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Experimental Solar Field at the Monterrey Research and Innovation Park PIIT

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EXECUTIVE SUMMARY

By 2020, CO2 emissions should be reduced by half while by 2050 the world's electric energy demand will duplicate. With this strong motivation, the Innovation and Research Technology Park (PIIT) and Schneider Electric's Design and Innovation Center (MDIC) both based in Monterrey, Mexico have partnered to create an Experimental Solar Field. The partnership between Schneider Electric and the PIIT follows the Triple Helix collaboration scheme, which the state government has incentivized and has had great success. This experimental solar field serves two main purposes that produce significant impact from the technological and socio-economic perspectives. The experimental solar field is found in a world-class prime location as it sits in one of the most favorable sun-radiation belts in the entire world. As a result of the successful operation of the Experimental Solar Field, Mexico's Northern border will prove that it is one of the most attractive places to invest and develop around this type of technology and associated infrastructure.

INTRODUCTION

The Experimental Solar Field at a Glance

The Experimental Solar Field at the PIIT is now fully operational in an area of 4800m2. The field features 900 interchangeable solar panels, 9 solar inverters, electrical distribution & protection equipment, and structural elements. It required 6 months of construction (July 2014 – January 2015) and a total investment of more than $1.5M USD. The construction of the solar field came as a result of a joint financial fund between the State Government of Nuevo Leon and Schneider Electric while the land was donated by the state. The solar field has a generation capacity of approximately 480,000 KWh per year.

Technological Perspective

From the technological perspective, this technology and infrastructure project located at the PIIT, is intended to create a suitable innovation environment that will foster the generation of new products for the renewable energy market (e.g. solar inverters, power electronics, DC electrical protection & distribution equipment, solar panels, etc.), breakthrough technologies on the field of materials (nanomaterials, smart materials, battery efficiency, etc.), and state of the art energy management techniques (monitoring, metering, control, data analytics, mobile apps, etc). In the next sections, the associated efforts and partnerships required to reach the desired technological progress will be described. It is important to note that all of these efforts encompass a direct collaboration between the MDIC, Schneider Electric's global R&D engine, government agencies, the National Science and Technology Council (CONACYT) network of research centers, and the academia. The aforementioned efforts between Schneider Electric's global research engines and some of the most prestigious universities, research centers and government agencies in Mexico encompass complementary skills, competencies and lines of research highly dedicated to the renewable energies sector and with a strong physical presence at PIIT.

Bringing New Products and Solutions for the Solar Energy Market

The Experimental Solar Field acts as a convergence point where experts from the industry and the academia collaborate, exchange knowledge, share infrastructure, test their developments and identify new opportunities. Advanced calculation, 3D virtual simulation, rapid prototyping, manufacturing pilots, and lab testing are some of the techniques, tools and shared infrastructure that will be used to build, verify and put into practice all the different efforts associated to solar energy. In this Experimental Solar Field, engineers and scientists will be able to obtain feedback in real time about their latest designs, concepts, solutions and theories. All these technological efforts will have a strong focus on: value creation, intellectual property generation, identification of new business opportunities, and the creation of mechanisms to capitalize all the knowledge into successful products and solutions in the market.

1.Field Research for Solar Inverters (Schneider Electric US and Canada)

Since 2007, Schneider Electric features a business unit which is totally dedicated to renewable energies: Xantrex, a Schneider Electric subsidiary which was acquired almost 10 years ago, represents an important step towards the exploration of new energy schemes. Based in Vancouver, Canada and Livermore, California; Xantrex has increased its presence into Schneider Electric's R&D engine during the past 5 years.

The MDIC has had an increasing R&D relationship with Xantrex through the Advanced Calculation and Simulation Department. Highly relevant projects in new designs for solar inverters have been totally conducted by Thermal and Structural numerical specialists based in Monterrey. There are some important challenges that have been faced by these specialists, as it is exemplified by the validation of next generation

enclosures that house high density power electronics under extreme environmental conditions such as the ones found in the Nevada desert.

The team at MDIC found effective and innovative solutions based on numerical methods and mathematical algorithms such as Finite Element Analysis (FEA) and Computational Fluid Dynamics (CFD). This success is the result of collaboration between MDIC, Tec de Monterrey, and the staff of Xantrex. Tec de Monterrey contributed with the human talent, graduated from MSc programs in which Schneider Electric has been an active partner contributing to identify talent and define academic curricula in the spirit of forming highly specialized resources capable of creating virtual models, as in this case.

Now, with the on-site experimental solar field along with extreme weather conditions such as the ones found in Monterrey, these new solutions will be able to be physically tested, verified and evaluated in a real life scenario. These conditions foster the ability to collect data, analyze performance, calibrate virtual models, and continuously generate concepts associated to renewable energy solutions. The solar field enhances the ability to have a direct interaction between the design engineer and the solution. This situation represents a fundamental step towards achieving miniaturized and more efficient renewable energy solutions capable of transforming the energy from AC to DC.

2.Field Tests for Medium Voltage Switchgear (Schneider Electric Spain)

Schneider Electric's Spanish subsidiary Manufacturas Electricas SA (MESA) based in Bilbao, Spain, specializes on Medium Voltage distribution equipment. MESA has been part of Schneider Electric for more than 20 years. For the last 8 years, MESA has done its Advanced Calculation and Simulation operations in the MDIC. As a result of FEA and CFD simulation, MESA and MDIC engineers have managed to design miniaturized Medium Voltage switchgears for Eolic applications, mainly. To solve this significant technology challenge, advanced knowledge on structural, thermal and electromagnetic phenomena was required. These physics were effectively used to overcome the challenges associated to a solution that needs to meet tight codes, standards and restrained space conditions as it sits inside the posts holding the Eolic generator. This successful application has created the idea to have a solar energy version in the short run that could even be smaller than its Eolic counterpart.

With the on-site solar field, engineers will test and evaluate new form-factor envelopes, suitable location and even easy mobility of the enclosure in order to have a suitable and miniaturized solution that can be easily transported, installed and displaced according to the flexibility and adaptability demanded in a solar field. Numerical specialists and design engineers who have been involved on these efforts regularly participate as invited professors or lecturers in Tec de Monterrey and the State University UANL to share the experience on how to effectively apply physical phenomena knowledge in the thermal and electromagnetic areas in the spirit of generating robust concepts for real-life challenges.

3.Field Tests on Interruption and Safety Devices for Solar Applications (Schneider Electric US)

Photovoltaic safety switches and DC circuit breakers are being developed by Schneider Electric in North America with the purpose of satisfying the growing global need of solar generation and the associated safety measures that solar fields must feature. Engineers at MDIC have been tasked on designing these safety switches with the intention of building up and offer that can meet the specific requirements of a solar field infrastructure.

Having this type of interrupters and DC breakers in the Experimental Solar Field in the PIIT, gives the opportunity for engineers in North America to further study and evaluate their performance on field with the objective to generate further innovation and optimization of these solutions. This effort will contribute to

strengthen leadership in a high potential market and will be the perfect scenario to create leaner, smaller architectures operating with DC power. These evolving architectures will not only meet all the requirements of current codes but will also bring a competitive advantage to the market. In a practical sense, the biggest advantage is that this product will be tested and evaluated in a real life scenario which features an environment with high variability in terms of weather conditions.

This advantageous situation supports the continuous technological evolution to maximize the efficient utilization of energy while providing all the required safety elements to guarantee the integrity of the operators and the infrastructure. These improvements will also allow increase the adaptability of the offer for future requirements coming from the utilities and independent power generators as well as being a primary driver for future evolution of norms and standards.

Collaboration in Materials, Structure and Smart Grids Design Research for Solar Energy with other centers at the Park and Local Universities

1.Field Tests on New Materials (CONACYT'S CIMAV)

Solar Energy is certainly a growing field on which the continuous development of new materials is highly critical. In this field, the importance of strategic alliances with academic and research institutions become highly relevant. The solar field has been projected to become a testing laboratory with the capability of collecting actual data from a real life application. Nanotechnology, new material substitutes, flexible cells, batteries, etc., are all ideal candidates to be implemented in the spirit of collecting further data that can prove their feasibility for a mass scale implementation. In all these opportunities, the Advanced Materials Research Center (CIMAV) at PIIT is a key partner helping to develop the required incubation and maturity processes as it holds the required skills and competencies, advanced knowledge on material applications for solar purposes, lab equipment and resource bandwidth to support all associated efforts on material research.

2.Field Tests on Solar Tracker Structures (Tec de Monterrey and CONACYT'S CIDESI)

Some of the most mature and fully developed competencies at the MDIC are mechanical design and applied mechatronics. With a solar field on site, these competencies are widely applied to develop next generation smart structures in the form of solar trackers in order to improve the ability to capture solar radiation throughout the day. These smart structures would enable the ability to adjust tilt angles and relative orientation as a function of the sun's position without the utilization of kinematic joints.

Mechatronic engineers along with Tec de Monterrey have already developed prototypes that represent a viable opportunity to scale these concepts up to a solar field application. By means of elastic materials that have great memory characteristics as well as required stiffness properties, engineers will create smart structures based on compliant mechanism characteristics that will hold the photovoltaic cells while providing the flexibility to be able to track the sun's path. In this area, important efforts associated to rapid prototyping take place, in collaboration with the Engineering and Design Center CIDESI at PIIT. 3-D printed parts as well as machined parts are intensely used to create scaled concepts that are used to evaluate the actual behavior and performance that larger applications could feature.

3.Smart Grids Based on Monitoring, Metering, Remote Control and Mobile Apps (Schneider US, Tec de Monterrey, State University UANL)

Schneider Electric has a great potential to position itself with the most complete renewable energy portfolio available in the market. Speaking about solar fields, new monitoring, metering and remote control technologies enhanced by mobile apps can provide valuable information about the generation, distribution and status of the energy produced by the solar field. New generation of current sensing technologies are

being developed along with Tec de Monterrey in order to get the right level of accuracy in smaller envelopes to drive miniaturization and lower production costs. In parallel, State University UANL is providing resources with the right set of competencies to facilitate the creation of firmware and mobile apps that enhance the ability of data collection, interpretation, communication, analysis and storage in the cloud.

Once all these components are in place, the Experimental Solar Field will allow testing new standards and regulations on how generated power by renewable sources could be bi-directionally injected to the grid back and forth. It will also enhance the ability to determine by self-intelligence when battery systems and back-up power should kick in. Additionally, this capability opens endless opportunities to provide support to the CFE, other independent power generators and end consumers to be able to track relevant data in real time and be able to make wise decisions to make the most of their energy. The collected data could contribute to further refine the energy legislation in the country as part of the latest Energetic Reforms stated by the Federal Government. Finally, the Experimental Solar Field will have the capability to test and model dynamic tariff schemes, demand/response options, and communicate alerts to utilities and end users.

Collaboration with users regarding New Energy Management Techniques

1.Field Tests on Solar Field Interaction with Massive Electrical Networks (Government: CFE Electrical Utility)

The solar energy has gained important traction during the last few years. One of the current challenges is how to effectively insert a new energy source into the already existing electrical network. The experimental solar field at MDIC represents state of the art technology that depicts potential ways to improve generation, management and insertion of this type of infrastructure into the electrical network.

As part of these ways to improve the insertion of solar fields, engineers and researchers from the integrated solution (Schneider Electric) and utility (CFE) sides will be able to fully understand and track performance of the different components therein contained. Researchers from both parties will be able to measure and take readings in real time under actual operation conditions. Solar cells, DC interrupters, energy collectors, inverters, etc. will all be available to study and improve their performance levels taking into account scalability for other applications such as industrial, commercial and residential sectors. Additionally, subject matter experts will be available to share with different stakeholders the recommended practices to effectively integrate the solar field system into the existing electrical network in order to guarantee that the energy is safe, efficient, clean and reliable. Furthermore, automated energy management systems will be installed in order to bring intelligence to the system so that it is capable of taking decisions in the best interest of the electrical network associates. The integration of all systems will continuously evolve to be scalable and upgradable.

Socio-economic Impact

From the socio-economic development perspective, it is expected that the associated efforts conducted at the Experimental Solar Field detonate new product development, manufacturing activities and supply chains in the regional area. This would represent a clear opportunity to create a sustainable link between the technology of new solutions and the community.

Employment, investment, robust and clean energy, lower cost solar panels, novel materials, etc. are just examples about the envisioned value. Additionally, as part of the collaboration between the government,

the industry and the academia, students are able and encouraged to visit the Experimental Solar Field and participate on technology projects dealing with renewable energies. Junior high and high school students are already visiting the site to see firsthand what a solar field looks like, engineering undergraduate students are being able to acquire more advanced knowledge by understanding how the theory and physics are applied in real life, while graduate students actually collaborate with relevant thesis projects leading to technological business incubation associated to renewable energies.

At the end of the day, this practice significantly contributes to motivate, engage, generate and capitalize a young and talented critical mass capable of providing sustainable solutions to the energy dilemma in the short, mid and long runs.

At a state and country level, these efforts will position the state of Nuevo Leon as a research, innovation, technology, new product development and infrastructure power house being capable to offer high value added and well compensated jobs. From Schneider Electric's side, the solar field represents an excellent forum to preach what the company is all about. Technology, environmental focus, innovation, energy efficiency, etc. are some of the company values that are clearly represented in the Experimental Solar Field. With an initial capacity to generate 320KW which translates to 480,000KWh per year, the solar field will provide approximately 30% of the total annual energy required by the whole MDIC to operate its full facility (offices + lab buildings featuring more than 6000m2). The goal is to create one of Latin America's first research and development buildings holding a Leadership in Energy and Environmental Design (LEED) Gold certification as well as to reflect the potential that other facilities would have with this type of sustainable solutions.

The CONACYT and the State of Nuevo Leon have created as very attractive and successful program that consists on granting full scholarships to high potential talent willing to pursue graduate degrees on the top 200 universities around the world. One of the strategic areas that the government greatly supports is energy. The state of Nuevo Leon has the vision to become the country leader in energy generation and management, reason for which levels of investment on this topic are high and accessible. This also represents a great opportunity for a new generation of technology and sustainability creation. As part of the Triple Helix model, Schneider Electric selects at least two of their engineers so that they can pursue advanced graduate degrees and specialize on areas that are highly relevant to the company. Two generations of Schneider Electric employees have already returned from their graduate degrees in the UK, France, Germany, and Australia to successfully apply their knowledge on new product development and technology incubation projects. Nowadays, the current generation of Schneider Electric employees studying abroad is getting trained on solar energy applications, management and technologies.

Conclusion

Energy trends, needs, legislation and practices are evolving as a result of a gradual proliferation of alternative sources, environmental regulations and a stronger focus on conservation, financials and efficiency. Governments and general population are becoming more aware about environmental and financial impacts as a result of their energy consumption habits as well as the great opportunities associated to developmental and value added activities. The Experimental Solar Field is a great real-life lab and tangible example that is bringing several opportunities to an advanced emerging economy that features one of the most important areas in the world in terms of solar energy potential. It also acts as a clear and successful case of what other companies and governments can do in terms of infrastructure projects, investment opportunities, contributions to the environment, and generation of wealth to the population at several levels. The existence of the Experimental Solar Field produces a traction phenomenon that triggers the evolution and consolidation

of entire productivity and supply chain networks. These networks will be key contributors to enhance opportunities for further growth and development. The Triple Helix is a great model that helps three main players converge with the purpose to innovate, generate value, and offer developmental opportunities to the population. This project proves the value of the Triple Helix and serves as a clear example on how joint projects between the government, the academia and the industry significantly increase traction and produce a higher impact to a region and/or industry.