OPAL-RT TECHNOLOGIES

ENGIE Laborelec: Expanding Microgrids Testing Capabilities with Real-time Simulation

ENGIE Laborelec

Application

- Microgrid

Related Products

- RT-LAB
- ARTEMiS
- OP5650

Type of Simulation

- Hardware-in-the-Loop (HIL)

INTRODUCTION

As a leading provider of expertise and a research center in electrical power technology, ENGIE Laborelec (based in Linkebeek near Brussels, Belgium) is an R&D lab that actively helps model its partners' successes. The company works with an impressive set of diverse customers in the fields of generation, transmission, distribution, storage, and final use--with a particular focus on the ongoing 21st-century energy transition and the three Ds: **decentralization, decarbonization, and digitalization.**

Established in 1962 to support electricity companies with a wide range of specialized services, ENGIE Laborelec is today a cooperative company—with ENGIE and independent grid operators as shareholders. ENGIE Laborelec has a global presence, with activities in more than 60 countries and offices in Belgium, the Netherlands, Germany, Chile, and Abu Dhabi, and they collaborate across the electricity value chain with all stakeholders.

One of the main laboratories in operation at ENGIE Laborelec, is the **Power Networks Lab**. Equipped with OPAL-RT real-time simulation platforms, power amplifiers, PV emulators, programmable loads, and others, the laboratory offer a wide range of tests for its clients. The microgrid laboratory has capability to test devices such as controllers, relays, and complete microgrid systems. Add to that a team of experts that offer consultancy services related to power production, storage, and management systems.

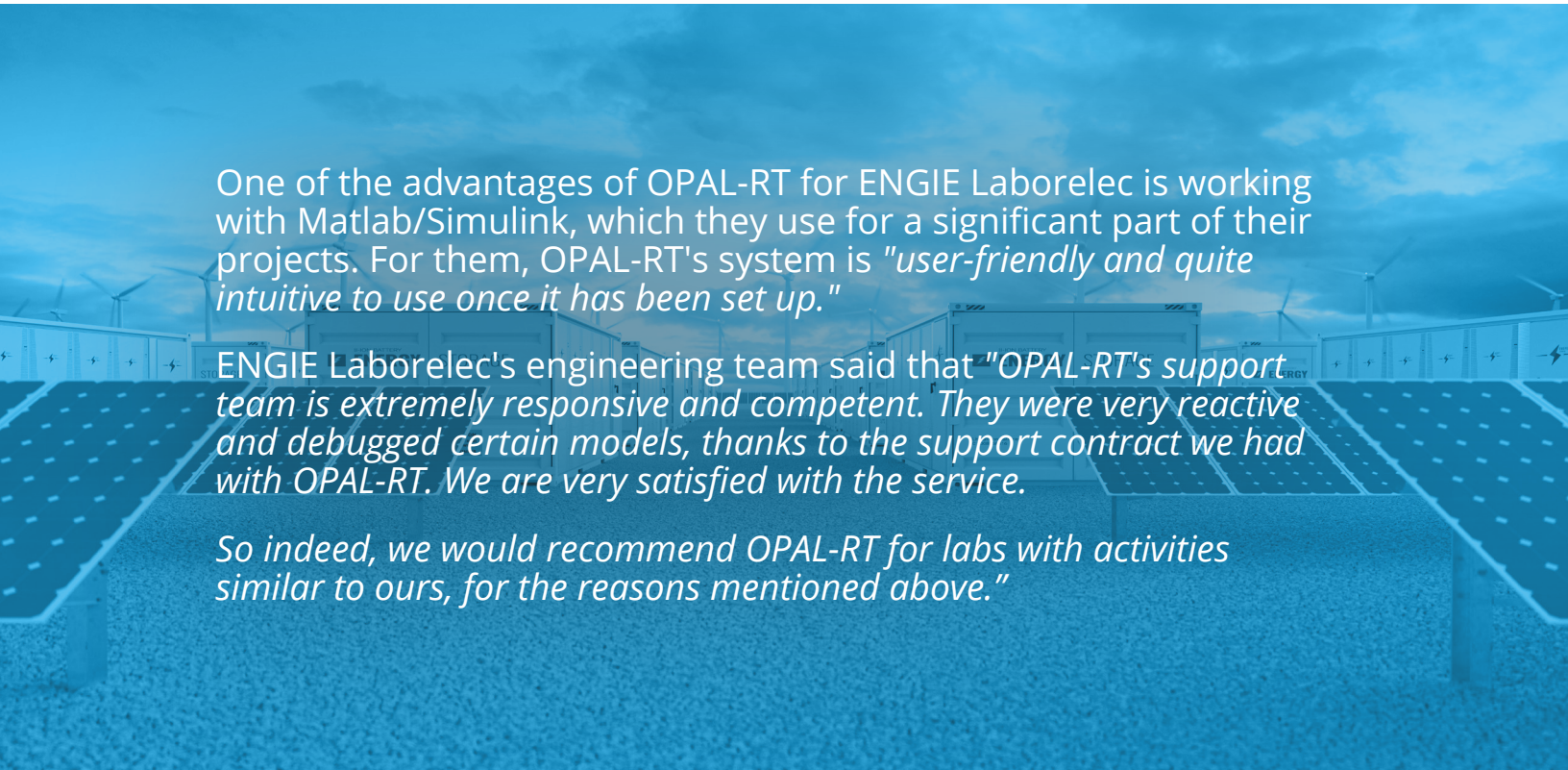
SOLUTIONS

In ENGIE Laborelec's activities with the various other business units of the ENGIE group, they are often involved in the validation of products and systems before deployment, either directly on-site for pilot testing or remotely at one or more of a client's sites. Now that OPAL-RT's HIL platform has been commissioned and is functional, they are able to provide even further extended expertise and more valuable recommendations—and all this in a drastically reduced amount of time.

ENGIE Laborelec's implementation depends on the specificity of the project, but they routinely use the following devices/features:

- A power amplifier (amplifies AC current/voltage waveforms from the simulated grids to external devices such as protection relays or control boards)
- A bi-directional AC source, controlled through the analog output of the OPAL-RT simulator, to create the AC conditions desired for the tests
- Python scripting automation integrated in OPAL-RT so that the tests can be run remotely and automatically
- Simulink models, developed inside the ENGIE group for simulation purposes, that can then be easily integrated into OPAL-RT's real-time simulation models

The key role of OPAL-RT—in addition to the configuration as described above--was to provide support to ENGIE Laborelec when things did not initially work as expected. (In experimental contexts, this is not the least bit surprising.) This represents added value for ENGIE Laborelec, as it enables them to gain time during project development, saving troubleshooting time to an absolute minimum. They were also able to avail themselves of the OPAL-RT Support Knowledge Base--located on our company's Support website--and found it quite useful as well.



One of the advantages of OPAL-RT for ENGIE Laborelec is working with Matlab/Simulink, which they use for a significant part of their projects. For them, OPAL-RT's system is *"user-friendly and quite intuitive to use once it has been set up."*

ENGIE Laborelec's engineering team said that *"OPAL-RT's support team is extremely responsive and competent. They were very reactive and debugged certain models, thanks to the support contract we had with OPAL-RT. We are very satisfied with the service.*

So indeed, we would recommend OPAL-RT for labs with activities similar to ours, for the reasons mentioned above."

PROJECTS

Power networks studies and simulations are an area where ENGIE Laborelec has been able to gainfully pick up a lot of expertise over the years. Additionally, they can host multiple activities on-site and perform testing of laboratory-based hardware equipment. To further extend their testing capabilities and especially the flexibility and speed of the tests they can perform, their investment in a real-time simulation platform seemed like a natural outgrowth of these projects and a logical step forward. Having previous experience and familiarity with the OPAL-RT platform, it has become an essential and central system in several ENGIE Laborelec's projects.

The following is a non-exhaustive list of the projects mounted with the OPAL-RT system and platform configurations at ENGIE Laborelec:

1 | Testing of controllers performed for distributed frequency reserve installation with BESS/PV on an island

Project:

For this project, ENGIE Laborelec received 3 PLCs (Programmable Logic Controller) (as the devices under test) integrated into the Controller Hardware in the Loop (CHIL) setup. On the OPAL-RT simulator, a full model of the power network of the island under investigation was run.

The main goal was to study the impact that communication delays between the various BESS/PV sites (three in total) could exert on the stability of the frequency control in the case of events on the grid. Then, the system dynamically distributed power between sites (at various locations on the island) in such a way to participate in the secondary reserve to restore the grid frequency to its nominal value. The challenge ensured correct coordination in real-time, taking into consideration the communications delays. The same tests were also performed in an entirely simulated environment to show the applicability of the HIL configuration for such projects.

Results:

ENGIE Laborelec were able to demonstrate the impact of communication delays on the stability of the control scheme (spread over 3 distributed power stations). They were also able to demonstrate the advantage of hardware-in-the-loop, because the simulations were stable without the hardware controllers. The HIL allowed them to fine-tune the simulation models to match these models to reality.

PROJECTS

2 | Test of protection relays and protection scheme for island with high renewable penetration

Project:

In this project, ENGIE Laborelec started with an island supplied with 100% of its Genset generation and studied the integration of the BESS/PV units, discussed above, and their effects on its protections. For this, protection relays installed on-site were interfaced with the HIL platform running the island's grid model, and the relays' settings were set according to what was current with that. ENGIE Laborelec started with one BESS/PV site and verified the protections were working.

They then extended this setup to all three sites and run the island on 100% renewable energy. Difficulties in the working protections' functioning may be expected to occur, as with the 100% renewables case. The second step of the project serves to modify the relays' settings to ensure they operate correctly with both reduced and variable short-circuit current amplitude and direction.

Results:

ENGIE Laborelec were able to illustrate the difficulties encountered by the operation of islands with distributed and renewable generators (shielding of protections, reduction of short-circuit current, etc.). They interfaced the relays with the model and were able to test the customizable functionalities of the relays (creation of personalized functions) to better ensure the protection of the network with the BESS/PV systems. The HIL allowed them to interface real hardware and have the real reaction of the system (or a reaction very close to reality).

3 | Inverter test bench

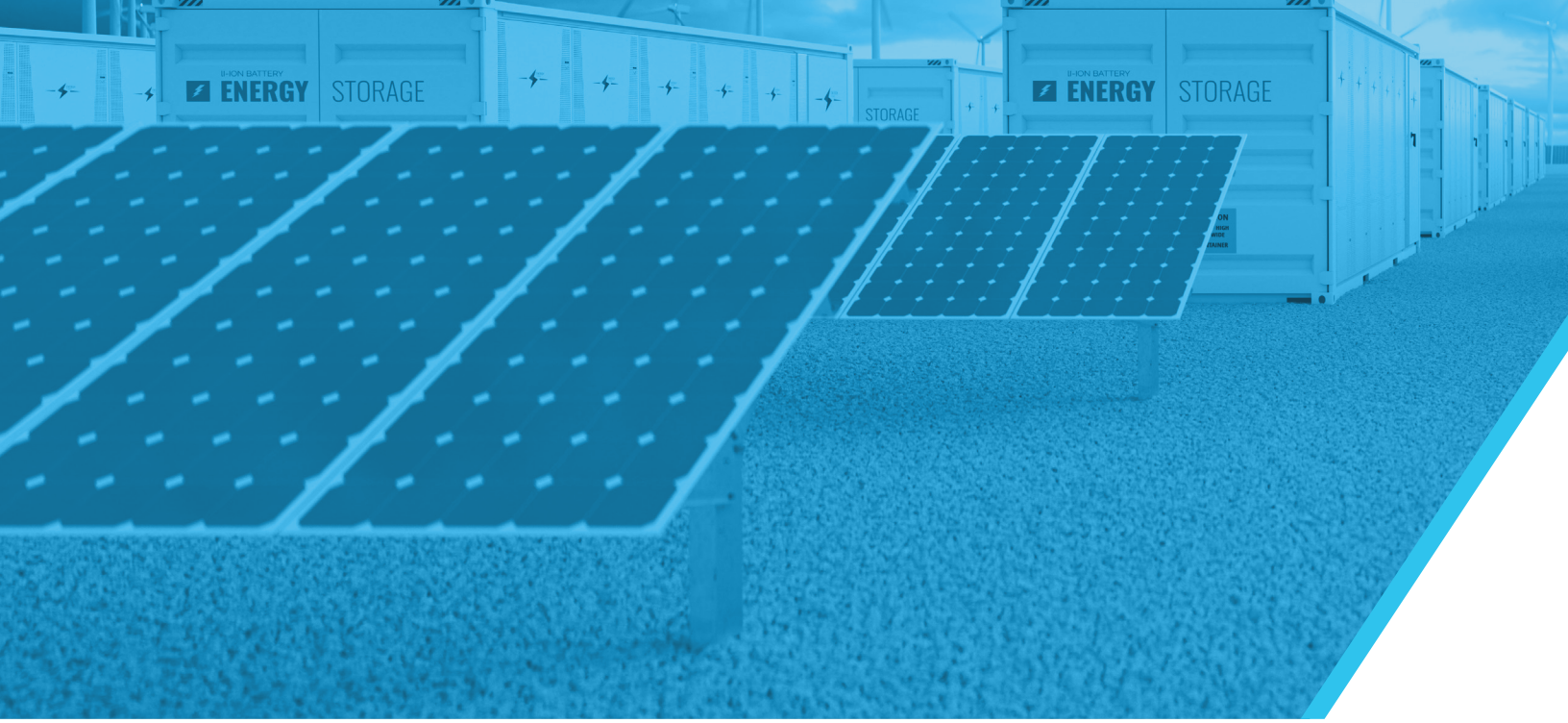
Project:

This project creates a testing setup able to test any inverter (or control board of inverters). For this, the OPAL-RT simulator will stand in for any type of grid, and control the bi-directional AC (Alternating Current) source that applies values of AC voltage waveforms to the AC terminals of the inverter under test.

Results:

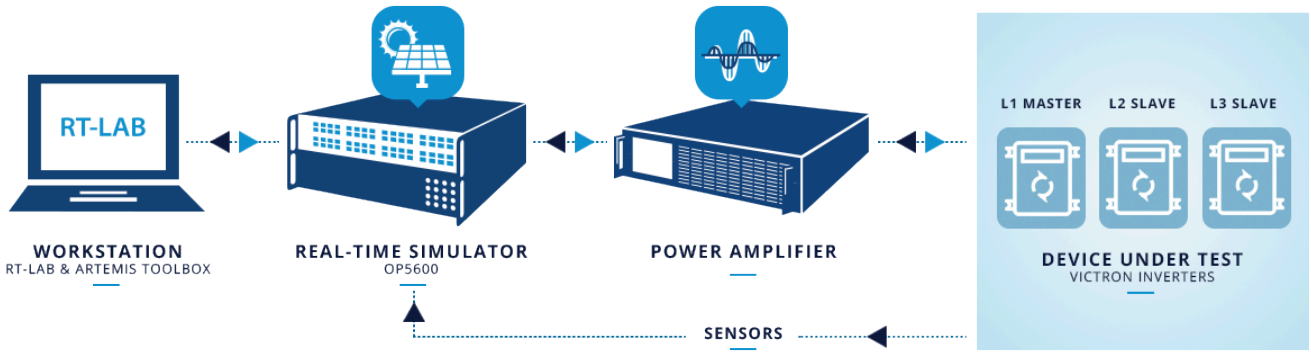
ENGIE Laborelec can now test up to 50 kW inverters and they plan to extend the setup to far larger power ranges.

ENGIE Laborelec have developed a separate test bench, controlled by Python scripts, in order to keep the HIL platform for other projects. However, they had made successful tests with the HIL platform. ENGIE Laborelec have been able to test the protection functions such as over/undervoltage and over/underfrequency, low voltage ride through, among others. As mentioned above, they still could bypass the HIL and use it for other applications if needed.



RESULTS

A consulting company such as ENGIE Laborelec depends more than most on tangible results. They were, in the final contexts, able to show the results desired, and this, in turn, allowed interesting conclusions to be drawn, all with further development on the HIL platform firmly in mind. And ENGIE Laborelec did want it known that a main and driving contribution of OPAL-RT was, for them, the exemplary Customer Support that they received from OPAL-RT's Support team, as described above. This support turned out to be a key and indispensable element when dealing with such extraordinarily complex devices and setups.



Inverter testbench configuration to emulate the electrical environment around the inverters