“Wind Energy Access for Remote Communities: A Regional Industry/Academia Technology Deployment Program”

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Summary

The trade winds that blow along the Atlantic coast from Morocco to Senegal represent one of the largest and most productive wind potentials available on earth. Because of the extremely harsh climatic conditions, populations in these areas are concentrated in a few remote cities where economic activities such as mining or fishing can be sustained. Isolated by long distances, these cities located in the middle of the desert function in fact as island communities as they are not grid connected and have to dispose of their own electricity supplies. The objective of our NATO Science for Peace SfP-982620 funded project ‘Sahara Trade Winds to Hydrogen’ involving 18 institutions from 6 countries, is to initiate a broad ranging bottom-up capacity building program aimed at improving local energy access solutions relying on the region’s knowledge centers, universities as well as industries. As an end-user driven program, the project consists in deploying wind-electrolysis test bench installations within the region’s universities to assess the synergetic potential for designing autonomous power supply options with local industries. A small wind turbine manufacturing program developed through collaboration between academia and the telecom industry is also aimed at enhancing power supply options for telecommunications infrastructures using wind power. As a result, a network of field measurements geographically spread throughout the region has been deployed, enabling the assessment of the trade wind resource. In remote communities, the potential for collaboration between various players can be very rewarding and must be pursued to the extent possible. The involvement of academia in this process, to train engineers and technicians to become familiar with these technologies represents a significant asset for the successful deployment of integrated solutions.

KEY WORDS: trade winds, wind resource assessment, capacity building, small wind turbine, decision support system, industrial synergies, pilot/demonstration projects

1. INTRODUCTION: WIND RESOURCE ASSESSMENT

As anemometer tower infrastructures represent the main investment of a wind monitoring program, and in order to maximize the impact of the Sahara Trade Wind to Hydrogen NATO SfP-982620 project [1], a wind monitoring program collaboration with the telecom industries was initiated on a regional basis. Since mobile phone coverage is widely distributed and generally made available before access to electricity, the main advantage of this technology is that it relies on a series of repeaters consisting of high mast tower infrastructures. The availability of high mast towers located on regular distances provides an ideal platform within which a wind measurement program can be conducted. The regularity of the telecommunication networks provide a good distribution setting enabling wind energy potentials of a region to be exhaustively mapped with a high level of accuracy and at much lower costs than any other on-site wind measurement programs.

Accuracy and certification of wind measurements represent in our case a capital generating added value for teams involved in this program. Hence, choices of wind monitoring equipments have focused on the use of certified, calibrated instruments, rather than low instruments costs. The access to mast tower infrastructures for wind measurements enabled us to focus our strategy on the value and reliability of the measurements carried out in this program as the quality of the data collected can already be used by financial institutions for funding wind project developments in the region. Our equipment deployment strategy relied on the selection of calibrated wind measurement instruments that have been installed at 30, 40, 45 and 50 meters height of telecom mast infrastructures [2].

Since the objective of our project is to reinforce the link between industry and academia, engaging the telecom companies in our program was an important first step in engaging end users. This activity, initiated in Mauritania by Sahara Wind inc. and the University of Nouakchott proved to be essential for duplicating collaboration protocols in Morocco, as Mauritania telecom (Mauritel) is in part a subsidiary of Maroc telecom which operates the largest mast tower infrastructure network in Morocco as well. The collaborative environment among institutions in Mauritania being more conducive due to the smaller communities and markets sizes have prompted us to rely on the high level of flexibility and availability of local operators to start an applied research partnership in a joint sharing of assets with local academic institutions. This represents a significant advantage that Island communities should take advantage of, as it enables the establishment of long lasting links that can lead to effective partnerships in the development of endogenous power supply solutions. Our collaboration with MAURITEL in supporting the University of Nouakchott's wind monitoring program has for that matter been quite exemplar, and we were very grateful to be able to pursue this work in Morocco accordingly.

Figure 1: Map of NATO SfP-982620 Sahara Trade Winds to Hydrogen Project

2. END USER DRIVEN APPROACH

2.1 Integrated Wind Monitoring Program

While costs reductions for the wind resource assessment was made possible and using fairly limited budgets, this approach enabled us to engage end users directly over the subsequent development and deployment of small wind energy systems. The potential applications of this project are enhanced through this end-user collaboration as telecom companies represent the very first commercial market niches for small wind turbine applications. These markets are likely to expand and get reinforced by the interests of utilities and agencies responsible for rural electrification programs that are also involved in our project.

In relying on the partnership between academia and end users, we are laying the foundations of critical links in future energy developments for both decentralized and distributed applications as well as larger-scale grid connected systems. In both cases, capacity building on renewable energy technologies centered on bottom-up applied research projects remains a fundamental step that requires genuine local sources of support. The integration potential of this resource within local end-users in case specific or industrial applications are one of the key objectives of the NATO Science for Peace SfP-982620 project.

2.2 Small Wind Turbine Manufacturing

After a thorough bibliographic research on technologies utilizing local materials that could be adapted to our settings, several designs concepts were considered. As this market is currently being covered almost exclusively by small and medium size enterprises, access to intellectual property on technology in manufacturing processes remains fairly restricted, while complete vertical integration in manufacturing processes are often time inexistent. Our challenge resided therefore in indentifying the right technology with a partner that was willing to share it. This objective proved to be very difficult to achieve within NATO countries as high individual costs of systems and a restricted access to technology, reduced our options to very few small wind turbine designs that we could get inspired by in our industrial engineering program. The choice for initiating adequate partnerships led us to favor technical requirements beyond NATO countries and consider collaborating with a non-NATO country equipment manufacturer which has accepted to support the approach carried out in our applied research project. Following a visit to the manufacturer's facilities, we came back with the certitude that we can start a manufacturing program for wind generator both in Mauritania and Morocco [3]. The rationale behind the small wind turbine manufacturer to get involved in our project is linked to the Company's strategy to expand its outreach and markets into developing countries using academic training infrastructures and programs. These tend to provide good exposure in support of local equipment deployments. Within the framework of the NATO SfP-982620 project, and based on the aforementioned, existing designs of small wind turbine technologies will be adapted by the ENSAM school of engineering. As NATO SfP-982620 partner institution, ENSAM is essentially an industrial engineering school with design and machine shops that can easily integrate these technologies as part of students training programs and curriculums. The reliance on the region's local materials and components to build small wind turbines is quite appropriate, particularly for the servicing of these systems within Morocco and Mauritania's remote locations. This aspect of the project is extremely important as capacity building for local maintenance of wind turbines remains a long term challenge hence, a priority for the sector.

The lack of adequate servicing is one of the main causes at the origin of dysfunction and failures of distributed energy generation systems. In desert regions for instance, and as has been witnessed during our field visits in Mauritania, this represented the main reason why many small wind turbines systems funded by a Global Environment Facility program were no longer running. Hence, it could be argued at the very least that a win-win partnership for the deployment of these technologies can be established. Academia can train and build local capacities on the operation of the systems and small wind turbine manufacturer are thereby in a position to rely on local expertise for the deployment and support of these systems over large areas. At best, the manufacturing of most of these systems could be integrated locally, and the region will be in a much better position to support its current rural/remote electrification programs.

Capacity building in Small Wind Turbine local manufacturing and maintenance will initially involve specific dedicated rotor designs. These can be developed, validated and tested in comparison to existing available designs. The following steps involve simulation of rotor structural designs, where ultimate strength and fatigue tests for all structural components and materials (blades, hub and shaft) can be verified though finite element analysis, calculations and simulations.

For the steel tower designs we resorted to currently to adapt conical towers used for public lighting as for them to support the weight of small wind turbines. Since wall thicknesses and materials are known, we can calculate the number of flat ring-stiffeners that may be required. To validate these models we will compare the obtained results with the data of that Small Wind Manufacturers use [4].

To assist us in our Small Wind Turbine manufacturing program, the International Standard Design Requirements book for Small Wind Turbines is a necessary reference and support source. Discussions are currently underway to identify how other NATO SfP-982620 partnering schools will complement each others in this applied research program. Cooperation with local institutions, industrial end-users as well as stakeholders is currently being carried out by Sahara Wind Inc. with the support of the expertise made available at the ENSAM and Al Akhawayn University in Morocco, and the University of Nouakchott in Mauritania that are our full partners in this project.

3. TECHNOLOGY DEPLOYMENT

3.1 Small Wind Turbine Solutions

As previously mentioned, while telecom companies represent a good market for small wind turbines, utilities and agencies responsible for rural electrification programs are interested in local developments of technical solutions capable of supporting and complementing their rural electrification programs. Indeed, small wind turbines are more affordable then solar Photovoltaic kits in terms of costs of installed electric capacities. Hence, such systems could become quite complementary to each other when deployed in support of existing rural electrification systems, where costs parameters and the necessity to dispose of an access to higher electric generating capacities are at stake. A 1.5 kW small wind turbine for instance costs the equivalent of a 300 Watt PV system. Seen limited resources available in rural areas particularly when it comes to upfront investments, access to higher power capacities can thereby be made available at lower costs. Although intermittency remains an issue, such systems nevertheless are aimed at supporting income generating activities in return. As Morocco remote electrification program is often used as a reference in the field by multilateral institutions, the electric utilities ONE, as well as the water utilities ONEP as partner in our project, are considering such upgrades, as they can be regionally well integrated with a local academic support. The partnership in our project of the University of Nouakchott with the "Agence Pour l'Accès Universel aux Services" (APAUS) the Agency in charge of rural electrification programs in Mauritania is for that matter quite edifying.

3.2 Regional Wind Energy Applications

The synergies that are possible within the local industries to integrate larger sources of wind energy in industrial processes for electricity generation, water desalination water treatment, and mine processing using electrochemical processes can be enhanced in terms of applications and expanded. The role of academia to initially test and develop decision support systems for the design of wind systems adapted to specific applications is quite relevant. Hence, these technologies are currently deployed within our partnering institutions to serve as test benches connected to a variety of applications. The installations are carried out in collaboration with large end user groups to analyze and compare the possible configurations that larger wind systems integrated within industrial applications can provide. In developing alternatives to reduce energy costs and logistics within isolated mine processing industries, the potential applications of wind generated electricity systems in industrial processes with high synergetic applications remains largely untapped.

These perspectives are currently being studied and evaluated within the framework our Science for Peace project. The project's results are likely to be followed through and support the deployment of pilot scale project within the region's main industries. This capacity building program is timely and comes as a prerequisite to development of decentralized applications for small, remote as well as larger scale integrated renewable energy systems.

4. CONCLUSIONS

The role of academia in its relationship with end-users can provide concrete benefits to all parties involved in our NATO Science for Peace project. As the wind monitoring program is expected to be of interest to many end-users, including telecom companies that are looking for solutions to power their isolated communications repeater infrastructures, this framework provides good support sources for training and building the research capacities of the future. Through this applied research project whose results are protected by Intellectual Property Rights agreements endorsed by all partners and backed by an intellectual property rights committee established by the NATO Science for Peace Program, the work of all participants is significantly reinforced. Capacity building through the deployment of programs to support existing centers of academic excellence on a regional basis enables critical expertise to be acquired in wind energy technologies. These are likely to enhance the integration of wind energy technologies within electric grid systems, opening thereby new perspectives on their maintenance and local manufacturing. These key aspects represent currently a major obstacle to the widespread use of wind energy in the region.

6. REFERENCES

1. The NATO SfP982620 Project partner institutions are: Department of State USA (NPD) - Sahara Wind Inc. Morocco (PPD) - Ecole Nationale Supérieure des Arts et Métiers ENSAM Morocco - Al Akhawayn University Morocco- Faculté des Sciences et Technologies, University of Nouakchott Mauritania- Ministry of Economic Affairs and energy of the State of North Rhine-Wesphalia Germany- Commisariat à l'Energie Atomique CEA France- United Nations Industrial Development Organization – International Centre for Hydrogen Energy Technologies UNIDO-ICHET Turkey. Project Web site: www.saharatradewinds.com

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