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Electricity In Flux

Electricity is changing. After many decades of gradual evolution, electricity systems are now in unparalleled upheaval. Since the late 1980s, governments have been overturning the guiding premises that shaped world electricity for a century. As a new century opens, many of the old ground-rules no longer apply. Technical innovation, financial pressures, environmental constraints, restructuring and internationalization are a potent combination. Their combined influence on electricity has initiated a transformation that will be more fundamental, more far-reaching and faster than most people yet realize. As these forces interact they are going to redefine the role and nature of electricity in human society.

The traditional electricity system, dating back to Thomas Edison's Pearl Street installation in lower Manhattan in the early 1880s, came about for one overriding reason: the economies of scale associated with generators driven by steam power or water power. Until the time of Edison, anyone fortunate and wealthy enough to boast electric light had the entire system - generator, cables and lamps - all on the same site. Edison's great idea was to scale up the process. Making individual generators larger reduced their capital cost per unit of output capacity; for steam power, increasing the size of the boiler also increased fuel efficiency, thereby also lowering unit operating costs. To be sure, some capital savings were offset by the additional cost of ever larger and more complex networks to subdivide and deliver the electricity output to users; and running cables across many properties and through public space raised other issues. But the overall effect of increasing scale of electricity generation and interconnected systems steadily reduced the cost of electric light and motive power. By the 1980s electricity was ubiquitous and indeed essential throughout modern industrial society. Moreover, although electricity systems were arguably the most complex industrial activity on earth, most people in modern industrial society took electricity and its many applications completely for granted.

In a traditional electricity system, electricity in the form of synchronized alternating current is generated by rotating machines in large, remotely sited generating stations, and delivered to users over elaborate networks including long high-voltage transmission lines and lower-voltage distribution networks. Throughout the twentieth century this configuration became the common technical model of electricity system, replicated all over the world. Because the network is an inherent part of the system, system operators argued that an electricity system is a natural monopoly. Politicians agreed. From the 1920s onwards, whether 'natural' or not, an electricity system was almost invariably granted a monopoly franchise in its service area, with a corresponding obligation to supply all the electricity that its users required, everywhere within the area, throughout the day and throughout the year. Either implicitly or explicitly the relevant government supervised or 'regulated' the monopoly, to ensure that it did not take unfair advantage of its captive customers.

The monopoly franchise proved to be crucial for the expansion of electricity systems, especially once most people in the franchise area had come to rely on electricity from the system. Captive customers buying an essential good guarantee a revenue stream. System planners were therefore able to order and finance ever-larger generating units, always pursuing purported economies of scale. Such enormous units might take up to ten years to construct and commission, and might have to operate for another thirty years or more to earn an adequate return on investment; but the captive customers bore the risk. From the 1960s onwards, in many places, this risk proved substantial; many power stations suffered serious and costly delays and budget overruns. The consequent financial burden - thousands of millions of dollars, in many currencies - fell on electricity users and taxpayers. Nevertheless the traditional electricity system continued to prevail. In the early 1980s, as it celebrated its first century, its adherents little imagined what lay in store.

The first signs of the impending upheaval emerged in Chile and the UK in the late 1980s. The governments of Augusto Pinochet in Chile and Margaret Thatcher in the UK, ideologically committed to 'free markets', decided to sell off their government-owned electricity systems to private investors. So-called 'privatization' of electricity was not of itself at all novel; electricity systems in the US, Germany and Japan, for instance, had long been privately-owned. In the UK, however, the free-market theorists did not want the powerful Central Electricity Generating Board to become a private monopoly. Almost as an afterthought, therefore, as well as privatizing the country's electricity system, the Thatcher government broke it up into a collection of separate companies for generation, transmission and distribution - 'restructured' it; and announced that henceforth the different generating companies would have to compete to sell their output. Customers would no longer be captive; they would be free to choose between competing suppliers.

The introduction of competition had a number of unexpected consequences. One in particular stands out. Electricity liberalization in the UK coincided with the sudden emergence of gas-turbine generation for baseload operation, and cheap and abundant natural gas to fuel it. Within less than five years, gas-turbine generation became the technology of choice for new power stations not only in the UK but essentially wherever natural gas was available. Gas-turbine generation marks a sharp break with the historical trend, in which the ruling assumption has long held that a better power station is always a bigger power station, probably farther away. A gas-turbine generator can be efficient and economic at much smaller scale than traditional generators. It can be ordered, constructed and commissioned in less than three years, often substantially less. It is modular, allowing incremental investment timed to correspond to the growth of demand. Firing natural gas it does not require a fuel store. It produces no solid waste, and its emissions to atmosphere can be very low. It is therefore easier to site; it can be located closer to users, and indeed even on the same site as its major load. It is therefore ideally suited to cogeneration, producing electricity, heat and possibly cooling, boosting fuel efficiency above 80 per cent, improving both its economics and its environmental performance.

The most attractive feature of gas-turbine generation, however, is financial. In a liberalized competitive context, tradition electricity investments, large-scale and long-term, become acutely risky - and the risks must be borne not by captive customers but by shareholders and bankers. Minimizing exposure to such risks leads to a fundamental shift in the choice of electricity technologies. Instead of traditional technologies, centralized, capital-intensive and inflexible, liberalized competitive electricity favours more decentralized technologies. A portfolio of smaller-scale, more numerous, more diverse and more flexible assets yields more rapid returns; it is also less vulnerable to the vagaries of an electricity scene beset by intensifying uncertainties - financial, technical, institutional and environmental.

Liberalization and gas-turbine generation are, however, only the beginning. A whole range of innovative small-scale modular generating technologies is coming to market, dramatically widening the options available. Major international companies are devoting substantial budgets to developing microturbines, fuel cells and renewable energy technologies including wind power, biomass power and photovoltaics. The attributes of these technologies are very different from those of traditional generation. Their economics benefit not from increasing unit scale but from series manufacture and a rapid learning curve. The options they offer for ownership, siting, operation, new network functions and system configurations are far removed from those of traditional generation. The implications for electricity systems are profound, and as yet far from fully appreciated.

The advent of these new generating technologies underlines a crucial fact usually overlooked. The traditional central-station electricity system arose for one reason only: it was the cheapest way to deliver electric light and motive power with the generating technologies then available. Everything else followed from that one consideration. Despite frequent pronouncements to the contrary, electricity is not a fuel. A fuel can be stored and held back from the market until the price is right. Electricity as we now use it cannot be stored. A fuel such as oil, coal or natural gas is a physical substance. It comes from a hole in the ground at a particular place. If you want to use it anywhere else you must physically transport it there. Electricity, by contrast, is not a physical substance; it is a physical phenomenon happening simultaneously throughout an entire interconnected system. You can generate electricity anywhere, at a price. Just ask the person with the hissing headphones sitting next to you on the bus.

Nor is electricity a commodity. Because it cannot be stored, any time you want to use electricity from the system all the relevant interconnected physical assets of the system must be in place and in operation to deliver the service you want. The vast infrastructure of 'electricity markets' now being laboriously erected in Europe, the US and elsewhere is predicated on the assumption that electricity can be treated as a commodity, and sold by the unit in a competitive market. The assumption may be tenable for a transition period; but it is already throwing up problems, and they will intensify. In the first decade of electricity liberalization, politicians have laid heavy stress on the price of a unit of electricity, to measure the success of the policy. The argument is shallow, to put it mildly. Tax regimes, depreciation rates and other asset accountancy, subsidies and cross-subsidies, and the regulatory treatment of monopoly networks mean that, in the words of Patrick Moriarty, respected one-time chairman of Ireland's Electricity Supply Board, 'The price of electricity is what the government wants it to be'.

In any case, if you are competing to sell anonymous units of electricity at a customer's meter, all you can compete on is price; your margins grow precariously thin, especially when you need to maintain major physical assets in order to compete. If, at the same time, your customer can change suppliers more or less at will, as is the case for instance in the UK, this kind of business will be a good way to go bankrupt. Enlightened companies are therefore looking for other ways to do electricity business - ways that can win and retain the loyalty of customers.

In a paper published earlier this year, I argued that the outcome may eventually see electricity come 'full circle', back to where it was 120 years ago, before Edison's

Pearl Street system (see ‘Full Circle’, by Walt Patterson; *Cogeneration and On-Site Power Production*, Launch Issue, January-February 2000). In this model, companies will contract with customers to design, install, operate and maintain integrated local systems, generating electricity where it is to be used, and ensuring that the buildings and other end-use equipment make optimal use of the electricity to deliver the services customers actually desire - comfort, illumination, motive power, refrigeration, information handling and so on. Some major companies are already offering such contract packages; more will undoubtedly follow.

If we were starting now to electrify society, with the technologies now available, electricity systems would look very different. As matters stand, however, modern industrial society already has a vast legacy of traditional electricity technologies, institutions and mind-sets that will impede and complicate the transition. In my book *Transforming Electricity* (RIIA/Earthscan 1999) I declared that ‘Electricity systems may be the most spectacularly successful technology of the twentieth century’. In this twenty-first century, nevertheless, traditional electricity systems are doomed. They have failed to reach two billion people - one-third of humanity - and the proportion of those without access to electricity is increasing, not decreasing. Moreover, the key technologies of traditional electricity, for large-scale generation and high-voltage transmission, all face financial, social and environmental problems that may become insuperable. The clash between tradition and innovation in electricity is likely to be protracted and messy; but my money is on the innovators.

What might all this imply for the future of your activities? I’ll leave you to draw your own conclusions.