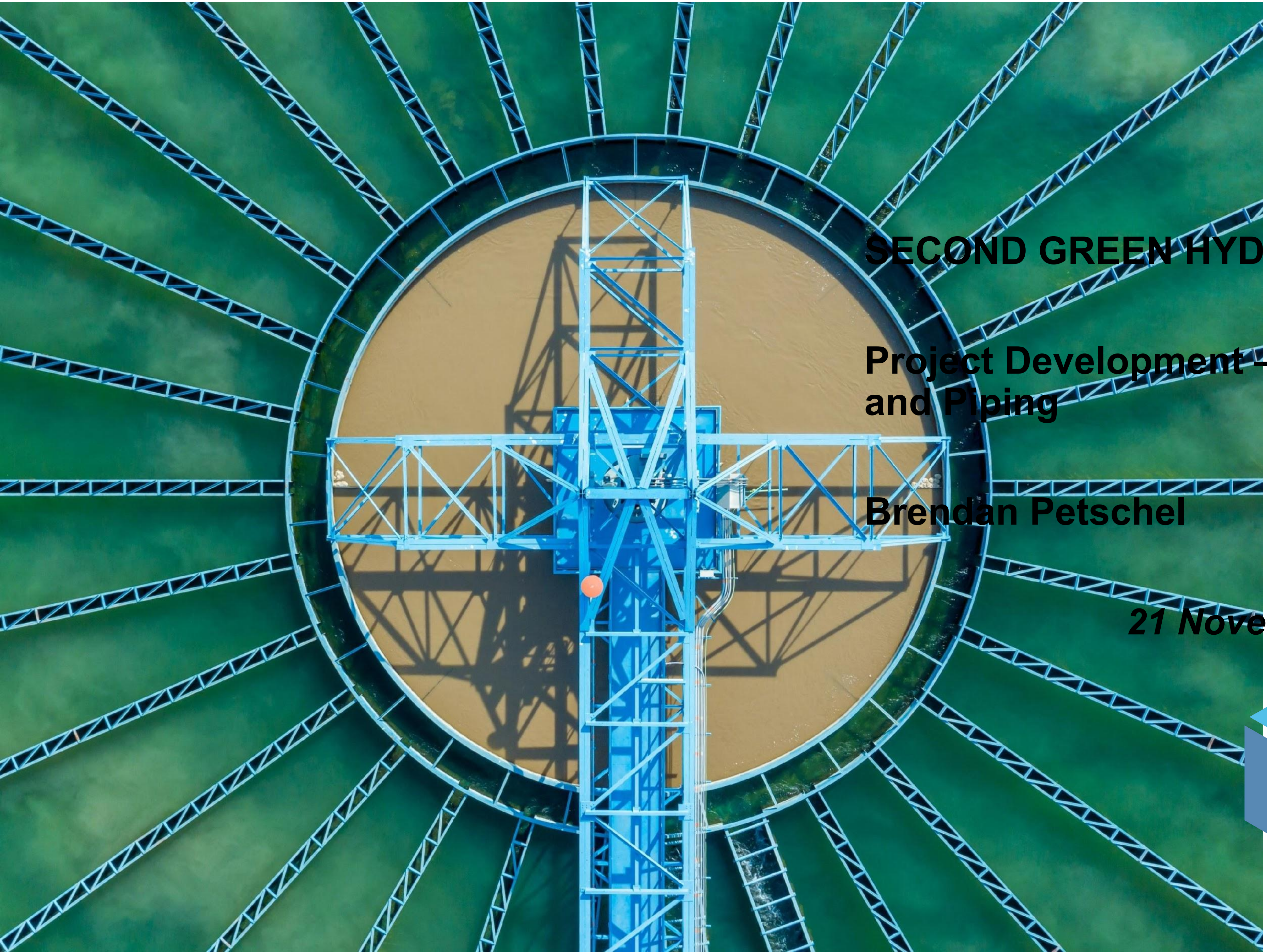

SECOND GREEN HYDROGEN MASTERCLASS

Project Development – Desalination, Pumping and Piping

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nafasi water

Project Development – Desalination, Pumping and Piping

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6. Setting up of desalination facilities – Plant
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9. Setting up of desalination facilities - project timelines

10. Setting up of desalination facilities – design considerations and equipment
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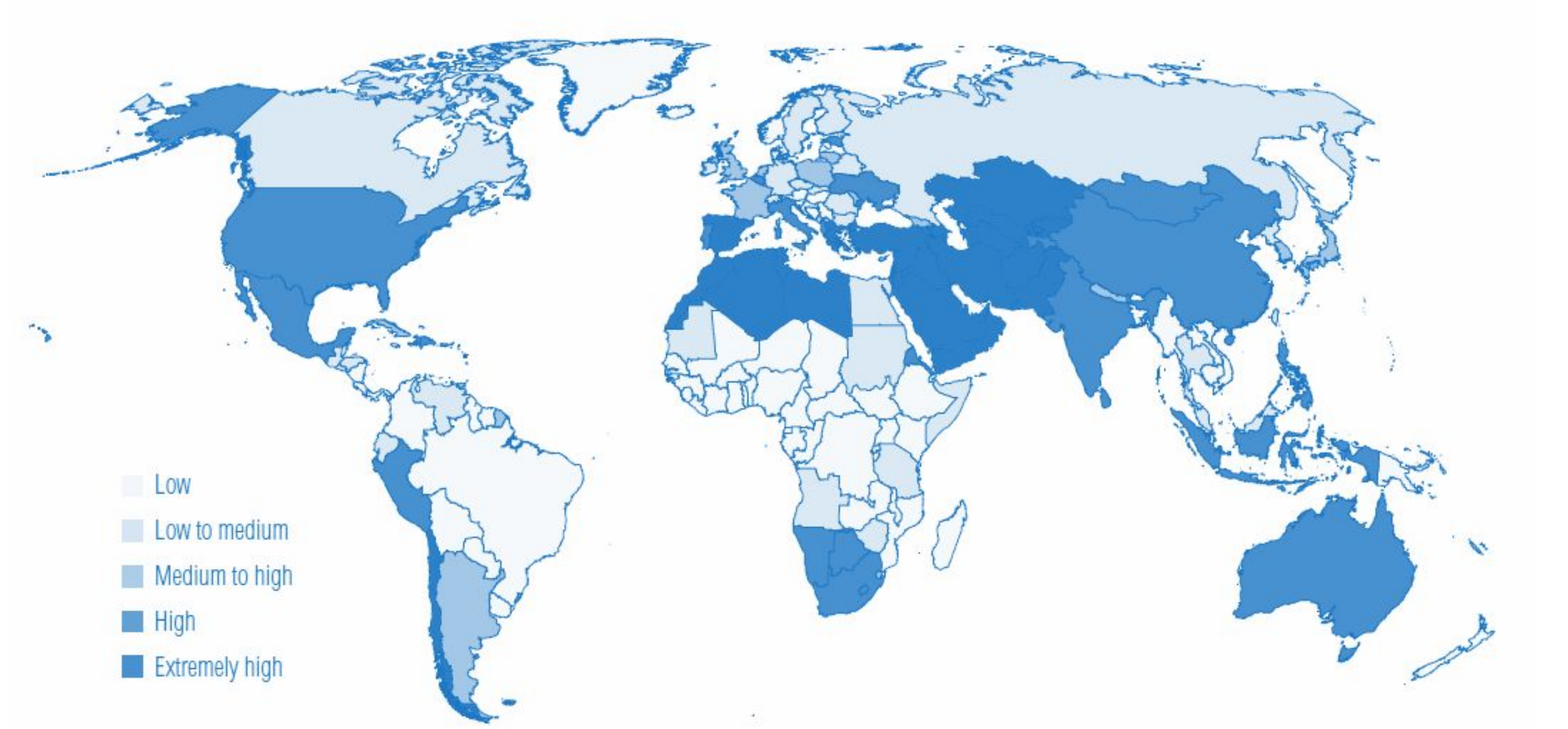
1. Local Water Capacity Needs

Namibia public and private water needs cannot be met by natural sources

- Due to its positioning between the Namib and Kalahari deserts, **Namibia is home to the most arid climate in Sub-Saharan Africa**
- Consequently only 2% of Namibia's unpredictable rainfall (c. 272 mm p.a.) is captured as surface run-off and only 1% is available to recharge ground water
- Namibia's high evaporation rates leads to an annual water deficit, relative to rainfall, of c. 1,300mm – 2,500mm which can be compounded by periodic droughts
- Namibia's sparse population exacerbates challenges in distributing its limited, erratic ground/surface water supply to both rural and urban settlements. Limited perennial rivers run along Namibia's Northern and Southern borders, 700-800km away from high demand areas such as Windhoek and Walvis Bay
- A key water demand area of Namibia in the Central Coastal region, home to mining, tourism and fishing industries through hubs in Walvis Bay and Swakopmund, is **expected to require 36,500 Mℓ p.a. (megalitres per annum) by 2030** for public and private use, of which only **12,000 Mℓ p.a. can be supplied from existing sources**
- In addition to major growth driving industries such as mining, NamWater in the Central Coastal region also needs to meet public needs for water supply in the region

2. Overview of the Desalination Process

Global Level of Water Stress by 2040



- Water Stress defined as ratio of withdrawal to the available renewable water sources

Global household water tariffs - 2019

Household Tariffs	Actual per m^3 (USD)
New York	10.33
Los Angeles	13.63
Rio De Janeiro	3.60

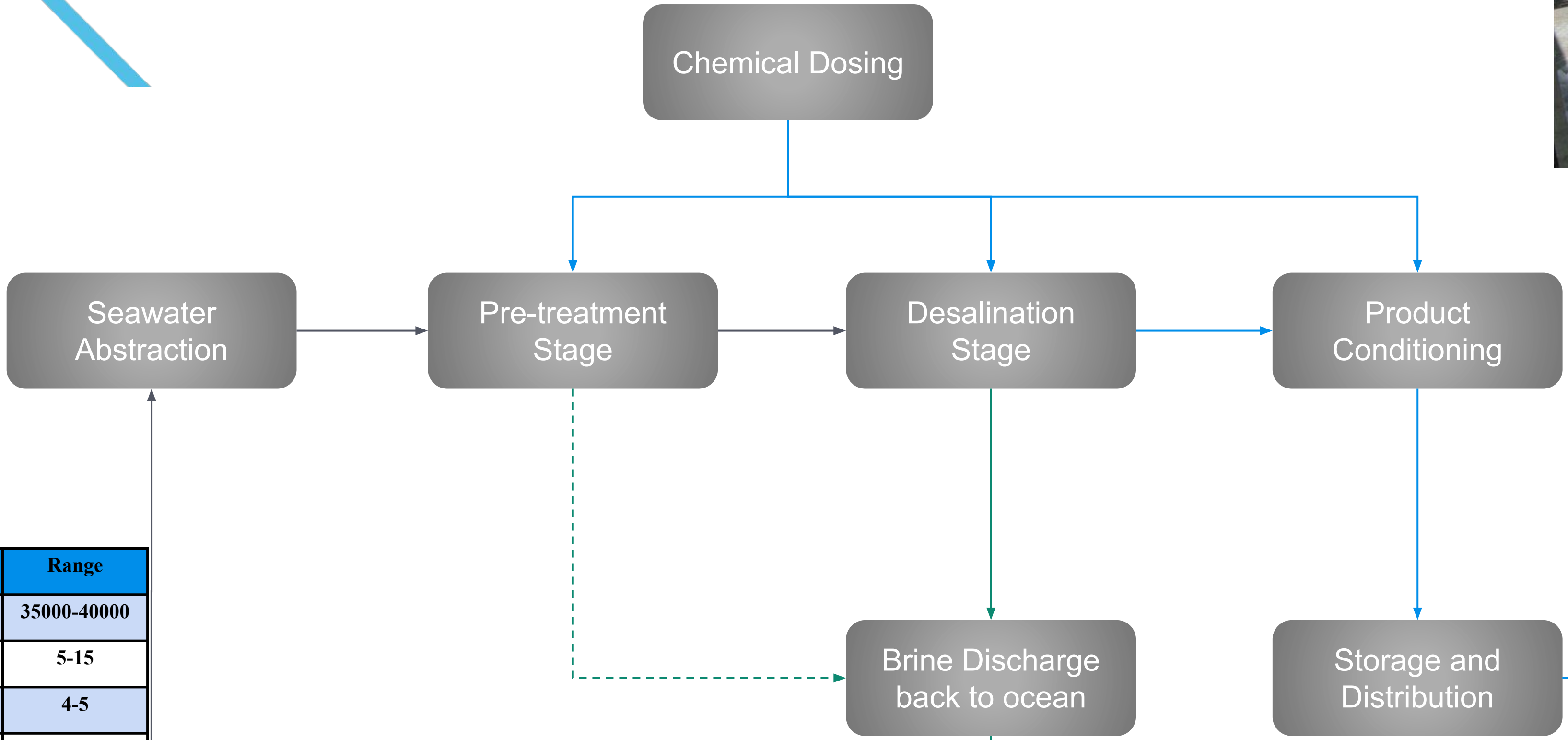
Household Tariffs	Actual per m^3 (USD)
London	3.15
Berlin	5.84
Paris	3.96

Household Tariffs	Actual per m^3 (USD)
Johannesburg	2.27
Lagos	0.65
Nairobi	0.86

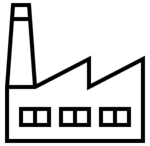
Household Tariffs	Actual per m^3 (USD)
Beijing	0.95
Mumbai	0.15
Tokyo	3.64

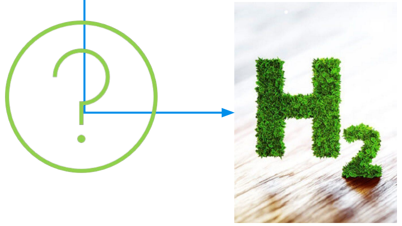
Source: Water Research Institute; Global Water Information; Tariffs are based on average US$ rates for 2019 and 30 cube per day utilisation

2. Overview of the Desalination Process



Determinant	Unit	Range
Total Dissolved Solids	mg/l	500-1000
Total Settleable Solids	mg/l	<1
Boron	mg/l	<2.5
Hydrogen Sulphide	ppb	Not detectable





Determinant	Unit	Range
Total Dissolved Solids	mg/l	35000-40000
Total Settleable Solids	mg/l	5-15
Boron	mg/l	4-5
Hydrogen Sulphide	ppb	5-15

Determinant	Unit	Range
Total Dissolved Solids	mg/l	90000-100000
Total Settleable Solids	mg/l	15-45
Boron	mg/l	12-15
Hydrogen Sulphide	ppb	15-45

3. Upgrading Desalination Product Water for Green Hydrogen

Typical Desalination Product Water

Seawater
35 000ppm TDS

→

Potable and Industrial Water
<1 000ppm TDS

Traditional RO can only purify the water so far.

Additional treatment steps (second pass RO and Electrode-ionising process) are required to achieve suitable qualities for electrolyser systems.

3 Grades of Water Required for Green Hydrogen

Potable and Industrial Water
<1 000ppm TDS

→

- Potable and Wash Water
  <1 000ppm TDS
- Cooling Water
  <500ppm TDS
- Demin Water
  <10ppm TDS

4. Setting up of Desalination Processes – Environmental Requirements and Permitting

- Technical Studies

- *Seawater Quality Analysis*
- *Marine Bathymetric Survey*
- *Marine Diving Survey – Surface bed analysis*
- *Topographical Survey – Plant area and pipeline route*
- *Geotechnical Survey – Plant are and pipeline route*
- *Climatic Condition Study*

- Environmental Impact Studies

- *Marine Impact Assessment*
  - *Wave Conditions*
  - *Water Levels*
  - *Dispersion modelling for brine dispersion*
- *Basic Assessment Report*
  - *Agricultural, animal and aquatic assessments*
  - *Archaeological and Cultural Heritage assessments*
  - *Civil aviation and defence assessments*
  - *Palaeontological and plant species assessments*

- Permitting and Approvals

- *EIA permit*
- *Land-use rights permits*
- *Government water use permit and rights for development of desalination plant*

5. Setting up of Desalination Processes – Intake and Outfall

The intake and outfall infrastructure is a significant undertaking for industrial scale desalination plants

- Type of intake [open sea, subsurface gallery, subsurface wells, etc.]

- Water quality requirements [TDS, TSS, H_2S and TOC]

- Nature of the surface bed and undersea ecology [sandy, rocky, forestry]

- **Sea conditions are a critical factor for intake and outfall construction [Significant P&G impact on project plan]**

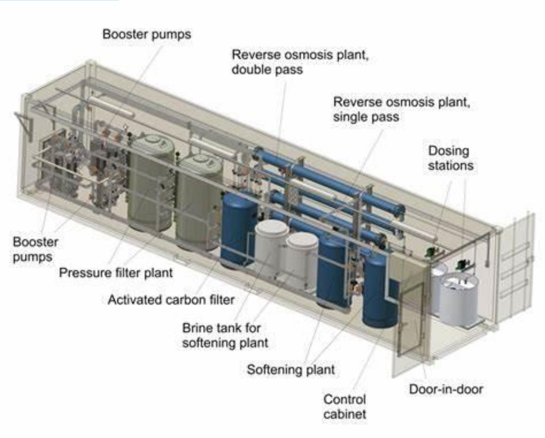
- Materials of Construction [HDPE or steel products with cathodic protection]

- Depth gradient of the surface bed [impact length of intake]

- Brine dispersion strategy [surf typically]

- *Brine beneficiation options a future consideration?*

6. Setting up of Desalination Processes – Plant



The plant infrastructure encompasses some of the following key considerations

- Type of facility [smaller packaged type system, or large-scale industrial system]

- Required Life of Plant [10 – 30 years] and size of plant [1000m^3/d @1600m^2 to 100m^3/d @34 000m^2

- Impact of end-use requirements on redundancy philosophy

- External corrosion protection from environment [Buildings or exposed]

- Extent of pre-treatment required based on feedwater quality

- Power cost optimisation [3.2 kW/m^3 to 5 kW/m^3]

- Emergency power requirements

- Offices, Laboratory, Workshop, Maintenance Store, Chemical Store

- Road infrastructure for chemical and equipment offloading

7. Setting up of Desalination Processes – Storage and Distribution

Storage and Distribution requires the following key considerations

- Size of Storage [Balance of end-user storage capacity and plant redundancy

- Location of storage to be determined, at plant or at off taker

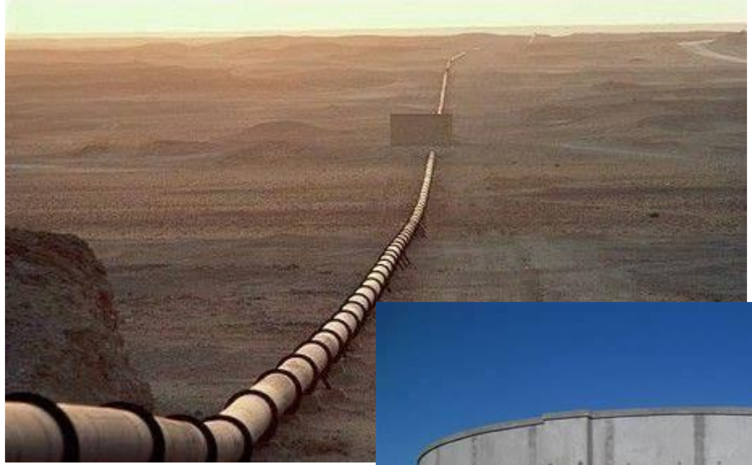
- Distance, gradeline of routing and the quantity of off takers are required for detailed hydraulic design

- Quantity of pump stations required to manage hydraulic requirements

- Infrastructure availability at the pump station locations [power, road access, water, proximity to town, network/internet]

- Material selection

- Dynamic water hammer simulation, specifically if large elevation gradients are experienced.



8. Setting up of Desalination Processes - Power

Although grid power is available in Namibia, Ideally the requirements for **power of water facilities should be linked to power supply systems for Green Hydrogen plants.**

Considerations are:
- Water plants run 24 hours per day

- Most renewable energy systems, specifically solar, will not be placed at the coastline

- Power requirements for water plants, excluding the transmissions systems, will average around $4kW/m^3$

The smaller the plant the higher this ratio will be.

Typically a 20 000m3/day facility will require 4MW of installed power

9. Setting up of Desalination Processes – Project Timelines

The table on the right shows indicative project timelines expected for desalination plants.

In practice the following factors will have a significant impact on the project timeline that are not reflected here:

- EIA process – *[Depending on the location can take between 6 and 13 months]*

- Intake system construction – *[The sea conditions on the Namibian coastline present a major challenge [impossible to plan accurately]*

- Procurement timelines for imported equipment – *external forces such as war, epidemics and middle-east market share impacting lead times [6 months for some equipment]*

- Availability of power for project start

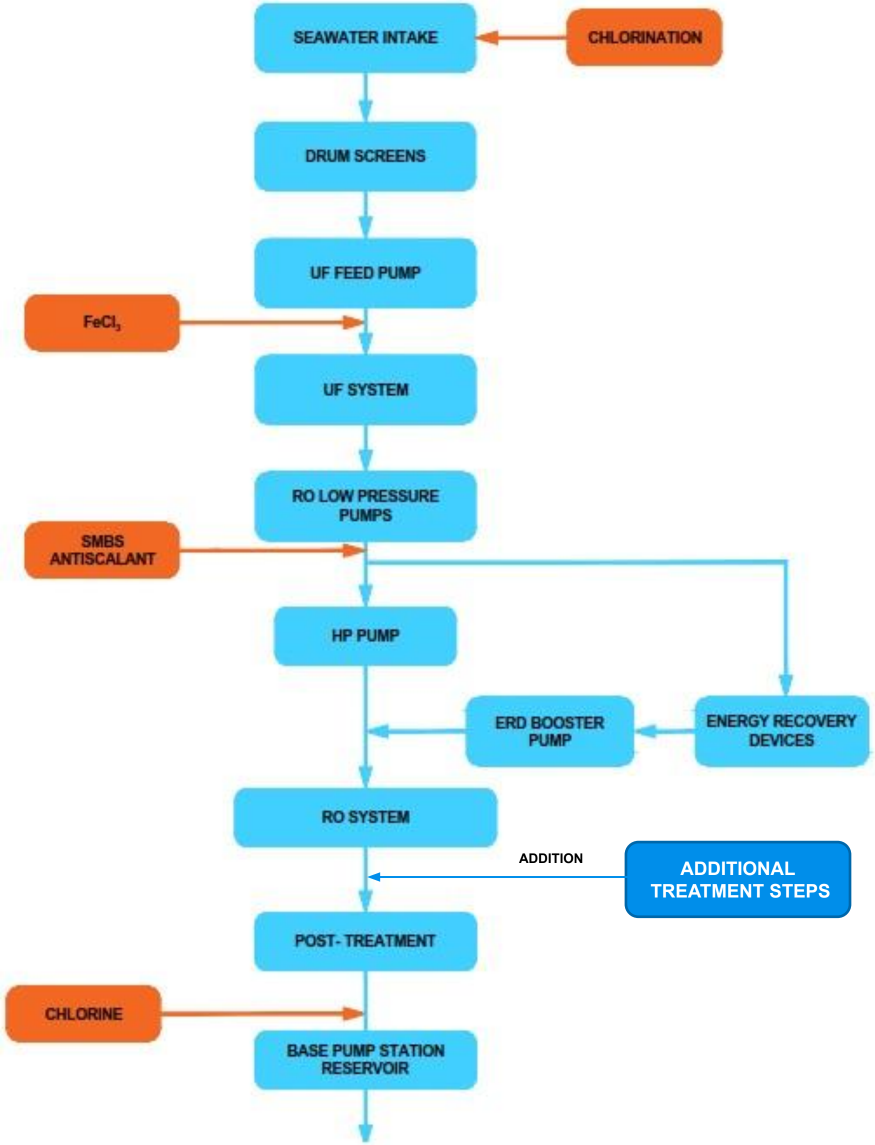
Plant Size, m³/day*	Design, Months	Construction, Months	Start-Up and Commissioning, Months	Total,† Months
Less than 1000	1–2	2–3	1–2	4–7
5000	2–3	4–6	1–2	7–11
10,000	2–4	6–8	1–2	9–14
20,000	3–5	8–10	2–3	13–18
40,000	3–6	14–16	2–3	19–25
100,000	5–8	18–20	3–4	26–32
200,000	6–10	20–24	3–4	29–38

*1 mgd = 3,785 m³/day
†Accelerated implementation of some of the activities is possible but is likely to result in a cost increase.

Table 4.6 Typical Lengths of Desalination Project Implementation

Table reference extracted from, "Desalination Engineering, Planning and Design", Nikolay Voutchkov, PE, BCEE, McGraw Hill

10. Design Considerations and Equipment



PRE-TREATMENT AND SCREENING SYSTEMS

TSS removal and preparation for RO feed

TSS removal and preparation for RO feed
Course Screening removal of muscles and other sea life. Various technologies able to achieve particle size reduction target.

Fine Screening removal of fine particle of sand and debris. Drum screens are robust systems able to achieve required size reduction target

Polishing Ultrafiltration, pressure media filtration or gravity media filtration are typically considered here depending on the objectives of the facility. These selections have different advantages and disadvantages for the life cycle costs and the process.

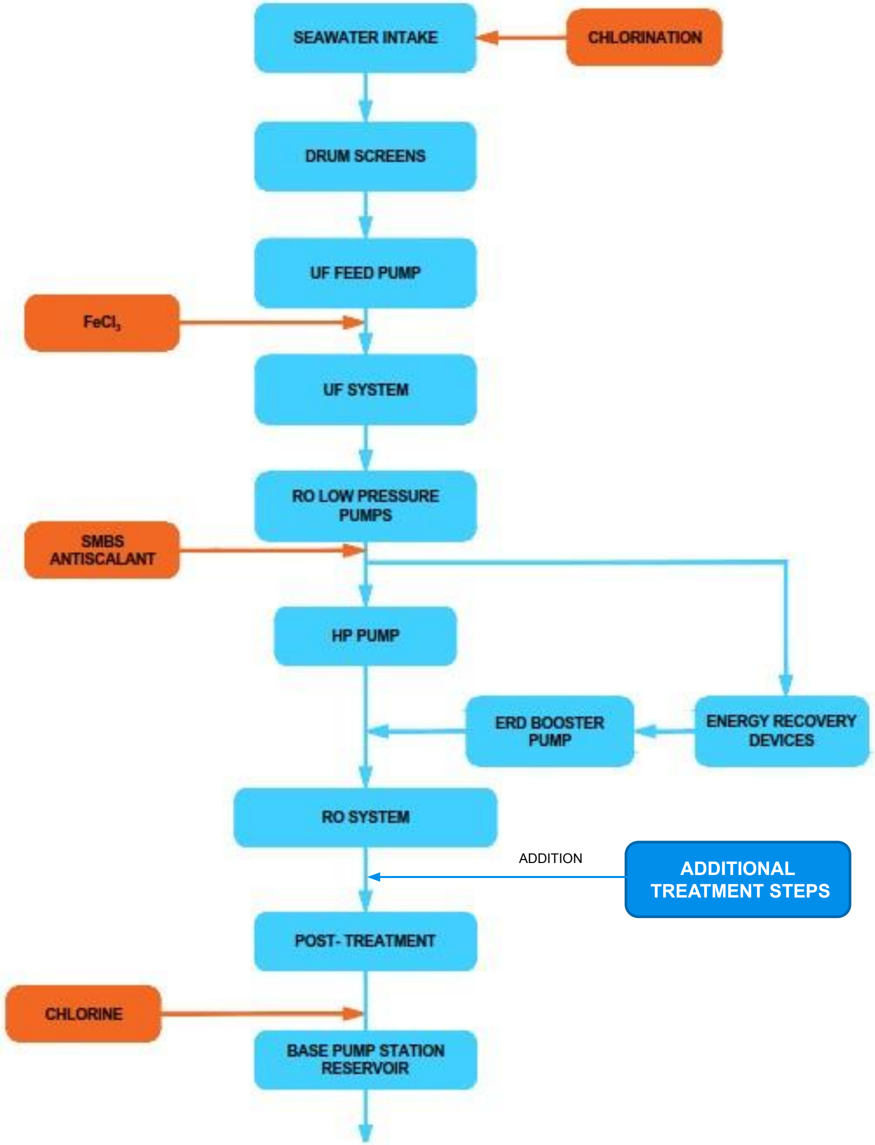
Pumps Pumps are a key consideration for life cycle costs, as a process unit are responsible for more than **90% of the power consumption**. Material consideration are important for these systems

Tanks Tanks are typically of concrete design for large systems

Sea water quality variability the coastline of Namibia presents a number of challenges in terms of variability of feed conditions. Namely, red tides, hydrogen sulphide plumes and jellyfish which bring with them additional organic load that the plant needs to be able to manage. The water is also cold relative to the large gulf facilities.

Interventions are cost-intensive, and these issues typically result in **mechanical availability impacts** on the plants. Consideration here inclusion of Dissolved Air Flotation Systems or dual media filtration to manage these periodic variances.

11. Design Considerations and Equipment



REVERSE OSMOSIS DESALINATION SYSTEMS

Reverse Osmosis Systems are currently the most suitable technology for large scale desalination of water. The following key design consideration will impact the selection of equipment here:

Single Stage, Two Stage or EDI the requirements for product water quality, will define the selection of configuration. The tighter the specification the more stages of treatment required.

Boron Specification for Agricultural processes Specialised membranes or multiple stages required to achieve specification

Energy Recovery Pressure exchangers or ERDs are two of several technologies that are typically used, the most critical factor being the **percentage energy recovery**. The RO unit will operate at approximately 80bar to achieve the required separation. Without energy recovery here the burden of power consumption will destroy the bankability of the project.

Pumps high efficiency and high material specifications required

POST TREATMENT, STORAGE AND DISTRIBUTION SYSTEMS

Stabilisation Stabilisation is critical for protection of erosion of transport systems as RO permeate water will scavenge surfaces to dissolve minerals to equilibrium . If ultra-pure water will be conveyed over long distances, the material selections of downstream systems to be carefully considered.

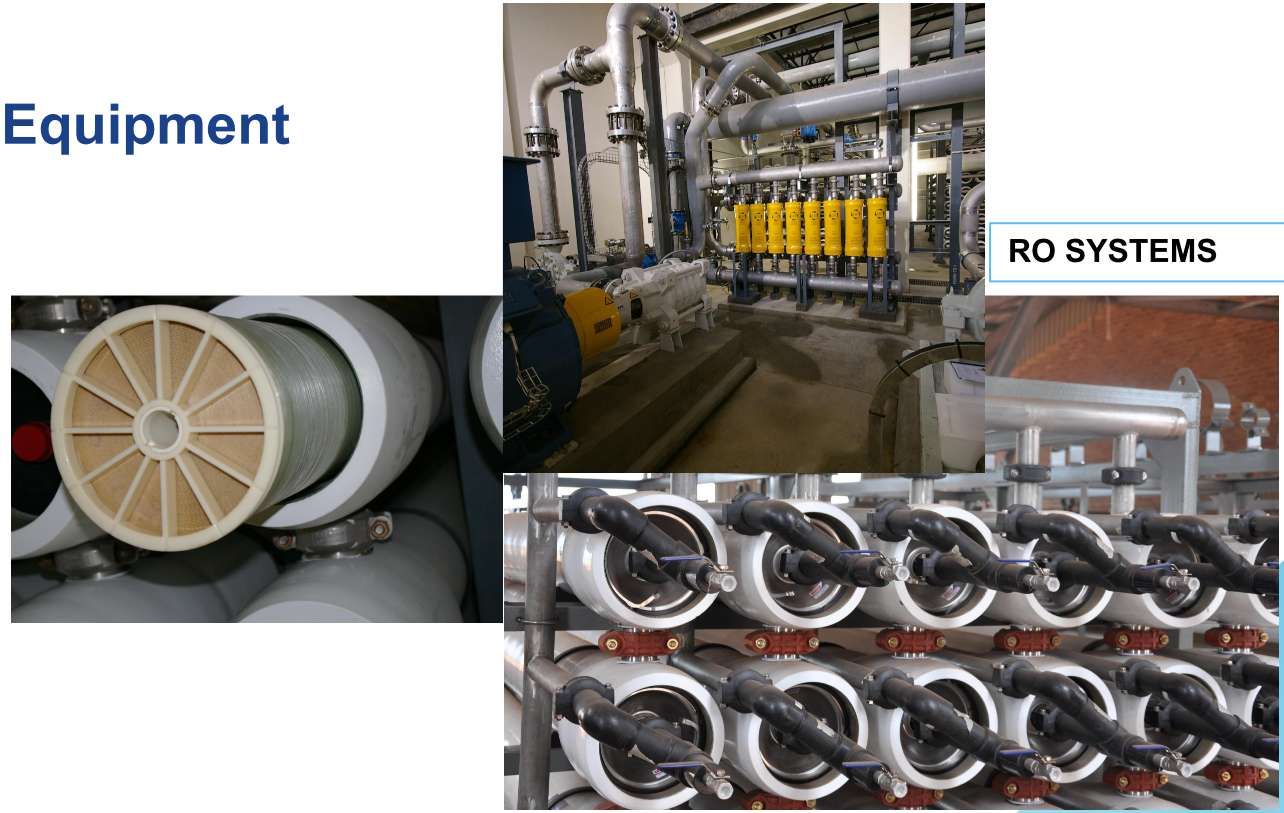
Chlorination Required for potable water distribution to maintain a suitable free chlorine level to stop growth of organic components.

Reservoirs Sizing of reservoirs is critical to act as a buffer between the plant and downstream users. Suitable buffer required to ensure continuous supply downstream while the plant is able to adjust to maintenance activities or events of operation.

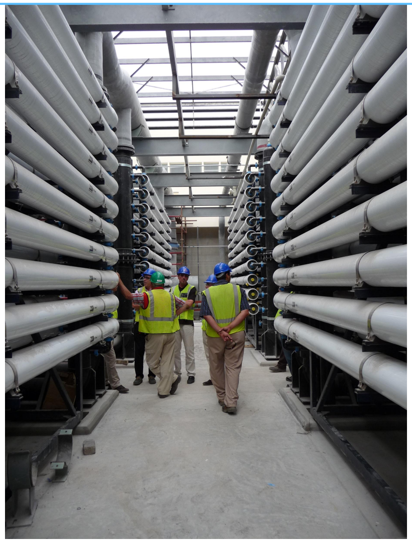
11. Design Considerations and Equipment

DRUM SCREENS

RO SYSTEMS



ULTRAFILTRATION



DUAL MEDIA PRESSURE FILTRATION

PRODUCT WATER CONDITIONING

12. Sourcing of Equipment and Lead Times

Equipment	Source	Expected Lead Time
Process Pumps	EUR, CHN, USA	The booster and HP pumps have long lead times of up to 28 weeks
Drum Screens	EUR, CHN, USA	16-20 weeks
Ultrafiltration Systems	EUR, CHN, USA	12-20 weeks
Dual Media Filtration Systems	Locally fabricated at scale, smaller systems can be imported	14-18 weeks
Dissolved Air Flotation Systems	EUR and IND companies specialise in these systems	18-20 weeks
Reverse Osmosis Systems	EUR, CHN, USA	16-22 weeks
Chemical Dosing Systems	Local Distributors in Namibia and RSA	12 weeks
Air Compressor Systems	Local	12 weeks
C&I Equipment	Local Distributors in Namibia and RSA	12 weeks
MV Electrical Equipment	Local Distributors in Namibia and RSA	21 weeks
LV Electrical Equipment	Local Distributors in Namibia and RSA	16 weeks
Back-up Power	Local	16 weeks

13. Maintenance of Facilities

Maintenance practices for desalination plants require rigorous asset and maintenance methodologies and support systems, the following aspects are critical:

- Spares and stock items management

- Preventative and corrective maintenance for external and internal corrosion

- Cleaning of Tanks and pigging of intake pipelines

- Equipment failure due to high pressure systems and unexpected surges

- Media and membrane health tracking to meet targeted life and budget requirements

- Regular diving checks of intake and caisson

14. Lifetime and Decommissioning of Equipment

Lifespan and decommissioning of facilities will be heavily influenced by the design decisions on the project. And depending on the type of facility established will have different impacts.

- Packaged plants are typically much **easier to decommission, disassemble** and remove off site. Associated infrastructure will also be much smaller to dismantle

- Large scale systems come with much more significant infrastructure in terms of reinforced concrete and elaborate intake systems. These will be **challenging to decommission and disassemble**, to my knowledge this has not been attempted to date.

- Lifespan of equipment is largely based on material selection.
    - Desalination plants requiring duplex material specification for most systems, which can last up to 20 years. Rotating and sealing parts will require frequent replacement and overhaul
    - G/FRP type systems are finding favour, but will require replacement at least every 10 years.

- Lifespan of pipelines is also based on material selections, which typically impacted by lower capex targeting
    - Plastic systems being typically less durable and having a shorter life [10 to 20 years]
    - GRP and steel systems a longer life [20 to 30 years]

- Civil structure can be designed for long life of up to 35 year and longer. Challenges and repairs faced are erosion , especially in the upfront systems as sand, shells and other particulate are often present in the intake systems

- Steel tanks will need to be high grade materials, or cathodic protection to survive for longer than 5 years

- Structures cand be designed for a 20 – 30 year life but will require regular preventative maintenance and recoating as the humidity and salinity in these coastal region readily degrade these coatings

13 . Health and Safety Requirements for Setting up of desalination facilities

Health and Safety requirements are similar to other industrial facilities, typical employer requirements are that the practices of contractor and service providers align with the ISO45001 certification.

Critical considerations are:

- Baseline risk assessments of the facility are essential

- Usage of local personnel is a key requirement and training programmes for safe practices are also essential

- Safety equipment suitable for handling dangerous chemicals is critical. The pumping systems for the Reverse Osmosis and transfer systems have very high noise levels and ear protection is critical.

- Bulk chemical usage [typical list shown on the right], chlorine and acid chemicals require special safety SOPs to ensure safe use

- High pressure systems are a danger, unexpected failure of clamps or flanges present a health hazard

- Working at heights and in enclosed spaces

- Divers, on staff or contractors will be required for regular inspection, requiring specific risk assessments to ensure safe practice

Chemical	Dosage, mg/L	Point of Application and Purpose
Ferric chloride or ferric sulfate	0.5–30	• Upstream of pretreatment systems for enhanced removal of solids and silt
Sulfuric acid	30–100	• At intake forebay for control of shellfish growth control in open intakes • Upstream of pretreatment systems for enhanced removal of solids and silt • Upstream of RO system for scale inhibition • Into permeate for reduction of pH and enhanced dissolution of calcite in post-treatment contactors • Into permeate for adjustment of the final product water's pH
Polymer (flocculant)	0–2	• Upstream of pretreatment systems for enhanced removal of solids and silt
Sodium hypochlorite	0–15	• At intake forebay (for open intakes) or well heads (for well intakes) and in intake pump station wet well for control of biogrowth • Upstream of secondary pretreatment for control of biofouling
Sodium bisulfite	0–50	• Upstream of RO system for removal of oxidant residual
Antiscalant	0.5–2	• Downstream of the point of addition of sodium bisulfite and upstream of the RO system for inhibition of scaling
Sodium hydroxide	10–40	• Into feed water of first or second RO passes for enhanced removal of boron • Into finished water for adjustment of pH
Lime	50–100	• Into RO permeate for addition of hardness and alkalinity
Carbon dioxide	30–80	• Into RO permeate for addition of alkalinity and enhanced dissolution of lime and calcite

TABLE 4.5 Chemicals Commonly Used in Desalination Plants

Table reference extracted from, "Desalination Engineering, Planning and Design", Nikolay Voutchkov, PE, BCEE, McGraw Hill

THANK YOU

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