European Association for the
Development of Renewable Energies, Environment
and Power Quality (EA4EPQ)

International Conference on Renewable Energies and Power Quality
(ICREPQ'12)
Santiago de Compostela (Spain), 28th to 30th March, 2012

Energy Production & Consumption – Next 25Years & Counting!

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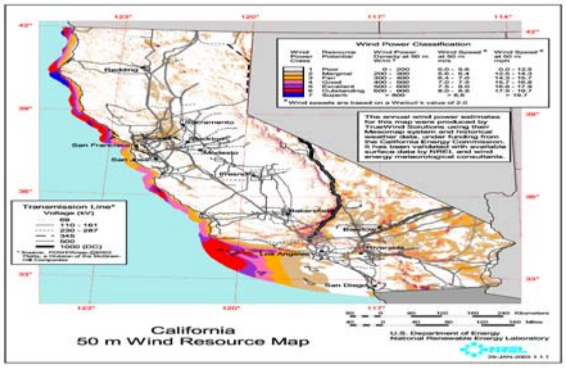
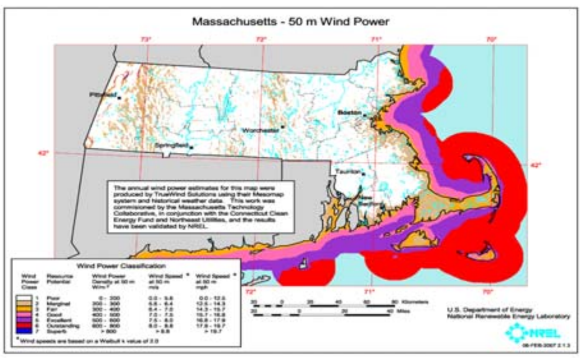
Abstract

Other than fossil fuels, we can look to five main alternative sources of power for domestic use and electricity generation: the sun, the heat inside the earth (geothermal), the wind, the ocean waves and tidal energy. The present authors have examined each of these energy sources for its relevance to the energy situation in the world, and hope that by so doing a number of pertinent questions would be raised and we can continue to work to find their solutions for small/medium scale industries. It appears that solar energy offers the best alternative to burning oil for most parts of the world, and it may be expected to come up to our present expectations. However, as an insurance against unforeseen delays in the oil supply/usage program, one or two of the other options mentioned above may well be worth closer consideration now. Wind energy, despite the windiness of selected areas of the globe, suffers in practical terms from a low load factor, which greatly inflates the capital cost. Geothermal energy in the tropics, geologically one of the most stable regions of the globe, would seem to be available only at depths too great to be presently attractive for electricity generation. Tidal energy although naturally available to us, again, suffers from high capital costs. Our pattern of energy consumption has been directed by living through periods when fossil fuels have been cheap and plentiful. In fact, the literature reveals that apart from oil, we might be burning more wood than is absolutely necessary without considering the long term consequences. This picture is bound to change during the next twenty-five years as a result of dwindling natural mineral resources, political, economical and social strains and, environmental pressures. Any of the resources that have been considered might, under definite circumstances, provide alternative sources and the obvious choice is either solar or probably wind energy source. "The future of harnessing energy will be community centric with localized, distributed power generation (distributed Grid system) from multiple alternative sources, using hybrid conversion technologies in independent and/or interconnected Microgrids. If we master what is called the 4C's of Energy – Creation, Conversion, Control and Conservation – we can improve and decisively influence the future energy landscape of our planet (Razvan Panaitescu[6] 2011)."

Keywords:
Creation, Conversion, Control, Conservation, Transmission, Distributed-Grids, Teaching-renewable-Technology, Storage & Forecasting.

About half of the population of the world relies on traditional or non-commercial energy, mainly for cooking. However, due to prolonged drought, increasing population pressures and urbanization processes, firewood scarcities are critical in many developing countries. A study by the Food and Agricultural Organization of the United Nations [1] shows that fuel wood scarcity involves approximately 100 million people who are unable to satisfy their minimum energy needs. A further 1,050 million rural people live in situations of growing deficits, where minimum needs are met at the cost of depleting existing resources. The consideration of various dimensions of energy problems in the world, particularly in developing countries has given impetus to prescriptions of new energy strategies. These are designed to reduce or avoid dependence on non-renewable hydrocarbon fuel resources and slow the process of depletion of domestic firewood.





Figures I & II. Wind Energy technology will expand the footprint for distributed generation to locate in marginal and fair wind areas where most of the population live.

Most of the increases in energy demand will probably occur in the developing world where population growth rates are high and industrialization and urbanization are under way. In contrast, demand for energy is expected to remain stable or drop in the industrialized countries where population growth rates are low [1, 2, 3]. The literature reveals that the energy intensity rose (ratio of energy consumption to gross domestic product), then fell, because of improvements in materials science and energy efficiency. Developing nations can avoid repeating the history of the industrialized world by using energy efficiently. Fossil fuel burning and deforestation in developing countries contribute to the buildup of atmospheric carbon in such forms as carbon dioxide and carbon monoxide. About two billion people of the world are without electricity.

The primary flow of energy that makes life on earth possible derives from the sun, and many of our additional requirements stem from a need to supplement its light and heat when and where the sunshine is least, especially at night time for parts of the Tropics where the phrase "the sun rises at 6:00 a.m. in the East and sets at 6:00 p.m. in the West"[4], is just as true today as it has always been. This means that in the tropics, vast quantities of solar energy are available at high intensity and for prolonged periods. The prospecting and exploitation of this energy therefore, though could be coupled with some form of storage, preferably as part of the conversion system, should be reasonably accomplished once its technology has been fully developed and perfected.

Another vast secondary source of energy, deriving from solar energy, is the energy of the wind. Here we may not find a good match with our requirements, particularly in the tropics, since the strongest winds occur in the higher latitudes of the Northern hemisphere. Wind power can be harnessed directly, with a wind turbine of some kind, or it might be tapped as a secondary form from ocean waves, which are themselves generated solely by the wind. In the case of a wind turbine, the large short term variations in wind speed demand an energy storage system. With wave power, the oceans not only provide a huge area for collecting the energy of the wind, they also supply a built-in short term storage system in the form of the high density and inertia of flow. In principle therefore, wave power has yet to be extracted in a practical manner, even by American and European standards, the economics for the tropics must be wholly speculative.

Wind Energy [5]

Wind energy can scarcely be called a new energy source since it has been used for many centuries. The amount of wind energy available is immense and almost inexhaustible especially in some specific areas of Europe, America and the Tropics. In fact, our study reveals that a country like Britain could meet most of its electrical needs by harnessing just a few percent of the available wind energy. However, like tidal energy again, it needs large and costly conversion equipment and in recent times its use has largely ceased, because mainly, of the availability of cheap power from fossil fuels and nuclear reactors. In the context of West Africa, except in high latitudes of the Northern Zones, high winds are restricted to coastal areas of which there are limitations. They may therefore have no recourse for wind machine technology in the short term.

Since the power available to a wind Turbine varies as the cube of the wind speed (**$P \alpha v^3$**), high average wind speeds are essential to reduce capital costs. Of this, only about **59%** of the theoretical Power calculated is available. Small scale generation of electricity from wind power is technically well established, but it has never proven competitive with existing non-renewable grid supply, largely because storage has had to be provided to cover windless periods. It is difficult to assess the cost of large scale machines, since none has been built recently, but past experience suggests that a figure of about $3.00 per kilowatt for a high-performance machine installed on a good site is not improbable. On the face of it, this compares from all records, favorably with nuclear power cost, but it is necessary to make allowances for the lower load factor of the wind powered generator and for the penalty associated with an unreliable source of energy (or the cost of storage plant needed to guarantee a firm supply at all times).When we allow for these factors, the cost of wind power turns out to be even higher than for nuclear power. However, a large wind turbine on a site with average wind speeds of 20 miles per hour (8.9 m/s) could achieve a load factor of about 35%, which would make its power competitive with that from the coal fired or oil-fired stations that it could off-load today.

The Role of Universities In Renewable's Research

Among all institutions, college and university campuses are probably the best positioned to contribute to changing the energy landscape of our world. In these places, millions of people are educated each day; thousands of buildings are heated or cooled, whether they are labs, classrooms or dorms. That will require billions of dollars to be spent on fuel and energy. It has been calculated that if all the more than 4000 campuses in America would exclusively use clean energy that would quadruple the current renewable energy utilization.

Universities were always at the forefront of technologies. They set examples and establish trends for their communities and for entire nations. Their role of centers of intellectual power, research powerhouses and leaders in technology will certainly influence how the energy efficiency and sustainable power generation will be handled in the future. Recognizing its role of leader in cultural and technological change, we believe that our sustainable power generation initiative Academia has traditionally been at the forefront of cultural and technological change, and campuses once again can be the catalyst that drives sustainable energy independence initiatives.

Before starting any new business or building a company anywhere else, one has to face and address a very big challenge: the shortage of electricity. If the company is located in a rural region, without back-up generators and UPS units that would keep the business running there is no chance to be productive and economically survive. That is because many developing countries are growing in such a rapid pace that it would need many hundreds of new power plants to cope with the electricity shortages, and fix an unreliable and undersized transmission and distribution system.

The lack of electricity is, nowadays, the menace of many economies. It is the decisive factor for the prosperity and sometimes the survival of a community, business or, in the end, nation. Supplementing the increasing need of energy for remote communities, farms, plants or businesses that would like to take advantage of special locations, or inexpensive workforce, can be done in two ways: 1) by building new Centralized Power Plants or 2) by Distributed Generation.

The decision between the two alternatives must be straightforward and should be entirely based on a simple efficiency comparison. The efficiency of any large central generation unit (coal or gas powered), depending on its age, is never greater than 28-35%, i.e. only about one third of the energy content of the fuel used is actually transformed into electricity. Surprisingly, the small fuel cell generators, or the small scale gas turbines or combined cycle units that can be used in distributed generation applications have efficiencies of 40-50%. Moreover, the newest technologies that hybridize the classic fossil with alternative energy sources such as the fuel cells / gas turbines and solar or biogas hybrid generator units may reach electrical efficiencies as high as 70-75%.

Today's Industry with their products that incorporate the emerging technologies required by the industry, are ready to play significant roles in the Distributed Generation landscape. Their complete drive-train ready offer for micro

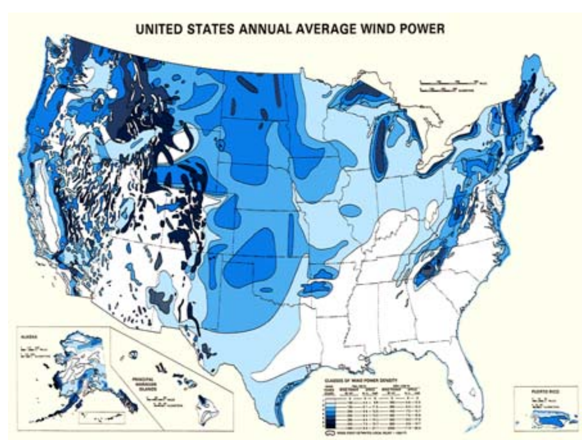


Figure 3. What We Have!!!

wind turbines, micro hydropower systems, bio-power turbines, solar thermal turbines, and power converters for fuel cells or solar PV are matured and ready to be applied and offered as flexible solutions. They represent the basis for projects like village electrification, stationary power market, sustainable farming, and energy efficient communities all across the globe.

But a Distributed Generation system does not include only the generation and conversion equipment. A sustainable Distributed Generation is ultimately a Micro-grid that should contain elements such as energy storage, on-site management (dispatch, control, communications), and all ancillary devices and services. An important cost for any power system is represented by the transmission and distribution (T&D) network. The T&D infrastructure in DG systems insures much higher service reliability and typically lowers the cost in the majority of applications.

In fact the very high cost per kW for upgrading a T&D system represent one of the biggest opportunities for offering a Distributed Generation solution. Siemens will actively pursue these opportunities by monitoring the locations where local delivery facilities are becoming too expensive to grow and permit our DG solutions to deliver significant savings. Load dispersion especially in developing countries is in itself a determining factor in increasing T&D costs.

The recent attention paid by federal institutions, announced strategic alliances with large organizations and discussions with various partners in the field of hybrid power conversion solutions confirmed our ability and strengthened our confidence in addressing the Micro-Grid, Distributed Power Generation applications. The Drive Technologies division in collaboration with all other divisions within Siemens Industry has the appropriate products and engineering know- how to address this market and safely offer solutions using off-the-shelf commercial equipment.

Whether the customer is a System Integrator, the Navy, the Military, a remote village in a developing area in need of a Micro-grid, or a Data Center that require stable power supply and alternative energy sources for achieving grid independency, they are all about the Distributed Power Generation and the Hybrid Conversion Technologies that will define the energy landscape of tomorrow.

The ability to combine several alternative sources (wind, water, fuel cells, batteries, solar, wheels, diesel generators) in an easily configurable architecture system, governed by a DC- Bus distribution and with elements that can work both on an island grid or synchronize with one, has become an intrinsic attribute of modern DT products, ready to enable the sustainable communities of the future. The Small Scale Sustainable Power Generation field is an important segment that today's industries strategically prepare for and are actively pursuing same with their core technologies.

With such important and powerful drivers, the innovation and technological advances are going to have in the very near future an energy centric focus. Some industries such as Siemens, has a complete set of products and technologies that are able to "Create, Convert, Control and Conserve" the energy in the most efficient and sustainable way. I think Peter Drucker was right when he said: "…if you want to control the future, you need to create it!" It is what one does within the DT Power Generation VMM. We need to be committed to creating solutions and market the standard products that answer the sustainability requirements of the future energy landscape: the localized and distributed energy conversion, the hybrid conversion solutions for combining multiple alternative sources in an independent off-grid or on-grid island power systems, deploy these solutions in remote areas with limited grid support or in developing countries with no grid at all, serving the navy or the military camps, on board or on land with flexible power conversion solutions that permit reducing fuel cost and increased operation safety and success.

An Interdisciplinary Renewable Energy Engineering Technology Program

The recent trend of declining enrollments in many Engineering Technology (ET) programs across the US has prompted universities offering BS degree programs in ET disciplines to seek strategies to maintain their identity, viability, and continued relevance in the face of competition from Engineering programs, and the prevailing poor economic conditions. Strategies adopted by some institutions have included the "if you can't beat them, join them" option of switching their programs entirely from ET to Engineering, renaming their programs to differentiate them from similarly named Engineering programs, seeking innovative ways to develop pipelines for students to enter their programs via articulation agreements with two-year institutions, or developing highly innovative and specialized new curricula that seek to differentiate the ET programs from Engineering programs. This latter strategy was considered to be the better option by the ET faculty at Southern Polytechnic State University. The faculty of the Electrical & Computer Engineering Technology (ECET) Department, working in conjunction with their MET colleagues has developed an innovative interdisciplinary curriculum in Renewable Energy Engineering Technology (REET) to meet the stated need of developing a technologically capable workforce that will be capable of addressing the future energy needs of the nation. This highly innovative "boutique" ET degree program is expected to capture the growing interest Renewable Energy Systems. The curriculum focuses on existing Alternate Energy Systems such as solar, wind, and oceanic, as well as promising new technologies such as Biomass, and fuel cell technology. It will also attempt to address the issues of efficient energy conversion and energy storage.

Teaching Solar Photovoltaic Concepts from Cell to System through Hands-on Laboratory Experiences

What truly makes this course unique is the fact that students are building a complete system from the ground up. They solder the individual cells and measure the relevant parameters individually but, toward the end, they work together as a team on the final multi-module system. The expanded version of this publication will report on what worked, what didn't work as expected, and the students feedback on the experience.

The fundamental operation of solar cells, especially when integrated into systems, is a complex and often times confusing concept for students. Most laboratory exercises either introduce the students to a full module or simply integrate a single cell with a low power device. This section discusses a different approach used in a hands-on solar photovoltaic course. The course discusses the theoretical aspects of solar cell operation in class and then carries the students through the construction of a complete solar photovoltaic system during a laboratory session. The students start with characterizing the performance of a single cell then expand their system to multiple cells to understand the influence of numerous factors including shading. Students are encouraged to explore different configurations and report on their findings. The next step is the construction of a complete module and its interface to a charging system. From here the modules are combined into a multi-module system. Topics such as battery storage, charge control, and power inverters are integrated into the laboratory experience as well.

References

1. Food and Agriculture Organization (FAO) (1981). Map of the Fuel-wood situation in the developing countries.
2. R. Davis, "Energy for Planet Earth", Scientific American, Sept. 1990, pp. 55-62.
3. Leach, G., Solar Energy: the social challenge. Joint Conference (c() proceedings, University of Reading and UK-ISES, September 1976.
4. Reddy, A. K. N., Non-commercial Fuels in developing countries, Proceedings of the Joint Conf.., (C9), University of Reading and UK-ISES September 1976.
5. Heronemus, W. E., Wind Power, look backward then move forward IEEE paper C74 098 - October 1974.
6. Razvan Panaitescu, PgMP, MBA, Small Scale Sustainable Power Generation ~ Mastering the 4 C's of the future energy landscape. Principal Business Development, Distributed Power Generation - SIEMENS

Acknowledgements:

The inspiration for this submission was borne out of a presentation by ***Gary L. Floyd****, Industrial Relations Manager at* ***Georgia Power****, on the Power of Nuclear Energy alternatives, at our 2011 National Society of Professional Engineers Annual Seminar in Georgia State, USA.*