Distributed power, alternative energy – sustainable!

Large, centralized power stations and overhead power lines that stretch to the horizon have long been seen as the norm, and the environmental price to pay for instant, reliable energy, available at the flick of a switch. Now a new model is emerging as a real alternative. In this model, combined heat and power (CHP) stations, wind turbines, fuel cells and other small generating units will be on the user's doorstep. They will be managed to meet local needs and to feed surplus power into regional and national electricity grids. It will be a case of power at the point, or close to the point, of demand.

ABB MT100 microturbine combined heat and power unit

Deregulation, privatization, electricity trading systems and growing political pressure to reduce greenhouse gas emissions are driving a trend towards so-called 'distributed' electricity production and supply. Large power plants will continue to be vitally important sources of electricity, but distributed power can provide an economical and environmentally preferable alternative for many people.

For example, there are some 755 million homes around the world with no access to a reliable power supply – 270 million of them in East Asia and the Pacific, 125 million in India, 65 million in sub-Saharan Africa, and 29 million in eastern Europe. These are developing regions where new, clean technologies have the power to offer a transformed lifestyle without damaging the environment.

Home alone?

But it is not just the less well-developed nations that can benefit from new approaches. In the USA, some half a million homes are not connected to the electricity grid. About 300,000 homes are built every year in isolated places where the grid has to be specially extended, at great cost, to reach them. Another 11 million US homes are in sparsely populated areas, and expensive grid connections are needed to bring power to these small, isolated communities.

ABB has set itself the goal of being the leader in this exciting new field. We are focusing our expertise and innovation skills in electronics and Internet technology on developing a whole range of products to make renewable and alternative energy systems economically and technologically viable.

The 50/60-Hz paradigm and other hurdles

One challenge is the fact that power from distributed sources, like small turbines or CHP schemes, comes in a form which is often incompatible with the main electricity grid. The smaller a generating unit, the higher the frequency it has to operate at to achieve a certain level of output and cost-effectiveness. A typical microturbine, for example, will generate power at a frequency of around 2 kilohertz. Most grids operate at the much lower frequencies of 50 or 60 hertz. Somehow that gulf has to be bridged.

At the other end of the frequency scale, fuel cells and photovoltaic units, like batteries, produce direct current (DC) power, but the local grids typically require alternating current (AC) power. Large wind turbines produce power with a variable frequency, depending on the speed of the wind. However, the grid needs the incoming power to be predictable and uniform. While it is possible to convert power from wind turbines into a usable form, it has been expensive until now to do so at the point of generation. By converting the variable frequency power from the wind generator to HVDC and then converting it to 50 or 60 hertz AC the problem is solved.

Technical hurdles such as these have kept alternative and renewable forms of energy in the wings, struggling to compete on price with fossil fuels. Now ABB has developed the technologies that will allow them to take center-stage.

Fuel cell

Windformer™

Sustainability – getting the equation right

Sustainability is rightly a critical factor in the selection of energy sources. However, even with all the benefits of green energy, for it to be widely adopted it still has to compare in cost with energy derived from more traditional sources. Working toward sustainable development means making alternative energy – wind power, fuel cells, photovoltaic units, microturbines and combined heat and power generation – affordable.

Supporting the move to distributed power generation are advances in information technology that make it possible to control many small power plants from a central point and to create e-Business mechanisms for on-line energy trading. These solutions and customers' greater freedom of choice will together play a growing role in meeting the world's future energy needs in a more sustainable way.

ABB works in several joint ventures and cooperates with leading universities to facilitate the growth of efficient and sustainable distributed power generation solutions.

Distributed power generation and the 'virtual utility'

The 'virtual utility' or microgrid [1] brings together clusters of dispersed power generators – many making use of the alternative energy options described – in an intelligent and optimized network controlled by Web-enabled systems. Being small, distributed generation systems can be built up incrementally, avoiding high up-front capital costs and allowing fast payback.

For the supplier such a network has many advantages. Since the generators can be sited close to end-users, T&D costs and electrical losses are lower. Energy can be 'stored' as fuel (eg, gas) and easily released at peak times. And the network can 'close ranks' if one generator is taken off-line, resulting in higher reliability.

End-users also benefit in many ways: Power is readily available and, depending on the fuel used, electricity prices are often lower. Energy efficiency – a traditionally low 28–35% with large, central generating units – is significantly higher with the new, emerging technologies. Even better efficiency is offered by cogeneration, in which heat and electricity are produced in parallel.

Cogenerating heat and power for maximum energy efficiency

HVDC Light – getting the most out of distributed assets

The power of technology

A whole host of new technologies are emerging that will secure the success of the virtual utility.

For example, ABB has joined together with Volvo to develop *microturbines* [2], which run at very high speeds to provide high-frequency AC power. Utilizing the exhaust heat for thermal loads can raise the overall efficiency of these machines as high as 80%. NO_x and CO emissions are less than 15 ppm, so a catalytic system is not needed.

ABB has also recently begun joint development with DuPont Corp. of an advanced *fuel cell* that promises low costs and high efficiency at the low end of the power scale. The units, which convert hydrogen and oxygen into electricity, heat and water, will be fueled directly with methanol to avoid the high costs and operational issues involving hydrogen reformers. By utilizing the heat produced during the electrochemical conversion, efficiencies of 80% and more are possible.

Wind power is another area in which ABB scientists and engineers are showing the way. Windformer™ [3] is a radically new wind turbine generator (WTG) based on technology that does away with the usual gearbox and transformer. As a result, the power output is increased by as much as 20% and maintenance costs are cut in half. This reduces the visual impact of wind farms considerably as fewer WTGs are needed for the same power rating.

And making it easy to link the wind farms to the grid is *high-voltage transmission* technology based on ABB power electronics which has made HVDC transmission economical at powers of just a few megawatts. Called HVDC Light [4], it also opens up new possibilities for improving the quality of supply in AC power networks.

Getting it together

Distributed power generation gives customers new options for supplying electricity, while enabling them to minimize investment, increase reliability and quality, and lower costs. By putting energy generation and storage as close as possible to the point of demand and at the same time ensuring highly efficient conversion and minimal environmental impact, it has the potential to reshape the way electricity production and delivery will look in the future.

The virtual utility or microgrid provides a coherent structure within which a distributed power generation system can operate. It will link and intelligently control and manage widely dispersed generation assets. Although technology neutral, the virtual utility builds on the many ABB technologies which are suitable for distributed power generation and can take full advantage of ABB experience and products in control and distribution. Eco-efficient and state of the art, these ABB products and systems for distributed power firmly underscore ABB's commitment to sustainable development.

References

[1] **T. Jones, E. Petrie:** Distributed power generation and creating a 'virtual utility' to manage it. ABB Review 3/2000, 13–21.

[2] **A. Malmquist, et al:** Microturbines: speeding the shift to distributed heat and power. ABB Review 3/2000, 22–30.

[3] **M. Dahlgren, et al:** Windformer™ – Wind power goes large-scale. ABB Review 3/2000, 31–37.

[4] **G. Asplund, K. Eriksson, K. Svensson:** HVDC Light - DC transmission based on voltage sourced converters. ABB Review 1/98, 4–9.