Renewable Energy Technologies and Challenges for Their Applications

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***Abstract* – In this paper renewable energy technologies and challenges for their applications and popularization are considered. These challenges are observed from different aspects, both technological (design and control, lifecycle assessment and demand response and smart grids) and social (economy and popularization and social networks).**

***Keywords* – Renewable energy, wind turbines, economy, lifecycle assessment, social networks**

I. Introduction

Renewable energy sources (such as wind, solar and geothermal) have a role not just to supply with electrical energy, but also to replace existing non-renewable energy sources. There is a strong urge to reduce CO2 emissions and to prepare us for peak oil (some sources claim that we are about to face it [1]). Applications (or a lack of applications) of renewable energy technologies can and will reflect on climate change and society. We need the best solutions as soon as possible.

II. Design, control, and location

We need the best solutions out of different technologies and designs.

Wind as an energy source is highly unpredictable over time. There are different control strategies of wind turbines, such as with variable or fixed pitch and/or speed and collective or individual control of blades. Physical model should be accurate enough (no more or less) for design of good controllers. Control systems are "expected not merely to keep the turbine within its safe operating region but also to improve efficiency and quality of power conversion" [2].

Besides of different control strategies, to increase efficiency of wind turbines, one must consider different designs of blades and turbines [3], materials used [4], and location (onshore or offshore [5], close or remote from forests [6] etc.).

Solar energy [7] can be used for thermal conversion (collectors), photovoltaic conversion (solar cells) and combined (hybrid collectors). Different designs and materials have been examined, such as monocrystalline, policrystalline and amorphous materials for solar cells. The exposition to solar energy of a certain region (and energy capture) changes over a day and a year. Some solar cells (more in experiments than in a practical usage) have a built-in control mechanism that allows them to follow Sun and to adjust the angle of exposition.

Geothermal energy [8] comes from the natural generation of heat under the Earth's surface. The locations for geothermal energy plants are on the places with higher gradients of temperature in which drilling as shallower and less costly. The resources of geothermal energy are from hot water and molten rocks. It is primarily used for heating and cooling, but also for electric power generation. Plants are big and require high degrees of automation for extruding (production well) and returning (injection well) of material.

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III. Lifecycle assessment

While discussing about lifecycle assessment of renewable energy technologies, we must consider three kinds of factors: environmental, economic and social [9]. People obviously do not focus on renewable energy just to make profit. The problem is that we can't evaluate the true value of energy systems because we can't evaluate their effects on quality of life and long-term economic effects. Lifecycle assessment takes into account [9]:

- Product lifecycles and their total system-wide impacts
- "Cradle to Grave" (lifecycles of materials, how they fit into a bigger whole)
- Quantity
- It is data-intensive
- Standardization (ISO)
- Becoming global (we need the best solutions on the global level during lifecycles of wind turbines)

When compared with coal power plants [9], wind power plants are much better for environment. Their main shortcomings are materials and their lifecycles: eco toxicity (comparable with coal power plants) and a big demand for minerals.

When for example new wind turbines are being designed, their components should be traceable [10]. Product Lifecycle Management (PLM) is a strategic approach to the management of information relating to a product, from its definition, into manufacturing, and through to include maintenance. Through "a redefinition of the various manufacturing processes and better communication and integration between the related heterogeneous systems", a change in one part of the system can reflect on the system as a whole. A requirements change can change the process, the products and/or the enabling products.

IV. Demand response and smart grids

While a penetration of renewable power generation increases, one must consider both supply and demand. The demand response [11] deals with many uncertainties, but it could (with the improvement of wind power prognosis tools) enhance costs and availability of energy generated by wind turbines.

Cyber-controlled smart grids [12], if widely implemented, could help in the usage of renewable energy technologies. The goals of their implementation are:

- To develop technology for integration, control of renewable energy sources, control of energy consumption and load management.
- To empower energy user for a sustainable living and to develop Distributed Generation system where energy user is also an energy producer.

Also, engineers and researches must be aware of the challenges for implementation of the smart grids:

- Highly variable supply patterns… stochastic problem – particularly wind turbines and solar energy
- Efficient distributed algorithms required to process massive amounts of data for real time control
- Adaptive and self-healing control algorithms required for attaining high efficiency, reliability, and security of the large-scale distributed system
- Secure protocols, firewall mechanisms, intrusion prevention

V. Non-renewable vs. renewable energy – economic aspects

Generally, wind turbines are considered as the most promising source of renewable energy. Our planet receives enormous amounts of energy from Sun, but it seems that it will not be the leader, at least not in the near future. Different sources anticipate different penetrations, such as e.g. 29% globally by 2030 [13], 15% globally by 2030 [14] or 44% by 2020 in the United States of America [15] (Earth Policy Institute, mentioned in the next section).

If renewable energy succeeds to produce more electrical energy than nonrenewable resources, it will turn the global economy upside-down. It's obviously one of reasons why people hesitated to financially and politically support it in the past. New and emerging technologies and their innovative implementations can be an engine for economies in certain regions, especially in this interconnected and globalized world and its unpredictable dynamics with possibilities for rich to become richer and poor poorer very quickly [16].

On one hand, renewable energy resources still fight the competitive battle with short-term investments. They are more perspective in the long run and they can in not so distant future cause tectonic changes in the global economy. There could appear new "wind turbine sheiks" with economically strong (and probably politically influential) regions around them. Wind power plants are owned and by businesses and not by public utility companies [17].

Besides of suggestion to regulate nonrenewable energy resources through taxes and prices that reflect real economic effects of their usage [15], it is worth mentioning here another innovative economic mechanism. Kiwah [18] (shortened from kilowatt/hour) is a suggested monetary system (currency) that encourages sustainability and reductions of CO2 emissions. It could be exchanged for usual currencies and used directly only for investments in renewable and sustainable technologies and activities. Its creators have a goal to reduce our CO2 emissions with 80% in a short period of time" (before the year 2020).

VI. Popularization and online social networks

There are some initiatives on the internet that try to gather people working on sustainable development. I shall mention here some that look interesting to me: Earth Policy Institute [19], Repower America [20], Four Years. Go. [21], WiserEarth [22] and 2020 Climate Solutions Meshwork [23].

Earth Policy Institute is relatively well known between people interested in sustainability. Its director is Lester R. Brown [24], an internationally recognized author of books on global environmental issues. They have the book Plan B (right now it's the fourth edition, Plan B 4.0). According to this institute, we must radically change the way we produce energy before 2020. It means that we should globally lower our energy production through nonrenewable resources by 80 percent before the year 2020. Their ambitions are bringing us to another optimistic initiative, Repower America.

America has been the strongest world's economy for very long time. Its economic strength relies heavily on consumerism and consumption of energy and resources. When Al Gore, a former American vice-president and Nobel Prize laureate stands behind Repower America, it must be considered seriously. According to their website [20], the goal is a transition to a new clean energy future that will revitalize American economy, strengthen their national security, and solve the climate crisis.

It seems that something is indeed happening. But, according to State of the World Forum (and current dynamics) it's not even remotely enough. Perhaps all initiatives concerned about sustainability should make their activities more visible and to mobilize society as a whole. It brings us to online networks that are obviously influenced by Facebook, MySpace and similar social networks.

WiserEarth gathers people interested in activism. As one can see on its website, it is "a free online community space connecting the people, nonprofits and businesses working toward a just and sustainable world". It looks very similar to groups in Facebook. It's probably good in developing a sense of community. Its success depends as much on design and functionality as on members' ability to create something new. I can't see how the activities there could be attractive for people not involved in the groups and for the media.

The Four Years. Go. campaign started in March this year. Its goal is to gather different organizations and companies and through online collaboration to move the global society to sustainable path. There is already a significant number of organizations, but they should still start seriously work together and make their collaboration and its results visible.

I am active in 2020 Climate Solutions Meshwork. Their goal is the same as Earth Policy Institute's: to reduce nonrenewable energy production by 80 percent before 2020. It's moving disappointingly slowly at the moment, but, with probably some improvements in design and functionality (I have suggested some changes that would in my opinion be improvements), it looks promising, especially because everyone can contribute and make his/her contributions, regardless of name and working/political position. Also, it supports different types of activities: groups, discussions, blogs (content), pages and documents. types of activities: groups, discussions, blogs (content), pages and documents.

In my opinion these (or very similar) online activities should be considered seriously if we wanted to shift to renewable energy sources (with wind energy as probably their leader). It seems that, with the growth of social networking, we are about to reach a tipping point in which the thin line between virtual and material reality will be less and less visible. It seems that it has been predicted by Turchin (metasystem transition) [25] and Engelbart (augmented mind and experiments with hypertext as a collaborative tool) [26] and by Friedman ("The World Is Flat" - already a witness of something new emerging) [27]. These initiatives and social networks need success stories attractive for the media.

VII. Conclusion

In this paper renewable energy technologies and challenges for their usage (technology and popularization) are analyzed.

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