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Who's afraid of natural gas?

Natural gas may be the most important single factor shaping a bright future for renewables. Changes in our electricity systems provoked by natural gas power generation technology are paving the way for large-scale renewables use in the future, argues Walt Patterson.

If you're promoting renewable energy, you probably abhor natural gas. Natural gas and gas turbines are now such a cheap and easy option for electricity generation that they appear to cast a pall over renewables. The market share of gas-fired generation continues expanding inexorably. Its cost continues to fall, setting renewables an ever more demanding competitive target. Nevertheless, paradoxical though this may sound, natural gas is actually the natural ally of renewables. Despite the fierce competitive challenge it represents, natural gas may even be the most important single factor shaping a bright future for renewables.

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This disconcerting assertion is one of the more unexpected findings of a long-running research project in the Energy and Environmental Programme at the Royal Institute of International Affairs (RIIA) in London. The book of the project, entitled *Transforming Electricity*, is shortly to be published by RIIA and Earthscan. *Transforming Electricity* examines the changing shape of world electricity, under the influence of technical innovation, liberalization, financial pressures and environmental constraints. It reaches some startling conclusions. Among them is the importance of natural gas for renewables.

The starting point of the argument is historical. Throughout most of the past century, a single fundamental factor has shaped the technical configuration of electricity systems all over the world: the economies of scale associated with water turbines and steam turbines. As a result, almost every electricity system of any size anywhere in the world has come to conform to a common technical model. Large-scale central stations remote from users generate electricity in the form of synchronized alternating current (AC), and deliver it to users over a network, including a substantial length of high-voltage transmission lines. To maintain the stability of the synchronized AC network, generators connected to it must be under some form of central control or dispatching.

The necessity for a network, and the requirements of central control, in turn meant that until only a decade ago almost every electricity system around the world operated as a franchised monopoly, under the auspices of government. A franchised monopoly delivering an essential good to captive customers has a guaranteed revenue stream. In such a context, financing enormous generating stations, that may take six years or more to come into operation and may then have to operate for two decades or more to cover the investment and earn a return, is not a problem. The captive customers will eventually pay whatever the stations cost. The captive customers also pay for recondite but essential AC system services such as reactive power and frequency control, as well as for all the redundancy of generation and network that ensure system stability even under serious fault conditions.

In the late 1980s, however, first in Chile, then in the UK, and subsequently in an expanding wave reaching from Argentina to Finland, and from Poland to New Zealand, governments around the world began to liberalize their electricity systems. Privatization of assets formerly owned by governments was the original intention, but soon liberalization extended even to introducing competition into systems previously operated as monopolies. However, even as they were overturning the institutional arrangements that had prevailed for most of the century, politicians and governments appeared to expect that electricity systems would continue to look much the same and function much the same way into the indefinite future. They were wrong.

Revolutionary new fuel and technology

Much to the surprise of the politicians, who had no such expectations in mind, a new fuel and a new technology for electricity generation burst on the scene: natural gas, and the gas turbine. In the 1950s natural gas was a nuisance and a hazard in oilfields. By the late 1970s it was a premium fuel too valuable to burn in power stations. In the 1990s its burgeoning abundance in more and more parts of the world has made it the fuel of choice for power generation wherever it is available. At the same time the gas turbine, once too inefficient and expensive to use for any but peaking applications on an electricity system, has become the generating technology of choice.

The advent of natural gas and gas turbines for electricity generation has changed the fundamental premise that shaped electricity systems for more than a century. Although gas turbines exhibit some significant economies of scale, they also -- and more importantly -- exhibit dramatic economies of series manufacture, with a rapid learning curve for improvements. A gas turbine station, even one that also uses steam turbines in combined cycles, can be ordered, built and brought into operation in under three years, sometimes well under, making it easier to finance, even in a competitive context. A gas turbine station is modular, expanding by replicating modules as required. Moreover, a gas turbine station is easy to site. It is clean and comparatively quiet, and requires no on-site storage of fuel or waste. Accordingly it can be built close to users, and indeed even on a user's site. If the user requires both electricity and heat, gas-turbine cogeneration is even more attractive.

These developments are altering the technical configuration of electricity systems. Gradually, and in some places not so gradually, the traditional shape of the electricity system has begun to change. Until recently, a better power station was always considered to be a bigger power station, usually farther away. Now a better power station is likely to be a smaller power station, probably closer. The traditional centralized configuration is giving way to a steadily more decentralized configuration, with more and smaller generating units much more uniformly distributed around the system.

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At the same time, as novel arrangements for network access come into play, the traditional redundancy on the system is diminishing. In a competitive context, every generator wants to operate at base load. A station that is not dispatched earns no revenue, and is likely to be summarily shut down. Even load-following becomes unpopular. In due course this state of affairs is going to make system stability an issue, and companies and other users will grow increasingly unhappy about power quality and reliability. With transients sloshing around the AC network, an AC spike can fry all the chips in a database in an instant. Having your own generation on site and under your own control becomes an appealing alternative. Power electronics, including AC--DC--AC links, can decouple sites from synchronized control, providing voltage support while blocking transients.

Changing shape of the electricity system

Meanwhile, the most exciting developments in generating technology are now not at the large end of the scale, but at the small end. Major gas turbine manufacturers are already demonstrating mini- and micro-turbines in sizes down to tens of kilowatts -- small enough to power individual factories and office buildings. Fuel cells, too, are improving rapidly, becoming cheaper, more reliable, more efficient and more versatile. At the same time, the capabilities of information technology for system management and control are leaping ahead at breathtaking speed. The opportunities for complete local systems, in which generation and use of electricity are optimized together for both economic and environmental benefit, become appetizing -- for perfectly sound business reasons. In short, in many parts of the world, within the next two decades the traditional shape of electricity systems will evolve almost beyond recognition, as *Transforming Electricity* discusses in much more detail.

Recent months have seen heated debates about ‘embedded generation’, including renewables. The key question must be ‘embedded in what?’ Natural gas and gas turbines are changing the traditional shape of the electricity system, towards a decentralized configuration much more congenial to renewables than the traditional system, with its gigawatt-scale generating units. Renewable energy technologies tend to come in comparatively small-scale, modular units. Individual wind turbines, for instance, are unlikely to be larger than a few megawatts; even the largest biomass cogeneration plants will probably have outputs of less than 100 MW, to avoid transporting fuel of low energy density over long distances. Accordingly, an electricity system consisting of many small decentralized generating units is going to be a much more comfortable context for renewables of all kinds. It is not going to emerge overnight; but it is going to emerge a lot faster than most people yet realize.

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For biomass, for instance, the first phase will be swift expansion of cogeneration, on more and smaller sites. Biomass is already successful for cogeneration in appropriate industrial contexts; it will become more so, especially as the technologies for advanced biomass utilization prove themselves. Many of the arguments in favour of cogeneration using natural gas apply equally to cogeneration using biomass, notably the advantage of having your own on-site generation under your own control. Moreover, many of the technologies now under development to use natural gas for on-site generation and cogeneration, including mini- and micro-turbines and fuel cells, may be readily adaptable to use fuel gas from biomass -- another example of the symbiosis between natural gas and a key renewable.

Over time, under the influence of decentralization and technical innovation, on-site generation and local systems will become steadily more common, not just in rural areas of developing countries but all over the world, including OECD countries. Local systems, and the whole-system thinking they foster, will give rise to fascinating alliances of different abilities and specializations, to optimize the combination of efficient, economic generation and efficient, economic end-use of electricity.

Finance and environment aligned

At the fourth Conference of Parties to the UN Framework Convention on Climate Change, in Buenos Aires in November 1998, governments, politicians and diplomats appear to have made little headway in their deliberations. But developments on the ground may be leaving them behind, as business, industry and finance come to regard climate policy not as a threat but as an opportunity. Electricity in particular offers signs of hope. It is one sector of the global economy in which finance and environment are now pointing in much the same direction, toward smaller-scale generation closer to users, and to local systems optimized for high performance and high efficiency -- better electricity services with lower adverse effects on the environment, local and global.

We ask ourselves what ‘sustainable electricity’ might look like, and how we might get there from here. In fact we may now be on the right track. Liberalization, natural gas and gas turbines have given us the initial breakthrough we needed. We must now take advantage of the new frameworks emerging for electricity, and push the desired changes farther and faster. Natural gas, for all its attractions, is still a fossil fuel. Renewables emit no net carbon dioxide. Natural gas has triggered the transition. But it will be a transition to renewables.

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