Regional Hydrogen Roadmap - Project Development Framework for the Sahara Wind Project

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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 erratic nature of winds however, wind electricity cannot be integrated locally on any significant scale, unless mechanisms are developed for storing these intermittent renewable energies. Developing distributed wind energy solutions feeding into smaller electricity markets are essential for solving energy access issues and enabling the development of a local, viable renewable energy industry. These may be critical to address the region's economic challenges currently under pressure from Sub-Saharan migrant populations. Wind-electrolysis for the production of hydrogen can be used in grid stabilization, as power storage, fuel or chemical feedstock in specific industries. The objective of the NATO SfP 'Sahara Trade Winds to Hydrogen' project is to support the region's universities through an applied research framework in partnership with industries where electrolysis applications are relevant. By powering two university campuses in Morocco and Mauritania with small grid connected wind turbines and 30 kW electrolyzers generating hydrogen for power back-up, as part of "green campus concepts", we hope to demonstrate that wind-electrolysis for the production of hydrogen could absorb larger quantities of cheap generated wind electricity in order to maximize renewable energy uptakes within the region's weaker grid infrastructures. Creating synergies with local industries to tap into a widely available renewable energy source opens new possibilities for end users such as utilities or mining industries when processing raw minerals, whose exports generates key incomes in regions most exposed to desertification and climate change issue. Initiated by Sahara Wind Inc., a private sector company, along with the Al Akhawayn University, the "École Nationale Supérieure des Arts et Métiers" (ENSAM) of Meknès and the University of Nouakchott; this project is funded under the NATO Science for Peace and security collaborative programs. Being associated to the larger scale Sahara Wind Project, this initial NATO funded Project serves as the foundation of an ambitious program aimed at tackling energy scarcity and sustainable development objectives through industrial synergies utilizing hydrogen energy technologies.[1] This combination takes advantage of the significant breakthroughs expected to happen in the near future, regarding hydrogen technologies when associated with larger sources of renewable energies.[2] Reliance on the ability of public bodies such as universities, public utilities and other institutions to concretize dynamic partnerships with the local industry and the private sector is the key to the success of this program.

Keywords: trade winds, intermittent storage, grid stability, high wind penetration, energy access, capacity building, industrial synergies, small wind turbines, electrolyzers, fuel cells, hydrogen.

1- Introduction

Wind-electrolysis offers great possibilities for absorbing large quantities of cheap wind generated electricity to produce hydrogen as a valuable fuel resource or chemical feedstock, while maximizing the renewable energy uptake of the weak grid infrastructures of the trade winds coastlines of Morocco and Mauritania. Wind-electrolysis for hydrogen production can be used for grid stabilization, power restitution/backup and as fuel or feedstock for specific uses in remote locations[3].

The equipping of wind-hydrogen laboratories in both Morocco and Mauritania enabled us to utilize the full length of the NATO Science for Peace SfP-982620 project (36 months); aimed at carrying out an exhaustive wind resource assessment program, in both countries in partnership with the region's telecom operators. Since mobile phone coverage is widely distributed and generally made available, even before access to electricity this technology 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 deployed. 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. [4]

Accuracy and certification of wind measurements represent in our case a capital, generating added value for all teams involved in this program. Hence, choices of wind monitoring equipments have focused on the use of certified, calibrated instruments, rather than lower instruments costs. The access to mast tower infrastructures for wind measurements enabled us to focus our strategy on the reliability of the measurements carried out in this project, 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 on several heights of the telecom mast infrastructures.

Since the objective of our project is to reinforce the link between industry and academia, working with the telecom companies in our program was an important first step in engaging end users. This activity, initiated in Mauritania by the University of Nouakchott and Sahara Wind inc. proved to be essential for duplicating collaboration protocols in Morocco, as Mauritania telecom (Mauritel) is in part a subsidiary of Maroc telecom, the later operating the largest mast tower infrastructure network in Morocco. Hence, the wind monitoring program was extended to Morocco thereafter, enabling us to dispose of a complete measurement protocol funded by the NATO Science for Peace and Security program covering a region of several thousand Kilometers' distance.

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 this applied research partnership in a joint sharing of assets with local academic institutions in Morocco as well.

The availability of high mast towers, located over regular distances, provided an ideal platform within which our wind measurement program could be conducted at minimal costs. Through this approach, the wind energy potentials of the region will be exhaustively mapped with a high level of accuracy enabling us to simulate the amount of renewable hydrogen; that could be generated through wind-electrolysis over a very large area. This allows going beyond weaker grid limitations for accessing the value of wind energy, as we are integrating this renewable energy potential into the simultaneous production of electricity and hydrogen in a synergetic context.

Meanwhile, we were able to identify specific industrial applications which could make use of hydrogen related processes, such as the mining industries; which along with the respective utilities of Morocco and Mauritania are the region's main electricity consumers.

Since this region is located on the edge of one of the largest electricity grids (that of the EU), its large renewable energy potential could be used to produce significant amounts of cheap wind energy that could ultimately end up supplying larger electricity markets[5]. This however, will require an effect of scale. Developing initial mechanisms to progressively firm these intermittent energy sources locally is an imperative first step; as this lies on the critical path of major alternative sustainable energy developments. The role of hydrogen in such case may be quite relevant as it applies to small distributed applications such as the telecoms or access to clean water as well as larger ones in the region's mine processing sector. These will be up scaled to industrial operations; which will ultimately be part of a much larger renewable energy supply network infrastructure [6].

The Sahara Wind Project with a capacity of 5 GW of wind energy connected to a High Voltage Direct Current infrastructure; to disserve both North African and European electricity markets, aims precisely at satisfying these objectives [7]. As an upstream project development activity for its Sahara Wind Project, the NATO 'Sahara Trade Winds to Hydrogen' Project coordinated by Sahara Wind Inc. -a company from the private sector- aims at getting local scientific communities, industries and end user groups to participate in an applied research program. The objective of the program is to develop and deploy exploitable energy systems capable of integrating the region's widely available renewable energies. Through an effective collaboration with the region's main industries in partnership with the academia under the aforementioned, the phasing of the large scale Sahara Wind Project can be significantly enhanced. Indeed, the NATO Science for Peace SfP-982620 project enabled applied research platforms to be deployed within the main research and educational centers of Morocco and Mauritania. Around these, adequate training and capacity building programs, together with subsequent pilot projects deployed within the region's industries (and NATO SfP-982620 project partners), will enable the integration of intermittent sources of renewable energies in the weaker grid infrastructure of the Saharan/Sahel region.

The region can make use of its qualified pool of university professors, engineers and scientists who lacked to a greater extent appropriately equipped research and training infrastructures. The NATO SfP-982620 Project aimed precisely at addressing this issue in providing wind- electrolysis hardware within an integrated energy strategy to support a long term vision.

Additional support for co-development of wind-electrolyzer test benches have been provided by the equipment manufacturers, as well as the educational institutions aiming for respective “green campus concepts” (a University Campuses that will be fed by small wind turbines stabilized by electrolyzers). Universities with industrial engineering curses will enhance their educational program by enabling engineering students to build small wind turbines; to better address the operation and maintenance of these systems, when deployed either around their campuses or in remote sites.

In order to make hydrogen technologies more accessible to a younger generation of future scientists and engineers, the electrolysis equipment (in the 30 kW range) has been integrated as a practical energy storage feature of a green university campus. Its direct association to renewable energies; plus the integration of more accessible small wind turbine technologies, will familiarize students with hydrogen technologies introduced on a scale that is more functional and somewhat larger then laboratory devices.

Morocco disposes of a larger scientific community then Mauritania, however many of the country's challenges in rural electrification are hardly being addressed by academia, but rather by utilities or agencies that do not conduct research programs. Through this NATO funded project, Morocco and Mauritania’s educational institutions were able to initiate a comprehensive applied research program aimed at developing the access to renewable energy through hydrogen production and an end-user synergetic approach integrating the country’s main industries.

As natural gas reforming processes represents today a large majority of the world’s hydrogen production, emitting over 6 tons of CO_2 per ton of hydrogen in the process. The production of hydrogen through wind-electrolysis is carbon free as this process can be duplicated over a very large scale in Morocco and Mauritania’s trade wind regions. In generating both electricity and hydrogen without CO_2 emissions, significant environmental and energy security concerns are being effectively addressed. Indeed, as natural gas supply disruptions to NATO countries have recently highlighted, the dependency on a single source of energy; relying on fixed infrastructures which required hefty investments is a highly sensitive matter. Taping into such natural gas resources to produce hydrogen, would strain these issues even further making the hydrogen economy hardly conceivable. Thus, the need to diversify away from natural gas supplies, whose demand is likely to rise even further, is of paramount importance to the collective energy security of NATO member and partner countries alike (including gas producing countries); as well as for the future of a hydrogen economy. Demonstrating its sustainability based on the renewable energy potentials of the trade winds is therefore a key pre-requisite.

Using wind-electrolysis over such a large scale provides a paradigm shift; as it highlights the role of a vast renewable energy source -the trade winds –, which can be used to generate simultaneously electricity and hydrogen on a significant scale. At the same time, intermittency, grid stability and power transmission issues [8] are sidestepped because on-site hydrogen production facilitates the access to wind electricity, as hydrogen becomes both an energy storage medium and a valuable feedstock used locally in the mine processing industries.

2- **Conclusion**

Since electricity cannot be stored, integrating wind energy systems locally is essential as it reinforces local ownership of the wind resource while supporting income earning and energy intensive industries on a regional basis. Using the power of the elements such as wind and sea water as feedstock to supply an industry such as mine processing in the region will enable wind energy to be accessed and a clean, sustainable, value added mineral processing industry to be established locally. This bottom up capacity building will lead to the development of large scale renewable energy networks linking energy markets with adequate resources from the trade winds such as the Sahara Wind Project. This project development approach can be essential to the collective energy security of NATO member and partner countries alike, as it would reinforce the perspectives of a hydrogen economy, address environmental security concerns and enable a maximization of the mineral resource outputs that can be drawn from inside the Sahara Desert.

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