Wind Energy and Steps Towards 100 Percent of Renewable Energy Penetration

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Abstract – **In this paper the idea of 100 percent of renewable energy penetration sometime in the future with wind energy as its important part is analysed. As a presumably more sustainable approach to energy supply than for instance fossil fuels, this concept needs to be capable to last for at least as long as the time interval from the first industrial revolution to this moment. This means the capacity to sustain future climate, economic, political, environmental and technological challenges.**

Keywords – **Wind energy, Generation mix, New economy, Grid, Research & development.**

I. INTRODUCTION

Wind energy is at the moment the fastest developing variable renewable energy technology. As such, it will have a significant role in the future transition towards the 100 percent renewable energy penetration if and when such a transition happens. During that time it will face many challenges and barriers. First of all, it is very challenging to develop scenarios for something so enormously complex spread decades in the future (the 21st century with all of its socioeconomic and technological changes and beyond). Such a radical change of an existing energy infrastructure requires a modified view of economics and coordination of many activities related to grid connection (as well as grid stability requirements and energy mix) in a way that they really provide a more sustainable system which is robust enough to last for centuries and allows improvements in technology and energy mix.

II. SCENARIOS

No matter when the goal of 100 percent of renewable energy penetration is achieved, any initiative towards a further development and implementation of renewable energy should be a step along the path that has 100 percent penetration as the goal. This goal is very abstract because:

1. The exact amount of needed energy production is uncertain. – Renewable energy needs to replace sooner or later fossil fuels and allow the system built upon relatively cheap fossil fuels working without too many disturbances. Also, when energy consuming machines and vehicles switch to electrical energy, there is a sudden increase of demand for it. National economies rising and declining can cause additional complications.
2. There is a disagreement about when exactly should the complete transition to renewable energy take place. – It will hopefully happen sometime in this century, but an uncertain timeframe of several decades is enormous in globalised business as usual.

The world we live in is the most complicated ever. The environment is being changed fast, human population is the biggest ever and there is no will at the moment to reverse the pressure towards a global growth of population and economy (both still perceived as patriotic duty among nations worldwide). In such a world renewable energy is supposed to replace fossil fuels. This is not just a technological or societal/economic challenge, but it also requires a totally new mindset: long-term thinking (towards the transition and after it) instead of short-term, abstract and hardly traceable goals such as leaving a better world and the environment in a better condition to the offspring instead of investments and profit and collective instead of self interests.

Some obstacles on the path towards renewable energy transition with wind playing an important role are:

1. There is a need for a lot of coordination across levels: transmission and distribution networks (a significantly different approach between fossil fuels being dug out of the ground and transported by trucks, ships and pipes and renewable energy on the surface demanding new transmission lines) and wind farm clusters, administration and communities of practice.
2. Already established societal structures and working places need to be modified in order to change an already established and deeply interconnected (primarily, but not only around financial interests of multinational corporations making profit on fossil fuels) system.
3. As a variable energy source becomes more present percentage-wise, there are changes in capacity credit (capability to replace energy produced by other conventional energy source) and a need for additional grid connection requirements [1].

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Even with comparable prices between non-renewable and renewable energy (fossil fuels will be expensive and later even nonexistent), there is a friction between two systems, the one already existent with its administration and defined silos of experts, working places and responsibilities and the one that shall hopefully develop (e.g. looking for energy under vs. above the ground and highly depending on weather, short-term vs. long-term planning, oil magnates vs. communities, mining vs. recycling, transparency and competition vs. monopolies etc.). Besides new transmission lines, there is a similar need for redefined working places for people and transmission and distribution systems collectively providing energy in a very different way.

While different scenarios for renewable energy transition are being analysed, they differ in generation mix and future demand (energy efficiency, economy). There are different future projections for achievable reaching the 100 percent renewable energy supply on a national level in published papers and presented by respected authors and magazines, such as for example by 2030 only by wind, sun and water [2] or for example by 2050 with biomass as a part of the energy mix [3]. Biomass [3][4] does have a closed cycle of organic matter and CO2 emissions and can theoretically be treated as a renewable energy source, but it requires organic waste (fuel, even if it is non-fossil). Whatever the case, as this transition takes longer, there will be more risk from sudden changes in supply and demand of technologies and energy worldwide [5][6].

III. NEW ECONOMY

New economy [7] is a concept that appeared in economic theory at the end of the 20th century. It was at the first place about the internet and dot-com bubble. Even if it seems that it failed at the beginning of this century during a recession, this concept still makes sense. Future challenges such as transition towards renewable energy and sustainability especially around the world will require proper use of information and networks (getting things done instead of profit making by and for a limited number of people and companies) perhaps even more for collective focus to the problems (tasks and solutions instead of profit as the main goal) than simulations and analyses.

There are differences between wind farms and conventional power stations. Wind farms are modular, meaning they contain more individual wind turbines and technical problems on a single turbine do not necessarily reflect to the whole farm. Also, costs are distributed differently during a life cycle and they are concentrated on building of a turbine, connection to the grid and later maintenance. While comparing costs of wind and other energy technologies, one must bear in mind that during the expected life time (approximately 20 years for a wind turbine [6]) wind turbines are very little influenced by fluctuating prices of fossil fuels and risks of reliance on import from a distant destination and country.

Since the role of renewable energy is to replace already existing energy sources, we need to understand that wind power stations need to respond to future challenges and to sustain under future circumstances different from what we have at the moment, meaning that infrastructure, technologies used (including grid codes and hardware and software used for management and control) should provide solutions instead of more problems. Potential problems are climate changes and financial and resources crises [5]. Renewable energy is supposed to become an integral part of a future upgraded energy system. A significant number of people around the world don't use electricity and many of them have even never made a phone call. Complexity is, according to historical records, an exception rather than a rule. Former complex societies have faced collapses when they were incapable to deal with the law of diminishing marginal returns. Once a society becomes so complex that its status quo is unbearable (expensive infrastructure and administration, high rate of consumption of energy and materials), a collapse can be the only way forward. This is exactly a danger with developed countries at the moment. Energy consumption tends to go up and these countries demand enormous amounts of energy and natural resources just to protect the established status quo and these trends cannot be spontaneously reversed.

Let's take for example two supergrids, one for wind farms and the other one for solar energy. They are expected to transmit energy from supplying areas to demanding areas for decades. During that time, there can emerge improvements for either technology (wind and solar) and requirements for expansion of one grid (connected to the location with the superior technology) and demand can change in the region and in the world as well as penetration of variable energy (grid code requirements and congestion management). Also, there are possible changes in energy mix. There were warnings about the limits of growth [5] on a limited planet decades ago and renewable energy still has problems to reach the mainstream. Radically changed grids (the transition to renewable energy and supposedly more sustainable configuration) will face problems if they change one more time in the future. Even if they stay similar,

there will be a need for strong national (transnational for transnational grids) economies and companies (and global competition, investments abroad and off-shoring) capable to maintain big, complex and expensive grids (possible problems with diminishing marginal returns). An established grid connecting demand locations with renewable energy should be much higher on the list of priorities for investments just to protect a new status quo than it was in the past (our present).

Building and maintenance of a new energy infrastructure requires a lot of money. In order to provide energy in the future, developing countries [8] need innovative methods such as distributed generation, tighter communities, ICT, exchange of information, locally manufactured parts, and others. These very methods should also be considered in developed and at the moment rich countries. A sustainable technology also needs to be economically sustainable.

IV. GRID CONNECTION

Wind always blows somewhere. Wind farm clusters [9] spread across larger areas have a lower correlation (the smoothing effect) of power produced by individual wind turbines and resemble more to a classic more predictable and controllable power station. This effect needs to be taken into account while new transmission lines connecting present and future wind farms are planned. For example, Spain is one of global leaders in wind energy and the future of this technology depends on connections with France [10].

In order to properly plan supply, wind power production needs to be predicted as precisely as possible [11]. These forecasts are needed for congestion management (short-term planning) and planning of the energy mix (long-term planning).

Grid codes [1][12] define special requirements for variable energy sources such as frequency control, power control (active and passive) and fault ride through. They vary between countries. New wind turbines need to be designed and the old ones need to be upgraded according to these rules.

Energy mix [13] is an important part of the overall stability. For instance, some technologies, including those still not widely used such as combined heat and power (CHP) and electric vehicles can by their specific behaviour in demand, conversion, storage, and supply add more stability to the system (if they are properly combined). Different types of regulation and optimization [14][15] can help to make a choice between possible combinations by assessed costs, dispatch and capacity expansion.

V. AVAILABLE TECHNOLOGY AND ITS LIFE CYCLE

A good model resembles reality and there are aspects of changes of reality that established models and perceptions can't properly describe. Such a case is feasibility studies and choices between options when people in charge are comparing already existing energy technologies and renewable energy such as wind. According to experiences from Denmark [13], one of the world leaders in wind energy exploitation, radical changes are possible exclusively under pressure outside institutions. Radical changes are often out of reach of perception of institutions deeply rooted in one way of thinking and working. Wind technology needs to expect even more friction in countries with less transparent political activities than Denmark mentioned here. The establishment will try to create a situation that looks like there aren't possible alternatives and that a new (for instance) coal-fired power plant is the only existing choice and as such the best one. Neoclassical economics [16] sees the world as a set of rational agents capable to choose between different options and cost benefits as the most precise assessment of value. Still, fossil fuels are limited resources and their price will very likely start irreversibly growing in not so distant future (peak oil sooner than other peaks), while at the same time wind turbines will grow larger and be attached to improved technology connecting them to the grid (frequency, voltage, and power stabilization) and become cheaper even without feed-in tariffs and other regulatory measures financially supporting renewable energy and lower CO2 emissions.

Renewable energy will go through three phases [13] (some countries have already passed the first phase):

1. Introduction – Wind turbines don't influence much grid stability, but there is a lot of resistance and misunderstanding from business as usual and official politics.
2. Large-scale integration – Grid code requirements are being developed for variable renewable energy and new turbines need to obey them and the old ones need to be adapted. Analyses of what to do in this stage need to bear in mind energy efficiency and savings and investments and planning of transmission and distribution lines as well as renewable energy mix needed to properly approach the next stage. This stage in its mature form needs to be a strategic step (instead of an obstacle akin to non-renewable energy technologies) towards countries and the world relying solely on renewable energy.

3. 100 percent renewable energy systems – The entire energy system relies on renewable energy. The energy mix needs to be close to the optimum and renewable energy technologies are competing between each other.

In every phase there is a need to allow the best results from research and development [6][17].

The book Limits to Growth (analysed in [5]) warned about the future complications forty years ago. It will be more difficult to cope with them now than back then. In order to do so, global leaders need to figure out how to simultaneously [5]:

1. Rapidly reduce dependence on fossil fuels.
2. Adapt to the end of economic growth.
3. Design and provide a sustainable way of life for 7 billion people.
4. Deal with the environmental consequences of the past 100 years of fossil fuel growth.

These tasks are directly or indirectly attached to renewable energy, especially its portion based on wind (the faster growing at the moment) and sun. The first one is obvious, because it is about replacement of one limited and harmful energy source with another. The second one is about approaching to business, differentiation between socioeconomic and business economic feasibility studies (different technologies working on the common goal of energy supply), and challenges to operate and maintain the new energy infrastructure even when the global economy goes down. The third and fourth task are not so obviously linked to wind energy, but if the first two tasks are properly implemented, they will inevitably raise choice awareness [13] (especially if renewable energy gets closer to 100 percent penetration) across society necessary for building a more sustainable world.

VI. Conclusion

Wind energy will, if and where it becomes a larger part of a national energy mix, on its way as a leader towards the 100 percent renewable energy future, necessarily cause many changes in the socioeconomic and infrastructural realm. As much as it needs to deal with the resistance from established institutions and ways of providing energy, it mustn't stay too much (some friction and delay between research and implementation is inevitable) on the way to provide the optimal energy mix and technology. Also, a supposedly sustainable technology and approach to business needs to be more capable to survive environmental, political, economic, and resources crises.

References

[1] M. Comech, M. García-Gracia, S. Arroyo and M. Guillén, "Wind Farms and Grid Codes", Spain, CIRCE-University of Zaragoza, 2010.

[2] M. Jacobson, M. Delucchi, "A Plan for a Sustainable Future: How to get all energy from wind, water, and solar power by 2030", Scientific American, pp. 58-65, November 2009.

[3] H. Lund, B. Mathiesen, "Energy System Analysis of 100 Per cent Renewable Energy Systems - The Case of Denmark year 2030 and 2050", Aalborg, Denmark, Aalborg University, 2007.

[4] D. Connolly, M. Leahy, H. Lund and B. Mathiesen, "Ireland's pathway towards a 100% renewable energy-system: The first step", Ireland, 2009.

[5] R. Heinberg, "The Post Carbon Reader Series: Foundation Concepts Beyond the Limits to Growth", Santa Rosa, USA, Post Carbon Institute, 2010.

[6] "Wind Energy – The Facts", Intelligent Energy - Europe programme of the Executive Agency for Competitiveness and Innovation, 2009.

[7] M. Boudourides, "Indicators & the New Economy", EICSTES Meeting, Vienna, Austria, 2002.

[8] A. Vaccaro et al, "Reliable Electric Power for Developing Countries", Humanitarian Technology Challenge, 2008.

[9] T. Ackermann, "Wind Power in Power Systems", Chichester, UK, John Wiley & Sons, 2005.

[10] P. Sonvilla, R. Piria, E. Zane, J. Bracker and D. Bauknecht, "Integration of electricity from renewables to the electricity grid and to the electricity market – RES-INTEGRATION, National Report: Spain", Berlin, Germany, Öko-Institut, 2011.

[11] B. Ernst, B. Oakleaf, M. Ahlstrom, M. Lange, C. Moehrlen, B. Lange, U. Focken and K. Rohrig, "Predicting the Wind", IEEE Power & Energy Magazine, 2007.

[12] M. Tsili, Ch. Patsiouras and S. Papathanassiou, "Grid Code Requirements for Large Wind Farms: A Review of Technical Regulations and Available Wind Turbine Technologies", Athens, Greece, National Technical University of Athens (NTUA), 2008.

[13] H. Lund, "Renewable Energy Systems: The Choice and Modeling of 100% Renewable Solutions", USA, UK, Academic Press, 2010.

[14] "LEAP: Long-range Energy Alternatives Planning System, User Guide for Version 2011", Somerville, USA, Stockholm Environment Institute, 2011.

[15] H. Lund, "EnergyPLAN: Advanced Energy Systems Analysis Computer Model - Documentation Version 9.0", Aalborg, Denmark, Aalborg University, 2011.

[16] C. Arnsperger, Y. Varoufakis, "What is Neoclassical Economics?: The three axioms responsible for its theoretical oeuvre, practical irrelevance and, thus, discursive power", Louvain, Belgium, University of Louvain, 2005.

[17] A. Vergnol, J. Sprooten, B. Robyns1, V. Rious and J. Deuse, "Real time grid congestion management in presence of high penetration of wind energy", 13 th European Conference on power electronics and applications - EPE 2009, Barcelona, Spain, 2009.