Blueprint for a Tender for a Renewable Energy Powered Desalination Plant

Blueprint Draft as of 18 April 2019
Part 1

- Introduction
- Technologies
- Reference Plants
- Indicative Costs
Introduction

Desalination is a Suitable Option to Meet Growing Demand for Water

- Global water demand is increasing by about 1% per year since 1980s and is expected to keep rising due to population growth, socio-economic development, and changing consumption patterns
- Freshwater sources are depleting: more than 2 billion people are currently experiencing water stress and more than 4 billion severe water scarcity
- Water stress will keep rising as water demand grows and the effects of climate change deepen
- Desalination is in increasingly more places the only available option to meet the rising water demand

Renewable Energy Powered Desalination

- The energy consumption of seawater desalination is significant and considerably higher than traditional water supply solutions (groundwater, rain catchment, rivers, lakes, etc.)
- Worldwide, operational desalination plants emit around 76 million tonnes of CO₂ per year. The emissions are expected to increase to around 500 million tonnes of CO₂ per year by 2040 if no actions are undertaken.
- The climate impact of desalination can be addressed through use of renewable energy systems to power the desalination plants.
- This is a sustainable and cost effective solution thanks to decreasing cost of renewable energy systems.

Baseline scenario assumes compounded growth rate of water desalination of 10% per year

Target scenario assumes gradual introduction of fully renewable powered desalination until 2040

Source: Global Clean Water Desalination Alliance
Introduction

The Global Clean Water Desalination Alliance - HO2 minus CO2

A climate initiative launched at COP21

- It is one of the initiatives under the Lima Paris Action Plan, focusing on CO2 emission reductions in the desalination industry.
- Alliance is open to all categories of actors, such as utilities, industries, research organizations, universities, NGOs, associations, local authorities and governments.
- The initiative is not based on a legal contract but on a moral commitment on actions and coordination for more coherence and effectiveness, and on the facilitation of sharing of solutions (such as knowledge platforms, capacity building actions, etc.).
Introduction

Objective and Targets

The overall objective of the Alliance is to stimulate reductions of CO₂ emissions from water desalination through committed actions and policies.

The Alliance aims to achieve the following targets:

1. Clean Energy Supply for Desalination Plants:
   - Existing plants: 10% clean energy supply by 2030

For future plants:

- 20% clean energy supply for new plants between 2020 and 2025
- 40% clean energy supply for new plants between 2026 and 2030
- 60% clean energy supply for new plants between 2031 and 2035
- 80% clean energy supply for new plants after 2035
Introduction

GCWDA Objectives and Targets

2. Incentives for Enhanced Energy Efficiency, System Integration and Demand Response:
   - Incentives can be tax credits, rebates, special tariff structures, etc.

3. Investment in additional Research, Development and Demonstration (RD&D):
   - All members together commit to put in place from 2017 onwards an additional investment on solution driven RD&D.

4. Investment in Education, Training and Outreach:
   - Members will support the dissemination of information on CO₂ emissions in the desalination sector.
GCWDA - to SUM UP

- GCWDA brings together all key stakeholders from the energy and desalination industries, water utilities, governments, financing institutions, academia and R&D with the goal to reduce CO2 emissions from existing water desalination plants and to scale up the use of clean desalination technologies through coordinated actions. Fostering integrated approach of issues. Its organization and structure of the Board reflects that diversity and ensure equal representation of all geographical zones,

The Alliance aims to reduce CO2 emissions from water desalination by promoting and leading the implementation of activities that:

- **Power new water desalination plants by clean energy sources**;
- **Replace fossil fuel based energy sources** of existing water desalination plants with clean energy sources;
- **Retrofit** existing water desalination **plants with more energy efficient technologies**;
- **Attract investments** in the water desalination sector for CO2 emission reduction purposes.

- The Alliance has set up a Trust Fund to support activities and projects and channel resources mobilized and signed a partnership agreement in January 2019 with **Office International de l’Eau** for its implementation.

- The Alliance has so far **around 176 members from 38 countries and 6 continents**.
The BLUEPRINT is a component of the work program of the Alliance – so far conducted by members themselves: report on status of RD, Seminar on regulatorily issues, Participation at COP and Climate summit events,

A working group, including various actors, including Head of IDA… based on our experience

Our objective is to promote clean desalination, to contribute to decarbonization and to the fight against climate change but make sure the price of the desalinated water stays or even becomes more cost competitive, taking into account present limits related to intermittence

- Take into consideration the different type of situations and the possible variation of the regulatory framework
- Put forward different kind of solution for clean desalination to allow authorities to use a pallet of solutions and make their own choices;
- So we looked at small scale desalination in remoted areas (2 options) and at utility scale clean desalination (several options), identifying solutions of couplet production of clean electricity and water
- But also at other ways to ensure that the electricity used in the desalination plants is clean, while not necessarily produced on the same site and by the same owner or operator

Introduction- the blueprint - looking at different options
Introduction - the blueprint - looking at different options

Small-Scale Renewable Energy Powered Desalination

- Suitable option for remote locations and small islands where the reliable and safe provision of drinking water is a constraint and expensive
- Communities on islands are often located in areas with access to seawater which can be desalinated
- Electric grid and water networks are often inadequate
- Small-scale renewable energy powered desalination can be the optimal solution to address the water constraints and provide the following key benefits to the community:
  - Increase of the security of water supply
  - Reduction of the fuel and/or water imports
  - Reduction of water costs
Technology Brief option 1: Small Scale Solar Seawater Desalination – Direct Coupling (Off-grid), No Storage

- This configuration is ideally suited for very remote locations with limited access to a reliable electricity grid and service personnel.
- The configuration avoids using batteries and uses water storage instead to allow a water supply during day and night.
- This reduces the need for operation and maintenance.
- The concept requires a special design of the reverse osmosis plant which is able to cope with variable pressure and variable feed flow conditions as the renewable power supply varies throughout the day. Such systems are available only from a limited number of suppliers.
Technology Brief option 1: Small Scale Solar Seawater Desalination - Grid Connected

- Good option for locations with access to a relievably electric grid
- The renewable energy supply system can be sized to completely offset the CO₂ emissions of the desalination plant
- Reduced maintenance requirements due to absence of storage and backup generators
- Distributed solution obviating the need for costly water transmission and distribution systems
- Provides constant water production over 24 hours
- Empowers local communities and provides local jobs for operation and maintenance
- Local renewable energy production is an option to complement water production
Technology Brief option 1: Small Scale Solar Seawater Desalination – Direct Coupling (Off-grid) with Storage or Backup Generation

- Good option for locations with inadequate grid supply but access to service personnel for batteries or back-up generators
- Distributed solution obviating the need for costly water transmission and distribution systems
- Provides constant water production over 24 hours
- Empowers local communities and provides local jobs for operation and maintenance
- Local renewable energy production is an option to complement water production

**Energy supply system**
- Photovoltaic modules/Wind turbine
- Batteries storage
- Back-up diesel

\[ \approx \text{OPTIONAL} \]

\[ \approx \text{OPTIONAL} \]
Introduction - the blueprint - looking at different options

Utility-Scale Renewable Energy Powered Desalination

- A new concept to produce drinking water in large quantities for cities or entire countries in a sustainable way in arid regions
- The concept strongly benefits from highly energy efficient desalination processes, such as reverse osmosis
- Ideal for countries having good renewable energy resources (solar, wind, geothermal)
- The renewable energy power plant does not necessarily need to be located at the same place as the desalination plant
- Facilitated by dramatic fall of REN cost in the last years, making this concept economically very attractive
- Renewable energy powered desalination represents a cost-effective option to
  - Decarbonize water production;
  - Reduce impact on the electricity grid through on-site renewable energy production;
  - Reduce production cost of desalinated water.
Technology Brief option 2: Utility-Scale Renewable Desalination - Grid Connected with Virtual Net Metering

- The Desalination Plant and the Renewable Power Plant are connected to the grid and don’t need to be co-located.
- This allows the placement of the Renewable Power Plant at locations with good renewable energy resources and sufficient space.
- The Renewable Power Plant is sized to completely offset the CO₂ emissions of the Desalination Plant (over the lifetime of the plant).

Desalination Plant
- Operates 24h per day
- Consumes electrical energy (and maybe heat in addition)
- Connected to the grid, using existing infrastructure to supply electricity 24h per day. In case of a thermal desalination plant (e.g. MED), steam needs to produced on site preferably using renewable energy.

- Purchases electricity preferably from the Renewable Power Plant through a direct power purchase agreement (wheeling fees may apply) and any shortfall from grid operator.
- Or, Green Energy certificates or carbon credits.

Renewable Power Plant
- Operates only during certain hours of the day producing electricity from sunlight or wind.
- Connected to the grid, using existing infrastructure.
- Electricity production does not match electricity consumption from desalination at all times, but on average over the plant lifetime.

- Sells electricity to the Desalination Plant through a direct power sale agreement and any access electricity to the grid operator.
- Or sells green certificates of carbon credits.
- Or co-invests.
Technology Brief option 2: Utility-Scale Renewable Desalination - Grid Connected with Captive (On-Site) Renewable Energy Generation

- This is an expansion or partial replacement of the “Virtual Net Metering” concept
- A portion of the electric energy demand of the Desalination Plant is met through “captive” (i.e. on-site) renewable energy production (e.g. though rooftop PV, façade integrated PV, etc.)
- On-site renewable electricity production is often available at lower cost than electricity provided by the grid operator
- This configuration also reduces the impact of the desalination plant on the electric grid, mainly the distribution system
This project in the Philippines uses a containerized solar RO solution which has the solar panels mounted on the roof and the water treatment station. The system was installed within 2 weeks. A water tank is included to store the drinking water on-site.

### General Information

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
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<tr>
<td>Owner/promoter</td>
<td>Elemental Water Makers</td>
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<tr>
<td>Location of SWRO Plant</td>
<td>La Union, Luzon, Philippines</td>
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<td>Year of construction</td>
<td>2018</td>
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<tr>
<td>Capacity of SWRO Plant</td>
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<td>PV plant</td>
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<tr>
<td>Capacity of RE Plant</td>
<td>4 kWp</td>
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Source: [https://www.elementalwatermakers.com/project-philippines/](https://www.elementalwatermakers.com/project-philippines/)
This solar powered seawater RO system from Mascara Renewable Water on Rodrigues Island, Mauritius, is the first solar desalination plant installed in the Indian Ocean. Mascara’s OSMOSUN®SW80 desalination system works without batteries. It is operated by the Water Department of the Rodrigues’ Regional Assembly and supplies the local drinking water system with 240 m3/day.

**General Information**

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<td>Owner/promoter</td>
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<td>PV plant</td>
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<tr>
<td>Capacity of RE Plant</td>
<td>66 kWp</td>
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The unit is fed with raw water with 35 g/l salinity through a beach well drilled in coral subsoil. The unit produces, along with the sun exposure, 80m3/day in complete autonomy, and when required by the local population, 160m3 powered by the local energy grid at night.

Source: [https://mascara-nt.fr/en/project/osmosunsw80-rodrigues-island-mauritius/](https://mascara-nt.fr/en/project/osmosunsw80-rodrigues-island-mauritius/)
This 100 m³/d containerized wind-solar powered micro-grid seawater desalination system with electric energy storage is installed on an island in the Hainan province, China.

System Configuration:
- 100 kW wind turbine
- 100 kW PV system
- 100 kW energy storage
- 100 m³/d 3-stage RO desalination

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<td>Owner/promoter</td>
<td>Jiang Su Feng Hai</td>
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<td>Hainan province, China</td>
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<td>Year of construction</td>
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<td>Capacity of SWRO Plant</td>
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<td>Type of RE Plant</td>
<td>PV plant and wind</td>
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<tr>
<td>Capacity of RE Plant</td>
<td>100 kW PV + 100 kW turbine</td>
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The Kwinana desalination plant is located in Perth, Australia. It is the first large-scale seawater RO plant in the world powered by renewable energy using green electricity procured from an Australian wind farm.

The desalination plant has been widely recognized for its very high environmental standards.

**General Information**

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<td>Owner/promoter</td>
<td>Water Corporation</td>
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<td>Location of SWRO Plant</td>
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<td>Year of construction</td>
<td>2006</td>
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<td>Capacity of SWRO Plant</td>
<td>144,000 m3/d</td>
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<td>TDS (design)</td>
<td>35,000 - 37,000 mg/l</td>
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<td>Specific Energy Consumption</td>
<td>4 - 6 kWh/m3</td>
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<td>Power requirement of SWRO Plant</td>
<td>24 MW</td>
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<td>D&amp;C Joint Venture</td>
<td>Suez-Degrémont/Multiplex/Worley Parsons/Water Corporation</td>
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**Kwinana SWRO Plant - Perth**

- The green electricity consumed by the desalination plant is provided by the 80 MW Emu Downs Wind Farm.
- The wind farm comprises 48 wind turbines and is located in a distance of 200 km from the desalination plant.
- The annual electricity generation from the wind farm is 150% of the desalination plant's annual needs.

**Emu Downs Wind Farm**

- **Kwinana is the first utility-scale SWRO plant @ “0” carbon footprint**
Cost of Renewable Water Desalination

The cost of desalinated water produced with renewable energy sources depends on many factors:

- Composition of source water (dissolved and suspended solids, turbidity, BOD, COD, boron, etc.)
- Requirements for the product water (use for drinking, irrigation, industrial use, etc.)
- Accessibility to source water
- Available renewable energy sources (solar, wind, geothermal)
- Production capacity
- Creditworthiness of water off-taker
- Availability of bank financing

Indicative average costs (assuming seawater desalination with grid connected PV powered RO)

<table>
<thead>
<tr>
<th></th>
<th>Utility-Scale (above 100,000 m³/d)</th>
<th>Small-Scale (around 1,000 m³/d)</th>
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<tbody>
<tr>
<td>CAPEX of RO system [USD/m³/d]</td>
<td>~ 1,200</td>
<td>-2,800 for 100% solar powered 1,200 for hybrid</td>
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<tr>
<td>CAPEX of PV system [USD/kW_{DC}]</td>
<td>~ 700</td>
<td>~900</td>
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<tr>
<td>OPEX of RO [annually as % of CAPEX]</td>
<td>~ 4%</td>
<td>~5%</td>
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<tr>
<td>OPEX of PV [annually as % of CAPEX]</td>
<td>~ irradiation1%</td>
<td>~1%</td>
</tr>
<tr>
<td>Levelized water cost [USD/m³]</td>
<td>~ 0.60</td>
<td>~1.00</td>
</tr>
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</table>

Assuming a location with good solar resource (i.e. global horizontal around 2,000 kWh/m²/a)
Part 2  WHAT IMPACT ON TENDERS

- Project Preparation
- Tendering
How shall a renewable energy powered desalination project be prepared and tendered?

- A project for renewable energy powered desalination needs to start with a **feasibility assessment**, in which key technical and commercial parameters are analyzed to determine if the project can be developed in a technically feasible and commercially viable way, and what changes here from traditional tenders is that it need to be **including the REN options existing**.

- Once the principal feasibility has been proven, the **regulatory framework** needs to be analyzed to find the most suitable approach how to structure the project commercially. **This aspect is key.** Possibility of net net metering, of PPA to sell electricity, to co-invest in REN production, to use carbon credit or green electricity certificates, etc...

- The next step is to establish a **marketing plan** in order to promote the project among relevant stakeholders. **This is new so you need to make sure everybody is well aware so as to get the best offers.**

- Finally, the **tender documents** need to be prepared and disseminated to potential tender participants.

- During and upon completion of the tender process, **workshops and training** - again as we are in a new set up - will ensure that the owner of the project will receive all relevant information (technical, commercial, legal, financial, etc.)

- **The following pages explain these steps in more detail.**

- **Will go fast over these slides, but there will be available later for you.**

- **Highlighted what is different from traditional tender documents as just mentioned**.
Project Preparation

1. **Feasibility Study**
   - **Key Activities:**
     - **Technical**
       - Site conditions (source water analysis, renewable energy resource assessment, availability of electric grid, water distribution system, etc.)
       - Desired water use and water production capacity
       - Sizing
       - Desalination technologies screening
       - How to couple the renewable energy supply with the desalination plant
     - **Commercial**
       - CAPEX
       - OPEX
       - Levelized water cost
   - **Key Aims:**
     - Provide guidelines for technology selection and plant location
     - Energy/water balance analysis
     - Define process parameters, identify interconnections and interfaces
     - Budgetary cost estimate
   - **Deliverables - Technical Aspects:**
     - Identification of suitable desalination technologies
     - Identification of available options for the RE supply
     - Recommended way to provide the RE power supply to the desal plant (direct coupling, connection via the grid)
     - Space considerations
     - Technical description of the desal plant and the RE plant
     - General recommendation for the next steps

2. **Regulatory Framework Assessment**
3. **Marketing Plan**
4. **Tender Process**
5. **Workshops and Training**
**Project Preparation**

1. **Feasibility Study**
2. **Regulatory Framework Assessment**
3. **Marketing Plan**
4. **Tender Process**
5. **Workshops and Training**

### Key Activities:
- Review of existing legislation and the **relevant regulatory framework**
- Develop recommendations for amendments, if required
- Review of legislation about available contractual options for the purchase of RE by the desal plant (e.g. net metering, direct RE power purchase, wheeling fees, green certificates, etc.)
- Selection of procurement method (single buyer of water and power or separated buyers of water and power, EPC vs IWP/BOO structure)
- Preparation of draft project agreements

### Key Aims:
- Ensure that the procurement method is in accordance with the legal and regulatory framework and suitable for the project
- Ensure that the further project implementation steps are in line with the regulations

### Deliverables:
- **Report about existing legislation and regulation**
- **Report about recommended changes to existing regulations**
- Decision/recommendation on most suitable procurement method and commercial structure
- Risk allocation matrix, risk register
- Draft Project Agreements
- Draft Project Implementation Plan
**Project Preparation**

1. Feasibility Study
2. Regulatory Framework Assessment
3. **Marketing Plan**
4. Tender Process
5. Workshops and Training

### Key Activities:
- Prepare a marketing plan to promote the project
- **Conduct a dedicated conference/event to promote the project or deliver key note addresses at high profile industry events**

### Key Aims:
- Marketing the project to key stakeholders (developers, EPC contractors, technology solution providers, financial institutions, community, policy makers, consultants, academia, media, etc.)
- Maximizing interest and establishing credibility
- Ensuring project marketability

### Deliverables:
- Background material for the marketing of the project i.e. presentation, press release.
**Project Preparation**

1. **Feasibility Study**
2. **Regulatory Framework Assessment**
3. **Marketing Plan**
4. **Tender Process**
5. **Workshops and Training**

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### Key Activities:
- Select a technical advisor
- Issue an invitation for an Expression of Interest (EOI)
- Prepare and issue the Request For Qualification (RFQ)
- Prepare and issue the Request For Proposal (RFP)
  - Conduct a site visit/pre-bid meeting
- Bid evaluation
  - Negotiation & selection of the preferred bidder
- Execution of project agreements and Financial Close

### Key Aims:
- Contract a technical advisor
- Issue the EOI, RFQ and RFP
- Shortlist bidders
- Execute project agreements
- Financial close

### Deliverables:
- RFQ
- Shadow Financial Model (financial model prepared by the Advisor and included in the RFP to be used for the evaluation of the bids. Bidders need to provide well defined inputs into the financial model so that the corresponding tariff can be calculated.)
- RFP package
- Bid evaluation methodology and report, clarification list for each bidder
- Updated risk allocation matrix based on final negotiated position
- Final project agreements for execution
- Financial close
Key Activities:
- Undertaking well-structured training program for client’s personnel to meet client’s specific requirements
- Training workshops to be conducted by relevant subject matter experts covering technical, legal, financial and commercial aspects of a RE desal plant

Key Aims:
- Provide training and knowledge transfer
- Develop in-house capacity for the client in key areas of the project

Deliverables:
- Background materials
- Workshop documents
Part 3

- Typical Structure of a Tender for RE Desalination Plant
Typical Structure of a Tender for RE Desalination Plant

**RFQ Structure**
- Part I: Initial briefing memorandum
- Part II: Pre-qualification process
- Part III: Criteria for evaluation
- Part IV: Scope of qualification requirements

**RFP Structure**
- Part I: General instructions
- Part II: Technical specification
- Part III: Bid forms
- Part IV: Drawings and Diagrams
- Part V: Draft Agreements
Part I: General Instructions to Bidder

This part shall indicate instructions for preparing the bid, closing date and submission formalities, tender validity duration and tender security details, envisage contract conditions, procedure for selection of proposals, including qualification conditions, responsiveness/rejection criteria, evaluation criteria and ranking and selection procedure.

Part I will comprise the following:

* Project description
* Definitions
* Tendering rules
* Bid bond (if applicable)
* Evaluation criteria and procedures for selection of preferred bidder

The instructions to bidders shall include a well-defined set of evaluation criteria and a clear description of the evaluation process. This will add transparency to the overall bid process and therefore be an encouragement for the bidders to prepare highly competitive proposals.

Part II: General Technical Specifications

The general technical specifications shall include:

* Scope of work
* Site conditions
* Design requirements
  * Renewable energy supply
  * Desalination plant
  * Integration or coupling of RE supply with desalination
* Minimum functional specification
  * Renewable energy supply
  * Desalination plant
* Interfaces
Part III: Bid Forms

Technical bid forms shall be provided to all bidders to ensure a consistent evaluation and fair ranking of the proposals. The bid forms need to cover engineering, financial, legal and organizational aspects. Clear instructions shall be given to bidders about boundary conditions, assumptions, interpretations and limitations.

Bidders shall be required to submit their technical data in a predetermined format using the same units. This will allow to accurately compare the bids and assess their compliance with the RFP.

The bid forms should also include the proposed implementation schedule.

Part IV: Drawings and Diagrams

This part of the RFP shall provide the Bidders with the following information about the project:

- General Information
  - Layout plan of the desal plant and the renewable energy plant
  - Site conditions for the desal plant and the renewable energy plant

- Basic Data
  - Analysis of source water
  - Renewable energy resource
  - Climatic data
  - Tentative Process Flow Diagram
  - Information about the electric grid, including grid connection and conditions and regulations for power transmission between the desal plant and the renewable energy plant (if applicable)

- Electrical drawings (mainly interface drawings, if applicable)
- I & C drawings (mainly interface drawings, if applicable)
Part V: Draft Agreements

The RFP shall include the following draft project agreements:

- EPC contract
- O&M contract
- Land lease agreement(s)
- **Power purchase agreements** (direct purchase, indirect purchase via grid including wheeling fees, net metering arrangements, green certificates, etc.)
- **Heat purchase agreement** (if applicable)
- **Water purchase agreement**
- Performance bond
The Global Clean Water Desalination Alliance planned to commission in next phase a report to provide detailed guidelines on the feasibility study, regulatory framework assessment, marketing plan, RFQ and RFP, and training plan.

The report will discuss how to deal with specific technical, commercial, financial and regulatory aspects on the integration or combination of desalination with renewable energy supply and how to formulate this in the tender.

The report will analyze existing examples of renewable energy powered desalination plants and based on these examples derive recommendations for best practices. It will look at different forms of PPA also - as we know there a different practices that have been developed,

The report will also include a section on benefits and risks of renewable energy desalination.

For further information please contact:
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Global Clean Water Desalination Alliance
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Thank You for your Attention