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A Global View of the Changing Electric Power Industry: or, Keeping The Lights On

Presentation by Walt Patterson

Cast your mind back to 1984. I don't mean the 1984 of George Orwell and Big Brother. I mean the real 1984, eighteen years ago. Were you working for the same company then? WAS it the same company, with the same name and in the same business? Somehow I doubt it. Can you recall what world electricity was like? It was made up of monopoly companies, with franchise territories inside national borders. Its generators were almost all either large dams with water turbines, or large coal-fired and nuclear stations with steam turbines. Natural gas was a premium fuel, widely banned from use for generation. Gas turbines were for emergencies. Renewables were a curiosity for weirdos. Chernobyl had not happened. Electricity systems and companies were planned, operated and managed by engineers. Most electricity systems belonged to a single owner, all the way from generators to meters. Those that did not divided up responsibilities in cosy partnerships. No one thought of competition or markets for electricity. No one from outside a country owned its electricity assets. The major environmental issues centred on acid rain, and on the anticipated vast expansion of nuclear power, including fast breeder reactors and plutonium fuel. No one had heard of climate change.

Does this sound at all familiar? You may have forgotten what world electricity was like, only eighteen years ago. But you probably realize why I chose 1984. Today, in 2002, we are eighteen years away from 2020. Can you imagine how much world electricity is going to change in the next eighteen years? In 1984 change had scarcely begun. Now it is in full, headlong flux. The momentum is going to carry us a long way - much farther, I suggest, than most of us can yet imagine. Unless we are very lucky it is going to be a seriously uncomfortable ride, even for the most fortunate among us. This morning I'll try to indicate why.

The starting point is what I call 'traditional electricity', the common technical model replicated all over the world during the past century. In this model, large central stations, remotely sited, generate electricity as alternating current and deliver it to users over networks including long high-voltage transmission lines. The traditional electricity system holds a monopoly, granted by government, in its franchise area. Within this area no one else is permitted to generate electricity for sale. The monopoly franchise guarantees a revenue stream, and allows system planners to make very large long-term investments, notably in power stations and networks, because the captive customers of the monopoly bear all the risks

Throughout the past century this traditional model was remarkably successful, making electric light, electric motive power and other electricity services part of the everyday fabric of industrial society. But the traditional model arose for one key reason: the economies of scale of the generating technologies then available, particularly steam turbines and water turbines. Making these generators larger steadily lowered the cost of the electricity they produced, up to generators of enormous size,

despite the cost of the accompanying delivery network. The technical configuration of traditional electricity was modeled on that for town gas; and the analogy was effective and useful for most of a century. Now, however, it is seriously misleading. The emergence of economic and small-scale decentralized generation as an option is going to invalidate the key premise underlying the traditional model of electricity. Moreover the traditional model has failed to deliver electricity services to some two billion people - one-third of humanity; and its key technologies - large dams, large coal-fired and nuclear steam-cycle stations, and overhead transmission lines - all face problems, particularly financial and environmental, that may become insuperable. The entire conceptual framework of electricity, its role and nature in human society, now requires urgent and fundamental reassessment.

This is because electricity is different. Despite all the prevailing assumptions to the contrary, electricity is not a fuel, nor a commodity. A fuel such as natural gas comes out of a hole in the ground at a specific place; if you want to use it anywhere else you must physically transport it there. Electricity, by contrast, is a physical phenomenon happening instantaneously throughout an entire interconnected system. You can generate electricity anywhere, at a price. You can store a commodity such as copper, wheat or coffee, and withhold it from the market until you get the price you want. But you cannot store electricity, in the form and quantity in which we now use it. If you are to satisfy your customers you must have a vast array of physical assets in place and in operation continuously, whether or not your customers want electricity from you. If you have a monopoly, that does not matter. If you don't, other factors come into play.

At the beginning of the 1990s the governments of Chile and the UK, ideologically committed to so-called 'free markets', overthrew the traditional model of electricity system, abolished the monopoly franchise and introduced competition in generation and supply to customers. The first unexpected consequence was the dramatic advent of gas turbine generation, fueled by cheap and abundant natural gas, both economically and environmentally beneficial. But gas turbine generation marks a sharp change in the historical trend. Historically, a better power station was a bigger power station farther away. With the gas turbine, however, a better power station is likely to be a smaller power station, easier to finance and to site, quicker to build and commission, more efficient and cleaner, closer to users and possibly indeed right where the electricity is required. In a competitive context, a large-scale long-term investment in traditional hydroelectric or steam-cycle generation is seriously risky; and the risks are borne not by captive customers but by shareholders and bankers. If a less risky option is available, traditional generation loses its appeal. Gas turbine generation, smaller-scale and more decentralized, is opening the way for even smaller and more numerous generators, down to household scale, that will soon be commercially available and attractive. This is going to cause trouble.

Three years ago I published a book entitled *Transforming Electricity*. I called Chapter 6 of the book 'Bumpy transitions'. At the time, however, I did not fully appreciate just how bumpy these transitions would prove to be. For the past three years I have been working on a follow-up book, entitled *Keeping The Lights On*. The longer I work on it, however, the more difficult I think keeping the lights on is going to be. Traditional central-station electricity is simply not compatible with innovative decentralized electricity, either technically or institutionally. This is most obvious with networks. Traditional networks are radial and one-way, designed to carry large quantities of electricity at high voltages from remote large-scale generators, and to divide the electricity up among loads several orders of magnitude smaller. Innovative decentralized electricity, with very

large numbers of small generators connected at low voltages, broadly similar in size to the loads, will require meshed, two-way networks, different in both configuration and function. Can networks evolve smoothly through such a dislocation? I hope so; but I don't yet understand how.

We are already seeing problems arising from traditional networks, as a consequence of liberalization. Traditional networks were never intended to function as a framework for market competition between generators with different owners, and especially not across system borders, much less national borders. Despite liberalization in Europe, the US and elsewhere, electricity networks continue as regulated monopolies, effectively centrally planned, paid for by captive customers as before. Issues of system stability, reactive power and other technical concerns arising from small-scale decentralized generation are aggravated by the insistence of some traditional system people that any significant move to decentralized generation will endanger system stability. A fully decentralized electricity system would offer an entirely different approach to stability; once again, however, the problem is how to get there from here.

Technical issues such as these are complicated in turn by the decision-making and financial procedures that have arisen with liberalization. The whole process of liberalization, as it has been implemented in OECD countries and elsewhere, is based on what appears to me to be a fundamentally misguided premise: the premise that electricity is a commodity, that the relevant market is a commodity market in anonymous units of electricity as measured by a meter, and that what matters most is the commodity price per unit of electricity. However, the price of a unit of electricity is made up in substantial part by the capital charges attributed to the system assets, especially the monopoly networks. The price of a unit of electricity to the final user is thus effectively arbitrary, a thoroughly unsatisfactory criterion by which to evaluate the success or otherwise of liberalization or reform of any kind. It is also an unsatisfactory basis for market transactions between system participants, especially when the future evolution of the electricity system, reconfiguring its physical assets, is going to require major long-term capital investment, on some acceptable basis, by someone.

As I wrestle with these problems I am sometimes bemused, that so many other commentators seem unconcerned - or perhaps not so much unconcerned as unaware of them. The reason may be that liberalization has drastically shortened the time-scale of thinking about electricity and its future. To the extent that most commentators have any long-term vision of electricity in society, they appear to believe that it will look and function much the same in 2020 and 2050 as it does in 2002. I think they are wrong.

The risk profile of traditional large-scale assets is increasingly ill-suited to a commodity market in instantaneous and ephemeral units of electricity. In some liberalized competitive systems, including that of the UK, the unit electricity price is now so low that some generators cannot even cover their cost of capital. Some generators are already shutting down power stations that do not earn an adequate return for operating. This reduces the redundancy on the system, with a negative effect on reliability. For many modern loads, system reliability and power quality are already a problem. That makes the option of decentralized on-site generation more attractive, not least as insurance against disruptions on the network. If the growing proportion of sensitive users install their own generation and remove their loads from the system, more system generation will become surplus to requirements and face shutdown, further weakening the system. We could see a feedback loop developing, in which those users who can leave the system will do so in favour of their own

decentralized generation, while users still dependent on the system have to accept steadily deteriorating service.

If we were starting now to electrify society, with the technologies now available, electricity and electricity systems would be very different. But we would strive to attain some of the key attributes we still associate with traditional electricity. We would want electricity services to be reliable, convenient and affordable. We would also, however, want attributes that traditional electricity does not and cannot achieve: we would want electricity services from systems clean and environmentally acceptable throughout; and we would want these services to be available to all, not merely to the fortunate two-thirds of us on the planet.

Let me give you a brief outline of what seems to me a promising vision. Electricity services such as illumination, comfort, motive power and refrigeration are not commodity services but infrastructure services. You don't measure them or buy them by the unit; you pay for the assets that deliver them to you when and how you want them - the buildings, the fittings, the appliances and so on. We have known for decades how to make these assets deliver much higher performance. We've called the objective 'energy efficiency', but I dislike the expression, because you do not measure either the energy input or the useful energy output of, say, buildings - much the most important part of our energy service infrastructure. For at least three decades we have failed to take advantage of the opportunities to improve infrastructure performance, for a variety of reasons, not least the so-called 'hassle factor' - 'I just can't be bothered'.

Now, however, with decentralized electricity generation, we have a whole new way to approach the issue. Local electricity service systems, incorporating generation, networks and high-performance end-use technology, including buildings, could be integrated and optimized for maximum economic effect. That would be attractive both to customers and to the companies that would design, establish and operate the systems. A contract for energy services would create a long-term link between company and customer, a much more stable form of business relationship than competing to sell anonymous units of electricity at a meter. Decentralized electricity systems, with their economic, social, political and environmental advantages, could be a crucial step toward 'sustainable electricity', in OECD, transition and developing countries alike.

Nevertheless, whatever 'sustainable electricity' may look like, how do we get there from here? The disruption and dislocation involved may be severe. The challenge for you, as electricity professionals, is to avoid the pitfalls and seize the opportunities, while keeping the lights on. It will not be easy. I wish you success.

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