Energy and Environmental Programme, Royal Institute of International Affairs
Transforming Electricity: Working Paper 2

Electricity: Liberal Futures
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1. Introduction: the liberal dimension

Like the international dimension of electricity discussed in Working Paper 1, the liberal dimension of electricity has emerged only recently, at least as a recognized concept. However, whereas the international dimension is genuinely new, the dimension now characterized as 'liberal' needs closer examination. The language of policy discourse is not always consistent. Until the 1990s, policy analysts habitually referred to the electricity industry as 'conservative', in the sense that it was resistant to change and deeply wary of risk. However, those who first acted to 'liberalize' electricity were themselves 'conservative', in conventional political terms, notably the governments of Chile and the UK in the 1980s. That apparent irony in itself suggests that 'liberalizing' electricity is a more subtle and complex process than the term itself might indicate.

To call the process 'liberalizing' conveys an aura of enhanced freedom of action, of wider choice among options, a 'bonfire of controls'. As applied to a synchronized alternating current electricity system, however, the term is at least tendentious and may be actively misleading, depending on the context and the consequences. What controls can be consigned to the bonfire, on what basis and with what consequences? This Working Paper will explore the new 'liberal' dimension of electricity, to see what actually happens in immediate practice in various contexts, and what this may imply in the longer term, to 2020 and beyond. What does 'liberal' mean when applied to synchronized AC?

In the 1990s, liberalizing electricity can refer to a whole gamut of policy measures. These measures are not mutually exclusive, and indeed often occur together or in succession. They include:

- permitting independent generation on an otherwise regulated franchised monopoly system;
- establishing a regulatory agency explicitly separate from government;
- 'corporatizing' part or the whole of an electricity system, taking its day-to-day activities out from under the direct control of government, while retaining it in government ownership;
- restructuring electricity systems, for instance by separating generation, transmission, distribution and supply into distinct organizational entities;
- 'privatizing' - that is, selling part or the whole of a previously government-owned system to private owners, possibly including foreign owners;
- introducing competition in generation, supply, and potentially other aspects of electricity, for some or all categories of user, possibly across national borders;
- abolishing the monopoly franchise; and

- extending national electricity policies across international borders, as Working Paper 1 has discussed.

Each of these policy measures has been implemented somewhere in the world in the 1990s, some in many different places. Yet two decades ago no one was advocating liberalizing electricity. As recently as a decade ago the concept advocated was not liberalization but the much narrower 'privatization', in which the change of ownership alone was presumed to be the major transformation. By definition, privatization can apply only to assets previously owned by government. Privatization of assets previously government-owned already had a history, albeit brief. But only Chile had privatized a synchronized AC electricity system; elsewhere the idea was still almost entirely hypothetical, more of a slogan than a policy. Liberalization in the wider sense now commonly accepted, applicable to systems with any pattern of ownership, was barely on the agenda. What has changed, in less than a decade, to make liberalizing electricity such a suddenly attractive concept to policymakers all over the world? Nor do the measures listed above in any way exhaust the possibilities for further change in electricity systems. However, as electricity systems continue to evolve, the term 'liberalization' may no longer be an appropriate description for the decision-making processes involved, as will be discussed below.

In the 1990s, liberalizing electricity is driven primarily by governments and the policy decisions they make. At least three motives may drive governments to liberalize. One is ideological: the 'free-market' ideology that the private sector will manage electricity systems better than government, and that competition is always preferable to monopoly. Another is financial: the need to mobilize private capital and private finance to meet the apparently insatiable financial demands of some electricity systems, to ease the burden on government budgets and to raise funds for government treasuries. In some cases, particularly when the government espouses 'free markets', these two motives concur, with perhaps different emphases in different places. In other cases, however, notably for many non-OECD governments, the financial motive has to overcome government reluctance to cede any control over the electricity system, which is regarded with some justification as a lever of government power. A third motive often important is that governments may find themselves under pressure from electricity users, especially those in energy-intensive industry, to cut the cost of electricity. Liberalization is seen as a way to cut costs, improving the economic performance and efficiency of the electricity system by imposing free-market disciplines and commercial criteria. In the short term, the most obvious way to cut costs is to lay off staff. Governments may be happy to hand this responsibility over to the private sector and let private-sector managers suffer the censure for job losses, rather than triggering political unrest directed at the government itself.

Immediate beneficiaries of liberalization may include:

- governments who acquire the proceeds of the sale of assets, and possibly relief from a financial burden;
- investors who purchase shares in system facilities being privatized, since the share price is usually set low enough to guarantee a successful sale, and almost always yields an instant gain;

- banks and other financial advisors on a privatization, whose fees for services often account for a significant fraction of the proceeds of the sale;
- senior management of a privatized system - or at least those who continue to hold their positions - whose remuneration often takes a sharp leap upward;
- large users, whose market power often allows them to negotiate more advantageous terms from suppliers in a liberalized system;
- foreign electricity companies whose activities at home are still tightly regulated, and who may find more attractive opportunities in owning part or all of a liberalized system elsewhere;
- natural gas suppliers, who frequently find substantial opportunities to supply fuel under contracts of up to 15 years for new generation projects on liberalized systems;
- entrepreneurs who add facilities to a liberalized system in which lenient regulation allows substantial profits; and
- engineering manufacturers able to supply the technology for gas-turbine combined-cycle generating plant, the technology of choice in the 1990s for new capacity on liberalized systems with access to natural gas.

Those, on the other hand, disadvantaged by liberalization may include:

- a significant number of employees of the electricity system, usually the less senior, who lose their jobs as the new private managers cut costs by cutting staff and closing facilities considered redundant;
- coal suppliers and their employees, as the main market for coal is eroded by new generating capacity based on natural gas;
- many owners and operators of nuclear plant, whose generating costs may be uncomfortably high compared to those of competing alternatives;
- engineering manufacturers of traditional large-scale steam-cycle generating plant, whose technology is less attractive to investors in a liberalized system because it is more difficult to finance; and
- the poor, without market power in a liberal competitive context in which social obligations previously tacitly acknowledged may be discarded.

As the winners and losers on systems being liberalized assess their circumstances, many immediate issues arise, including:

- stranded investment;
- scale and nature of regulation;
- reconciling regulation with competition;
- central control for synchronized AC;
- access to the network;
- dispatching - who is and who is not connected to the network, and on what basis;
- maintenance of stability, including margins and redundancy;
- reliability and power quality, especially for sensitive loads;
- access to information for regulators and customers;
- mergers and acquisitions on a liberalized system;
- ‘obligation to supply’, or not;

- social obligations, especially electricity services for the poor;
- collapse of traditional 'demand-side management' (DSM) mandated by regulation;
- energy efficiency versus sale of electricity; and
- environmental protection in a liberalized context.

Working Paper 1 also noted a range of international issues arising from liberalization. As in that paper, however, the focus herein is not so much on the urgent and confused debates surrounding all these issues in the short term, but rather on their longer-term implications. In the 1990s, no matter what the motive for any particular policy measure to liberalize an electricity system, one corollary always appears to be evident. The motive is invariably to achieve purported benefits in the short term. The longer-term implications are left vague at best, when not simply ignored. This in itself is a striking change. Electricity systems have historically operated with strategic programmes extending as far as forty years or more into the future. In the 1990s, however, governments appear to be assuming that the same guiding premises about the longer term will continue to hold, even as they are overturning the ground rules on which such premises have hitherto been based. In particular, they appear to be assuming that the traditional technical configuration of central-station synchronized AC will continue indefinitely to be compatible with a liberal policy framework. This Working Paper will explore the implications, including inconsistencies already beginning to obtrude. Is a liberal dimension ultimately consistent with large-scale central-station synchronized AC?

2. Electricity and controls

According to Chambers's Dictionary, 'liberal' means 'free from restraint' and 'not bound by authority'. In any context, to be sure, such attributes may be relative rather than absolute. In the context of a synchronized AC electricity system they are of strictly limited validity. As discussed in Working Paper 1, a central-station synchronized AC system must be under some accepted form of central control, if it is to remain stable and functional. It cannot be 'free from restraint'; it must be 'bound by authority', at least to the extent required to sustain it in stable operation. To what extent, then, can the process now in train in so many countries be characterized as 'liberalizing' electricity? What restraints are being relaxed, and how? How is the role of 'authority' changing? What may these changes imply for the longer-term future of electricity?

An electricity system must be subject to a variety of controls - technical, financial, institutional and environmental. Controls imply decisions taken and implemented. Consider first the controls without which a synchronized AC system cannot function moment by moment. The absolute necessity of these controls distinguishes a synchronized AC system from other network systems and infrastructure. In the traditional model, users of the system are genuinely independent, connecting and disconnecting loads at will. The rest of the system must respond accordingly, augmenting or reducing generation to match the changing load. The requisite decisions are taken centrally: as load varies, generating capacity is 'dispatched' to match it, by a central controller to which all generators above a certain size must respond. The authority of this central controller must be absolute if the system is to remain stable. Working Paper 1 argued that under the traditional model the authority of the central controller is guaranteed by the relevant national government, directly or indirectly.

If the system is a monopoly franchise with an obligation to supply, generating capacity can be augmented or reduced according to a hierarchy with criteria in common, a so-called 'merit order'. In a traditional merit order, the generating sets are connected to the system in increasing order of short-term marginal generating cost. (Systems with a high proportion of hydroelectric capacity are dispatched differently. Some aspects of the analysis herein are therefore less applicable to existing hydro-based systems, a point that should be kept in mind.) Historically this criterion has more or less corresponded to the technical attributes of the various types of generation. The largest and least flexible units are also the newest and most efficient, have the lowest marginal generating cost, run continuously at maximum output and supply the 'base load'. Smaller, older, less efficient and more expensive units run intermittently and at partial capacity to follow load, and a few especially flexible units with swift response are held in reserve to supply the infrequent peaks of maximum load on the system. The dispatcher - that is, the central controller - thus has available a portfolio of generating capacity that can be and is adjusted moment by moment as necessary to maintain stability. On the traditional system model, this portfolio includes excess generating capacity, to allow for unexpected plant failures or surges of load. It also includes redundant network capacity; in the event of a failure on the network, electricity can flow along alternative stable routes to reach users.

Working Paper 1 pointed out that the actual ownership of the various components of such a system is immaterial, given one proviso: all the separate owners must cede control of their operations to the central controller. Historically, such arrangements have been commonplace. Indeed countless small distribution systems in many parts of the world own no generating capacity, but operate as part of a larger synchronized network whose generation belongs to other owners. In itself, transfer of ownership, even in the dramatic case of privatization of a system previously owned by government, does not really imply 'liberalization' in the sense of freedom from constraint, so long as the new owners continue to submit to the authority of the central controller. A similar comment can be made about what has come to be called 'independent generation' by 'independent power producers' or IPPs. They may be independently owned, but they cannot be independently operated.

This is not a trivial point. If an individual generating unit is identified, for instance, as an individual accounting unit or profit centre, its revenue stream will depend substantially on whether it is dispatched - that is, on whether the central controller calls upon its services, or not. Almost all the IPP capacity recently constructed on commercial terms, in OECD countries and elsewhere, has been financed on the premise that it will operate at maximum output through the day and through the year, at base load. Nevertheless, on some systems, for instance that of England and Wales, the amount of new generating capacity from gas-fired combined-cycle stations is already rising past the level at which it can all operate at base load. In the short term this may not be a problem; but it will almost certainly become so. Ceding control of a station's role on a synchronized AC system also means ceding a crucial measure of control over its revenue stream. The same applies whether the station is purchased in a privatization or constructed as a new project, whether the system is in an OECD country, a transition country or an emerging country, as long as the station's revenue stream depends on how much electricity it generates for the system.

Even on a monopoly system the question of central control, 'to dispatch or not to dispatch', may become important as the system evolves and individual units age or obsolesce. In a system involving competition it is yet more challenging. In a monopoly system, the criteria establishing the merit order are established and applied internally. In a system involving competition, the criteria must be external, a manifestation of a 'market'. The choice thus far has usually been to create a 'pool', into which the various generators bid prices at which they will deliver electricity to the system over a given brief period, usually a particular half-hour. The concept is that the prices bid then establish a 'merit order', perhaps better called a 'connecting order', the cheapest generator first on the system and so on until the generation matches the load during that half-hour. Since all the generation is required for stability in that period, all the generators may be paid the price of the most expensive generator on the system; alternatively they may be paid the price they bid. As the load on the system changes through the day and through the year, generators are connected and disconnected in order of price. An extension of this process is to include not only generators but also loads in the bidding. To balance the system, disconnecting a load is effectively equivalent to connecting a generator. Some systems invite industrial loads to offer to disconnect at times of heavy demand, and to bid the price they would require to do so.

The concept of 'connecting order' according to the price bid has an attractive simplicity; but the practical reality proves to be Byzantine in complexity, and more than a little arbitrary. A large central-station generator cannot be connected and disconnected at half-hourly intervals to follow load; it is much too inflexible. (As noted parenthetically earlier, the process is much easier on a system with a high proportion of hydroelectricity, such as Scandinavia's Nordpool. Perhaps partly for that reason, the Norwegian system, essentially 100% hydro, was one of the earliest to liberalize, and remains one of the most transparent in operation.) Even adjusting the power output of a large unit can only be done gradually. In a vertically integrated monopoly system the economic impact of maintaining necessary redundancy and operating at below full capacity, not to mention the wide range of other technical operating services required to maintain stability, is effectively averaged over the whole system and the operating year. In a competitive market context each of these activities has an impact on the economics of the system; but establishing the correct price for each activity, and identifying who is to pay and who to be paid, at half-hourly intervals on a continuous and uninterruptible basis, is daunting even in theory. In practice it becomes, inevitably, arbitrary, a matter for the judgment of the regulator.

On a system with abundant redundancy, including most OECD systems recently liberalized, potentially controversial regulatory judgments are cushioned by

- the redundancy already available, bought and paid for by the captive customers of the former monopoly;
- the operational engineering culture carried over from the decades of monopoly and obligation to supply; and
- the generous financial rewards for the moment on offer.

Nit-picking about second-order issues is not worth the effort. In the years to come, however, as system margins narrow, competition becomes central rather than peripheral, and profits are not so easy to accrue, disputes over dispatching, access to the network and payment for system services appear likely to escalate. On a synchronized AC system, the owner of any individual generating unit has one independent form of action available: not to operate. The possibility has already played a significant role as a short-term strategy employed by generators bidding into the pool in England and Wales, raising the price paid for other units belonging to the same owner that do operate. In the longer term, especially as ownership becomes diversified into wide portfolios well outside national borders, the possibility that an owner will shut down a station whose system access is too limited to earn the required revenue becomes a serious consideration.

With that potentially significant proviso, the immediate operation of a synchronized AC system is therefore controlled by independent users and the central controller. Generators, transmission and distribution must act accordingly, immediately and without fail. This crucial aspect of central-station electricity has been essentially taken for granted in the early years of liberalization. Policy analysis and dispute has focused on other aspects, as the various participants on a liberalized system strive for maximum benefits while avoiding concomitant risks. The structure of immediate control for system stability, and the corollary requirements for longer-term control - in particular planning additional system capacity and bringing it into operation under the same central control - have yet to be tested in a liberalized competitive system close to its operating margins.

On a system with a monopoly franchise and a corresponding obligation to supply all the electricity required by all prospective users in the franchise area, planning for future development of the system has been taken for granted as a responsibility of the system operator, and ultimately of the central controller. Without new capacity to match growth in use and compensate for the retirement of older plant, the central controller will be unable to keep the system in stable operation. In a liberal context, however, the central controller may no longer be able to initiate or direct procedures to add new capacity. In the 1990s, those promoting liberalization assert with confidence that price signals will prompt entrepreneurs to construct new capacity when system margins dwindle. The example of the UK, with its upsurge of new gas-fired generation, might seem to support this argument. But the UK may be an anomaly; its new capacity was built not because system margins were dwindling, but in spite of egregious over-capacity, for other reasons. The assertion that price signals will stimulate new investment to increase system margins has yet to be borne out in practice, even for generation, to say nothing of network capacity. If the assertion proves unfounded, no obvious fallback position is easy to discern.

The fundamental technical attributes of an electricity system thus raise questions of control different in kind from questions relating, say, to pricing of electricity, or to allocation of the proceeds accruing. In the 1990s, most regulators on liberalized systems have focused their attention on system finances, overseeing the monopoly components and refereeing disputes about the revenues and profits of the various participants. The regulator, however, is not the central controller, whose role is much more fundamental for the stable operation of a synchronized AC system. On systems in the US now moving towards liberalization, for instance, this role is to be played by an ‘independent system

operator' or ISO, who will control and presumably mandate connection to the network, including dispatching and matching generation with load. How well this will work in practice remains uncertain. To take but one obvious question: if network capacity is constrained, will an ISO be able deny a generator access to the network? In a litigious country such as the US, ISOs had better be prepared to spend a lot of time and money in court. Whether in the meantime they can keep the system stable, and keep the lights on, is yet another question.

In summary, then, liberalization can readily relax some controls without affecting the basic technical configuration of an electricity system. But relaxing others may jeopardize the function of the system. Unfortunately, the controls themselves are not easily separated into these categories. Over time, reasserting the link between ownership and control in a liberalized context could pose major problems for the integrity of a synchronized AC system.

3. Liberalization and electricity finance

The financial structure of a regulated monopoly franchise electricity system depends fundamentally on the monopoly that makes its customers captive. Expenditure on investment, fuel, operations and maintenance, plus a return on the investment, can all be recovered in the revenue stream from customers who have no choice but to pay the established tariff. A system can be liberalized to a significant extent - introducing independently-owned generation, creating a regulator independent of government, corporatizing and even privatizing the system - without breaching this condition; the critical stage, at which the condition breaks down, is the removal of the monopoly, in favour of some form of competition. Once customers have the option to choose among different providers of electricity and electricity services, the financial structure of the electricity system encounters risk that may be dramatically higher than under the monopoly condition. Nor can competition be introduced into a government-owned system to any credible extent. A government cannot compete with itself; private ownership of at least a substantial part of the generation on the system is a prerequisite for true competition. A private owner will not have the same government-backed guarantees for loans and investment, and is therefore unlikely to be willing to compete against government-owned parts of the same system. The egregious anomaly in the liberalization of electricity in England and Wales was the status of nuclear plant between 1990 and 1996, not only retained in government ownership but subsidized from a levy on the competing fossil-fired generation, a bizarre distortion of the purported 'competitive market'. True competition and its financial corollaries can arise only on a system in which all the generating capacity is privately owned, by more than one private owner.

Given the technical nature of an electricity system supplying varying loads, some of the generation will not be operating, and not earning revenue, for some of the time. In a monopoly framework this does not matter; the overall proceeds will be high enough for the regulator to allocate a suitable share to every asset on the system, including standby generation and other redundancy. A competitive framework for electricity generation means, conversely, that assets not operating are not earning anything for the owner, unless the owner is paid simply to keep them available. In a competitive framework, who

is to determine such a payment, and who is to pay it? Margins cost money. In the transition phase from monopoly to competition, systems generally have the necessary margins already available and paid for. But financial pressures will erode these margins, with ominous implications for longer-term stability of systems.

The private owners of generating capacity on a competitive system may hold an assortment of contracts linking them financially both to fuel suppliers (not, of course, for hydro-based systems) and to electricity customers. Such contracts, for up to 15 years, are often the basis on which the generating capacity itself is financed, since they minimize the risks associated with the requisite loans. Such contracts, however, are already proving problematical. Fuel price movements may make the electricity from a particular unit more expensive than electricity from a unit not bound by long-term fuel-supply contracts and able to take advantage of cheaper spot supplies, as has already happened with gas-fired combined-cycle stations in the UK in the 1990s. This problem may spread, especially on systems in which electricity use is growing only slowly, as is the case in the OECD countries most actively liberalizing. In a liberal context, the possibility that a particular station may be pushed off a system in less time than its fuel-supply contract stipulates is a genuine and serious risk.

Conversely, however, a unit relying only on spot or short-term fuel purchase, especially a gas-fired unit with limited fuel flexibility, is exposed to the opposite risk, that fuel supplies may become significantly more expensive. If its entire output is contracted to customers, they may bear or at any rate share the extra cost, depending on the terms of the contract; but if its output has to be sold to the system, it may once again find itself priced off the system. The contract least vulnerable to such an eventuality will be for on-site generation for a major user. In a genuinely competitive context, the status of any given electricity generating unit may therefore come to resemble that of the old free-standing individual power stations before the advent of the grid, forced to operate only when the output can be sold, raising the cost of capital carrying charges and thus of output, in a vicious spiral. Units planned, financed and contracted on the assumption of operation at base load over a long period may be in for unpleasant surprises. On the other hand, a new breed of so-called ‘merchant plants’, with little or no contract cover, is beginning to emerge, assuming from the outset the competitive context, operating in a spot market on the basis that its electricity will be competitively priced whatever its competitors are doing.

Another risk, with implications as yet unclear, arises from the role of the network itself as an essential link between generator and customer. In a liberal competitive context, if network failure breaks this link, what liabilities arise, and who pays them? Failure of the link between a large generator and its customers even for a few hours could create costs running into six figures at least, quite apart from any actual damage incurred as the result of the outage. Reduction of operating margins in a competitive context makes network failure more probable, and more difficult to rectify. Insurance might be available to cover such eventualities, but establishing liability for a network failure, when so many distinct parties are connected to it and may be partially at fault, will create a field day for lawyers.

In sum, the financial status of a fully liberal and competitive electricity system, its owners, operators and users, will bear very little resemblance to the traditional regulated

franchised monopoly, with its low risks and effectively guaranteed returns. During the transition to liberal competitive frameworks, attention has been focused on short-term advantage and disadvantage, as the participants try to maximize their own immediate financial benefits and minimize their own immediate financial risks. Beyond the transition, however, lies a financial minefield as yet unmapped, with business failures and bankruptcies for those who put a foot wrong, and possibly dismaying consequences for the systems in which they do it. The full impact of competition has yet to be felt. Governments, private investors and electricity users should all be bracing themselves.

4. Liberalization and electricity technology

Central-station synchronized AC electricity systems spread across much of the world throughout the twentieth century because of the economies of scale available for large steam and water turbines, and the consequent spectacular reduction of the cost of electricity so supplied. By the 1970s, financing investment in units of 1000MW and even larger was possible because the units were built on systems with a monopoly franchise. Captive customers would pay the necessary costs over the necessary timescale, often well over two decades. In a liberal competitive context, however, such long-term commitments are a very risky approach to electricity generation. The implications are already changing the priorities among technology choices for electricity systems, and these changes appear likely to accelerate.

Long-term commitments in themselves are not novel. Major oil and gas developments, for instance, including infrastructure such as pipelines, entail even larger and more long-term investment. But over this timescale the physical difference between natural gas and electricity cannot be ignored. Natural gas is a real physical commodity. It emerges from a hole in the ground at a particular location, and must be delivered to users located elsewhere. The production and delivery infrastructure, including its physical and geographical scale, is an essential constituent of the system. If a particular gasfield is to be brought into use, major infrastructure is a prerequisite. Electricity, by contrast, is not a physical commodity but a physical phenomenon, and can be generated anywhere, at a price. In the 1990s the range of technical options for electricity generation is expanding rapidly; and the relationship between generating technology and delivery networks is evolving apace. Large-scale long-term projects to generate electricity can still be undertaken, if governments, private finance or corporations themselves are willing to accept the risks; but such projects have to be compared with economically comparable generating options with different and possibly lower profiles of risk.

A crucial determinant of the risks arising, and their influence on choice of technology, is the degree to which a system is liberalized. Minimal liberalization, for instance, might entail admitting independent power production onto a monopoly franchise system. In this context an IPP will usually require a bankable power purchase contract; if the system is government-owned the banks in turn will usually require a guarantee from the host government. With such a contract and guarantee the IPP may be prepared to opt to build, say, a major hydroelectric installation or a large coal-fired steam-cycle plant, with a high capital cost and a long amortization period. In the 1990s a number of such IPP projects have proceeded on systems in emerging countries, albeit not without conflicts and controversies. However, in OECD countries with electricity systems in the process of

more far-reaching liberalization, including limiting or abolishing the monopoly franchise, traditional large-scale generating plants are much more risky and vulnerable investments, and have fallen dramatically out of favour in recent years.

The persistence of analytic assumptions carried over from traditional central-station systems nevertheless loads the analysis in favour of generation of this type, even if on a smaller scale than before. The assumption of central control and dispatching, of synchronized AC electricity as the carrier, and of cost of electricity at the output of the station as the key factor, regardless of location on the network, distorts comparisons between generating technologies even on a monopoly franchise system. Comparative analysis on this basis tends to favour remote-sited traditional generating technology using steam or water power, for which the analytic tools were developed. It is biased against newer generating technologies such as gas turbines, fuel cells, wind power, photovoltaics and other renewable sources, that may often be sited close to users, with concomitant lower delivery costs, and indeed against cogeneration in which heat may be the primary output.

Comparative economic analysis of technical options in a liberal context is as yet heavily coloured by assumptions drawn from franchised monopoly systems, not least because the existing technical infrastructure of many such systems, of existing power stations and networks, is usually the starting point for the process of liberalization. Technologies considered for addition to an existing system perforce must meet its technical requirements, even if the system is otherwise liberalized. For liberalization that retains the monopoly franchise, this necessity impedes rapid change of the system's technical configuration. Liberalization that abolishes the monopoly franchise, however, shifts risks from customers to other system participants, particularly generators. To minimize risks they will want generating technologies that are flexible and adaptable, easy to site, rapidly constructed, reliable and readily maintained; and they will want to develop close and lasting ties with customers to reduce the possibility of losing their business. A particularly advantageous way to do so is to build generation or cogeneration on the customer's own site, with the network connection primarily as backup. Some technologies that meet these criteria are already available, in particular gas turbines, in simple or combined-cycle operation, which have dominated additions to generating plant in liberalizing systems for the past decade. But other generating technologies are not far behind, in at least some existing contexts; and their emergence will accelerate the change of system configuration already under way.

The change of technical priorities that liberalization produces may in itself impede liberalization. In many emerging countries, in which the desire for electricity is increasing faster than system capacity, governments are eager to add large increments of generation, to head off public discontent and possible political unrest. In the absence of infrastructure for natural gas, the options available for large individual increments are traditional water and steam power, the latter usually coal-fired. Scarcity of capital, and the desire for modern technology, usually prompts governments to solicit international involvement in new generating capacity. Different emerging countries find themselves competing to attract international IPPs; and one condition IPPs in turn require is that they face as little risk as possible. They prefer to do business with the host government, and let the government and its taxpayers take the risk, by giving guarantees and long-term power

purchase contracts. A liberal context, especially one involving competition on the system, is unlikely to see IPPs agreeing to build large-scale generation based on water or steam power. Accordingly, governments wanting water or steam power will stop short of introducing competition - possibly well short. The token quasi-liberalization of IPPs on a monopoly government-owned system may be the extent of liberalization in evidence. Governments themselves may then have to carry the burden of enlarging the network, a daunting and potentially overwhelming challenge. The consequence may be a steady divergence between the structures of OECD systems, both institutional and technical, and the structures of systems in emerging countries. This may create unexpected stresses, particularly for multinational companies active in both contexts. On the other hand, the cost and difficulty of enlarging centrally-controlled networks may prompt increased interest in local networks not connected to the central system. Such local networks, perhaps at village level, are already becoming an attractive option in some emerging countries. If local networks prove themselves in non-OECD countries, they may become an influential consideration also in some OECD countries, as will be discussed in Working Paper 3 on *Decentralized Futures* and Working Paper 4 on *Network Futures*.

Transition countries, whose circumstances in the 1990s differ from those of both OECD and emerging countries, confront yet another array of technical options and constraints, whose priorities will once again depend on the extent and rate of liberalization that transition governments undertake. For most transition countries a distinctive determinant will be liberalization of the rest of the economy, and the corresponding impact on industries that have been historically the main electricity users under the former communist regimes. Losing their subsidized electricity will be among the factors that force these industries to become more efficient, to refine and redefine their productive activities, or to shut down. Many transition countries already have long if ambiguous experience of cogeneration, for industry and indeed for district heating. One important technical option in a liberalizing context in transition countries will therefore be modern cogeneration on site, with a significant move to gas turbines. Liberalizing the electricity system will enhance the potential of this option, if on-site generation is paid an economic price for electricity supplied to the system, and if prices for heat and electricity are linked appropriately to their relative costs - admittedly likely to be a matter for dispute. On-site generation and cogeneration may even be insulated to some extent from the introduction of competition on the system, since most of the output is likely to be designated for the site itself on a long-term basis, probably with long-term contracts for fuel supply. Transition countries, like emerging countries, will have to compete among themselves for the involvement of the major multinational companies, for capital, technology and possibly management. In the case of transition countries, however, multinational companies in general will be seeking more liberalization, not less, as a precondition for significant participation.

One conclusion is clear. The pattern of technology choices for the coming evolution of electricity systems will be affected profoundly by the extent to which systems are liberalized. In a liberal context, especially if the monopoly franchise is removed, technology choices now available, or likely soon to be, will interact with the system itself in ways whose long-term implications for the technical configuration of the system should not be overlooked or underestimated.

5. Liberalization and electricity institutions

Throughout the twentieth century an extraordinary assortment of institutional structures evolved in different places to plan, manage and oversee electricity systems. More extraordinary still is the corollary that all this institutional variety arose in the context of the same common technical model, the central-station synchronized AC system. From one standpoint, the fact that such a variety of institutional structures can sustain the same technical model underlines the robustness of the model. An alternative standpoint, however, might suggest that the crucial attribute hitherto has been the role of the central controller of the system, backed by the monopoly franchise, both established under the authority of the national government. All the multiplicity of institutional superstructures have been variants superimposed on this crucial attribute. Taxpayers to governments and captive electricity users have been the ultimate source of revenue for the system. The institutional structure has been able to keep the system robust by relying on this assured revenue to sustain all the requisite redundancy, and allocating the revenue among the institutional participants as it sees fit. From this alternative standpoint, liberalization that undermines the role of the central controller or weakens the monopoly franchise must eventually threaten the continuing stability of the system itself.

The validity or otherwise of these two contrasting views is likely to be tested to a conclusion in coming years. What institutions does an electricity system entail, and how are these institutions affected by various degrees of liberalization? For a synchronized AC system the key institution, as noted earlier, is that of the central controller, which in turn determines access to the network. Other essential institutions include:

- laws and regulations stipulating technical requirements;
- monopoly laws or regulations controlling pricing in the parts of the system where monopoly conditions prevail; and
- some institutional process whereby the system can be altered or expanded to match the changing requirements of electricity users - of necessity, in coordination with the central controller.

The rest of the institutional superstructure - for instance general company law governing legal and commercial entities involved, employment law, environmental law and regulation, and even international agreements affecting cross-border activities of electricity systems - have much in common with industrial and commercial institutions elsewhere in the economy. So long as liberalization does not jeopardize the essential institutions noted above, the traditional technical model of central-station electricity system remains plausible. If, however, liberalization threatens the role or authority of the central controller, or fails to provide for the other essentials listed above, the traditional technical model will be severely stressed. In the 1990s most attention has been directed to the policies affecting more peripheral institutional arrangements, such as ownership and price regulation. Even on a system such as that in England and Wales, where liberalization is considered to be far advanced, the crucial institutions have yet to face a test. The longer-term impact of abolishing the monopoly franchise is still hypothetical. The authority of the National Grid as central controller has never been challenged, although its demand in autumn 1997 to dispatch generators as small as 10MW may yet provoke the first serious opposition it must face. Problems of system capacity are those of

excess, not shortage, as some IPPs are beginning to discover to their cost. The real institutional crunch is yet to come.

6. Liberalization, electricity and environment

The environmental impacts of electricity systems are numerous and various. In the past two decades, environmental impacts - initially local, then regional and ultimately global - have risen up the policy agenda, exercising a significant and growing influence on the evolution of many electricity systems. Decisions affected by environmental considerations include facility siting and design, choice and design of technology, and choice of fuel - that is, the key determinants of the physical and technical configuration of the system. Governments, demonstrating their responsibility for the public interest, however defined, have established procedures to assess, evaluate and manage environmental impacts of electricity systems. Until recent years these procedures have been applied almost invariably in the context of a monopoly franchise system. In such a context the starting point is that the management of the system, under the oversight of the regulator and the central controller, has decided to add, say, a new power station, transmission line or other facility, to fulfil the obligation to supply. The presumption is that the management has endeavoured to comply with all relevant environmental criteria, for siting, emissions, effluents, waste and so on. The environmental assessment procedure is then directed essentially to establish whether in fact the proposed addition to the system does comply with the government's environmental criteria. The answer will be Yes or No, and will be fed into other aspects of the go/no-go decision on the proposed facility. Environmental impact is essentially a limiting condition on decision-making by the system management, usually in the context of investment in major facilities. System managements are expected to comply as a matter of course with environmental standards laid down by governments for system operations; failures are usually accidental, at least in OECD countries. The more profound interactions between electricity and the environment, however, seldom figure in such procedures.

One exception to this general rule is 'least-cost planning', 'demand-side management' (DSM) or 'integrated resource planning', which has been stipulated as a regulatory requirement on systems particularly in the US but also to some extent elsewhere. In such procedures the environmental impact assessment is carried out not in isolation, on a single proposed facility, but as an exercise comparing, at least implicitly, the environmental impacts of alternative options for modifying the system. The assessor may then direct the system management to proceed in a way held to be more environmentally acceptable but possibly more costly, for instance by supporting energy efficiency measures or renewable energy technologies. On a regulated monopoly franchise, the assessor or regulator can compel compliance with such directions. However, the jurisdiction of the regulator may not cover the entire network; and in a competitive context competing suppliers from outside the jurisdiction may not have to carry the same regulatory burden on behalf of the environment. This state of affairs already arises in parts of the US undergoing liberalization. It will become an increasingly important international factor in a cross-border competitive context like that established by the EU's 1996 Directive on a single market in electricity. In consequence, DSM and related procedures mandated by regulators are fading from the scene almost as rapidly as they

arose; and some environmental activists and organizations have decried liberalization of electricity systems as environmentally damaging.

Another viewpoint, however, is that liberalization may lead to profound changes in the structure, role and nature of electricity systems, and that these changes may indeed bring with them substantial environmental benefits. From this viewpoint, environmental considerations may represent not merely an array of limits and constraints on electricity activities, but the potential for positive opportunities, including commercial opportunities, for forms of business that are both economically and environmentally advantageous. The outlines of this argument, as it might emerge in Europe, were presented in RIIA Briefing Paper 34, entitled *Liberalizing Europe's Electricity: Impacts on Generation and Environment*, by the present author and Michael Grubb, published in November 1996. The response to this Briefing Paper since its publication indicates that the viewpoint it presented is widely shared in the international electricity policy community, albeit not yet perhaps as widely recognized by politicians and planners. This viewpoint will be explored in greater detail in Working Paper 5 on *Business Futures*.

One important corollary of this viewpoint is the need for governments to revise their approach to electricity and the environment, to foster the positive environmental potential of liberalization. As yet, governments embarking on liberalization of their electricity systems appear to pay little if any attention to the environmental implications of the process, leaving traditional environmental controls and constraints in place but implementing no innovative measures. They may be missing a valuable opportunity. In discussing the potential environmental benefits that liberalization could bring, the Briefing Paper noted the key role to be played by government policy, including

- the way in which continuing liberalization legislation is framed to reflect the full value of decentralized generation and encourage the activities of energy service companies;

- finance and taxation regimes affecting electricity investments on different timescales;

- research and technology development (RTD) and market supports to encourage continued technical advance in relevant generation technologies, including mechanisms to support currently less developed technologies such as biomass gasification and solar cells; and

- measures to affect relative prices, such as taxation or tradeable emission permits, that would help to internalize environmental costs and accelerate a transition towards cleaner electricity and heat supplies'.

Although the Briefing Paper focused on Europe, the relevance of such government policy measures is much wider. They could help to ensure that electricity liberalization, wherever it happens, is not detrimental but beneficial to the environment. As governments endeavour to fulfil their international environmental commitments, especially those under the Framework Convention on Climate Change, they may come to see electricity liberalization not as an impediment but as a step in the right direction.

7. Liberal electricity futures

As the foregoing commentary has atttempted to show, those who set out to 'liberalize' electricity appear not to have recognized just how profound the consequences might eventually prove to be. Seeking short-term immediate benefits, particularly for the governments initiating the process, they have nevertheless set in train sequences of change whose long-term implications may be sweeping. Because the short-term upheaval is so dramatic, and the sums changing hands so substantial, attention has tended to focus on the turmoil in the foreground - the confrontations and conflicts between those promoting liberalization and those opposing it, the battles between potential winners and potential losers, the policies and politics of an issue whose very novelty makes it compulsively engrossing even for many onlookers nominally on the sidelines. Over time, however, the process and consequences of liberalizing electricity will ultimately affect the daily life of every electricity user and potential electricity user on the planet.

It is a process - not a single change but a continuing series of changes. In due course these changes will alter not only the ways the world generates and delivers electricity but also the relationship between electricity systems and users, the financial structures and transactions involved, the types of business to be done, and the technical configurations of systems themselves. The trends and tendencies are already evident; but how fast and how far they may go in different places remains a matter for conjecture, not forecasts. One prognosis nevertheless appears robust. Electricity once liberalized is unlikely to retrace its steps in an 'illiberal' direction; the changes brought about by liberalization are almost certainly irreversible. In the new international context of electricity, a national government that decided to confiscate significant privately owned electricity assets without compensation would become a pariah; and no government is likely to be able to afford to pay acceptable compensation. A monopoly franchise once abolished is unlikely to be reimposed. The political outcry from competing entrepreneurs would be incendiary, especially from those whose fixed assets would be excluded from the new monopoly. Once electricity users become accustomed to choosing among competing offers, they will refuse to subside back into passive acceptance of monopoly pricing from a monopoly provider of monopoly services, the Hobson's choice of 'take it or leave it'.

At the same time, however, a liberal framework also allows much wider scope for mergers, acquisitions and alliances between private companies active in electricity, both within and across national borders. The speed and scale of such transactions is already breathtaking. Accordingly, even where the monopoly franchise is shrinking, regulation will still be crucial, especially if electricity systems come to be owned and operated by a small number of global corporate entities whose market power promises near-monopoly even with no franchise. In a liberal global framework for electricity, the tension between competition and consolidation may become a more profound challenge to regulators than any mere monopoly franchise could ever be. National governments, too, will have to rise to the challenge, establishing new ground rules to ensure that a liberal regime for electricity benefits the many, not the few.

The worldwide success of the common technical model of central-station synchronized AC electricity throughout the twentieth century has created a global appetite for electricity services, and the end-use applications technology to deliver them. But even as

the world has learned to appreciate electricity services, it has also learned that they can now be delivered in more acceptable ways. If the world were starting from scratch, to deliver the benefits of electricity using the optimum combinations of technology now available, it would not set up the infrastructure that currently exists. The inertia of this existing infrastructure and the institutions that have grown up around it will impede and prolong the process of change that liberalization has set in train. But the process will continue. In due course its effects will be felt throughout the whole of global society.