on the livelihood of the neighboring peoples. Recommend suitable mitigation measures.

The ESIA report will be prepared by the authorized agencies with the involvement of various professionals including environmental and social experts, and concerned engineers.

5.1.1 The Project & Location.

This site was selected as the project proponent has already acquired land for the development of an integrated GH2/PtX hub at Pudimadaka. This green hydrogen hub will have a capacity of 1200 TPD (tons per day).

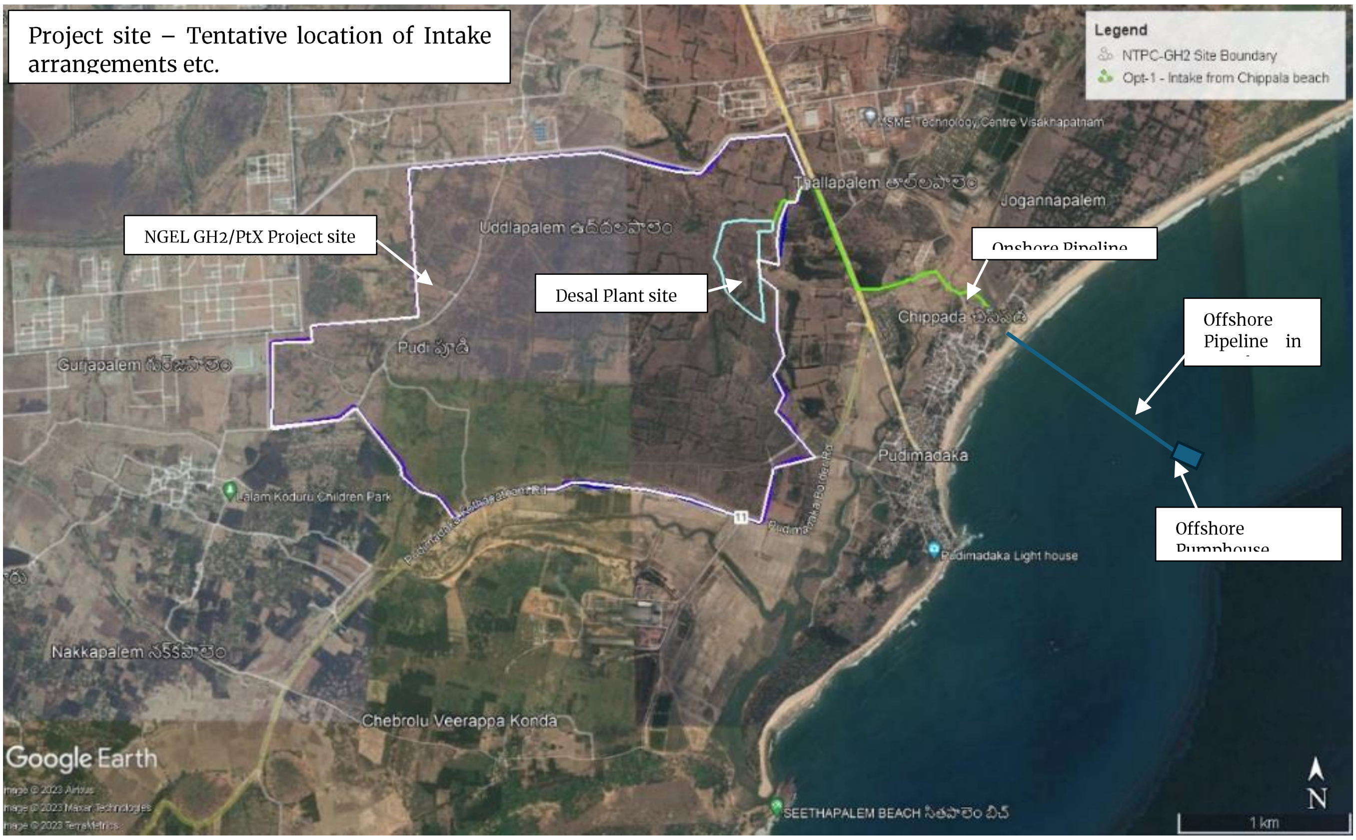
For the production of GH2/PtX, water is one of the essential inputs. As India is a water-scarce country the allocation of fresh water for the industries in coastal areas is not encouraged. Based on the information shared by the Project proponent a 60 MLD desalination plant is to be developed for the supply of desalinated water to GH2/PtX plants. The quantity of desalinated water may vary but the scoping being addressed will remain the same.

This preliminary ESIA report focuses only on the 60 MLD SWRO desalination plant which needs CRZ clearance as per CRZ Notification 2011 & 2019. It does not cover the Environmental clearance to be obtained for GH2/PtX plants and other supporting industries.

This proposed 60 MLD desalination Plant is proposed to be developed within the 1200 acres of land acquired by NGEL for the development of GH2/PtX plants and allied industries near Pudimadaka in Andhra Pradesh. The Location map of the proposed project site is given below:

Figure 5-1– *Location Map*

Figure 5-2 – *Showing the tentative location of* the *Project site, Offshore Intake Pumphouse, and Onshore & Offshore pipelines.*



Note: The above intake & Outfall locations are only indicative. These will be finalized based on the detailed onshore & offshore field studies and Front-End Engineering and Design (FEED). Detailed EIA & CRZ studies to be done by Authorized agencies.

The project has been planned to produce 60 MLD desalinated water through the SWRO process. For this purpose, about 150 MLD of seawater will be drawn from the sea near Chippada through an Offshore intake pumphouse with an intake pipeline through the trestle. The brine reject of about 90 MLD resulting from the process will be discharged into the sea where sufficient dilution is available. Major components of the project involve units such as an Offshore seawater pumphouse, trestle for carrying intake & Outfall pipeline and also for the access to the pumphouse, pretreatment unit, R.O. unit, post-treatment unit, desalinated water storage tank, etc.

5.1.2 Coastal Regulation Zone

The CRZ map has to be prepared by the approved agencies for the demarcation of HTL/LTL. The CRZ report on 'Demarcation of High Tide Line (HTL), Low Tide Line (LTL) and CRZ map for 60 MLD desalination plant in Pudimadaka, Andhra Pradesh' has to be prepared separately.

5.1.3 Structure of report.

The structure of the ESIA report is indicated below.

- Chapter 1: Introduction
- Chapter 2: Project Description
- Chapter 3: Selection of Intake and Outfall Location
- Chapter 4: Description of Environment & Social
- Chapter 5: Impact Assessment & Mitigation Measures
- Chapter 6: Post-Project Monitoring
- Chapter 7: Risk Assessment and Disaster Management Plan
- Chapter 8: Modelling Studies
- Chapter 9: Project Benefits
- Chapter 10: Environmental Management Plan

5.2 Project Description

5.2.1 Type of project

The Project proponent proposed to develop GH2/PtX plants along with supporting industries in Andhra Pradesh. To support the GH2/PtX project, it is proposing to establish a SWRO desalination plant of 60 MLD capacity to produce desalinated water. As part of the desalination plant, the establishment of different facilities such as a seawater intake pumphouse, intake pipeline over the trestle, intake water collection pond, pre-treatment unit, RO plant, brine reject outfall pipeline and diffuser system will be constructed in the allocated land within 1200 acres of project site Pudimadaka.

5.2.2 Need for the Project

To become self-reliant in energy by 2047 and achieve net zero by 2070, the Government of India (GoI) is implementing the Green Hydrogen mission.

Substituting the present use of hydrogen with production from renewable sources, particularly in the industrial sector and transportation sectors, will be an important step in India's green transition.

To adopt the above policy Project proponent has proposed to develop a Green Hydrogen Hub with a captive 60 MLD desalination plant near Pudimadaka, Andhra Pradesh. It already acquired 1200 acres of land for this project.

5.2.3 Project location

The project location is Pudi village, Pudimadaka Gram Panchayat, Atchutapuram block, Visakhapatnam district, Andhra Pradesh. It is near AP state Highway 154 and is 42 km from Visakhapatnam. The nearest Airport & Seaport is at Visakhapatnam. The total area of the Project site is about 1200 acres. Details of connectivity and salient features of the project site & surrounding area are presented below,

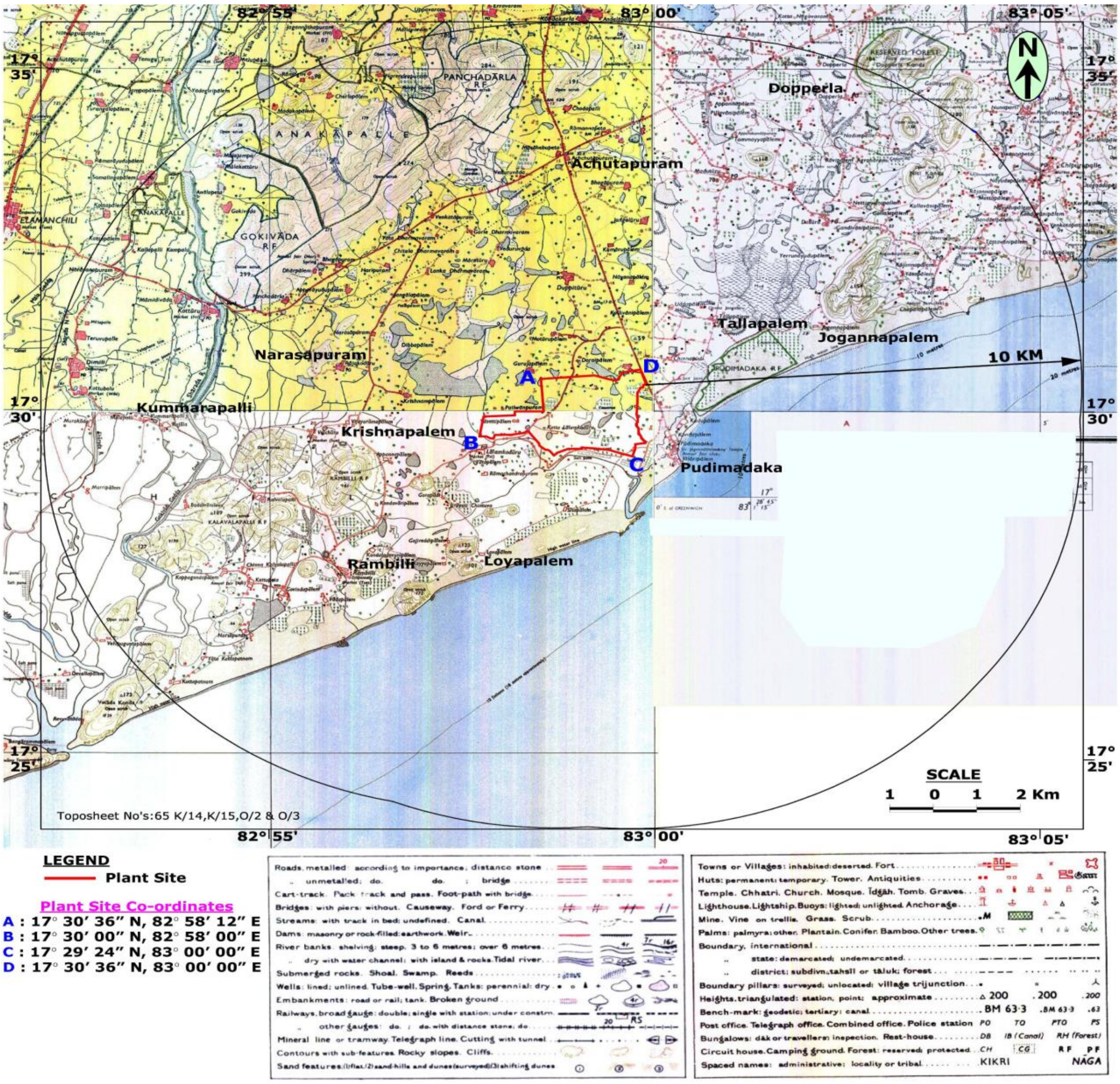
Table 5-1– Salient features of the project site & surrounding

Particulars	Details
Approx. Geographic location	Latitude 17° 30' 03" N and Longitude 82° 58' 58" E
Administrative location	Pudi village, Pudimadaka, in the Anakapalle Taluk, Visakhapatnam district, Andhra Pradesh.
Topography	The topography of the site is undulating with spot levels of the natural ground varying between RL (+) 3M to RL (+) 20M.
Elevation range	Terracing at different FGLs for efficient drainage and to balance cut & fill of earthwork, EL(+) 7.0M, EL(+) 10.0M and EL(+) 14.0M
Current land use	The site has dense vegetation of coconut trees, cashew trees, and palm trees along with thick bushes and shrubs
Nearest Town	Atchutapuram
Rivers / Streams / Creek	There are four drains in the vicinity of the project area and one natural Nala flows through the project area on the east side feeding two ponds. Small natural ponds exist in the project site.
Nearest Highway	AP State Highways 154
Nearest Railway station	Ellamanchili
Nearest Airport	Visakhapatnam
Protected areas (National parks/ sanctuaries)	None within the 10 km radius
Sites of Historical/ Archaeological importance	None within the 10 km radius
Forest area	Pudimadaka RF (1.47 km) Sitapalem R.F (1.50 Km) Rambilli R.F (3.00 km) Panchadarla RF (6.7 km)

Particulars	Details
Seismic Zone	Zone II.

	
Figure 5-3- Green Hydrogen Hub Site – Main Gate	*Figure 5-4– Chippada Beach – Southside*
	
Figure 5-5 – Chippada Sea front east side	*Figure 5-6 – Chippada Beach Approach Road*

Figure 5-7– Project Map (Source: Draft EIA report for 4 x 1000 MW super Thermal Power Plant in the same project location by NTPC)



5.2.4 Technology and Process Description

Desalination process: Desalination is a process that removes minerals from saline water. Sea water is desalinated to produce water suitable for human consumption or here as input water to the GH2 plant. The principal process uses membranes to desalt saline water principally applying Reverse Osmosis (RO). The RO membrane processes use semi-permeable membranes and apply pressure (on the membrane feed side) to preferentially induce water permeation through the membrane while rejecting salt.

The proposed desalination plant and all associated systems & accessories will be designed, manufactured, inspected, and tested for established engineering practices and safety codes of the latest applicable Indian/ISO standards. The general layout of the 60 MLD desalination plant is shown in Annexure - 6.

The main elements of the desalination process include the following:

- Sea water intake,
- Pre-treatment of feed water (screening, coagulation, flocculation and filtration),
- Reverse Osmosis,
- Post-treatment (Remineralization and Disinfection) and
- Discharge of brine

Offshore Intake pumphouse and raw water conveying main

The offshore intake pumphouse and raw water pumping main through trestle arrangement is recommended. A typical offshore pumphouse will consist of:

- Offshore intake well & Pumphouse
- Stop log gate
- Trash bar / Travelling water screen
- Pumps with associated electro-mechanical items
- EOT crane
- Maintenance area
- Electrolyser house/chlorine storage area with dosage pumps (may be in near shore)
- Electrical & Control rooms.
- Trestle connecting the offshore intake pumphouse with the shore
- Intake pumping main laid over trestle.

- The electrical cables shall also be taken from shore through the trestle.
- A necessary motorable path shall also be provided in the trestle for all weather to access the offshore pumphouse.

The seawater shall be pumped from the offshore pumphouse to the desalination plant through suitable pumping main which shall be laid over trestle in the offshore and will be buried below the ground in the onshore up to desalination plant.

SWRO desalination plant

a) Pre-treatment process

This system pre-conditions the seawater and makes it suitable for the Reverse Osmosis (RO) membranes as per membrane manufacturer's guidelines. The various sub process components in the pre-treatment process largely varies depending on the sea water quality, availability of land, O&M cost etc.

Typically, the pre-treatment process consists of the following sub-systems and equipment.

- Stilling chamber
- Flash mixers
- Flocculator
- Lamella clarifiers
- Rapid Gravity Filters
- Pressure Filters / UF (as may be required based on the detailed process design)

At the offshore intake pumphouse, seawater is screened using a travelling water screen for floating and larger matter. This water, after initial screening, is transferred to the stilling chamber through Intake pumps.

Chlorine dosing is considered in the stilling chamber. The chlorinated seawater from the stilling chamber shall flow to the Lamella Clarifiers via Flash Mixers. The coagulant shall be dosed in the Flash Mixer at the upstream of the clarifier/s. Ferric Chloride shall be used as a coagulant. Flocculent shall be dosed in the Flocculator. A suitable polyelectrolyte shall be used as Flocculent.

Each of the Lamella clarifier units shall generally contain Flash Mixers, flocculation chambers, and inclined plate settlers that are located suitable to Hydraulics. This unit shall consist of multiple compartments/ zones- viz-flash mixers, flocculation, pre-settling cum clarifier compartment and underflow compartment/zone.

The underflow chamber of the clarifier shall receive the sludge-laden water. Sludge gets settled and is collected in sludge pit from which it can be easily discharged.

Sludge generated is non-hazardous and non-toxic. The sludge from the bottom of the seawater clarifier is discharged to a sludge pit and then transferred to an outfall tank for further disposal.

The clarified water from the clarifier shall be led to the Rapid Gravity filters where further suspended particles are removed and led to filtered water Storage tank. From filtered water storage tank water is pumped through pressure filters / Ultra Filtration system for further treatment of suspended solids removal.

The product water from this filter system will be led to SWRO system.

b) Reverse Osmosis (RO) process plant

The RO system is generally designed with modular type. The independent trains of Sea Water Reverse Osmosis (SWRO) units will be decided based on the overall desalination plant capacity and the possible variations in the product water demand.

The RO plant shall consist of following sub-equipment:

- Antiscalant and SMBS dosing systems
- Cartridge filters
- High pressure pumps and PX booster pump (as applicable)
- Membrane element assembly unit
- Energy recovery unit

- Auto dumping system
- Remineralising system
- Clean in place system
- Flushing water system

Pretreated and filtered seawater is fed to the RO plant, at the suction of the High-pressure (HP) feed pump. The high-pressure pump pressurises and feeds it to the membrane assembly unit. Cartridge filters shall be provided at the upstream side of the HP pumps for the final protection. Each train of SWRO consists of dedicated High-pressure pump, energy recovery unit and the Membrane element assembly unit.

Each HP pump with its drive motor shall be mounted on a single base frame. The energy recovery unit shall be able to discharge brine against a backpressure without the need for additional pumping equipment. The HP feed pump shall be VFD driven to regulate the feed flow to the membrane assembly. The pump shall be designed to operate in the entire range of operation of the feed system.

The pressurized sea water is sent to the polyamide semi-permeable membranes which separate the permeate (less salty water) and brine (high concentrate salt water). Membranes are loaded in the high pressure FRP vessels which are mounted on steel frames. The brine is disposed back to the sea through outfall tank after recovering the pressure energy in the brine, by passing through the energy recovery device.

The energy recovery device recovers a substantial part of energy consumed by the high-pressure pump, resulting in reduction in energy consumption. State of the art high efficiency energy recovery device and energy efficient high-pressure pump shall be used in these RO units, to optimise the energy used for the RO system. In case of pressure exchanger being used for energy recovery, a PX booster pump shall be installed in parallel with main HP pump and the PX booster pump shall be VFD driven.

The materials coming in contact with seawater shall be either non-metallic or superior or Super Duplex SS to avoid corrosion. Equipment not meeting the above requirement are protected by Cathodic protection.

PVC/CPVC/FRP/GRP/HDPE pipe materials are used for low-pressure piping and super duplex stainless steel is used for high-pressure seawater feed and brine piping.

The permeate water is treated to correct the pH and LSI and the water is then transported to the product water Storage tank in the desalination area for further transmission to GH2/PtX plant. A disinfection dosage facility will be provided for potable water application.

Cleaning and Flushing systems are provided to protect the membrane from fouling and scaling. The cleaning system facilitates cleaning of the fouled membranes and the flushing system flushes the membranes off High TDS water with low TDS water during shutdown operation.

c) Post-treatment process units

The pH and LSI of the SWRO permeate water will be corrected to the desired product water quality limits. The correction will be made by dosing Lime (Ca(OH)2) and CO2 online to improve the LSI before transferring into the final storage tank Alternately, limestone filters may be provided.

The post-treatment system is common for the entire plant and shall be provided with chemical tanks, mixers, dosing system to dose the correct quantity of chemicals automatically.

d) Chemical dosing system

The following chemical dosing systems are envisaged for this project.

- Pre-chlorination system
- Coagulation and flocculent dosing system
- Antiscalant and De-chlorination (SMBS) dosing system
- Limestone filter and CO_2 dosing system
- Post chlorination dosing system

All the chemical systems will be automatic control system based on the flow rate as well as the dosage rate.

e) Chlorination System

Bio-fouling control or chlorination is effected to kill and prevent the biological growths, so as to keep the water clear of biological growths. Hypochlorite dosing system shall be considered in the in the Pre-Treatment Plant. Shock Chlorination shall also be done at the offshore intake pumphouse.

In the Pre-Treatment Plant, Chlorine will be dosed in the Stilling Chamber r to maintain a residual chlorine level as 0.5 ppm.

The seawater will be de-chlorinated before RO system, as per the membrane manufacturer's recommendation by dosing sodium meta bisulphite (SMBS).

The chlorination and SMBS systems shall be provided with chemical tanks, mixers (as applicable), dosing system to dose the desired quantity of chemicals automatically.

f) Storage & pumping of product water

The product water will be stored in a storage reservoir within the Desalination plant boundary. The size of the storage tank shall be decided based on the water requirement of GH2/PtX plant and its working hours etc. Generally, for this size desalination plant the storage tank can be for one day storage. Along with storage tank necessary pumping system will be provided to pump the product water to GH2/PtX plant.

Offshore outfall system for disposal of reject water

The purpose of the outfall brine water (reject water) disposal system is to discharge brine and other process reject water to the identified outfall location the total reject water will be about 90 MLD. All the brine from the SWRO shall be collected in an outfall water storage tank. This tank will be connected through pumps to the disposal point in the sea through GRP / HDPE / equivalent pipes. Sludge collected from the pretreatment section will be dewatered and the supernatant water will be transferred to the outfall tank.

All other effluents as below are also pumped to the outfall tank.

Filter Backwash water

Ultra-filtration wastewater (if applicable)

Supernatant water from the sludge thickener and sludge dewatering arrangement

Neutralized effluent.

The outfall pipeline shall also be laid along the intake conveying main till the intake pumphouse then the same shall be buried below the sea bed and taken to a suitable location for proper dispersion.

The location of the brine outfall shall be identified based on a detailed modelling study conducted to prevent brine recirculation into the intake and to disperse the excess salinity to the ambient condition within a specified area.

Generally, the outfall will be provided with a proper dispersion arrangement by providing diffusers. The design of diffusers will be based on the quality of reject water, salinity, depth of sea and current at the disposal location, and the outcome of dispersion modeling, etc.

5.2.5 Resource requirement

Seawater will be the major resource used for the production of quality desalinated water through the SWRO process. The details of resource requirements such as Water, Land, Manpower, Power, infrastructure etc. are discussed below:

Water requirement

The required seawater for the desalination plant will be met from the Bay of Bengal near Chippada. No groundwater will be abstracted from the local area for project activities. The seawater requirement to produce 60 MLD will be about 150 MLD.

Land requirement

The total allotted barren land area of - - -(*to be filled based on the allotment of land for the desalination plant)* acres will be considered for the development of desalination plant. The allotted land boundary coordinates are given below (*to be filled based on the allotment*):

Table 5-2 – Allotted land boundary coordinate

Geographical Coordinates		UTM Coordinates (WGS 84 -Zone - XX)	
Latitude, N	Longitude, E	X (m) Y (m)	X (m) Y (m)

The land area will be used to develop different facilities such as a pretreatment unit, R.O. unit, Post-treatment unit, Process water storage tank, etc.

Energy requirement

The desalinated water from this desalination plant will be supplied to GH2/PtX plant and hence the power to be used for this desalination plant should also be RE. The tentative energy requirement is about 8.75 MWH. or about 0.21 million units per day.

Manpower requirement

The total manpower requirement for the desalination plant operation is estimated to be about 50 numbers including both skilled and unskilled labourers. The local people will be employed to the extent possible. The occupation of the inhabitants in the nearby villages is mainly dependent on fishing and agriculture. Opportunities for jobs under the proposed project will serve as a source of permanent livelihood for the local people and will pave the way for further developments.

5.2.6 Cost of the Project

The estimated total EPC cost of the Project is over Rs. 600 Crores. (To be confirmed based on the DPR)

5.3 Marine Facilities

For a desalination plant, it is essential to draw seawater and discharge brine at the appropriate location for the effective functioning of the plant to enhance the positive impact of the project and to reduce the negative impacts. The locations depend on various factors such as tide, current, bathymetry, brine dispersion pattern, distance from the shore, cost, etc.

5.3.1 Intake location

Based on the site visit it is proposed to tap sea water from the Chippada Sea front. The tentative Site Boundary, Desalination plant site, and Intake pipeline alignment from the Chippada landfall point to the desalination plant are shown in the below image.

Figure 5-8 - *Image showing proposed Intake pipeline alignment from Chippada Sea Front*

The highlight of this location:

- The raw seawater shall be drawn from offshore near Chappada beach
- The offshore Intake arrangement shall be an offshore intake pumphouse with a Bridge for pipelines and vehicle access. Because such offshore seawater pump houses already exist in this region at Simhadri for NTPC power plant and also for HNPCL plant.

- The length of the onshore Intake pipeline length from the Chappada seafront to the Desalination plant will be about 2.15 km only.
- The brine reject outfall pipeline shall also be in the same alignment and can be buried beyond the intake pumphouse as the required distance for batter disbursement and to avoid recirculation of reject water to the intake pumphouse.
- The location of the offshore pumphouse shall be fixed based on the Bathymetry survey and sea bed formation.
- Along the pipeline alignment there is no settlement/habitations.
- There is an existing access road from the Project site to the Chappada Seafront.
- It is easy to provide the HT power from the Project site to the offshore pumphouse.
- As per the Coastal Zone Management Plan, Andhra Pradesh Sheet No. E 44 R2 /SW Map No. AP 113 the proposed intake pipeline alignment is not crossing CRZ 1A.

5.3.2 Outfall location

The outfall location shall be finalized based on the Dispersion and recirculation modelling study. The outfall pipeline shall be taken in the same alignment up to the offshore intake pumphouse and then buried below the seabed till the outfall location.

The outfall brine will be dispersed into the sea through a suitable diffuser arrangement.

5.4 DESCRIPTION OF ENVIRONMENT

The baseline environmental study to be done by the authorized EIA consultant will include both terrestrial and marine with respect to existing environmental attributes. The study area shall cover a 10 km radius of the project boundary.

EIA notification requires that a 10 km radius area surrounding the project site shall be covered under the study to adjudge the existing baseline environmental condition and the same is denoted as a study area. As part of the study, a description of the biological environment and human environment such as environmental settings, demography & socio-economics, land-use/land cover, ecology & biodiversity have to be carried out for the entire area.

5.5 TERRESTRIAL ENVIRONMENT

The baseline data collection has been done for assessing ambient air quality, ambient noise level, surface water quality, groundwater quality, soil quality, ecology, and socio-economic status in the terrestrial environment following EIA notification 2011.

The methods adopted for the collection of baseline data shall also be described in detail for each parameter.

The samples collected shall be analyzed through accredited by the National Accreditation Board for Testing and Calibration Laboratories (NABL).

5.5.1 Air Environment

The Air environment shall cover the following:

- Micro meteorology
- Temperature
- Average Pressure
- Visibility
- Cloud
- Humidity
- Rainfall
- Wind

The part of the report shall also cover the methodology, selection of monitoring stations, duration of sampling, results and interpretation, etc.

5.5.2 Water Environment

Water quality parameters of surface and groundwater resources within 10 km radius of the study area have to be studied for assessing the water environment and evaluating anticipated impact of the project.

5.5.3 Land Environment

The Land environment shall cover Topography, Land Use / Land Cover, and soil.

The study area at Pudimadaka is predominantly plain with few hillocks observed adjacent to the project site. The maximum difference in levels would be about 36 m – 40 m.

5.5.4 Noise Environment

The noise levels at all the monitoring locations in the study area during the daytime and nighttime shall be within the permissible limits.

5.5.5 Socio-Economic Environment

Mapping of Socio-economic conditions around the project site shall be done by a social expert taking into account the Demographic conditions, Land use, education, health, etc.

The need for Rehabilitation & Resettlement (R&R), and employment opportunities to be studied as a part of the above.

Group discussion with the stakeholders may be required. Suitable backup documentation shall be prepared and CSR requirements and the cost shall be identified.

At Pudimadaka the land identified is industrial land with a compound wall and no settlement. Hence there are no R&R issues.

5.5.6 Ecology and Biodiversity - Terrestrial

Introduction:

Ecological evaluation aims at developing and applying methodologies to assess the relevance of an area for nature conservation. As such, it is to support the assessment of the impact of a proposed development by providing guidance on how to describe the ecological features within the area affected, how to value them, and how to predict the value losses caused by the development. The evaluation of the ecological significance of an area can be undertaken from different perspectives and consequently with different objectives. One such perspective focuses on the conservation of biological diversity or biodiversity. Among the human activities that pose the highest threat to the conservation of biodiversity are developmental projects in particular. Such projects represent artificial elements that cut through the landscape and interfere with the natural habitat and its conditions by emissions that may be solid, liquid and or gaseous. This in turn influences the abundance and distribution of plant and animal species, i.e., the biodiversity of the areas impacted.

Most of the background data needs to be acquired from governmental agencies or the scientific literature. This information is typically complemented by field visits, site surveys, and sample collection. The description of the actual ecological assessment provided by the ecological baseline study serves to set a reference for the subsequent impact analysis. Moreover, it helps decision-makers and EIA reviewers to become familiar with the environmental features and the needs of the study area

Objectives of the study

This study is to be undertaken with the following objectives to assess both terrestrial and aquatic habitats of the study area:

- To assess the nature and distribution of vegetation in and around the proposed project site.
- To assess the Flora and fauna in the study area.
- To understand the ecology of the water bodies.

- To ascertain the migratory routes of fauna, presence of breeding grounds, and sensitive habitats in the study area, if any.
- To assess the presence of protected areas in the study area.
- To review the information from secondary sources and discuss the issues of concern with the relevant authority and stakeholders; and
- Impact prediction based on primary and secondary data sources to formulate mitigation measures.

5.6 Marine Environment

The Seawater samples need to be collected at three water depths i.e., surface, mid-depth and bottom.

Seabed sediment samples and biological samples need to be collected at the vicinity of intake & outfall.

The water quality parameters are to be analysed by National Accreditation Board for Laboratory (NABL). The method of collection and analysis protocols are to be tabled.

5.6.1 Physical parameters

A necessary offshore field study is to be done by the competent agencies to collect real data on Waves, Tide & current measurements, and a Bathymetry survey to map the sea bed profile. Necessary historical data near the seaside is also to be collected from corresponding departments/line agencies and also from the public data bank.

This part of the report should also clearly mention the following:

- Methodology adopted for the entire field studies
- Location of the study area
- Details of permission obtained for conducting field studies
- Duration of field study
- The details of Tools & plants used for the study

- The details of experts involved in the study
- Details of baseline data collected
- Geo-reference and TBM used
- Data interpretation and conclusion

5.6.1.1 Storm

According to the available disaster inventories, AP is the state that has suffered the most from the adverse effects of severe cyclones. It has been estimated that about 44 percent of AP's total territory is vulnerable to tropical storms and related hazards, while its coastal belt is likely to be the most vulnerable region in India to these natural phenomena.

Cyclones on the east coast originate in the Bay of Bengal, the Andaman Sea, or the South China Sea, and usually reach the coastline of Tamil Nadu, Andhra Pradesh, Odisha, and West Bengal, which are the most vulnerable to these types of hazards. Two of the deadliest cyclones of this century, with fatalities of about 10,000 people in each case, took place in Odisha and Andhra Pradesh in October 1971 and November 1977 respectively. The super cyclone of Odisha in 1999 caused large-scale damage to life and property. Along the Andhra coast, the section between Nizampatnam and Machilipatnam is the most prone to storm surges. Vulnerability to storm surges is not uniform along Indian coasts.

AP with its coastline of 974 km is more vulnerable to cyclones compared to other disasters like drought, storm surges, and floods. As per IMD, all together, 184 cyclones of all categories including depressions crossed the coast from 1891 to 2019. AP is at risk of at least one cyclone each year on an average and maximum during October and November

From the Flood Hazard Map, Visakhapatnam, AP it is understood that the Project site is having Low flood hazard.

5.6.2 Seawater quality

The seawater sampling needs to be taken at the proposed intake and outfall locations and to be tested at the authorized laboratory for various parameters.

The project proponent took the seawater samples in September 2023 and the results are tabulated below:

Table 5-3 – Seawater samples result

SEA WATER ANALYSIS FOR THE MONTH OF SEPTEMBER 2023						
Parameters	pH	Cond.	Turb	Re.Cl_2	T.H.	Ca.H.
DATE/Unit	--	µS/cm	NTU	PPM	ppm as $CaCO_3$	ppm as $CaCO_3$
01-09-2023	8.30	55200	4.34	Nil	4200	1240
02-09-2023	8.32	54900	6.79	Nil	4400	1260
04-09-2023	8.29	54600	4.53	Nil	4000	1220
05-09-2023	8.31	54000	5.49	Nil	4000	1200
06-09-2023	8.30	53700	6.01	Nil	4200	1240
07-09-2023	8.28	52300	6.04	Nil	4000	1280
08-09-2023	8.31	53300	7.13	0.5	3800	1340
09-09-2023	8.33	53700	6.73	Nil	3800	1400
11-09-2023	8.30	54100	8.41	Nil	4000	1380
12-09-2023	8.29	53900	9.01	Nil	4200	1360
13-09-2023	8.28	53500	7.68	Nil	4200	1400
14-09-2023	8.32	53300	6.01	Nil	4000	1340
15-09-2023	8.34	54300	9.39	Nil	4200	1320
16-09-2023	8.33	54600	7.87	Nil	4400	1360
18-09-2023	8.29	54600	9.01	Nil	4000	1300
20-09-2023	8.30	53700	5.61	0.5	4000	1280
21-09-2023	8.32	53800	7.41	Nil	4200	1260
22-09-2023	8.30	51500	4.01	Nil	3800	1220
23-09-2023	8.33	52800	5.66	Nil	4000	1260

SEA WATER ANALYSIS FOR THE MONTH OF SEPTEMBER 2023						
Parameters	Mg.H	Chloride	P-alk.	M-alk.	Sodium	Potassium
DATE/Unit	ppm as $CaCO_3$	ppm as $CaCO_3$	ppm as $CaCO_3$	ppm as $CaCO_3$	ppm as Na	ppm as K
01-09-2023	2960	29046	20	108		
02-09-2023	3140	29328	18	110		
04-09-2023	2780	28764	16	106	15600	316
05-09-2023	2800	28482	18	108		
06-09-2023	2960	29046	16	106		
07-09-2023	2720	28200	14	104		
08-09-2023	2460	28764	18	108		
09-09-2023	2400	29046	20	110		
11-09-2023	2620	29328	16	106	16800	324
12-09-2023	2840	28764	18	108		
13-09-2023	2800	28482	16	104		
14-09-2023	2660	28200	20	110		
15-09-2023	2880	29046	22	114		
16-09-2023	3040	29328	24	116		
18-09-2023	2700	29046	20	112	17200	328
20-09-2023	2720	28764	18	110		
21-09-2023	2940	28482	22	114		
22-09-2023	2580	28200	16	108		
23-09-2023	2740	28764	18	110		

Here the seawater sample shows conductivity is consistent and ranging from 51,500 to 55,200 µS/cm which is suitable for the R.O. system. The Turbidity is not very high and hence no pre-sedimentation tanks are required.

5.6.3 Seabed sediment quality

During the offshore field studies necessary seabed samples are to be collected along the proposed trestle and at offshore intake pumphouse location. The sediment samples are to be tested by an accredited laboratory. The results help to understand the seabed characteristics.

5.6.4 Ecology and Biodiversity

The biological status of an area is an essential prerequisite for environmental impact assessment and can be evolved by selecting a few reliable parameters from a complex ecosystem. Changes in physio-chemical properties of water bodies and seabed sediment ultimately result inevitably of biological nature.

Among the marine states of the East Coast, Andhra Pradesh finds a unique place with 980 km. Coastal length and a Continental shelf of 3.30 million hectares.

Detailed study on the present Ecology and Biodiversity to be done by the concerned experts. The report should provide the details of all important species and the possible impact on these species because of the proposed project and the necessary mitigation measures are also to be provided.

5.7 Marine National Park and Marine Sanctuary

5.7.1 Marine National Park

There is no Marine National Park near the Project site

5.7.2 Marine Sanctuary

There is no Marine Sanctuary near the Project site.

5.7.3 Forest block in the study area

The details of the forest blocks in 10 km radius of the proposed plant are presented are to be collected and tabulated. The possible impact due to the proposed peoject on the Forest blocks to be examined and incorporated. If there will be any impact then necessary mitigation measures also to be identified and furnished in this report.

5.7.4 Eco-sensitive zone

There is no ecologically sensitive area within a 10km radius of the project area.

5.8 IMPACT ASSESSMENT AND MITIGATION MEASURES

5.8.1 Identification of Impacts

Identification of impact on account of the proposed project shall be studied for both construction & Operation phases. The impact could be temporary or permanent. Suitable mitigation measures will required to be adopted and implemented to reduce the adverse effect on the environment.

Project activities are planned both in terrestrial and marine environments. i.e., construction of a desalination plant, construction of offshore pumphouse, trestle, and laying of intake & outfall pipeline. As the desalination plant will be constructed in barren land devoid of human settlement the anticipated impacts on the terrestrial environment during the construction phase and operational phase appear to be minimum. The construction of offshore structures will cause certain impacts on the marine environment for a limited period.

Based on the activities involved in the construction and operational phase of the desalination plant, construction of intake arrangement, and laying of the outfall pipeline, the impacts are identified and are listed below:

Significant aspects to be assessed for impacts	
Terrestrial environment	**Marine environment**
(i) Impact on Air Quality	(i) Impact due to offshore pumphouse construction
(ii) Impact on Noise quality	(ii) Impact due to trestle and outfall pipeline construction
(iii) Impact on water quality	(iii) Impact on Ecology
(iv) Impact on Land use and Soil	
(v) Impact on Socio-economics quality	
(vi) Impact on Occupational health & safety	

An account of the analysis of different impacts during the construction and operation phases is presented below along with mitigation measures.

5.9 TERRESTRIAL ENVIRONMENT

5.9.1 Air Quality

During Construction Phase

The impacts during the construction stage of the project are short-term and limited to the construction phase only. Impact on air quality during construction is most likely fugitive dust from construction activities due to leveling and concrete mixing, gaseous emission from operation of vehicles and machinery, etc.

Mitigation Measures:

- Regular water sprinkling to reduce dust emissions.
- Only PUC-certified vehicles are to be deployed.
- Regular maintenance of the machinery.

During Operation Phase

The air pollution from the operation phase in the plant will be minimal. The main sources generating air pollution are DG Sets and vehicle movements. There will not be any addition of Particulate Matter (PM10 and PM2.5) and gaseous pollutants (SO2, NOx, CO).

Recommendations

The following measures will be adopted by the industry.

- Provision of dense green belt along all internal roads, outer periphery of industrial unit and office will be made.
- Provision of tarred roads to minimize dust generation due to vehicular movement will be made.

5.9.2 Noise quality

During Construction Phase

The major noise-generating source during the construction phase is vehicular traffic, and construction equipment like dozers, scrapers, concrete mixers, crane, generators pumps, etc. During construction, this equipment will generate noise ranging between 75-85 dB (A).

The impact of high noise intensity on the environment is likely to be reduced, localized in nature, and mainly confined to the day hours. The noise level will drop down to an acceptable level, once the construction period is over.

Mitigation Measures

- Regular maintenance of the construction equipment / machineries
- Proper traffic management plan will reduce the noise expected from horn keys

During Operation Phase

Noise during the operational phase will be mainly on account of running equipment

Mitigation measures for noise levels are of the following types:

- Prevention at source.
- Control of transmission path.
- Personal Protective Equipment at work place.

Recommendations

The following measures to be adopted by the industry:

- While procuring major noise-generating machines/equipment, adequate measures to minimize the generation of noise shall be adopted.

- Acoustic enclosures for noise-generating machinery to reduce impact.
- Planting thick bushy trees in and around the industrial area to intercept noise transmission.
- Restructuring of work patterns such as job switching etc. to be adopted to reduce pressure on workers.

5.9.3 Water quality

During Construction Phase

The impact on water quality during the construction phase may be due to non-point discharges of solids from soil loss and sewage generated from the construction workforce stationed at the site. The construction water requirement to be met from external sources.. The overall impact on the water environment during the construction phase due to the proposed project is likely to be short-term and insignificant.

Mitigation Measures:

- The layout of the plant shall be designed so that natural flow can be maintained.
- The run-off from the construction site to be disposed of after settling the pond.
- Temporary sanitation facilities (septic tanks and soak pits) to be set up for the disposal of sanitary sewage generated by the workforce

During Operation Phase

Surface Water

Desalination plants produce liquid wastes during the operation phase that may contain some chemicals used in the treatment.

Mitigation Measures:

- The effluent collection, treatment, and disposal facilities always remain in a good shape.
- No untreated effluent will be allowed to be disposed of on-land or in surface water bodies.
- Effluent samples shall be analyzed and monitored to meet the statutory requirements.

Ground Water

Similarly, as no groundwater source is proposed to be tapped to meet the water requirements during the operation of the plant, no impacts on groundwater resources is envisaged.

5.9.4 Land use and soil quality

Construction phase:

Impact: Disturbances such as excavation or surface soil removal would alter the soil profile by destroying the soil horizons. The land use pattern in the project will be changed to built-up area from barren land, which may pose the following impacts on the land environment.

- Removal of soil from the site,
- Mixing of the topsoil and subsoil,
- Change in soil structure due to compaction of soil.

Mitigation:

- Reuse of excess excavated material for approach road development, landscaping and green belt development,
- Effective stabilization of altered landforms to minimize soil erosion.

Operational Phase:

Impact: During the operational stage of the project, no impact on soil quality is anticipated. However, damage to pipelines due to natural hazards like storms, earthquakes, extreme waves, scouring on the foreshore, and tsunamis.

Mitigation: In case of breakage of the pipeline, immediate attention to the pipeline shall be taken up.

5.9.5 Socio-economic Environment

Andhra Pradesh Industrial Infrastructure Corporation Limited (APIIC) has allotted the land to the project proponent on a long lease basis of 33 years. APIIC has duly compensated the Project affected families and then handed over the land to the project proponent. Hence, Resettlement and Rehabilitation for the proposed project is not applicable.

The impacts on demography and socio-economic status of the area due to construction and operation will be positive as well as negative in nature. These impacts may be broadly classified as below:

- Direct impact due to acquisition of land.
- Change in the socio-economic scenario of the area.
- Increased stress on public utilities and resources of the area; and
- Indirect impacts due to Immigration of work force.

Impacts Due to Immigration of Construction Workforce

The immigration of workforce for the construction phase (including contract labours) would have a marginal impact on the demography (e.g., changes in total population, sex ratio, literacy level, main workers, etc.) of the immediate vicinity area. In addition, the socio-economic status of the area may also be affected due to flow of men, material and money. The positive impacts are the following:

- Increase in employment opportunity to unemployed population in the study area as unskilled and semi-skilled workers to the contractors / subcontractors.
- Growth of services and increase in employment and trade opportunities in service sector.
- Influx of persons with higher spending power and different socio-cultural backgrounds will improve the socio-cultural environment of the area, though occasional tension as a result of this influx cannot be totally ruled out; and
- Increase in per capita income and overall economic upliftment of the area and improvement in transport, communication, health and educational services.

The negative impacts could be summarised as:

- Strain on civic amenities (like road, transport, communication, water supply and sanitation, power supply, health care, education and recreational utilities etc.) due to increase in population.
- Further urbanization of the area leading to appreciation of land cost and house rents, increase in labour rate.
- Increase in consumer prices of indigenous services and produces like egg, fish, vegetables, milk, etc.
- Interference with the rural life of neighbouring villages and social conflicts be between the guest and host communities; and
- Loss of open space and visual impairment to the residents in the contiguous areas.

It is difficult to assess the above impacts quantitatively on a measurable scale. However, most of these impacts will be short term and limited to the construction period only. While increase in employment opportunities (project and service sector) and overall economic upliftment of the area is certain to happen, the negative impacts would be limited to construction phase. The infrastructural facilities shall be augmented / strengthened during construction of the project, if necessary.

Majority of the people living in this area are involved in agricultural and auxiliary activities. The tribal people depend on forests and other natural resources for their livelihood and sustenance perspective but also with livelihood perspective. Many a times, these indigenous tribal populations remain marginalised. This is a major developmental challenge both in terms of economic growth and, more importantly, socio-cultural perspective.

Mitigation Measures

During the construction phase, labour colony will be constructed at the earmarked space for the labour force. The labour colony shall be provided drinking water and sanitation facilities. Temporary toilets as per PHED norms will be constructed for the work force during construction period. Suitable septic tanks and soak pits of appropriate capacities will be constructed for treatment of sewage before disposal.

Project proponent shall implement the community development programmes under Corporate Social Responsibility for surrounding villages like capacity building, infrastructure development, provision of drinking water and sanitation, women empowerment, irrigation, agricultural development, education and health services etc. This problem will be solved by capacity building of local youth by vocational training, development of ITI. Other facilities include self-employment opportunities in the form of small contracts like vehicles, gardening etc. through PAP Cooperatives, Shops and other services in township, Employment opportunities with Contractors will be provided to develop confidence in local people regarding employment. Project proponent will provide necessary training to affected woman for self-employment like stitching, weaving, tailoring, making household items etc. will be provided for self-development & employment for women. Emphasis would be given to increase girl education in the affected area.

5.9.6 Occupational Health

Impact: Applicable occupational health and safety hazards including those associated with desalination operation such as working at height, working inside confined spaces, exposure to noise, contacting with equipment, electricity, high pressurized fluid, and fire.

Mitigation: The control measures that can be introduced to mitigate the level of identified risks to an acceptable level are the development of procedures for working in confined space entry , care in dealing with power supply while dealing with electrical equipment, guarding all rotating parts of the machines, provide the right equipment for working at height, reduce the exposure time to noise and providing sufficient training, information, and safety instructions to the employees

5.10 MARINE ENVIRONMENT

This part of Bay of Bengal is not Eco sensitive zone and there is no National Marine Park nearby.

The proposed project will influence the marine environment during the construction and operational phases. Brine discharge during the operational phase can typically cause a localized increase in seawater salinity.

However, the potential impact that will arise due to the project will be mitigated through proper intake and outfall location where enough dilution is available.

Activities such as Laying of pipeline, Construction of offshore pumphouses, trestle, and Outfall discharge will have an impact on the marine environment only during construction phase. The details anticipated impacts are detailed below,

5.10.1 Laying of pipeline

- Construction of temporary bund across the surf zone which will locally alter the shoreline,
- Hindrance to local fishermen during laying of pipeline,
- Installation of diffuser in seabed and the jet plume discharge will locally alter the flow pattern within the initial mixing zone,

Mitigation:

- Laying operation shall be done in shortest duration,
- Installation of marker buoy to warn the fishermen.

5.10.2 Seawater intake pumphouse, trestle, and outfall diffusers

Temporary disturbance to the sea bed and marine life (localized) during the construction phase. The impact on the marine environment due to the laying of pipelines, and construction of offshore pumphous and trestle is unavoidable. With proper control measures, the impact on the benthic community can be minimized in pipeline corridors and in construction location. With proper selection of location, engineering design and laying of pipeline as mentioned in the mitigation measures will be the key to minimize impact on marine environment

Mitigation:

- Since the construction of the seawater intake pumphouse and trestle is for a short period during the construction phase only, the seabed is expected to get back to its original state soon.
- The outfall diffuser should not have any sharp projection and should not pose any risk for the boats and fishermen moving around the region.
- Part of the outfall pipelines before the diffuser ports may suitably be placed to avoid hindrance for fishing and the movement of the boat.

Operational Phase:

Impact: Impact during the operational phase of the project will be limited to brine discharge and associated increase in salinity and therefore deterioration of water quality.

Mitigation: It is advisable to discharge brine at a location where enough dilution takes place within a short time of discharge so that the detrimental effect can be kept to minimum. The diffusers will be designed such that the discharge of brine may not affect marine ecology as net increase in salinity will be 2 ppt.

5.10.3 Mangroves

No components of this desalination plant including intake & outfall pipelines, trestle connecting the shore to the offshore pumphouse, and the offshore pumphouse will be constructed near the mangroves. Hence this project will not make any impact on the Mangroves which are away from the project.

5.11 POST PROJECT MONITORING

The post-project monitoring is an important aspect of in Environmental Management Plan. In order to verify the outcome on the implemented mitigation measures and also to alter the proposed mitigation, the post project monitoring becomes inevitable.

MARINE WATER AND SEDIMENT QUALITY MONITORING

Water and sediment samples collected from at least 3 locations in sea have to be analyzed for various physical, chemical and biological parameters (phytoplankton and zooplankton) with required frequency.

MONITORING OF MARINE BENTHIC FAUNA

The benthic population and community structure around the outfall have to be monitored periodically to assess any change. If the change in benthic standing stock is noticed, the treatment of effluent shall be improved.

MONITORING OF WATER QUALITY

Periodic monitoring of the outfall region would be carried out to evaluate any change in water quality, sediment quality and biological characteristics.

Periodic monitoring would be carried out at alternate years till five years. If the results of water quality, sediment quality and biological characteristics are in the agreement of baseline data, the periodic monitoring would be conducted at the frequency of once in five years. The records of monitoring would be maintained and kept ready at site for any inspection by PCB or any other concerned authority.

REGION TO BE MONITORED

The region of about 5 km radius around the intake and outfall points in the sea has to be monitored.

Sl. No	Plan	Frequency
1	Wastewater quality	Once a day
2	Water quality around the outfall in sea	Once a month
3	Biological quality around the outfall in sea	Once a season
4	Change in seabed in the vicinity of the outfall	Once a year
5	Current measurement and dispersion	Once a year

5.12 Risk Assessment and Disaster Management Plan

5.12.1 Risk Assessment

To manage and control the risks and also to mitigate the impacts of the proposed activities and effective functioning of the desalination plant, it is suggested that an Operation and Maintenance Manual shall be prepared and strictly followed. It should include Comprehensive Maintenance Management System (CMMS) Guidelines, Emergency Procedures, Incident Management Plan and Environmental Response Plan.

Identification of risks related to the project and assessment of their impacts shall be carried out along with suggestions for control measures and presented in the form of a Table by the EIA study agencies.

5.12.2 Disaster Management

Disasters can happen due to floods, Cyclone, Tsunami, Earthquake, Lightning, etc., and also on account of war, terrorist activities, sabotage etc. An effective disaster management plan helps to minimize the losses in terms of human lives, assets and environmental damage and to resume working conditions as soon as possible

The location-specific possible disasters shall be identified by the EIA study agency and applicable disaster management approaches shall be explained. The applicable guidelines shall be the National Disaster Management Plan, and Andhra Pradesh State Disaster Management Plan

5.13 Modelling Studies

Dispersion modelling & studies using suitable hydrodynamic software shall be conducted to identify a suitable location for brine outfall. Various inputs such as flow rate, salinity of brine & ambient seawater, bathymetry, tide & current shall be used in the study to arrive at dispersion details. This study would also provide the requirements for the design of a suitable diffuser arrangement for effective dilution and secondary dispersion of brine within a short radius.

The recommendations of the modelling studies shall be brought out in the report.

5.14 Environmental Management Plan

An environment management plan is required to implement the mitigation measures of environmental impact both during the construction phase and operation phase explained earlier in this document. The Plan shall primarily meet the objectives of MOEF&CC.

- To maintain or improve marine water and sediment quality in compliance with sediment and water quality guidelines documented.
- To maintain the integrity, ecological functions, and environmental values associated with the marine environment both coastal and offshore.
- To maintain the abundance, species diversity, geographic distribution, and productivity of marine flora and fauna.

- To ensure that any impacts on locally significant marine communities are avoided, minimized, and/or mitigated.
- To ensure that appropriate consideration is given to cumulative impacts so that the proposed activity does not cause considerable damage to the sustainability of the ecosystem.
- To protect Specially Protected (Threatened) Fauna by the provisions of the Wildlife Conservation Act.

A proper EMP shall be prepared and presented by the study agencies as a part of this report.

5.15 EMP budget

The project proponent will provide a sufficient budget for carrying out all the above activities.

6 Suitability of Brine treatment and upcycling Technologies

6.1 Brine treatment and upcycling technologies

Desalination plant brine treatment is a crucial aspect of the desalination process, as it involves the management and disposal of concentrated brine, a byproduct (reject) generated during the production of desalinated water. Brine typically contains high concentrations of salts and other minerals extracted from seawater. Improper disposal of brine can have environmental impacts, so effective disposal methods are essential.

The quality of brine rejection from a Sea Water Reverse Osmosis (SWRO) plant depends on numerous factors, including the specific design and operation of the plant, the quality of the feed water, and the efficiency of the membrane filtration system. However, in general, brine from a seawater RO plant typically has a higher concentration of salts and other impurities compared to the incoming seawater.

The brine reject is the concentrated solution left behind after the freshwater has passed through the RO membranes. It contains salts such as sodium chloride (table salt), magnesium, calcium, sulfate, and other minerals, that were present in the original seawater. The concentration of these impurities in the brine reject will be higher than that of the incoming seawater. The environmental impact of discharging brine reject back into the sea is an important consideration, as it can affect local marine ecosystems due to the increased salinity and concentration of dissolved solids.

Efforts are made to minimize the environmental impact of brine discharge, and various methods such as dilution, dispersion, or controlled release are often employed to mitigate the effects. Additionally, some seawater desalination plants explore brine management strategies, such as using the brine for industrial purposes or extracting valuable minerals from it to reduce waste.

6.2 Indian legal minimum requirements for brine treatment and waste management

The Indian government authorities & their line agencies do not specify the parameters for the disposal of brine. However, a general understanding of how environmental regulations might address these issues in India is narrated below:

In India, environmental regulations are primarily governed by the Ministry of Environment, Forest, and Climate Change (MoEF&CC). The key legislation related to environmental protection includes:

A. **Water (Prevention and Control of Pollution) Act, 1974:** This law addresses water pollution and the prevention and control of water pollution. It empowers the central and state pollution control boards to establish standards for the quality of water and regulate the discharge of pollutants into water bodies.

B. **Environment (Protection) Act, 1986:** This overarching law provides the framework for the protection and improvement of the environment. The act authorizes the central government to take measures to protect and improve the quality of the environment.

C. **Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016:** These rules provide the legal framework for the management of hazardous and other wastes. The rules prescribe procedures for the collection, segregation, storage, transportation, treatment, disposal, and handling of hazardous waste.

D. **Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs):** These bodies play a crucial role in enforcing environmental regulations. They set standards for various pollutants and monitor compliance by industries.

When it comes to brine treatment and waste management, agencies/companies developing SWRO plants are required to obtain Environmental Impact Assessment (EIA) / Costal Regulation Zone (CRZ) clearance from the State pollution control boards, State Coastal Zone Management Authority(CZMA) & CZMA of GOI (MOEF&CC). The CRZ clearance will specify the conditions under which the discharge of effluents or brine is allowed. Suitable chemicals shall be used in the desalination process such that the outfall quality meets the disposal norms. Extract of CPCB guidelines for marine disposal attached as Annexure – 7

Any treatment methods, and disposal arrangements required to mitigate the environmental impact will be presented by the project proponent for consideration and clearance by MOEF&CC.

6.3 Overview of existing brine treatment and upcycling technologies

Brine treatment and upcycling technologies have been actively explored to address the environmental challenges associated with brine disposal from various industries, particularly desalination plants.

As on date, the most adopted arrangement is solar evaporation using salt pans for manufacturing Sodium Chloride salts and/or more concentrated brine for certain processes that can gainfully use the same in Chlor-Alkali plants. It may be noted that a large land area will be required for implementing salt pans. Hence only a small portion of the brine can be utilized for this purpose.

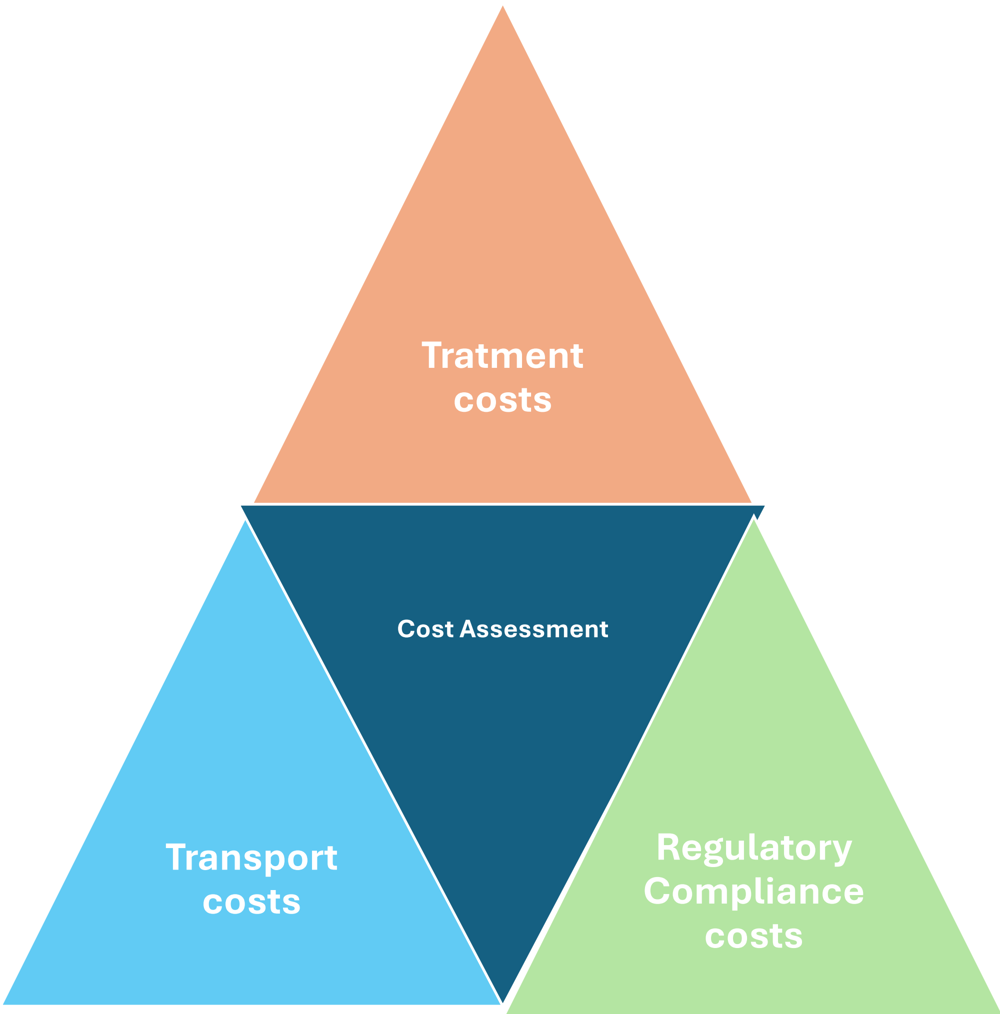
- Further various technologies are being studied and some have been implemented on a small scale for upcycling of brine. Some of them are listed below:
- **Brine Concentrators:** Increase the concentration of salts in brine through evaporation, reducing the volume of liquid waste.
- **Forward Osmosis (FO):** Involves drawing water from brine through a semi-permeable membrane using a more concentrated solution.
- **Crystallization:** Induces the formation of salt crystals, allowing for the separation of salts from brine.
- **Freeze Crystallization:** This involves freezing the brine to separate ice crystals, leaving behind concentrated brine.

- Uses a hydrophobic membrane to separate water vapor from brine, which can be condensed into freshwater.
- **Brine Mining:** Extraction of valuable minerals from brine, such as lithium, magnesium, and potassium.
- **Selective Ion Exchange:** Utilizes ion exchange resins to selectively capture and recover specific ions from brine.
- **Pressure Retarded Osmosis (PRO):** Harnesses the osmotic pressure difference between freshwater and brine to generate power.
- **Vortex-induced vibration (VIV) Systems:** Converts the kinetic energy in brine flow into electricity.
- **Nanofiltration and Nanocomposite Membranes:** Improve the efficiency of desalination processes thereby reducing the quantity of brine discharged.

Each technology mentioned above comes with its own set of advantages and disadvantages. The selection of a specific technology should be based on a comprehensive assessment of various factors, including the techno-economic aspects, the geographical location of the desalination plant, the quality and quantity of brine waste generated, overall costs involved, the complexity of brine disposal into the sea, and challenges related to meeting Coastal Regulation Zone (CRZ) disposal requirements. Careful consideration of these factors is crucial to make an informed decision that aligns with the specific requirements and constraints of the given desalination project.

6.4 Assessment of cost, level of environmental impact mitigation, and Technology Readiness Level (TRL)

Evaluating the cost, environmental impact mitigation and technology readiness level (TRL) associated with brine disposal necessitates a comprehensive analysis of diverse factors linked to disposal methods. These factors encompass considerations such as brine composition, available technology options, the geographical placement of the desalination plant, and the quality of both seawater and brine waste, among others, tailored to the specifics of the project. Now, a direct comparison of the costs of different technologies within the same platform remains challenging due to these nuanced variables. Nevertheless, a foundational framework for assessing these aspects is outlined below:



6.4.1 Cost Assessment:

Treatment Costs Optimization:

Evaluate the financial implications of treating brine to meet disposal standards or facilitate reuse. This assessment encompasses expenditures associated with advanced technologies like membrane filtration, crystallization, or evaporation. Notably, these technologies demand substantial Capital Expenditure (CAPEX) and Operational Expenditure (OPEX), rendering them economically viable only when the resultant products, such as salts and minerals, can be sold to offset treatment costs and generate marginal profits.

Efficient Transportation Management:

Examine the expenses linked to transporting brine to disposal sites, through pipelines. This transportation process involves significant CAPEX investments in the installation of pipelines, pumping stations, pumps, and other electromechanical components. Additionally, Operational Expenditure (OPEX) considerations include power consumption and maintenance costs, emphasizing the need for strategic cost-effective transportation solutions.

Regulatory Compliance and Permitting:

Integrate costs related to regulatory compliance when obtaining permits and adhering to environmental regulations governing brine disposal. Furthermore, the treatment and upcycling of brine may necessitate additional permits and clearances from entities such as the Pollution Control Board. The temporal and financial investment required for securing these permits should be factored into the overall cost assessment for brine treatment. Recognizing the importance of compliance in both disposal and upcycling processes is crucial for a comprehensive understanding of the financial landscape.

6.4.2 Environmental Impact Mitigation:

- **Ecosystem Impact Assessment:**

Conduct a comprehensive analysis to gauge the potential repercussions of desalination brine disposal on local ecosystems, encompassing water bodies, soil, and aquatic life. Implement a thorough evaluation of mitigation strategies, such as dilution, dispersion, or treatment, aimed at minimizing adverse environmental effects.

When addressing the disposal of desalination brine waste, it is crucial to emphasize the high salt concentration. Optimal environmental impact reduction can be achieved by directing disposal into the sea at a depth not less than 7 meters, meticulous dispersion arrangements with suitable designed diffusers for quick dilution to ambient conditions within small area for minimal impact on aquatic life is imperative for sustainable waste management.

Tailor the approach to the specific site, considering existing aquatic life, flora and fauna, fishing activities, marine transportation routes, nearby shore habitats, and local livelihoods. Conduct a detailed Environmental Impact Assessment (EIA) for brine disposal into the sea, exploring potential impacts and proposing suitable mitigation measures. This information should be an integral part of the application for Environmental Impact Assessment (EIA) and Coastal Regulation Zone (CRZ) clearance for brine disposal into the sea. By providing a comprehensive assessment and proposing effective mitigation, we can ensure responsible and sustainable waste management practices in desalination projects.

- **Chemical Composition:**

It must be noted that brine is only a more concentrated form of seawater. Outfall water can contain chemicals used in pre-treatment and RO cleaning. However, these are so small in quantity that their presence will not make any change in the outfall water quality.

For example, if the feed seawater TDS is 36,000 ppm and the permeate recovery is 40%

then the brine reject will be 60% and the TDS in the brine will be = (36,000/0.6) = 60,000 ppm.

Most of the heavy metals will be removed during the pre-treatment and the sludge which contains these heavy metals will be further treated separately and disposed of safely.

Any residual chemical used during the pre-treatment and in the RO system in the brine will be neutralized.

There will be no variations in the temperature of the brine during the SWRO treatment and hence the brine will also have the same ambient temperature of seawater.

A typical chemical composition of the brine based on the specific seawater quality is given below:

Table 6-1 - Tentative feed water & brine water quality

Tentative feed water & brine water quality				
S.No.	Parameters	Units	Sea water	Brine water #
1	Total Dissolved solids	mg/l	38000	63333
2	Chloride	mg/l	19000	31667
3	Sulphate	mg/l	6000	10000
4	Nitrates	mg/l	150	250
5	Calcium	mg/l	250	417
6	Magnesium	mg/l	1500	2500
7	Sodium	mg/l	11000	18333
8	pH (Range)		7.6-7.9	8.0 - 8.5
Note:	# - Tentative quality of brine considering 40% recovery of fresh water.			

Tentative feed water & brine water quality				
S.No.	Parameters	Units	Sea water	Brine water #
1	Total Dissolved solids	mg/l	38,000	63,333
2	Chloride	mg/l	19,000	31,667
3	Sulphate	mg/l	6,000	10,000
4	Nitrates	mg/l	150	250
5	Calcium	mg/l	250	417
6	Magnesium	mg/l	1,500	2,500
7	Sodium	mg/l	11,000	18,333
8	pH (Range)		7.6-7.9	8.0 - 8.5
Note:	# - Tentative quality of brine considering 40% recovery of fresh water.			

Note: The brine water quality will change based on the change in feed seawater quality and freshwater recovery rate.

Reuse Opportunities:

Explore options for reusing treated brine in industrial processes or for other purposes to reduce the overall environmental impact. Properly reusing brine presents a significant opportunity to mitigate the environmental consequences of brine waste. While various methods for reuse are being implemented globally, the most effective technology for safely disposing of brine involves utilizing it in the production of salts and in the Chlor-Alkali plant, as explained earlier.

Solar Evaporation Method: One approach to reusing brine is to employ it as feedwater for salt pans operating through solar evaporation. In this method, the brine feed yields more salt compared to a normal seawater feed, and the system utilizes solar energy for evaporation, promoting environmental sustainability. It is essential to note, however, that one feed may take several days to evaporate and undergo crystallization. Additionally, salt pans are non-operational during the rainy and winter seasons, necessitating alternative brine disposal methods during these periods.

Using Brine as Feedwater in Salt Manufacturing Factories: A manufacturing company based in Haryana, India, specializing in evaporators and dryers, claims that it has developed an innovative system to utilize brine and produce various salts. According to them, this process involves a falling film evaporator followed by a forced circulation evaporator to extract salt from rejected brine. The resulting water undergoes treatment through a reverse osmosis (RO) system, providing potable water. Furthermore, various salts such as Magnesium Chloride, Magnesium Sulphate, Potassium Chloride, Bromine, and Potassium Sulphate (used as fertilizer) can be separated, making this a zero-liquid discharge (ZLD) system.

The company asserts that the economic viability of this project will be realized through the sale of these high-purity salts and potable water with a Total Dissolved Solids (TDS) level of less than 100 ppm. It is crucial to note that the company is currently in the process of obtaining patent rights, categorizing this information as technical.

6.5 Overview of global best practices and circular economy models for brine management

Circular economy models offer valuable frameworks for optimizing brine management practices. Here is an overview of global best practices and circular economy models for brine management:

6.5.1 Reduce, Reuse, and Recycle:

- **Reduction:** Minimize the generation of brine by implementing water conservation measures and optimizing industrial processes to reduce the overall salinity of effluents.

- **Reuse:** Explore opportunities for reusing brine within the production processes or in other industrial applications, where high salinity is acceptable.

- **Recycle:** Investigate technologies and processes for recovering valuable components from brine, such as extracting minerals or extracting freshwater through advanced treatment methods.

Across the world, various approaches are being undertaken for brine treatment and upcycling. These are already listed in the chapter 6.3 above. While certain technologies like Salt pans and Chlor-Alkali plants are already utilizing brine, other technologies listed are still in the R&D and demonstration stages. In this way, the circular economy shall be created. However, in this sector, no circular economy is presently possible.

6.6 Assessment of the suitability of brine treatment and upcycling technologies for the four selected sites.

Table 6-2 - *Assessment of upcycling technologies for the four selected sites*

S.No.	State	Desalination Plant Location	Requirement of marine outfall system for brine disposal	Probable Brine treatment / Upcycling technologies.
1.	Tamil Nadu	Tuticorin	Yes	Brine may be used in exiting salt pans to get a higher yield of salt. The brine may also be supplied to the existing chlor-alkali plants in Tuticorin.
2.	Andhra Pradesh	Pudimadakka	Yes	As the desalination plant proposed in the Industrial belt, brine may be used in a Chlor-Alkali plant.
3.	Gujarat	Mandvi	Yes	No salt pans in this region. Brine may be used in a Chlor-Alkali plant.
4.	Odisha	Konark	Yes	Sensitive area no possibility of developing salt pans or Chlor-Alkali plant.

6.7 Cost implication of brine treatment and/or upcycling technology on the production of green hydrogen

It is important to emphasize that obtaining Coastal Regulation Zone (CRZ) clearance is a prerequisite for the captive desalination plant aimed at providing desalinated water to GH2/PtX plants. Additionally, establishing a suitable outfall disposal system for the responsible discharge of brine into the sea is imperative. This requirement stems from the reality that existing viable brine treatment/upcycling technologies cannot efficiently manage the entirety of brine produced by the desalination plant around the clock. Consequently, the CAPEX cost for implementing the outfall arrangement remains unchanged.

As previously detailed in earlier sections, the provision of brine to salt pans and/or Chlor-Alkali plants signifies the reuse of brine by external entities. Importantly, this does not impact the capital expenditure (CAPEX) or operational expenditure (OPEX) of the desalination plant. Therefore, the provision of brine to salt pans and/or Chlor-Alkali plants does not pose any financial implications for the captive desalination plant serving GH2/PtX plants.

6.8 Conclusion

The brine waste generated by the Sea Water Reverse Osmosis (SWRO) process exhibits a salinity concentration exceeding 1.5 times that of the ambient seawater. Improper disposal of this brine directly into the sea may affect marine life, flora, fauna, and fishing activities. To mitigate these concerns, it is imperative to either subject the brine to further treatment for its reuse or dispose of the brine to sea through properly designed diffusers at a location identified by mathematical dispersion modeling in an environmentally friendly manner.

Treatment of Brine:

Several brine treatment technologies are available, but many are economically impractical due to additional Capital Expenditure (CAPEX) and Operational Expenditure (OPEX) requirements. One potential solution, particularly relevant in India with its abundant solar energy availability over three hundred days a year, involves evaporating the brine using solar power. However, implementing this method requires vast expanses of land (about 250 m^2 /m^3 per day) for evaporation ponds, making it impractical for desalination plants catering to Green Hydrogen (GH2) or Power-to-X (PtX) facilities.

Recycle of Brine:

Instead of using seawater, the brine can be redirected as feedwater for Salt Pans, with the caveat that not all discharged brine can be accommodated for recycling due to daily discharge volumes. This operates on the same principle as evaporation ponds. The proximity of salt pans to the desalination plant becomes crucial for this method, limiting its feasibility to specific locations in India. This is also used in Chlor-Alkali plants to produce Sodium Hydroxide and chlorine.

Brine Discharge into the Sea:

Regardless of whether brine undergoes further treatment or is recycled, the development of a responsible outfall arrangement is crucial for any desalination plant. Proper selection of the outfall location, considering factors such as brine quantity, quality, sea depth, tide currents, and hydrodynamic modeling, is essential to minimize environmental impact. The design of outfall diffusers, coupled with necessary measures and monitoring, ensures that the discharge process into the sea is effective.

Annexure 1 - GoI, MF&CA, Department of Revenue Notification dated: 6th September 2002

Annexure 2 - Green_Hydrogen_Policy

Annexure 3 - Policy gaps & Intervention

Annexure 4 - CRZ_Application - Form - I

Annexure 5 – PWD for SWRO Desalination Plant

Annexure 6 – PFD for SWRO Desalination Plant

Annexure 7 –CPCB guidelines for Marine disposal

Annexure 8 – Capex Calculation Sheets

Annexure 9 – O&M Calculation Sheet

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