People's Democratic Republic of Algeria
Ministry of Higher Education and Scientific Research
National Higher School of Technology and Engineering-Annaba

SMART MOBILE DESALINATION NETWORK CHALLENGE

Building the future with IIoT

2000 Places Pédagogiques Sidi Amar, Annaba, Algeria https://ensti-annaba.dz/ desalination.challenge@ensti-annaba.dz

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1. Challenge Presentation

The SMDN-Challenge is a competition focused on the design and development of a network of mobile seawater desalination stations. These stations must be intelligent, autonomous, and interconnected via modern technologies such as APIs, HMIs, SCADA, and IIoT protocols. The goal is to address the challenges of providing access to drinking water in coastal areas and regions suffering from temporary shortages, particularly during periods of high water demand. Participants will need to study, develop, and optimize a network of stations capable of cooperating to supply drinking water while being energy-efficient and environmentally friendly.

2. Objectives of the Challenge

- Design and build smart and mobile desalination stations using APIs for control and communication.
- Implement a communication architecture based on IIoT to enable centralized supervision and control.
- Create an HMI interface and a SCADA system for real-time monitoring of each station.
- Optimize the energy consumption of the stations using renewable resources such as solar energy.
- Ensure compliance with water quality standards and minimize discharge impact.
- Develop students' skills in industrial automation, IIoT communication, SCADA management, and sustainable design.

3. Challenge Schedule

- **Challenge Launch:** Call for Applications - November 30, 2024.
- **Submission Deadline :** January 20, 2025.
- **Finalists Announcement :** Between February 6 and 8, 2025.
- **Challenge Final :** May 17-19, 2025.

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4. Participation Conditions

1. **One team per institution:** Each institution can present one team, with up to 5 members.
2. **University Enrollment:** Team members must be enrolled for the 2024/2025 academic year at the same institution.
3. **Functional Solution:** Each team must present a working prototype of a mobile desalination station integrating APIs for sensor management and wireless communication.
4. **Online Submission:** Application forms and reports must be submitted exclusively online.
5. **Application Form:** The form must be signed by the director of the team's institution.
6. **Deadline:** Applications are accepted until January 20, 2025.
7. **Compliance:** Solutions must meet drinking water quality standards.
8. **Finalist Selection:** Only teams selected between February 6 and 8, 2025, can participate in the finale.
9. **Required Equipment:** Finalist teams must bring their laptops and necessary software for their proposed solutions during the finale (May 18-19, 2025).
10. **Travel Arrangements:** Teams are responsible for their travel to the finale venue.
11. **Reception of Finalists:** Finalists will be received starting May 17, 2025, from 2 PM.
12. **Identification Documents:** Each team member must provide a student card and an official ID.
13. **Technical Report:** A complete report documenting design steps, results, technical choices, and a detailed techno-economic report is required.
14. **Final Presentation:** Teams must present their solutions and demonstrate the performance of their station during the finale.

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5. Challenge Phases

Phase 1: Preparation and Selection (November 30, 2024 – January 20, 2025):

- **Teams must submit a complete application, including a report not exceeding 20 pages. The report should detail the mobile station concept, proposed technical solutions, and highlighted innovations.**

Phase 2: Development of Proposed Solution (February 8 – May 16, 2025):

- **Selected teams will develop and optimize their complete solution, which will be tested on equipment provided at ENSTI-ANNABA during the finale.**

Phase 3: Finale and Evaluation (May 18-19, 2025):

- **Each finalist team will present their complete solution to a jury of experts and professionals during the final event. Evaluation criteria include technical quality, innovation, presentation, and performance in terms of energy consumption, water quality, and production cost.**
- **Participation certificates will be awarded to all finalist teams.**
- **Prizes will be awarded to the top three teams.**

Scan the QR code to submit your proposal directly via our submission portal.

Specifications Document

1. Context and Problem:

Access to potable water is a major challenge, especially in coastal regions where demand surges during the summer. The need is even more critical in areas with limited or intermittent resources. This competition aims to design a network of mobile desalination stations capable of adapting to various contexts, such as temporary deployment during summer, rapid intervention during shortages, or emergency response in natural disasters.

The objective is to create autonomous stations interconnected via modern industrial communication protocols and integrated into an Industrial Internet of Things (IIoT) architecture. This intelligent network will enable centralized management and continuous adaptation to local needs while optimizing energy resources and water production.

Participants will use Programmable Logic Controllers (PLCs), Human-Machine Interfaces (HMIs), and Supervisory Control and Data Acquisition (SCADA) systems to design, size, optimize, validate, and implement stations that coordinate in real time using protocols such as MQTT (Message Queuing Telemetry Transport) and OPC UA (Open Platform Communications Unified Architecture) through standard wireless communication means.

2. Objectives of the Challenge:

The primary goals are to:

1. Design, size, and develop mobile desalination stations controlled by PLCs and equipped with standard wireless communications.
2. Implement an IIoT communication architecture based on MQTT and OPC UA protocols for information exchange and supervision.
3. Develop HMI and SCADA systems for centralized monitoring and control.
4. Optimize energy consumption and desalination performance based on demand.
5. Ensure the scalability of the network to process various types of brackish water.
6. Monitor brine discharge for sustainable management.

3. Sizing of Desalination Station Units:

- Production Capacity: Determine the daily volume of desalinated water based on demand.
- Raw Water Quality: Analyze the concentration of salt and impurities to select the appropriate technology.

- Desalination Technology: Choose the method according to the raw water quality and the required capacity.
- Energy Consumption: Assess requirements to ensure efficiency and economic viability.
- Infrastructure and Location: Select the site based on available resources and environmental impacts.
- Produced Water Quality: Ensure compliance with applicable quality standards.

4. Technical Requirements and Deliverables:

Participants must:

1. Configure and program PLCs to control pumps, water quality sensors, and energy management.
2. Implement wireless communication (e.g., Zigbee, Wi-Fi, BLE) and long-range communication (e.g., LoRa, NRF).
3. Use MQTT for rapid communication between stations and SCADA.
4. Integrate OPC UA for robust interoperability with SCADA and HMI.
5. Create a local HMI for each station to display desalination parameters and energy levels.
6. Develop a SCADA solution to monitor the network with visualization, control, and anomaly alerts.
7. Optimize energy consumption by integrating renewable energy sources such as solar.
8. Propose methods to minimize brine production and its environmental impact.
9. Develop an environmental monitoring solution to assess and mitigate discharge impacts.
10. Ensure compliance with water quality and waste management standards, incorporating an automated alert system.
11. Guarantee the safety of personnel and equipment.
12. Produce a technical report detailing architecture, PLC programming, HMI, and SCADA configuration.
13. Present the final solution, sharing the approach and test results.

5. Evaluation Criteria:

Teams will be assessed on:

1. Research conducted, proposed sizing, and prototype developed in the final solution.
2. Quality of PLC programming and desalination process optimization.
3. Integration of MQTT and OPC UA protocols, including communication efficiency and data centralization.
4. Ergonomics, functionality, and effectiveness of the HMI and SCADA interface.
5. Energy optimization and station autonomy.

6. Professionalism and quality of documentation and presentation.

6. Required Equipment:

Teams must utilize specific industrial equipment for control, communication, and water treatment:

6.1 Control and Automation Equipment:

- PLCs: Industrial PLCs from Siemens (e.g., S7-1215C DC/DC/DC) or Schneider Electric (e.g., Modicon M340) with justification for the choice.
- HMIs: An HMI interface to visualize real-time data, supervise, and manage the unit (e.g., Siemens KTP700, Schneider Harmony HMISTO, etc.).
- SCADA Systems: Solutions like Siemens WinCC or Schneider EcoStruxure for data collection, alarm management, and supervision.

6.2 Communication Equipment:

- Wireless communication modules: LoRa, Zigbee, NRF, BLE, or Wi-Fi for reliable coverage.
- MQTT and OPC UA protocols for data exchange between units, PLC, IoTs and SCADA.

6.3 Water Treatment Equipment and Sensors:

- Reverse Osmosis Desalination System: Membranes with a maximum production capacity of approximately 400,000 liters per day, configurable based on demand.
- Water Quality Sensors: For salinity, pH, and conductivity (e.g., Hach CDC401, Yokogawa FU20).
- Energy Consumption Sensors: For real-time measurement (e.g., Siemens SENTRON PAC3200).

6.4 High-Pressure Pumps:

- High-pressure pumps must ensure adequate flow rates for reverse osmosis:
  - Flow Rate: Based on production requirements and membrane specifications.
  - Operating Pressure: Minimum to overcome osmotic pressure.
  - Energy Consumption: Minimized for efficiency.

6.5 Additional Participant Tasks:

- Integrate and configure high-pressure pumps, ensure proper regulation to protect the membranes against pressure surges, hydraulic shocks, and flow variations, while guaranteeing optimal system operation.
- Develop safety controls to prevent overpressure and optimize operation based on demand.
- Use safety PLCs, if possible, equipped with Safety CPUs to enhance reliability and protection.

- Calculate and monitor pump energy consumption within specified limits.

6.6 Example of a Summary Table of Equipment Specifications

Equipment/System	Technical Specifications	Function/Use
High-Pressure Pump	Flow rate: 15–20 m^3/h; Pressure: Min. 60 bars; Energy consumption: Max. 30 kWh/m^3	Provides pressure for reverse osmosis, enabling salt separation
Reverse Osmosis Unit	Capacity: 400,000 L/day; Salt rejection: >99%; Recovery rate: 40–60%	Filters salts and impurities to produce potable water
Pretreatment Unit	Multistage filters: Activated carbon, sand, microfiltration; Pore size: 1–10 microns	Removes particles before reverse osmosis
PLC	Siemens S7-1200 or Schneider Modicon (Safety PLCs are recommended)	Centralized process control and communication via MQTT and OPC UA
SCADA System	Interface for control and supervision (e.g., Siemens WinCC, Schneider EcoStruxure)	Station supervision, alarm and data management
Water Quality Sensors	Conductivity: 0–20 mS/cm; pH: 6.5–8.5; Turbidity: 0–100 NTU; Temperature: –5 to 50°C	Monitors produced water quality

Keywords:

Reverse Osmosis, PLC, VFD, HMI, SCADA, IIoT, LoRa, Wi-Fi, MQTT, OPC-UA, NTU.