RENEWABLE ENERGY: A REVIEW OF TECHNOLOGIES AND POLICIES

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Abstract **- The paper provides a brief review of the technological, economic and political aspects of the fast developing renewable energies. Particular emphasis is placed on the European perspective with some details of recently agreed targets discussed. It is suggested that the electrical machines industry can benefit significantly from the emerging new energy market.**

I. INTRODUCTION

The need to dramatically reduce greenhouse emissions, the search for clean energy, the shifting political landscapes and associated control of available resources, as well as changing attitudes of governments, industrial decision makers and ordinary people, all contribute to the ongoing process of rethinking the concepts of generation, transmission, distribution and consumption of electrical power for the future. New ideas emerge all the time and even the famously conservative power utilities are themselves often leading new developments. From the point of view of manufacturers and users of electrical machines, new opportunities are opening as the traditional optimal solutions may no longer be the best under new circumstances. In particular, with the growing importance of embedded generation, new or improved types of machines may be required to match the expectations and requirements of the increasingly changing power systems. This paper is an attempt to set the scene by reviewing the emerging technologies and new policies associated with renewable energy.

Major threats of climatic changes due to pollution and exhaustion of fossil fuels, combined with increasing world population and environmental, social and political risks associated with reliance on imported energy, have forced governments and relevant industries to consider alternative sources of energy. The term *green energy* refers to environmentally friendly sources, normally *renewable* and *non-polluting*. Green energy includes natural processes which can be harnessed, such as wind, geothermal, tidal, wave, solar and biomass power. Renewable energy is derived from regenerative resources which (practically) cannot be depleted. The majority of renewable energy technologies are directly or indirectly powered by the Sun.

Nuclear energy is sustainable, arguably renewable and produces virtually no atmospheric pollution during the production stage. However, it generates waste which is a pollutant, thus claims of nuclear energy to be green are controversial, to say the least, and a topic of hot political debate. Likewise, medium or large-scale hydroelectric power, as well as burning biomatter or petroleum, are often excluded. Moreover, no power source is entirely impact-free. All types of energy sources require some form of energy investment and lead to pollution resulting from manufacture of technology. Generation, transmission and distribution of electrical power is part of this much broader issue of *energy*.

II. EUROPEAN AND WORLD PERSPECTIVE

Electrical energy constitutes about 35% of global energy production in the world. The total electric power generating capacity is around 4,000 GW (USA 1,000, Europe 800, Asia 1,200). The contribution from different types of energy varies considerably and in Europe the split is 56% thermal, 21% hydro, 18% nuclear and 5% 'green' (similar figures for USA are 74%, 14%, 10% and 2%) [1, 2]. In terms of the total energy production by source, 40% comes from oil, 23% from coal and 23% from natural gas. Thus most sources today use energy from sunlight in the form of fossil fuels, but once these stored forms are exhausted, the long-term energy usage available to humanity will be limited to that from the sunlight falling on Earth (the total consumption today is equivalent to less then 0.1% of that), but ways of exploiting such energy are far from obvious.

When discussing *energy resources* it is worth noting that the current definition does not include the economic feasibility of exploitation or the fact that such resources may not be recoverable using current (or even future) technology. All forms of energy production require energy investment; once the investment is greater than the energy produced, then the fossil resource is no longer an energy source, resulting in large parts of the fossil fuel resources and especially the non-conventional ones being unavailable for energy production (they can still be exploited economically to produce raw materials though).

Renewable technologies require capital cost which varies significantly depending on the type of technology used, but also on geographical and political circumstances. The capital cost in $/kW is estimated as 5k−10k for wave power, 2k−6k for tidal power, 1.5k−6.5k for solar thermal, 5k−15k for solar photovoltaic, 2k−5k for biomass, 1k−7k for hydro power, 2k−5k for offshore wind and 1k−2k for onshore wind [3]. The economics of renewable technologies is therefore as important as the technologies themselves.

The power generation industry, taken as a whole, is the world's biggest industry and as such has a large effect on the conditions on Earth. Environmental and political constraints are making a direct and big impact on the technical decisions and cannot be considered independently.

III. EU TARGETS

At the European Union summit on 8-9 March 2007 [4] it was agreed that the EU should unilaterally extend its current Kyoto treaty commitment (of an 8% greenhouse gas reduction, from 1990 levels, by 2008-2012 [5]) to a 20% emission cut by 2020 – or even up to a 30% cut, but only if matched by other developed countries. The European Commission also wants countries to pledge to increase the use of renewable fuels by 2020 to 20%. Another summit commitment was to raise the

level of bio-fuel to 10% of all transport fuels by 2020. The targets for renewable energy are in fact more controversial then for the emissions. The agreed measures could include a (possible) ban on filament light bulbs by 2010, forcing people to switch to fluorescent bulbs, which last longer but are more expensive to buy. There was also a specific commitment to increase the use of solar, wind and hydroelectric power.

The next big steps on the political agenda will be the G-8 summit at Heiligendamm in June and the United Nations climate change conference at Bali in December 2007. However, all these potentially positive effects will depend on member states delivering on what their leaders have signed up to. It has already been alleged in Britain, for example, that the recently agreed targets are simply unrealistic and are a result of possible misunderstanding between what the ministers intended to propose (20% of electricity from renewable sources) and what EU agreed as a target (20% of ALL energy − including fuel for home heating and transport). Moreover, the obvious question is whether, and how quickly, individual states can agree to share the burden of their collective targets.

IV. New Developments

Europe's desire to secure electricity supplies for the future, but at the same time growing dependence in imported energy (especially from countries which are politically or economically unstable), combined with pressures to tackle climatic changes, has lead to many new strategies and concepts. Embedded generation is already quite strong in some countries, but its growth will accelerate when (or if) full plans for implementation of wind power go ahead as intended. But there are uncertainties regarding the impact of such generation on system's robustness, stability and efficiency. With the advent of the so called 'green homes', it is envisaged that customers will be buying as well as selling electricity to the grid, while many parts of the existing (older) distribution installations are not capable of handling the opposite power flow. Moreover, only 10% of Europe's electricity is traded across borders due to weak interconnection points, so there is effectively no free movement of electricity across national boundaries, which is instead controlled by a number of large, monopolistic companies.

There are considerable opportunities in introducing novel technologies, such as high temperature superconductivity, to significantly reduce losses associated with generation and transmission of electricity. With much smaller generating units, typically of a few MW rather than hundreds of MW, the choice of an optimal type of a generator is an open question; in fact there is scope for development of new types of such generators particularly suitable to operate in, say, wind farms.

Technological advances in wind turbines and power transmission have prompted several companies to put forward far reaching new proposals. As an example, Airtricity – an Irish renewable energy firm – has proposed building a huge, pan-European electricity 'Supergrid' that would connect offshore wind farms from the Baltic Sea to the Mediterranean, via the North Sea and the Atlantic. These farms will ultimately use about 2000 turbines to produce 10GW of electricity (enough to power six million homes). One of the project's strengths is its ability to 'smooth out' the inherently variable wind power by aggregating it across Europe's geographically dispersed areas. The most ambitious part of the project is the construction of the undersea Supergrid itself, which is envisaged to use high-voltage DC power lines to link the turbines to the national grids of Germany, Holland and the UK. All that is needed is support of the politicians.

V. Controversial Issues

The future of the energy in Europe is a political issue, as has been argued in this article, and as such has many controversial aspects. National and regional interests come into prominence and the final agreements – if ever reached at the forthcoming summits or in more distant future – will be a result of several compromises. The recently agreed targets by the EU have been hailed as a spectacular success, but the 'small print' reveals the extent of concessions made in favour of particular countries or regions. For example, the agreement recognises the contribution that France's nuclear power generation makes to a low-carbon economy, despite the huge controversy if nuclear power should be considered as green at all. It also acknowledges the worries of the poorer East European states about having expensive renewables imposed upon them. Moreover, some countries simply lack the wind resources available to coastal states.

Power industry is notoriously conservative and very good at explaining why things cannot be done, or at least not now, whereas small companies often think big. It is no accident that the environmentally Smart car was designed by a watchmaker (Swatch), not a car manufacturer. Similarly, what is striking about many small energy companies is their inventiveness and courage. For some, the battle for 'new' energy will be very profitable and very justly so.

There are also changes to people's perceptions and general awareness of environmental issues. These are reinforced by policies of local authorities, which increasingly encourage the use of renewable energy sources through a system of incentives. Moreover, in the UK, local planners are requiring that non-residential buildings provide at least 10% of their predicted energy requirements from renewable sources (this will soon become a condition for a planning permission). And this is just the beginning, the British government plans to increase this requirement for sustainable and renewable energy to around 30% for residential and 20% for commercial buildings by 2010.

VI. Conclusions

This paper reviews recent technological and political changes relevant to the future of renewable energy. It is argued that such changes are driven by the advancements in the technology itself but also, and possibly even primarily, by political and economical pressures. The European Union has put energy at the top of its priorities and several targets have been agreed, even if there is no certainty that they are realistic. There is an important role to play by power industry and an opening, in particular for small companies, to 'jump on the energy wagon' and accelerate the implementation of new ideas while producing significant profits. The electrical machines industry has its own window of opportunity of developing novel machines, more efficient, better suited to the emerging new type of power generation and transmission.

References

[1] P. Breeze, *Power Generation Technologies*, Elsevier, 2005.

[2] US Energy Information Administration http://www.eia.doe.gov/

[3] P. Breeze, *Future Renewable Power Generation Technologies*, http://www.globalbusinessinsights.com/content/rben0187t.pdf, Business Insights, 2006.

[4] European Council meeting, 8-9 March 2007, http://consilium.europa.eu/cms3_fo/showPage.asp?id=668&lang=en

[5] Kyoto Protocol to The United Nations Framework Convention on Climate Change, http://unfccc.int/resource/docs/convkp/kpeng.pdf