Webinar «French Overseas:
A successful example for Solar & Storage in Islands»

Q&A

Answers by Reuniwatt and Naldeo Technologies & Industries (NTI)

FORECASTING CHALLENGES

Q. What plant data do you need to provide forecasts?

A. Reuniwatt: It is very important to understand early in the process which meteorological variables are required by discussing with the plant operator and the EMS operator. The most commonly requested meteorological variable is the Global Horizontal Irradiance (GHI): It is essential for us to have at least access to the data from an in-situ GHI sensor. In the case we are asked to provide solar radiation forecasts in the plane of the panels, i.e. the GTI (Global Tilted Irradiance), we also collect the data from the pyranometers in the plane of the panels in order to recalibrate each meteorological variable to the reference measurement.

Q. What is the precision of your forecasts?

A. Reuniwatt: The question of precision is a real scientific issue, still much debated in the forecasting community. What is important to remember is that performance can be described along three axes:

- The **weather sensitivity** of the location: For the French overseas islands, it is mainly the tropical climate, to which must be added the extremely important concept of microclimates. For example, on the 2500 km² of Reunion Island, there are no less than 200 microclimates! We must also add the notion of seasonality. In tropical climates, the summer is generally very hot. With the sea nearby, this will create a favourable ground for evaporation and therefore for cloud formation. In winter, evaporation being weaker, we will mainly see clouds moving. Thus, the meteorological phenomena to be taken into account vary according to the location and will directly influence performance.

- The **quality of input data**: Reuniwatt aggregates a lot of data from different sources, as well as data from the power plant (in particular, measurements from pyranometers in real time and to which Reuniwatt applies a "quality check"). This input data is then used to calibrate our forecasts, which means that there is a real O&M (Operations & Maintenance) challenge to work on over time so that this quality monitoring system remains effective throughout the power plant's life.

- The **metrics**: How do we evaluate the precision of a forecast? The most commonly used scientific metric is the nMAE ("normalised Mean Absolute Error"). It is interesting and important, but knowing whether gaining 1 point of nMAE translates into an improvement in the plant's profitability is a subject that is still being studied at present. Indeed, profitability is expressed at several levels: Via the EMS and the forecasting system, but also in terms of the plant's O&M.

Some opportunities allow us to assess the performance even before starting the operational phase of the plant: Climatological analyses to identify the meteorological phenomena at the plant location or "backtests" (forecasts made under real conditions but on past data sets) that can be transmitted to the EMS supplier - NTI for example - in order to anticipate the management and operation of the plant with results close to reality.

It should also be noted that forecast performance will improve during the lifetime of the plant.

Q. What is an acceptable level of uncertainty in the forecast?

A. Reuniwatt: It depends on the type of application. If we are talking about forecasting for a whole territory, there is a statistical compensation of the errors that are made on one or two plants, which means that we can reach a level of performance in the order of 2 to 4% of nMAE. When we look at tropical island climates, the performance can vary from 4% nMAE in winter for time steps 15 to 30 minutes in advance, to 6.5% nMAE in summer. These errors only take into account daytime data. Taking into account the night data allows to divide by two the errors.

Q. Did you have a chance to analyse historical and real-time irradiance data over the Indian Ocean? What is the difference between different models?

A. Reuniwatt: Having developed our systems on Reunion Island in the Indian Ocean, we have a large dataset of historical irradiance data from this region, as well as high proficiency regarding its complex microclimates. In the benchmarking process of SunSat™, our satellite-to-irradiance model, we achieved an average error of less than 4% based on the ground-based measurements at the power plant. Comparing our satellite-based irradiance model with ground-based measurements from three meteorological stations in Reunion Island, respectively at 1.3km, 3km and 45km of distance from the power plant site, we showed that our satellite-to-irradiance estimation lies close to the closest meteorological station at 1.3 km (see image):

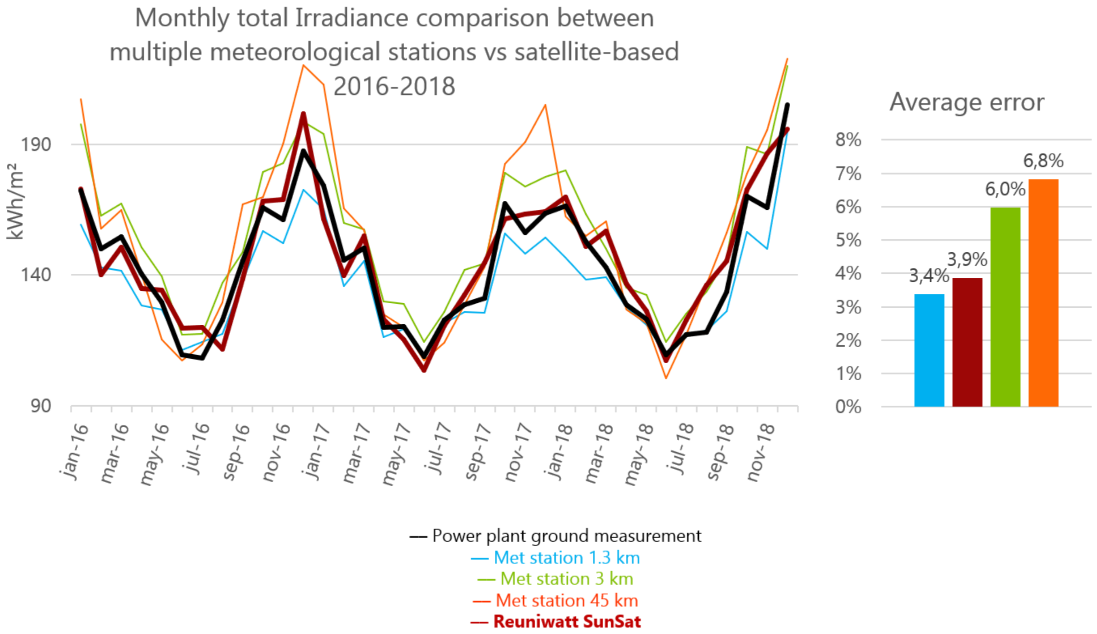

Image: SunSat™ satellite to irradiance accuracy benchmark @Reuniwatt 2019

For more information about SunSat™, you can take a look at the product page.

REGARDING THE EMS

Q. Do your solutions allow real-time communication? What is the protocol used? Does it allow you to be as dynamic as the PV injection changes?

A. NTI: The protocol we use is robust, standardised and unique for many reasons. It relies on MODBUS communication, that is to say a protocol which will pass by an Ethernet network to communicate with all the equipment installed on site. The information is thus exchanged digitally with highly structured exchange tables that allow for easy communication between equipment. The advantage of this protocol is that most of the equipment such as inverters also offer it, as do many PLCs. In terms of reactivity, the loop times are in the order of 200 to 300 milliseconds, which is the same type of dynamics that can be observed in a PV field. It is accepted that a solar power plant can lose a major share of its production in about 1 second. We are setting up a real-time control system capable of giving several instructions per second, and therefore able to adapt quite quickly to a sudden cloudy passage.

Q. Regarding PV inverters and battery inverters, what specific communication features do they require to ensure that the communication will be fast enough?

A. NTI: What is important for the inverter is to know how often it will come to read new instructions that Enerbird may have issued. Ideally, it should be as fast as the control unit on the other side that sends out instructions. The communication characteristics do not have much of an impact, but the regulation characteristics do: Is the equipment capable of quickly reaching the set point it has been given? The response time of battery converters can be very fast (100 milliseconds or less to go from full charge to full discharge) as soon as the order is received. On the other hand, the response time of PV inverters to curtail PV production (voluntarily limiting the production) is a little bit slower (1 to 2 seconds) because several layers are involved. In these cases, the faster the inverter is able to respond, the more accurate it will be since the instructions issued are respected. On the contrary, the longer the equipment takes to respond, the more delicate it is to adjust the control architecture and the upstream regulation loops (although this is done in all cases), and the more likely it is that this delay will generate penalties, for example by causing the equipment to go out of its range of tolerance.

Q. On which models is the solar generator production forecast based?

A. NTI: Our models are well proven and are the result of research work carried out by laboratories (particularly in the United States). They are made available through scientific publications or through computer libraries that offer the types of modelling found in major potential estimation software (PVSYST, HOMER, SAM). At Naldeo Technologies and Industries, we have our own models based on these existing and proven resources and we calibrate them to achieve the performances obtained with PVSYST, the reference software in the PV business.

Q. Who are the clients and competitors of ENERBIRD?

A. NTI: Our clients are primarily developers of PV projects (with or without storage), wind projects and, more broadly, projects involving renewable energy (e.g. biomass). The latter call on us for two reasons: on the one hand, for study services to help them estimate the performances to validate the feasibility of a rather innovative project in terms of renewable energies; on the other hand, when it comes to equipping their power plants with energy management software or to performing the real time control only (if the energy management part is not applicable).

Our competitors can be classified in three categories: Equipment suppliers (inverters or batteries with plant-wide control solutions, but which do not necessarily offer adapted solutions because the control is very specific to the project while their equipment is mass-produced), EMS providers like us (who really focus on the energy management part for several types of applications) and finally the project developers themselves (who wish to keep the EMS part in-house since it allows them to control the revenues generated and the profitability of the power plant - even if this choice does not allow them to benefit from the feedback of experts such as NTI).

Q. Can you give a pricing information regarding your EMS solution?

A. NTI: Our products and services are permanently being improved, and therefore pricing schemes have changed over the years. Today, we have a price policy which takes into account the size of the PV installation, as well as the complexity of the operation, which are project-specific. To provide a rough estimate, projects under CRE-tenders range somewhere between €25-75 k for the purchase of the solution, plus a yearly maintenance fee. Additional features, such as web-application (for the monitoring and performance analysis) and production forecasts, are charged separately.

Q. Do NTI's algorithms use machine learning and get optimised for each project?

A. NTI: Currently, our solution does not include machine learning at its core, because each project is very different and we want to have good data from the first day, so we cannot wait until actual operational data is available from each project. Our algorithms are based on dedicated models for each project. However, we do improve these models on a project-by-project basis as a part of our O&M services. We collect operational data and use machine learning to improve the models and make sure our data is of the highest quality.

Q. Can the EMS detect a faulty inverter and readjust the forecast accordingly?

A. NTI: The inverter (and storage) availability is taken into account by the EMS. Both for real-time operation and to schedule the production. On site equipment provide status information, so the EMS automatically takes faulty equipment into account for real-time regulation of the plant. Furthermore, when the unavailability of an equipment can be anticipated (e.g. for maintenance), the EMS can manage this predictive unavailability and issue production schedules that take into account that part of the PV (or the storage) won't be available during a certain period of time.

Q. Would the EMS generally also work with a CSP system with storage?

A. NTI: We have mostly worked with renewable electric power and battery storage systems, but also thermal energy production & storage, hydrogen, and other systems. The answer comes down to which kind of system model we use, and basically every kind of system can be modelled. Therefore, the answer is that our EMS will work for a CSP & Storage project. A second aspect to consider is the complexity of balancing out the system: Predictive control can quickly become complex if there are many variables and constraints, and the EMS plays an important role in these cases. In simpler cases the operators have to ask themselves what the operating conditions are (e.g. day-ahead engagement, penalties) and whether they really need to use predictive control.

Q. Is the EMS suitable for off-grid projects?

A. NTI: Yes, we have several Solar & Storage hybrid projects with gensets, PV and batteries, which are off-grid projects. We have demonstrated the interest of advanced energy management strategies based on modelled predictive control for this type of projects as well. An advanced EMS able to integrate forecast data in its control strategies makes it possible to further reduce fuel consumption compared to the state of the art.

FINANCIAL CHALLENGES

Q. What is the average cost of your solutions? What is the average time of return on investment?

Q. NTI: For the energy management part, it will depend first of all on the peak power of the plant because the gain of income brought by the solution depends on the quantity of energy that will be produced. In order of magnitude, an EMS solution is a few tens of thousands of euros. The duration of a return on investment is difficult to quantify for several reasons, as it is not solely proportional to the size of the plant. It depends on the one hand on the size of the batteries, since they allow to exploit the evening peak in several ways, but also to avoid penalties or curtailment. It also depends on the selling price announced by the project developer themselves, on which we have no impact. In addition, NTI has developed new features since the implementation of Enerbird on the first power plants it supported: it is therefore very difficult to quantify the profit made today. For each plant, the answer is unique and the bigger the plant, the more significant and faster the return on investment. You should know that we are working internally and with Reuniwatt to better quantify this.

R. Reuniwatt: On our side, we operate with a Service Access Fee, invoiced at the beginning of the service, and then with a subscription system for the yearly forecasting service. We are currently in the process of restructuring our commercial offers to better make our clients understand how they break down. First, there is the core of the forecasting system for which we have to secure our subscriptions to the weather data sources (e.g., subscriptions to satellite feeds to retrieve real-time data) but also pay for the servers that perform the calculations. Other costs depend on the time required to draw up the ICD (Interface Control Document), the understanding of the meteorological variables to be manipulated (the more data there are, the more algorithms need to be executed and the more costs there are on Reuniwatt's side), the interfacing according to the protocol used (standard or custom), the profitability stakes on the operator's side (greater mobilisation in terms of performance monitoring and reactivity in case of a problem, for example). On the first installations that we accompanied, we were able to test a few models that showed that our forecasting system made it possible to gain between 8 to 10% in performance compared to a less intelligent forecast (persistence type). As specified by NTI, these were our first forecasting models that we have been developing and improving since then.

Q. Are there any financial guarantees related to forecast performance?

Q. Reuniwatt: As explained, there is a good partnership necessary for the evaluation process, since the input data must be of good quality to guarantee the quality of the forecasts. Fairly complex work needs to be carried out in order to establish a working forecasting system of excellent quality. This is something we are already doing within some plants for which we have made performance commitments - which we have systematically kept. In addition, we are improving our forecasting system on a very regular basis. The first criterion for non-performance would be that the forecast could not be transmitted in time or that we had an unavailability of a data source (for example, a satellite that is under maintenance for a few hours).

Q. What is the division of responsibility when applying penalties, between NTI and the project owner?

R. NTI: The project owner is responsible for ensuring that the Enerbird software meets the expected functionality. After the final acceptance (which may include a probationary period), penalties are the responsibility of the project owner. We ensure a follow-up of exploitation to eliminate the abnormal penalties. As an option, we also offer a performance guarantee on a case-by-case basis, where we commit ourselves to the economic performance of the plant and pay a penalty in case of underperformance.

Q. What is the gain in performance of your algorithms, on resale? Is there a real interest in investing in algorithms and associated equipment for island-scale production?

A. NTI: Typical sales prices for projects on French overseas islands range from €50 to €150/MWh, while the premium applied during the evening peak is set at €200/MWh. Depending on the size of the battery, 15-30% of the injected energy can be shifted to the evening peak. This represents between 20 to 100% additional revenue compared to a solar PV plant. This benefit justifies the implementation of a storage + forecasting + predictive EMS system. In addition, these systems limit the intermittency of the production and allow the integration of more renewable capacity for an entire island. The returns on the EMS + forecasting part are difficult to isolate, but the adoption of these systems on a large scale by project developers confirms that the return on investment is there.

Q. Considering that batteries are expensive, would it be possible to integrate Solar + Pumping Storage?

A. NTI: The implementation of different types of storage is feasible within the actual EMS framework that we have developed. In fact, any kind of production or storage technology can be integrated.

A. Reuniwatt: The implementation of different storage types is feasible from the point of view of the forecasting provider. In general, the project infrastructure and financial resources might be the limiting factors for selecting the best type of storage for a project.

ACHIEVING 100% RENEWABLES ON FRENCH OVERSEAS ISLANDS

Q. What are the future innovations that will help the French overseas islands reach the goal of 100% renewable energy?

A. Reuniwatt: Our experience with the projects from CRE's tender scheme has shown us that this is a system that works well, with attractive outcomes for both the grid operator and the utility. We also offer other types of services that are aimed specifically at certain players. To give a concrete example aimed at network managers, we use our satellite expertise to reconstruct the production in real time over the entire photovoltaic park of a territory or to provide aggregated forecasts over a given territory.

A. NTI: We have demonstrated that for a power plant (all capacities combined) it is possible to combine a forecast of what is actually going to happen and an arbitration between several levers of flexibilities to achieve a management that makes sense and gives good economic performance. So, the next step that can be taken by us, by developers and by network managers, is to try to increase the scale. The idea would be to succeed in coordinating several PV power plants, each equipped with a system to forecast their production, in order to make the proper decisions and to control central or distributed storage devices, in order to move towards a "Smart Grid", where there is communication at a maximum of possible levels, with a flow of data that improves the operation of the entire network. The variability of renewable energies only bothers us because it is not under control, which forces us to compensate by controllable means. With enough information, this variability ceases to be a handicap because it can be anticipated.

Q. What are the short-term perspectives (2025) regarding the developments (forecasts and piloting) for the grid operator and the French Energy Regulator (CRE) to raise the threshold of 30-35% of variable renewable energies in the French overseas areas?

A. NTI: We hope that the experience obtained from the CRE will be sufficient to raise the threshold. Any additional initiative that combines intermittent production, controllable production, storage and/or demand management also seems promising, in the form of power plants or autonomous microgrids.

Q. Do you have experience with similar solar-storage schemes in non-French insular territories?

A. NTI: We are regularly consulted on various hybrid projects calling for a dispatchable and guaranteed PV production through storage systems. We see this kind of requirement in various insular territories, but also for hybrid plants meant to be connected to larger but weak grids.

A. Reuniwatt: We have similar Solar & Storage projects in different regions. One example mentioned in the webinar is a project in Mauritius, but also other islands like New Caledonia, Madagascar, Tonga and Palau (not necessarily including storage).

Reuniwatt Naldeo Technologies & Industries SynergÎle Pôle d'innovation de la Guadeloupe

BEYOND SOLAR & STORAGE IN THE FRENCH OVERSEAS ISLANDS

Q. Will you develop solutions on other energy sources such as wind power?

A. Reuniwatt: Yes. Historically, we had more interest in positioning ourselves in PV because it was a market with very few existing solutions. After a lot of investment, we are now a leader in innovation in this field. We have done several tests to see to what extent some of our algorithms can be translated to wind power plants. For the moment we are providing some wind forecasting services through a partnership. We also have several R&D projects that aim to understand the specificities of this domain. On a case-by-case basis, we can therefore already respond to incoming requests for wind forecasts.

Q. Is the Enerbird EMS suitable for off-grid systems?

A. NTI: Yes, the control of an isolated microgrid, which must ensure that the voltage and frequency features of the grid are maintained at all times, depends mainly on the equipment that is installed. Today, battery inverters, PV inverters, generators with simple electronic controllers are almost capable of keeping an isolated electrical network (of a size proportionate to the size of the equipment, of course) afloat. However, if a battery is left alone to power an isolated microgrid, it will inevitably end up discharged. By coupling it with renewable generation solutions, there is likely to be more generation than consumption, and therefore opportunities to charge the battery. But without a control layer, we have no way of knowing when the battery is fully charged or discharged. Once again, the EMS is a kind of conductor that controls the different elements of the power plant to manage the batteries. When they are almost charged, the renewable energies must be depleted, and when they are almost completely discharged, the controllable generators must be started or consumption reduced in order to preserve them. More generally, Enerbird makes sense as soon as it is possible to apply a certain logic and a certain balance between several equipment or variables that exist in the system: the more variables there are, the more interest there is in having a "brain" that carries out these balancing operations in the power plant.

Q. Are you working on systems that include storage other than batteries? Can your tool respond to a PV system coupled with hydrogen fuel cell production?

A. NTI: Yes, we have already worked on thermal storage, hydrogen storage and different types of batteries. An advanced study for a PV + hydrogen fuel cell project is underway.

BUSINESS-TO-BUSINESS RELATIONS

Q. You mentioned Bertin Technologies at the beginning of your presentation, can you recall the links between NTI Technologies & Industries and Bertin?

A. NTI : Naldeo Group is a French SME based in Lyon. Naldeo Technologies et Industries (NTI) is a new company within Naldeo Group. It has been created to host the former activities of Bertin Energy Environment a department of Bertin Technologies. This department was transferred to the Naldeo Group on 1 October 2020. Even if our name has changed, our missions, our teams, our know-how and our clients remain the same. This merger is strategic because the rest of the Naldeo

Group has clients and expertise that are complementary to ours (territories and local authorities for Naldeo vs. industry for NTI; water and waste for Naldeo vs. process and energy for NTI).

Q. What is the relationship between Reuniwatt and INES/CEAtech?

A. Reuniwatt: INES is a research laboratory. Reuniwatt invests a lot in R&D and as a result we have established many partnerships with research laboratories, even if we have not yet had the opportunity to develop one with INES/CEAtech.