

## MASERA MICROGRID FOR AFFORDABLE AND SUSTAINABLE ELECTRICITY IN REMOTE AREAS

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### ABSTRACT

*Semakau, 8km South of Singapore, is hosting the largest hybrid microgrid testbed and research platform in Southeast Asia in the framework of the **REIDS project (Renewable Energy Integration Demonstrator – Singapore)**, led by NTU (Nanyang Technological University) and supported by the Singapore Economic Development Board (EDB) and the National Environment Agency (NEA). Among the industrial partners, a consortium of world leading corporations, **EDF R&D** has signed a four-year Research Collaboration Agreement (RCA) with the University, with the support of the French DSO **Enedis**, to develop the **MASERA microgrid**.*

### INTRODUCTION

Addressing the needs of a new and fast growing value segment for electricity utilities, microgrids are today a key technology for rural electrification in which EDF wants to play a major role at international level.

All over the world, many isolated, under-electrified and rural areas can rely upon microgrid solutions to support their economic development while limiting environmental impacts.

In this context, **MASERA (Microgrid for Affordable and Sustainable Electricity in Remote Areas)** has been officially launched during the Singapore International Energy Week 2017, symbolized by the RCA signature between EDF R&D and NTU on the 24<sup>th</sup> October.

Through this demonstrator, EDF R&D and its partners (such as Enedis) aim to design, develop and promote an innovative and affordable microgrid based on:

- Renewable energy penetration
- Innovative storage technologies
- Affordable electricity costs to meet market expectations in SEA
- Innovative communication control and optimization technologies.

EDF's ambition is to develop a fully integrated microgrid, easily deployable, reaching local needs with an affordable electricity production cost.

Based on strong differentiators, MASERA will bring the opportunity to promote EDF R&D and partners' developments as well as implementing new approaches

that will be described in this paper.



Figure 1: Semakau island, South of Singapore (source: NTU)

### MASERA: INNOVATION AND LOW-COST APPROACH

Over four years, REIDS will be the opportunity for EDF R&D, NTU and Enedis, (alongside other partners from the FrenchThink Smartgrids association), to test and demonstrate at a large scale the combination of a **complete low-cost approach with innovative assets and features**.

MASERA will be made up of photovoltaic panels (around 50kWp generation capacity), innovative storage components (zinc-air prototype, second life li-ion batteries from electric vehicles), and for safety reasons, diesel gensets, and also different loads: charging station and electric vehicles, desalination plant, real time simulation of residential loads of typical consumptions in South East Asia. These assets will be managed by a smart controller architecture based on EDF solutions.

MASERA will aim at bringing a better quality of life to local communities, through access to green, **affordable and reliable electricity, leveraging innovative technologies, ensuring enhanced reliability and resilience**.

From 2018 to 2021, the first of the three different phases of the project (design/studies – tests – evolutions and research) will be materialized by the commissioning and the inauguration of the microgrid by the end of October 2018 in the context of the Singapore International Energy Week summit (SIEW) and the France-Singapore Year of Innovation. Furthermore, in 2018, Singapore will chair the ASEAN (Association of South East Asian Nations) that aim at further developing prosperity and regional competitiveness.

### Design to cost

In the MASERA project, the low-cost objective is not necessary a question of equipment unitary quality and cost, but much more about the thinking and the ways to reach a global offer answering dedicated need in terms of reliability, resiliency and renewable energy penetration at an affordable price.

In that way, as a part of the whole project, alongside technical and electrical developments, we give a strong place to the technical-economic study in order to develop a consistent and homogeneous offer, to support local socio-economic development, fitted to the needs.

Leveraging Enedis and EDF R&D experiences, references and developments, some other levers will be explored:

- Specification of client needs.
- Definition of an offer that can fit to large number of cases with only minor adaptations.
- Reuse of internal developments and equipment recovering
- Lean approach for each step of the project.
- Solution based on rugged and well-known components, ensuring the resiliency and the reliability of the grid, allowing to reduce the operation & maintenance costs.
- Interoperability, in order to be compliant with most of the equipment and situations.
- Smart electricity management and remote control, enabling to operate the microgrid with cyber secured communications.

In this sense, every step and every technical study of the project will be analyzed through this vision.

### Combination of innovative and rugged solutions

One of MASERA main objective is to demonstrate that innovative and rugged solutions are not opposed, and can be complementary, ensuring overall efficiency and affordability.



Figure 2: MASERA pillars

EDF, through its references in microgrid projects (with Enedis, EDF Island Energy Systems) will implement solutions already tests and approved in remote areas (in

the fields of storage, renewable energies integration, microgrid operation, etc.) as well as innovative features developed EDF R&D.

### **Storage**

More particularly with regard to energy storage systems, the demonstrator will host two kinds of batteries, with different technical attributes, both innovative.

The first one will be a second life lithium-ion battery coming from an electric vehicles. As the EV market is still growing up more and more, the question of the re-use of the batteries at the end of their first lives (approximately 80% of their initial capacity) will be crucial. This point will be an opportunity to get a rugged stationary storage at a reduced cost, allowing to offer a capacity fitted to a small microgrid (like MASERA), and with the electrical characteristics to form the grid. The other advantage will be the number of batteries available in a few years, ensuring significant supply.

At its side, the Zinium zinc-air battery prototype from EDF R&D spin-off and start-up ZnR Batteries, will be complementary to the Li-on battery, more energy oriented and with other valuable attributes: safer, affordable, less polluting, high density and without rare materials.

### **Generation**

On the generation part, MASERA will propose around 50kW photovoltaic bi-facial panels and for safety reasons, 40kW diesel gensets capacity. Most of isolated under-electrified areas are powered by gensets, which are costly, noisy and polluting. The idea is to substantiate that the solution will be able to adapt to current facilities in a first time (allowing to reduce the cost) with PV, and then, increase the renewable energy penetration up to 100%, inducing reducing the operation and maintenance costs (fuel, transportation,...) and the pollution.

Bi-facial PV panels are very suitable with the South East Asia context as the weather and the climate: diffuse irradiance, constant all over the year, etc. allowing to produce up to 10% more electricity in comparison with classical PV panels, at similar cost.

### **Electrical design**

Alongside these assets, another way to ensure the resilience and the reliability of the grid is the electric design itself.

To that end, MASERA 400V grid will also be based on EDF R&D and Enedis experiences on protection plan, grid design, distribution, stability studies, etc. already implemented in several project in France and in remote areas.

Beyond electrical design, the idea is to develop the concept of “critical loads”. It means that the microgrid being based on renewable energies, the power production can evolve over time, allowing flexibility to power some

loads or not, and, in order to maintain the grid and to power the essentials loads, MASERA will prioritize the critical loads.

The goal is to, by design, ensure continuity of service. Thus, it will reduce the necessity to intervene on-site thereby reducing costs incurred by transportation, and interventions.

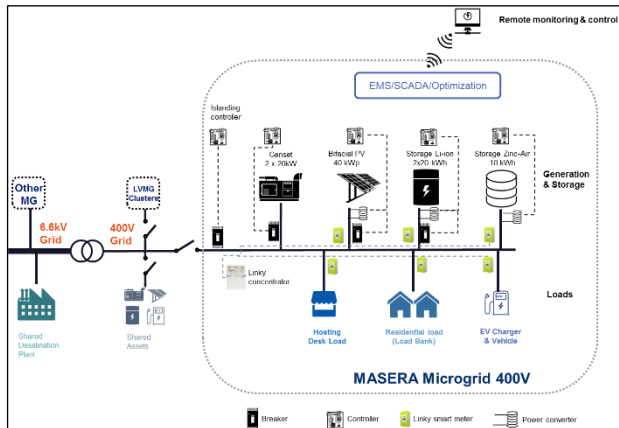


Figure 3: MASERA overall description

### Optimized microgrid control

As an essential part of the microgrid, in the same way as the electrical grid and the equipment, the control architecture will play a crucial role in MASERA for the quality of the supply and for the **optimization of power production, consumption and storage as well as for remote operations.**

This will be all based on EDF R&D internal solutions and spin-off (EDF Store & Forecast), control environment will be composed of several **interoperable, standardized and cyber secured components.**

### **Communication with the assets**

The first level of this complete architecture is realized by our internal EDF R&D gateway and interface which is able to take into account a large number a protocols in order to ensure interoperability and communication standardization between the assets and the control environment.

This key component is based on the IEC 61850 (international standard defining communication protocols and data model for intelligent electronic devices at electrical substations), and natively cyber secured.

### **PEGASE Energy Management System and SCADA**

Every MASERA distributed energy resources and loads equipment will be managed in real time by Pégase EMS and its SCADA both developed by EDF Store &

Forecast.

Communicating locally with the assets through the internal gateway, Pégase integrates advanced algorithms for system services, production and consumption peak shaving, load flexibilities, taking into account characteristics from different assets.

Pégase will be able to ensure renewable energy production and the balance of demand-response.

The SCADA will allow to operate the microgrid both in Singapore and from France, from a region control center of the grid of the French DSO, Enedis, with the same interface and the same information.

### **PILOT: scheduler and optimizer**

Pilot is a planning software from EDF R&D, optimizing the use of a production system based on Mixed Integer Linear Programming algorithms.

The software processes a large number of variables and allows to schedule and optimize the use of different microgrid assets: battery, genset, load, PV panels, etc.

Pilot sends to Pégase the energy production, storage and consumption optimization curves, taking into account production forecast, energy prices, renewable energy penetration and technical constraints.

### **Weather and PV production forecast**

On the top of MASERA control architecture, the weather and production forecast adds an important parameter to the control and optimization strategy.

Based on three different timescales, the tool is able to give a clear vision of the PV production forecast from several minutes to few days:

- Minutes: 360° ground images
- From a few minutes to a few hours: satellite images
- From a few hours to a few days: weather forecast

All this data, combined to our PV panels features are processed together, allows to refine the solar production, enhancing the energy management and schedule.

### **Smart meters serving optimization**

With the same aim on optimizing MASERA energy management, Enedis Linky, based on PLC (Power Line Communication) technology, smart meters will be integrated in the control architecture.

Collecting data on energy consumption and production through the Linky concentrator, EDF in-house solution interface will use the information to integrate it in the supervision and management of the microgrid.

### **Innovative loads**

MASERA will take advantage of the Semakau Island testbed particularity to test and demonstrate different kinds of innovative loads in terms of characteristics, electrical needs and functionalities.

**Desalination**

Beyond proposing electricity provision, EDF has the willingness to use a desalination plant on-site.

The process of desalination plant usually requires a high, continuous and steady power, which is not necessary appropriate with renewable energy generation.

Benefiting from NTU shared assets, MASERA will be able to connect electrically and control this station to test and integrate it as flexible load according to the needs and the power generation while assuring the service provision.

**Electric Vehicle**

Alongside the economic and innovative aspects, MASERA demonstrator third objective is to reduce CO2 emissions.

Electric vehicles tends to be one of most promising global markets, with a lot of players, always innovating. In this way the demonstrator will host an EV allowing to test breakthrough features: flexibility, vehicles to grid, smart charging...

In addition, the EV will complete our idea of circular economy, as the battery, at the end of its first life could be used as an energy storage system.

**Load simulation**

MASERA targets Southeast Asia remote villages, it means the solution needs to meet local expectations in terms sizing and power generation as well as the criteria to support socio-economic development.

The load bank will allow to simulate a large number of use cases, consumption curve, etc. in order to fit the solution at the closest to the reality.

This asset will also allow to add flexibility and detail the concept of critical loads.

**MASERA, FROM REIDS TO THE CLIENTS**

Benefiting from its expertise and references, EDF thus will profit from REIDS cluster infrastructure and support, with the collaboration of NTU and Enedis to address technical and commercial ambitions based on innovative and rugged solutions. In France, the DSO Enedis will use this experience to develop new services towards local authorities and local communities.

With the objectives to enhance the quality of the grid, while reducing the operation, and thus the costs, MASERA's equipment and developments will be essential to build a complete and integrated offer.

The presence of other French partners, from startups to industrials, will strengthen the collaboration between Singapore and France.

MASERA will be therefore a unique opportunity to complete technical business challenges, while developing skillsets, serving Southeast Asia electrification purpose.