

Electricity: International Futures

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1. Introduction: the international dimension

Within a very few years electricity has leapt into the realm of 'international affairs'. A decade ago this was not the case. Electricity was simply not 'international' - not as a focus of policy. Oil, natural gas, coal and nuclear power all gave rise to significant issues of international policy, sometimes fraught with serious tensions; but electricity as such did not, at least not directly. Electricity technology, for power stations and other facilities, was sometimes traded and financed internationally, as was fuel for electricity generation. But electricity systems themselves were confined within national borders, both physically and institutionally, interacting across them only in limited and mainly cooperative exchanges, apart from a few cross-border contracts for hydroelectricity. The major decisions affecting any particular electricity system were taken within the relevant national border.

In the 1990s that situation has undergone a dramatic change. Electricity is now an international issue in its own right, indeed an entire complex of interrelated issues, evolving at a hectic rate. Governments, corporations, international bodies and non-governmental organizations are all caught up in the tumult. Moreover, the new international dimension of electricity is interacting with parallel developments in other aspects of electricity, including liberalization, decentralization, networks and business activities. This Working Paper will focus on the international dimension. Subsequent Working Papers will consider these other dimensions.

The new international dimension of electricity is already raising issues relating to finances, technology choices, institutional frameworks, environmental controls and sustainable development, among others, with many variations and nuances in different parts of the world. Consider for instance the following:

- Most of the distribution networks and a sizeable fraction of the generating capacity of the electricity system of England and Wales now belong to owners outside the UK. Significant proportions of the systems of Australia, Brazil, Finland, Portugal and a range of other countries now likewise belong to foreign owners.
- Although the US and French governments look with favour on the purchase by their electricity companies of foreign systems, neither government will allow foreign majority ownership of its own domestic electricity systems.
- Within the 1990s electricity generation fuelled by natural gas, especially in gas-turbine combined-cycle stations, has emerged as the technology of choice wherever natural gas is available, posing a growing challenge to generating technologies based on steam or water turbines, including coal-fired and nuclear power and large-scale

hydroelectricity. The fuel for many of the new combined-cycle stations is delivered continuously through international pipelines, some extending thousands of kilometres, in some cases through territories that are politically volatile. Unlike a coal-fired or nuclear station, a combined-cycle station is connected umbilically to its fuel-supply pipeline. Some stations hold stocks of liquid fuels as backup in case of interruption of gas supply, but many do not. Any protracted interference with international pipeline deliveries will rapidly exhaust alternative supplies, and make continued operation of stations affected substantially more expensive if not impossible.

- Some electricity systems that until recently operated with monopoly franchises granted by government, and with a corresponding obligation to supply all prospective electricity users in the franchise area, are now losing the monopoly franchise. As the monopoly franchise disappears, so does the obligation to supply. Attempts by governments to continue imposing this obligation through regulation may be difficult to sustain when system facilities belong to foreign owners.
- After eight years of tortuous negotiations, member states of the European Union in June 1996 agreed a directive according to which from 1997 onwards electricity users throughout the EU will be able to purchase an increasing fraction of their electricity from suppliers outside their national borders. But permission to arrange such deals will be allocated to users by member governments. Conflicts are already surfacing.
- Within an individual country different levels of government sometimes clash over responsibilities for electricity. Adding an international level creates further complications. For instance, the Indian government invited foreign companies to finance, build, own and operate new generating capacity on India's hard-pressed electricity systems. But one of the first eight so-called 'fast track' projects, at Dabhol in the Indian state of Maharashtra, suffered a prolonged and expensive delay when elections brought in a state government of a different political party from that of the national government. The new state government disowned the international agreements already signed, precipitating an international legal battle of alarming ferocity. Although a revised agreement was eventually reached, the longer-term effects on international confidence in such projects will cast a shadow of doubt over future international negotiations between corporations and the governments responsible for electricity systems.
- More than 150 governments have become parties to the UN Framework Convention on Climate Change. According to the Berlin Mandate agreed in April 1995 by the first Conference of Parties to the Convention, governments are committed to establish quantitative targets and timetables to reduce emissions of the 'greenhouse gas' carbon dioxide. Electricity generation from fossil fuels is the largest emitter of carbon dioxide from human activity. If governments are to meet their international commitments, many will have to adopt policies affecting the use of fossil fuels for electricity generation, on a basis not only national but international. Thus far they show few signs of doing so.

This is but a cursory selection of the international issues now affecting the world's electricity systems. Their short-term implications are so pressing and urgent that governments and corporations caught up them have little opportunity to look beyond them. But the current preoccupation with the turmoil in the immediate foreground should not be allowed to obscure the longer-term implications of the new international dimension of electricity, on which this Working Paper will focus. How the consequences evolve will have a profound influence on the shape of world electricity in the coming century, to 2020 and beyond.

The term 'international' of course implies nation-states, defined by government, borders, and relations with neighbours. The emerging international dimension of electricity therefore poses three key questions for national governments:

- Will the trend of the 1990s towards increasing internationalization of electricity continue?
- In an international and indeed global context for electricity, what issues will remain the proper concern of national governments, and how will they address these issues?
- If the trend towards internationalization of electricity continues, how may national governments act to fulfil international commitments, notably those undertaken at the UN Conference on Environment and Development in Rio in 1992, and in particular those under the UN Framework Convention on Climate Change?

These questions also underline and give particular point to a yet more fundamental question: what will be the responsibilities and competences of national governments in 2020 and beyond? The changing relations between governments and electricity systems offer a revealing microcosm of an issue much wider and even more challenging. At the same time, and partly as a corollary of the foregoing, the burgeoning international dimension also has major implications for electricity business and industry. This paper will explore possible international futures for electricity, and their implications.

2. Electricity and governments

What difference does the emerging international dimension of electricity make? One key difference is in relations between central-station electricity systems and governments - particularly national governments. After decades of comparative stability, these relations have plunged into a period of hectic change all over the world. Since the time of Thomas Edison's original Pearl Street installation in Manhattan in the 1880s, central-station electricity systems all over the world have always existed in a distinctive symbiosis with governments, initially local, then regional and national, for many reasons and with many local variants. One attribute, however, has been essentially common to all. For any given system, significant decisions have almost invariably been taken within national borders, and therefore ultimately under the aegis of the national government. In the 1990s, for a growing number of electricity systems, this is no longer the case. The longer-term consequences of this development are as yet unclear, and may be controversial. How will

international activities affect the role, responsibilities and powers of a national government in relation to electricity within its national borders?

At the heart of this question lies an intriguing paradox. In the 1990s, after a century of development, each central-station electricity system around the world is unique. Each has its own institutional structure, its distinctive framework of ownership, finance, law, and regulation, different from any other. Each system has grown up as a sort of fiefdom with its own internal rules, almost always as a franchised, regulated monopoly within clearly defined administrative boundaries, in a functional symbiosis with the relevant government. Yet each of these systems is in a crucial respect the same as all the others: each conforms to a common technical model. In the past century this common technical model has been replicated all over the world. It has given electricity an international dimension at once ubiquitous and almost unnoticed, because it is taken completely for granted.

In this model, large generators in central stations produce synchronized alternating current (AC) at a tightly controlled frequency and voltage, and deliver it over a network into equipment designed to operate with this electric current. While connected to the network, the end-use equipment is also part of the system. In effect, each synchronized AC system - generators, network and end-use equipment - is a single enormous machine, possibly extending over millions of square kilometres, in which electricity is generated and used essentially instantaneously throughout the system. Every component attached to the system must comply with strict technical standards and protocols, established and controlled centrally for the entire system. Any deviation from these standards can cause almost immediate shutdown of the offending part of the system; a serious deviation may trigger the progressive shutdown of the entire system in a matter of minutes. In December 1996, to mention but one recent incident, some 145 million people in northern India were deprived of electricity when an overload caused the system to collapse. In physical terms, synchronized AC electricity is not a commodity. Unlike, for instance, water or natural gas, electricity cannot be stored. It is a physical phenomenon happening simultaneously throughout the entire system. The energy taken out of the system by users must be replaced essentially instantly with an equivalent amount produced by generators. To be sure, if the system is large enough, it can adjust easily to relatively small changes of load and generation; but such adjustments must always be made, on a continuous basis, to keep the system in stable operation.

Accordingly, everyone attached to the system must be subject to the decisions of the central controller responsible for keeping the system stable. In the 1990s, in most countries of the world, electricity systems deliver services essential to society. Guaranteeing the stable and reliable operation of these systems has become an accepted responsibility of national governments, under the vague but impressive rubric 'security of supply'. A national government with this responsibility must therefore back the authority of the central controller of the system, either implicitly or explicitly. In other words, the apparently inexhaustible variety of institutional arrangements for central-station synchronized AC systems around the world must all ultimately support the overriding requirement of central control, to keep the system stable - to keep the lights on. This central control must ultimately be guaranteed by the national government, whatever its political or ideological character.

Nevertheless, precisely because the common technical model of synchronized AC has proved so robust, so adaptable and so successful, policy-makers have come to take it for granted; and most still do so. Its advantages have long been manifest. Generators driven by water power or steam power exhibit impressive economies of scale. Throughout the twentieth century, increasing the unit size of generators has dramatically lowered the cost of electricity, even after the additional capital outlay for delivery networks. The availability of low-cost electricity has in turn fostered spectacular growth in its use. In the 1990s, a modern industrial society would collapse in chaos if its electricity system failed. Its national government must keep the lights on. However, even as electricity has become essential to society, the technical model responsible for its worldwide ascendance is coming under insidious but relentless pressure. The attributes of a central-station synchronized AC system, in particular its absolute requirement for central control, makes it less than ideal as a basis for the liberal and international electricity regimes now emerging around the world. Tensions are already evident; they will intensify. National governments, preoccupied with the short-term effects of policies toward liberalization and internationalization, should not overlook their longer-term implications. In the coming century the common technical model of the central-station synchronized AC system, under the ultimate control of the national government, is likely to evolve beyond recognition. So may the responsibilities of the national government. Will it still be expected to keep the lights on? Will it be able to?

For most of the past century national governments have exercised a wide range of responsibilities over electricity systems within their jurisdiction. The simplest solution has been for the national government to own the entire system except the end-use equipment, effectively as a department of government, on the basis that delivering electricity is a 'public service' and thus properly the responsibility of government. The OECD country most committed to this approach - internally if not externally - is France, with Electricité de France. Other OECD countries including Greece, Ireland, Italy, New Zealand, Portugal and the UK entered the 1990s with similar arrangements, as did the former communist countries of central Europe, the then Soviet Union, and most countries in Africa, Asia and Latin America. In Australia, Brazil, India and several other geographically large countries, provincial or state governments rather than the national government owned the electricity systems within their territory. In OECD countries including Germany, Japan and the US, by contrast, electricity systems were owned primarily if not entirely by private capital, sometimes in complex cross-ownership between different systems and parts of systems. In other OECD countries including Austria, Finland, Norway and Sweden ownership was divided more evenly between government and private capital. In many countries, moreover, local distribution networks were owned by local communities, municipalities or cooperatives, taking their electricity from a high-voltage supply under different ownership.

In the 1990s, these patterns of ownership have shifted dramatically away from governments to private capital, including foreign capital, and the shift is continuing. However, whatever the particular pattern of ownership of a given system, one corollary remains clear. Ownership of part of a synchronized AC system confers strictly limited control. Oddly enough, the prevailing assumption everywhere is that the only participants with complete freedom on a central-station electricity system are the users, who can

connect or disconnect equipment effectively at will. The rest of the system is committed to respond accordingly, to maintain overall stability; and it does so under central control. The owner of a particular power station cannot operate it at will, but must adjust its output as the central controller instructs. The only absolute right the power station owner has is not to operate - to remain off the system, and of course to forgo any revenue that might otherwise be earned. In appropriate circumstances, to be sure - if other available generating capacity cannot match the load on the system - this right may prove extremely potent. At the beginning of the 1990s, electricity systems in most OECD countries had a significant redundancy of capacity for generation and transmission, constructed to ensure system stability, for instance by having standby generators ready in the event of outages. This redundant capacity was built almost exclusively in the context of a system holding a monopoly franchise, and was paid for by the captive customers of the monopoly. In a liberalized future, private ownership may be less willing to construct redundant generating capacity that may not earn revenue. The implications for system stability may be problematical, and will be explored further in Working Paper 2 on *Liberal Futures*.

Given the necessity for central control, the pattern of ownership of a synchronized AC system is therefore of only secondary importance, if enough total generation and transmission capacity is available. A national government does not have to own a system to keep the lights on, provided the private owners accept the requisite central control. But even apart from keeping the system stable, a national government has other historical responsibilities for electricity within its borders, some of which are also changing rapidly in the 1990s. Historical responsibilities of national governments for electricity have also included:

- company law on trade and commerce, including control of monopolies;
- planning permission for installations, and wayleaves to run networks through public spaces and private land;
- licences and other permits for access to the electricity system;
- health and safety standards and oversight:
- employment law;
- environmental standards and controls;
- regulation of tariffs and other charges for system use and services;
- investment approval and other financial oversight;
- sovereign guarantees for loans, investment and contracts;
- taxation;
- subsidies;
- insurance;
- research and technology development;
- fuel procurement;
- equipment procurement;
- appointment of senior staff; and
- international agreements affecting electricity systems.

In the 1990s, in many countries, many of these historical responsibilities of national governments are being reassigned, redefined or abandoned. As yet the process of change is still in its very early stages, and appears to be following widely different courses in

different places as governments feel their way into unfamiliar institutional territory. In the 1990s governments clearly expect to retain the advantages of central-station synchronized AC electricity, while relaxing or reshaping institutional provisions previously taken for granted as a concomitant of this technology. Much of the reorganization now under way is taking place purely within national borders, and will be considered in later Working Papers. This paper will focus on reorganization that gives electricity a new international dimension.

In OECD countries, electricity systems established under the traditional regime of regulated franchised monopoly are in general mature, functional and robust. As reorganization proceeds, the physical and institutional margins inherited from the old regime will probably enable systems to withstand the sudden injection of administrative uncertainty, at least for some time to come; but the stresses already evident will intensify. At the same time, as a corollary of internal reorganization within national boundaries, innovative and aggressive electricity entrepreneurs from OECD countries are moving beyond their borders in search of new business opportunities, including new kinds of business; and opportunities appear to be abundant. In countries in transition from former communist regimes, electricity systems are already struggling to recover from decades of mismanagement and maladministration, with varying degrees of success. Reorganization is not optional but essential; and so many of their historical assumptions have recently been overthrown that an additional measure of physical and institutional uncertainty may make little difference. Countries that used to be called 'developing' now include many whose electricity systems are hard-pressed to deliver enough output, as electricity use burgeons explosively. In these 'transition' countries and 'emerging' countries, national governments attempting to cope with their internal electricity problems have looked for assistance internationally. In doing so they too have been caught up in the process of change away from the traditional ground-rules for electricity. The old electrical fiefdoms, each self-contained within national borders and enjoying a mutually supportive symbiosis with national governments, are starting to dissolve.

Subsequent Working Papers in this series will consider other longer-term implications of liberalizing electricity policy - abolishing the monopoly franchise, introducing competition in generation and supply, privatizing electricity assets previously owned by government, and relaxing government constraints on the production and sale of electricity and electricity services. This paper focuses specifically on one important corollary of liberalization. The liberalized electricity policies introduced by some national governments - those of Australia, Brazil, Chile, Finland, New Zealand, Norway, Sweden and the UK, among others, with more to follow - have introduced the concept of foreign ownership and management of power stations, networks and indeed entire electricity systems. In itself, of course, foreign ownership of assets is not novel; it has long been commonplace in many countries and many contexts. Nevertheless, in the context of a central-station electricity system, it raises a potentially sensitive issue. Over the past half-century, in OECD countries and a growing number of others, people have come to take electricity for granted as an essential feature of civilized society. They assume moreover that under all conceivable circumstances the government - that is, ultimately the national government - is responsible for keeping the lights on. In an international future for electricity, can this assumption still hold?

3. Internationalization and electricity finance

In the early years of central-station electricity, when entrepreneurs such as Edison were promoting the new technology across North America and Europe, finance for electricity developments had a prominent international dimension, as did ownership of at least some systems. Throughout most of the twentieth century, however, as systems grew steadily larger and their interactions with national governments more intense, the financial structures of systems in OECD countries withdrew within national borders. Ownership, investment and revenue became national or subnational. In the Soviet Union, of course, electricity finance was entirely under the control of the national government in Moscow; the communist satellite regimes that took over in central and eastern Europe after 1945 followed the same pattern. Distinctive instances of international finance for electricity did continue to arise, particularly in developing countries eager to expand their systems. The so-called 'Atoms For Peace' programme, launched by the US and endorsed by the UN, provided bilateral and multilateral international support, both financial and technical, to help establish nuclear power programmes in developing countries including India, Pakistan, Argentina and Brazil. Egypt, Zaire, Argentina, and Mozambique, among others, attracted international finance for very large hydroelectric projects, at Aswan, Inga, Itaipu and Cabora Bassa respectively, intended primarily to provide cheap electricity for huge new industrial installations. Such megaprojects were a manifestation of the philosophy the World Bank and other major financial players then espoused, that equated electricity more or less uncritically with development.

In general, however, as the role of electricity in society became steadily more important, national governments came to exercise almost complete control over system finances, either directly or indirectly. From the 1940s onwards some, including France, the UK, Italy and Portugal, did so by nationalizing the systems, taking them into government ownership and placing them under government control, on the basis that this would foster rationalization and economies of scale. Even in countries like the US, Japan and Germany, where systems were mostly privately owned, national and regional governments could and did exercise powerful leverage over them. They legislated and enforced technical standards for connection to the synchronized AC system, with concomitant costs. They granted monopoly franchises, imposed an obligation to supply, and established regulatory mechanisms and processes with potent influence on investment, revenue and proceeds. They supervised securities, imposed taxes and mandated various forms of subsidy. Elsewhere, meanwhile, national governments and regional governments intervened more explicitly in the financial affairs of the electricity systems in their jurisdiction. In various ways, governments granted or refused approval for investments; advanced loans on advantageous terms from government funds; underwrote and guaranteed other loans; directed fuel purchases and equipment procurement; mandated subsidies and cross-subsidies; and otherwise exercised the main responsibilities and prerogatives of system management. Underlying all these activities, whether direct or indirect, was the presumption - by now widely taken for granted by both the government and the public - that the government was ultimately responsible for the financial health of the electricity system. No matter what happened, the government could not let the system go bankrupt. In financial as in other terms, the government had to keep the lights on.

By the 1970s, electricity systems in most OECD countries had achieved a degree of maturity. System capacity was more or less in balance with system loads. Despite occasional flurries of controversy, change was gradual and could be accommodated without serious disturbance to the prevailing comfortable equilibrium - financial, technical and institutional. Beneath this placid surface, however, disconcerting ideas were starting to circulate. In many OECD countries a furious debate about nuclear power gradually spread to embrace wider issues, eventually challenging key assumptions about the structure and function of electricity systems. Outside the OECD, in general, systems were in any case far from such comfortable equilibrium. Systems in countries under communist rule were suffering increasing stress, as central planning and inadequate decisions misallocated financial, physical and human resources. Far from keeping the lights on, governments were turning them off. At the same time, systems in many developing countries were steadily losing ground. No matter how rapidly they expanded system capacity, the desire for electricity expanded faster, exacerbated by prices kept low for political reasons, and extravagant subsidies to politically influential constituencies such as industry and agriculture. Some megaprojects with international financial support failed to achieve their intended capabilities, further complicating matters. Systems in developing countries were almost invariably run as a department of government, financially and otherwise. System investment, procurement, tariffs, and employment had to conform to the government's political agenda, almost regardless of other financial and economic criteria. The public, of course, blamed the government for the shortcomings of the electricity system, further aggravating the mounting tension.

Over time, in a growing number of countries, both OECD and non-OECD, governments began to feel that their monopoly electricity systems were becoming difficult if not impossible to control. The first major break with the established patterns came in Chile. In the mid-1980s Chile's electricity system, like those of many OECD and almost all non-OECD countries, was owned and operated as an arm of the national government. In 1985, however, the Chilean government informed the various entities constituting the nationally-owned electricity system that they were to be sold to private investors. In 1988 the government split up the two major companies into an array of separate generating companies and distribution companies, plus two separate high-voltage transmission grids, and sold almost all the assets in a public offering. The government aimed the privatization and liberalization programme essentially at indigenous Chilean investors, rather than potential foreign participants; as noted earlier, the longer-term implications of privatization and liberalization of electricity systems will be the focus of the next Working Paper in this series. But the Chilean process also acquired an international dimension. Foreign companies were soon scrambling for a foothold in Chile's new liberalized system; and other national governments, encouraged by Chile's example, set off along similar paths.

The government of the UK, like that of Chile, was committed to a free-market ideology and opposed to government ownership of economic enterprises on principle. But both governments also recognized that selling off government enterprises could raise substantial revenue for the national treasury, and both had pursued extensive and lucrative programmes of privatization, Chile since 1974 and the UK since 1981. In 1988 the UK government announced that it would break up and privatize the UK electricity system. The process proved to be untidy and ad hoc, as initial intentions were confounded

by subsequent events. Almost a decade later the process of liberalization is still in train; its longer-term consequences are still obscure. However, as with the process in Chile, electricity privatization in the UK soon acquired an international dimension of widening scope and import.

One of the most visible early manifestations of this new international dimension was the rise of electricity evangelism. Flushed with enthusiasm for the new private-sector electricity system, UK electricity organizations despatched representatives on international missions all over the world, to spread the gospel of privatized electricity on the 'UK model'. However, whereas in Chile and the UK the initial stimulus toward privatization was at least arguably ideological, elsewhere it was unambiguously financial, even in countries by no means eager to surrender direct government control of the electricity system. Many other governments examined the 'UK model' with keen interest, as did their electricity organizations. But the ideological acclaim for free markets and competition was of only secondary interest. What generally held the attention of many governments was the possibility of getting out from under the financial burden imposed by their national electricity systems. Ironically enough, throughout the 1980s, the UK system before privatization had been paying a steady and substantial return to the UK government. For many other governments, however, especially those in developing countries, the electricity system, with its insatiable demand for capital and often also for foreign exchange to pay for imported fuel, was a perpetual and wearying drain on the national budget, especially when tariffs were held artificially low for political reasons. Equating electricity to development, long a justification for rural electrification and other debatable investment in electricity systems, intensified the dilemma.

In the 1990s, therefore, the government initiatives to privatize and liberalize electricity systems in Chile and the UK have been followed by a rising wave of similar moves by governments all over the world, in OECD, transition and emerging economies alike; and the process is accelerating. Finance is not always the cited motivation. In some OECD countries, for example, government rhetoric stresses the virtues of competition as a way to improve economic efficiency, reduce prices and enhance service to customers. Whether the rhetoric is validated by results will be examined in Working Paper 2. In the background, however, finance is clearly playing an influential role even in OECD countries; in transition and emerging countries it is undoubtedly the prime motivation. Indeed it is such a potent motivation that it is overriding the reluctance of many governments to relax their grip on their electricity systems.

This process is different in key respects from earlier international participation in electricity projects. Over the years, of course, many power stations and other facilities have been built by foreign firms under contract to the electricity system or its government owner. But the contractor then hands over the plant to the buyer; the contractor has no subsequent responsibility for the operation of the plant as part of the system, and - apart from warranties for performance - no financial involvement in the plant as part of the system. In the 1980s the government of Turkey, facing financial constraints on expanding its system, proposed a major modification of this arrangement. The Turkish concept was initially called 'BOT', for 'build, operate, transfer'. Instead of paying the contractor directly to build the station, the government invited the contractor to finance it, to build it, to operate it and to sell its output to the national electricity system, over a period of time

long enough to recover its costs and earn an appropriate return on its investment. When this period - perhaps twenty years, but negotiable - expired, title to the plant would be transferred from the builder-operator to the host government or its electricity system, which would presumably continue to operate it and retain subsequent proceeds. Although the concept sounded promising in theory, especially in the 1980s when power plant manufacturers were struggling to find orders, its practical impact was limited. Protracted negotiations for proposed BOT plants in Turkey and elsewhere were overtaken by the much more sweeping innovations of privatization and liberalization, into which BOT and its variants have been largely subsumed.

In the 1990s the acronym most often quoted is IPP, for 'independent power producer' - a generating plant that sells its output to the system and operates in compliance with the system, but is not owned by the system. An IPP owner-operator is under no obligation to surrender title to the plant during its lifetime, or limit its earnings to any level previously agreed with the host system or government. In that respect an IPP is under significantly less stringent control by the host system or government. IPPs, however, face other financial hurdles not always easy to resolve, notably those of tariffs for the sale of output; to earn an adequate return, IPPs usually require higher prices than are paid for the subsidized generation elsewhere on the system. Moreover, for a proposed IPP, liberalization extending to competition is not an enticement but a deterrent. Partly because of these hurdles, the immediate practical effect of most electricity liberalization in the 1990s has not been to stimulate financing or construction of new capacity. Instead it has been manifest mainly as the sale of existing government-owned electricity assets, including power plants, transmission lines and distribution networks, to private buyers, often foreign.

Because the government arranging the sale is eager for it to proceed, sale prices either for public offer of shares or for direct sale to a single purchaser must not be set so high as to deter prospective buyers. In consequence, many privatizations attract criticism that the government is disposing of taxpayers' assets at knockdown prices. In some cases, analysts argue that government control of electricity systems has been so tenuous that the government simply does not know the value of assets to be sold. Some critics go so far as to suggest that those ideologically opposed to government ownership of economic assets sell them at a low price, so that no successor government can afford to renationalize them except by refusing compensation. That would effectively be confiscation, a politically explosive measure at the outer limit of plausibility, at least in the 1990s, in any OECD country and indeed in many others. Certainly the prospect of reversing the process, and taking electricity assets back into the ownership of the relevant government, looks highly implausible essentially wherever system assets have already been successfully privatized. Be that as it may, a steadily increasing proportion of the world's central-station electricity systems is now owned not only by private capital but by foreign capital.

4. Internationalization and electricity technology

The most long-standing international dimension of electricity has been the gradual but irresistible spread of the common technical model of the central-station synchronized AC system. In the 1990s almost any discussion of electricity technology starts from the premise, usually unstated, that the technology is or will become part of a synchronized AC system. Historically, even while individual systems have been local fiefdoms at or below national level, trade in technology for synchronized AC has been conspicuously international. Throughout the past century, electricity technologies traded internationally have included boilers, steam turbines, water turbines, diesel engines, alternators, transformers, switchgear, transmission and distribution cables, monitoring and control equipment and countless smaller components.

In the course of the twentieth century a number of countries came to have major indigenous manufacturers of electricity technology, especially the largest items of plant such as boilers, turbines and alternators. These manufacturers expanded their production capacity in line with the expanding requirements of their indigenous electricity systems for more and larger units. From the 1950s onward, national governments with significant indigenous manufacturers generally stipulated, formally or informally, that electricity systems in the country must purchase major items of new plant such as new power stations from indigenous suppliers, not from foreign competitors. OECD countries including Belgium, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, the UK and the US each had major national manufacturers of power station technology, with a more or less privileged home market. Some, including Germany, Japan, the US and the UK, had several major manufacturers, making the home market itself competitive, at least in theory if not always in practice, between the indigenous manufacturers. In general, however, international competition took place only outside the collective home territory of these manufacturers.

One particular anomaly should be noted. The advent of civil nuclear power after the mid-1950s prompted a flurry of international dealing involving national governments, major manufacturers, the United Nations and the International Atomic Energy Agency it established. From that time onward nuclear power technology has been a special category of electricity technology, subject to its own rules and with its own international dimension, unlike any other category of electricity technology. The significant and singular status of nuclear power has had a potent influence on electricity technology ever since. In economy of scale and its corollaries, a nuclear power station is the apotheosis of the technical evolution of the central-station electricity system.

While electricity systems in OECD countries were expanding rapidly, their indigenous suppliers of steam-based power plants were thriving. They expected and received a steady diet of orders for new plant, each larger than the last, with more demanding technical parameters for efficiency and performance. Hydroelectric plant manufacturers, to be sure, were less happy; suitable sites were harder to find, and public opposition to dams and reservoirs was becoming troublesome. In OECD countries, before the end of the 1960s, the age of the big dam appeared to be over; but that of the big steam-powered station appeared to be emerging in its place. It proved to be disconcertingly short-lived.

The OPEC oil shock of 1973 changed the energy ground-rules. Among its many effects, both immediate and longer-term, was a dramatic change in the context of central-station

electricity systems within the OECD. Systems that had come to expect uninterrupted and relentless growth in electricity use at rates up to 7% per year found instead that growth rates shrank to 1% or less; on some systems, for some years, electricity use stopped growing entirely, or even declined. For manufacturers of steam-cycle power plants this was profoundly unwelcome news. The systems in their home territories already had many new plants under construction, in unit sizes up to 1000 megawatts and even larger, ordered in anticipation of future growth in load that by then looked very unlikely to materialize. By the late 1970s orders for new plant in OECD countries were evaporating. Plant manufacturers saw their protected home territory, recently so fertile, wither away.

Their obvious option was to look for business beyond their borders. Manufacturers of fossil-fuelled and nuclear steam-cycle plants stepped up their efforts to find buyers for their established technology of very large units - up to 1000 megawatts and even larger - in developing countries. But they faced one obvious and major problem. Electricity systems in many developing countries were indeed desperately short of generating capacity to satisfy their compatriots' desire for electricity. But they were also short of capital; and large power stations, especially nuclear stations, devour capital. Many countries that would happily have ordered new coal-fired or nuclear plants from OECD manufacturers simply could not afford them. For their part, the manufacturers were used to receiving orders on a turnkey basis. Once the plant was completed and handed over to the purchaser, the manufacturer collected the final payment and had no further responsibility for the plant apart from warranties. Longer-term commitments were outside their corporate experience and strategy.

In the 1980s, developing countries did manage to order a few steam-cycle plants. The coal-fired and oil-fired plants usually had financial backing from the World Bank or regional development banks; one nuclear plant, in southeastern China north of Hong Kong, was turned down by the World Bank but generously financed by France's export credit agency in support of the French manufacturer Framatome. Meanwhile, however, the international dimension of electricity technology was undergoing a rapid and far-reaching change. In the 1990s the old concept, of a manufacturer simply selling a power station to a foreign buyer, handing over all responsibility and control, has been largely and surprisingly superseded by very different arrangements. These different arrangements carry intriguing implications for the particular technologies that may be chosen, and for the role of the technology manufacturer in the process. Over time the outcome may be significant change in the overall technical configuration of the electricity system.

One additional technical constraint, with financial implications, should also be noted. To ensure the stability of a synchronized AC system, its operators must have available standby generating capacity in readiness to take over almost immediately if a working unit should fail. Good practice considers that this so-called 'spinning reserve' has to be at least as large as the largest working unit that can fail. In the 1990s, for systems in OECD countries, the requisite redundancy is generally available; the systems can usually accommodate units of 1000 megawatts and larger while ensuring stability. For a smaller system in a developing country, however, a 1000-megawatt unit could represent more than 10 per cent of total system capacity. If such a unit fails, the result may well be rapid and total shutdown of the entire system. In general, therefore, the most modern designs of large steam-turbine units, of the type historically ordered in the OECD, are ill-suited for

such smaller systems. OECD manufacturers of generating plant seeking to trade internationally in electricity technology have long been hampered by this technical mismatch between what they can sell to systems on their home territory and what they can sell for export. In the 1990s, however, an unexpected crossover is beginning to materialize. As systems in emerging countries grow to accommodate larger generating units, those in OECD countries, where electricity use is increasing much more gradually, are now ordering smaller units. In the short term, the consequences for international trade in electricity technology may be to reverse the previous mismatch. Over time, however other possibilities may also materialize.

Until the 1990s one dominant factor in the market for the sale of technology for electricity systems has been that the manufacturers of major plant for generation, transmission and distribution have been - with the exception of certain nuclear manufacturers such as Framatome - privately-owned corporations. Outside certain OECD countries, however, the electricity systems buying the technology have been government-owned. Government backing has facilitated finances and contracts for large-scale long-term projects, by reducing the risks involved, the cost of capital and the consequent required rate of return. The participation of governments has thus enabled fast-growing electricity systems in emerging countries to follow the technological pattern previously established in OECD countries, in pursuit of the classical economies of scale of large generators and high-capacity networks. In the 1990s, however, potentially conflicting trends are surfacing. On one hand, electricity systems such as those in southeast Asia are adding capacity as fast as they can, trying to keep up with increasing electricity use. On the other hand, such systems are under mounting pressure to relax government controls and liberalize their administration, possibly even permitting competition. Liberalization means reducing government participation in the electricity systems within their territory. If this in turn makes governments less inclined to offer unqualified backing for finances and contracts, the risks to private investors will go up, and so will the cost of capital. In such a context the apparent economic advantages of large projects with foreign participation may be weakened, if not indeed vitiated by the risks. The growing reluctance of the World Bank and other international funding agencies to support megaprojects will reinforce this trend. Foreign private investors, already wary of risks, prefer continuing monopoly, rather than competition, putting them increasingly at odds with the World Bank and other advocates of liberalization, and further undermining the support for large projects.

Where governments do continue to play a dominant role in managing electricity systems, another factor can influence technology choice. The largest and most expensive projects are the most politically visible, and the most potentially vulnerable. Host governments still tend to want large projects for reasons of prestige; but host governments can change. While the state government of the Indian province of Maharashtra was attacking Enron's gigawatt-scale Dabhol project, elsewhere in India at least eight smaller independent power projects with foreign participation were proceeding without hindrance. The lesson may not be lost on major international manufacturers.

All these factors may shift the balance of preference between central-station generating technologies from larger-scale to smaller-scale units, even on fast-growing systems. For such systems, except where hydroelectricity remains a plausible option, the choice for

some time to come will still be mainly between steam-turbine units firing coal or oil and gas-turbine units firing natural gas, probably in combined cycles, and may be determined principally by the availability and price of natural gas. If a new generating unit on an electricity system in an emerging country is to be gas-fired, it will almost certainly entail international involvement, not only for the gas turbine but also for the natural gas supply including gasfield development and delivery network, which may itself be international. In the short term, some governments may be perturbed by the prospect of substantial international involvement in gas-fired generation. That may pose problems for some systems, such as those in northern China, and tilt the balance towards entirely domestic projects using domestic finance, domestic technology and domestic fuel, almost always coal. On the other hand, China and Russia are already discussing possible cooperation on cross-border development of Russian gas for Chinese electricity, and similar proposals are taking shape elsewhere.

Where gas-fired generation is politically and technically feasible, it has obvious attractions, not least because it has become the technology of choice for new capacity on systems in OECD countries. The potency of international example should not be underestimated, especially when international engineering companies can benefit by fostering convergence. Over the longer term, under policies of liberalization and competition, mature OECD electricity systems may continue to evolve towards more small-scale generation, including on-site generation and cogeneration. If these concepts are adopted by systems that are still expanding rapidly, the technical configuration of these systems may diverge significantly from that of the classical central-station system typical of OECD countries. Systems with fewer large generating units and a much higher proportion of smaller units would be inherently more distributed and decentralized. Governments that currently maintain tight control over their electricity systems might, of course, have other ideas. Later Working Papers will explore the possibilities.

5. Internationalization and electricity institutions

Over the first century of electricity systems, institutional frameworks affecting them have grown up essentially within national borders. Laws, statutes, regulations, organizational structures and administrative procedures for electricity systems have emerged under the aegis of national governments, each in its own national political context. International influence on these frameworks has been limited and indirect, arising in particular from the actual or presumed common requirements of the common technical model of synchronized AC. In general, however, this international influence on institutional frameworks has crossed national borders by example and analogy rather than more formal international arrangements.

Historically, institutional arrangements for electricity have been established by governments, initially local, then regional and in due course national. Until the 1990s, however, international institutional arrangements for electricity have been largely confined to agreements affecting delivery of electricity across national borders, either through cooperative load-balancing links such as those of the Union for the Coordination of Production and Transmission of Electricity (UCPTE) in continental Europe, or in

contracted purchase agreements such as those between Hydro-Quebec in Canada and electricity systems in New York state. Parties to such transactions must comply with mutual technical protocols to maintain stability of the AC networks on either side of the national border. The international agreements covering the cross-border relations contain agreed procedures for resolution of disputes, and explicit acknowledgment of the relevant jurisdictions for decisions. In other respects, however, each party has been subject to the institutional arrangements in place within its own national borders. As the international dimension of electricity continues to expand, the institutional arrangements must be revised accordingly. Doing so has already proved difficult, as national governments are compelled to concede an increasing measure of international involvement in their national policies for electricity. The protracted controversy over the proposed 'Single Market' for electricity within the European Union is but one striking example of the conflicts now arising. Despite the Electricity Directive that came into force on 1 January 1997, stubborn disagreements continue about cross-border competition, access to networks and other intractable differences. Member countries of the EU have very different institutional and regulatory structures for electricity. No common framework exists, nor can one be readily envisaged. Similar problems will arise elsewhere.

Consider again the list, cited above, of historical responsibilities of national governments for electricity within their borders. National governments around the world have passed legislation, laid down regulations and procedures, and created, staffed and financed departments, agencies and other organizations to fulfil these responsibilities. Even in the context of liberalization and internationalization of electricity systems, some of these historical responsibilities will remain unambiguously within the remit of individual national governments, so long as national governments themselves remain recognizable in their present form. National governments will still establish and administer company law on trade and commerce, including control of monopolies, and employment law, even when the law must also apply to international companies operating within the country's borders. Governments will still grant or refuse planning permission for installations, and wayleaves to run networks through public spaces and private land. They will create and oversee standards for health and safety, and also for environmental impacts, although international considerations such as industrial competitiveness, fair trade and other issues will exert pressure for international harmonization of national standards. National governments will continue to impose and collect taxes wherever they deem appropriate in electricity activities; indeed, if international pressures affect the processes of taxation, the implication for the role and nature of the nation state will be profound. National governments, of course, will be responsible - almost by definition - for negotiating and implementing international agreements affecting electricity systems.

On the other hand, however, some governments have already surrendered some of their historical responsibilities for electricity. Other governments and other responsibilities may go the same way, as a consequence of liberalization, internationalization or both. The effects of liberalization itself on national institutions for electricity will be considered further in Working Paper 2. This paper will concentrate on the international dimension. Even with very limited liberalization, perhaps to the extent of accepting independent power producers to add generating capacity to an otherwise traditional government-controlled monopoly franchise system, international considerations already often interact

with government responsibilities, and alter the way governments exercise these responsibilities.

In many non-OECD countries, for instance, governments still directly control their electricity systems and have hitherto been explicitly responsible for setting tariffs, holding them anomalously low for internal political reasons. The case of India is perhaps the best-known, but by no means unique. Now, however, a government wishing to attract foreign investment in IPPs faces relentless international pressure, from the International Monetary Fund, from the World Bank and from other sources of multilateral finance, as well as commercial banks, to increase such unrealistic tariffs as a precondition for international financial support. One way to deflect the consequent political opprobrium is for the government to set up a separate regulatory agency, at least nominally independent of direct involvement by the government.

International pressures are thus already bringing about changes in the institutional framework even where liberalization has only the most limited foothold as yet. Where liberalization is well under way, international involvement often enhances its effect, further diluting the residual control of the national government. Foreign ownership also has more subtle effects. Senior staff of an electricity system in a given country may no longer be citizens of the country, or indeed even residents. A national government can no longer instruct electricity systems to procure either fuel or equipment from indigenous sources, if foreign sources offer better terms. One less obvious corollary is that even if a government still devotes significant funds to research and technology development for electricity, it cannot be sure that the technology will be adopted by systems within its borders. This in turn further undermines the rationale for government-supported research and technology development (RTD) for electricity, and the institutional arrangements for such RTD.

How will national governments accommodate themselves to such cumulative changes in their indigenous electricity institutions in an international context? One general principle, already identified in the Energy Charter Treaty, is that of 'national treatment'. According to this principle, national governments that accede to the Treaty will treat foreign companies active within their borders at least as well as they treat indigenous companies - adapting indigenous institutions accordingly, imposing no constraints on foreign companies that are not also imposed on indigenous companies and so on. As applied to electricity, this principle has yet to be tested in practice; but it could come to figure prominently if and when electricity developments take their place alongside oil and gas developments in countries party to the Treaty. It may also be called into play in countries not party to the Treaty, simply as a principle of international equity, although its application may fall foul of governments accustomed to keeping their electricity systems and related organizations under close control.

One conclusion at least is clear. Existing international institutions as yet fall well short of those that will be required for the international futures already emerging for electricity, involving not only international technologies and finance but also international ownership, international trade, international environmental commitments and other international aspects. Institutional innovation to maximize benefits and minimize conflicts will be both a challenge and an opportunity.

6. Internationalization, electricity and environment

Well before electricity itself became an international issue, environmental impacts of electricity generation acquired an international dimension. To be sure, many environmental impacts arising from electricity systems - visual intrusion, noise, water pollution, smoke and particulates, solid waste - were and remain more or less local, within the vicinity of the facilities causing them. However, in the 1970s scientific evidence demonstrated that sulphur dioxide emitted from fossil-fuelled generating stations was becoming a significant and unwelcome export from countries in Europe and North America. The introduction of tall stacks, intended to 'dilute and disperse' pollutants, had turned a local environmental impact into a regional impact, with deleterious effects often hundreds of kilometres beyond the national borders of the country of origin. Damage to waterways and forests in Scandinavia was attributed to acid precipitation originating in the UK, Germany and Poland, and damage in Canada to sources in the US. International tensions mounted. At length, intense diplomatic negotiations under the auspices of the UN Economic Commission for Europe led to agreement on a Convention on Long-Range Transboundary Air Pollution, according to which countries would undertake to reduce their emissions of sulphur and nitrogen oxides on an explicit timetable. Many national governments party to the Convention passed legislation stipulating the installation of flue-gas desulphurization (FGD) and control technologies for nitrogen oxides on new generating stations, and sometimes on existing stations. Germany, for example, retrofitted some 37 gigawatts of generating capacity with FGD in less than five years, a major financial burden on its electricity systems. The cost implications remain contentious, in the context of subsequent moves towards liberalization.

The sulphur-control issue demonstrated a critical feature of international environmental policy. An agreement negotiated internationally must then be implemented by the national government, which will have to balance the pressures from its international diplomatic and trading partners with those from organizations and individuals within its borders who may see their interests suffer as a result of measures agreed internationally. Some industries have already threatened to move elsewhere if national governments impose stringent environmental controls. For electricity systems confined within national borders, such an option is not available. However, as the international dimension of electricity expands, national governments may face novel and daunting forms of opposition to tighter environmental controls, including the flight of capital.

Be that as it may, the international problem of sulphur control has been merely a foretaste of the role that international environmental concern has since come to play, applying pressure on the electricity policies of national governments. The issue of overriding importance is that of carbon dioxide, an inevitable concomitant of burning fossil fuels. The Intergovernmental Panel on Climate Change, in its Second Assessment Report published in June 1996, concluded that 'the balance of evidence suggests a discernible human influence on global climate'. Electricity generation from fossil fuels is the largest single human contribution to emissions of carbon dioxide to the atmosphere. Policies and measures, targets and timetables negotiated at the third Conference of Parties to the Framework Convention on Climate Change in Kyoto in December 1997 must address the

problem of carbon dioxide from electricity generation. How they may do so as yet remains to be seen. A wide range of options is available, but none is free of awkward problems; and the expanding international dimension of electricity will impose serious constraints on national governments attempting to implement measures on systems inside their national borders.

One option in which interest is steadily growing is that of so-called 'tradeable permits' for carbon emissions. The US already has an active market in tradeable permits for sulphur emissions, administered by the Chicago Board of Trade. However, even allocating the initial tranche of carbon-emission permits on a global rather than national basis poses acute diplomatic difficulty. Administering a subsequent market in such permits, and policing compliance with the permits held, would require a degree of global supervision that appears to be close to the outer limits of plausibility, if not beyond them. Nevertheless the proposal is receiving careful study by international organizations and national governments, notably that of the US, as a market-based mechanism with obvious potential in the longer term. If it could be established and set in train, it would carry profound implications for future evolution of electricity systems, not least because electricity facilities are likely to be easier to police for compliance than, say, transport facilities.

If the climate issue continues to rise up the global agenda, it will affect every aspect of electricity systems - technologies, finances, institutions and businesses - and intensify the pressures for change. It seems likely to be an ever-present backdrop hovering behind every other area of electricity policy, national and international. In the pursuit of 'sustainable development' to which governments have committed themselves since the UN Conference on Environment and Development in June 1992, one essential component will be 'sustainable electricity'. Electricity policy-makers face the challenge of ascertaining what 'sustainable electricity' may look like, and how to get there from here.

7. International electricity futures

The international dimension of electricity will not go away. By 2020 it will be all-pervasive. Production, delivery and use of electricity will thus join other economic activities as fundamentally international and indeed global, despite electricity's distinctive attributes as a physical phenomenon rather than a commodity.

The financial framework for electricity systems will be international, indeed global, as will movement of capital, flows of revenue and expenditure. Taxation as responsibility of national governments will face severe pressure, as will subsidies of whatever kind and for whatever purpose. International contracts for electricity services will stipulate explicit allocations of international risks, including, for instance, currency risk.

Technologies for electricity systems will likewise move across national borders - design, construction, maintenance, upgrades, indeed all relevant activities, possibly even including RTD. Manufacturing activities will likewise be international. The scale factors that will influence the choice of technology are as yet unclear, and their influence will depend on the particular combination of circumstances affecting the system into which

the chosen technology is to fit. But the range of scales will be much wider beyond 2020 than in the 1990s. The largest end of the scale, for instance generating units of more than 500 megawatts, will receive less emphasis, in favour of a much more prominent role for mid-range technologies, for instance generating units of up to 100 megawatts, and an increasing role for small and very small generating technologies. Ownership of technologies even on a given subnational system will be international.

Systems will be linked internationally, both alternating current (AC) and high-voltage direct current (HVDC), but much less tightly integrated, including within national borders. International management of system stability will be very different, because it will involve competitive interactions rather than the simple cooperation generally practised before the 1990s. Control of systems and subsystems will be dispersed across a wider range at both ends of the scale. The role of information technology will be crucial. It will provide real-time data on system operation, real-time distributed control, and real-time pricing and billing at system nodes and major junction points between networks, including internationally.

International movements of fuel for electricity systems will depend much more on networks, in particular gas pipelines, than on batch cargoes of coal or oil. LNG cargoes will be carried by sea, but fed into land-based gas networks for final delivery. International gas networks will be of critical importance not only for gas but also for electricity. The international dimension of gas will probably continue to be more important than the international dimension of electricity; but gas and electricity will be much more tightly interwoven, both physically and institutionally, than they are in the 1990s.

The international dimension of environmental policy will exert much more pressure on national electricity policies than it does in the 1990s. International treaties, conventions and other international instruments will be embodied in national legislation on the environmental aspects of electricity, including in particular emissions to the atmosphere. A global regime of tradeable permits for greenhouse gas emissions could be in place and functioning by 2020, possibly significantly sooner, with sweeping implications for electricity systems. Other possible international policies and measures could include, for instance, agreed minimum performance standards for various categories of energy technology, including end-use technologies, with agreed sanctions for infractions. International commitments to foster 'sustainable development' could become functional reality rather than vague rhetoric. Therefore a key international factor for electricity futures will be environment - including both the transnational and global environmental impacts from electricity, and international commitments by national governments.

What do all the foregoing points indicate about how the international dimension of electricity will enhance or impede the transition to 'sustainable electricity' worldwide? Electricity policy-makers need to explore, consider, analyse and comment on these issues, confronting one obvious dilemma. 'Business as usual' for electricity systems worldwide appears likely to lead to serious damage to the planet; some would phrase it more emphatically. The objective should therefore be to devise a plausible way to get off the traditional track and onto one that looks more promising, as well as feasible, economically and politically. However, the requisite changes cannot rely on 'command

and control' or centrally directed measures by national governments. The emerging international context for electricity will make it increasingly difficult for any national government to sustain such central control over its electricity system. Where systems were once isolated and amenable to such central control, the international dimension seriously undermines any possibility of effective central control.

In the coming quarter-century, the changes in electricity systems will take place against a yet more disconcerting backdrop - the changing nature of national governments themselves, under the pressures of globalization of communications, commerce and even currencies. What could happen? An oversimplified but suggestive metaphor contrasts the polar opposites of isolation and interdependence. Electricity systems have begun a striking transformation. Less than fifteen years ago each system was a self-contained isolated fiefdom under well-defined central control. In the 1990s these isolated fiefdoms are evolving into complex entities under decentralized control and interdependent out to global level. Could national governments be facing a similar transformation? The question is far beyond the scope of this paper. But it cannot be lightly dismissed. Within coming decades, what happens to electricity systems may reflect in microcosm what is also happening to national governments.

What role will national governments fulfil within the international dimension of electricity? How will relations between national governments and electricity systems be affected by the growing international dimension? Important aspects of this issue must be deferred for consideration in subsequent Working Papers. Nevertheless, one interim conclusion can be suggested here. Earlier sections of this paper have argued that central control by a national government has always played an essential role in maintaining the stability of a large-scale synchronized AC system. Conversely, a large-scale synchronized AC system has come to represent a vivid and immediate manifestation of the role and responsibility of a national government, affecting the life and well-being of everyone within the jurisdiction of the government. This argument in turn suggests that the international dimension of electricity points to two main possible longer-term trends for electricity futures to 2020 and beyond:

1. One possible trend will be for the national government, that perhaps of China for example, to maintain control. It will have to finance the system internally or with government guarantees for foreign direct investment. The technology chosen can include very large generators based on big dams and traditional steam-turbine units, both coal-fired and nuclear. The institutional structure will support cross-subsidies and opaque finances, including the costs of the requisite redundancy on the system. The system will be a franchised monopoly subject to regulation under the direction of the government - effectively the traditional pre-1990s OECD model. Within this model, however, the role of independent power producers, especially those in foreign ownership, on a longer-term basis is doubtful. Will they accept the controls the government imposes, especially if the government then changes the rules, as governments do? Will they provide technology for peaks, for instance, and if so on what financial basis? The case of China in particular, with a quarter of the world's people, is further complicated by issues arising from technology transfer and China's approach to international intellectual property rights. This in itself is an important

international dimension, for electricity as for other technologies, as yet far from resolution.

2. The alternative trend will be for the national government to relax its central control, by liberalization and the internationalization that will almost inevitably accompany it. Working Paper 2 will consider the longer-term effects of liberalization itself, which appear likely to be fundamental and far-reaching. A longer-term liberal future for electricity almost inevitably implies a gradual reconfiguration of systems, away from the typical pre-1990s central-station large-scale integrated network based on synchronized AC. Technical reconfiguration will be accompanied by changing patterns of finance, technologies, institutions and environmental implications. Internationalization will be a concomitant of these other changes, arising straightforwardly as national governments relax their control of electricity within their borders. Electricity as an economic activity - ownership, management, business, transactions - will become global rather than national.

Accompanying this trend, the roles of national governments with respect to electricity will be different from those in the 1990s, but not necessarily less important. In the 1990s the roles of governments already differ widely, from setting general legal and institutional background to intimate involvement in every aspect of planning, operation and finance. By 2020 and beyond, the latter end of this spectrum will be much less emphasized, as national governments move from direct to indirect involvement with electricity systems. But the indirect influence of governments is not trivial or incidental. It will be more subtle but nevertheless fundamental in transforming electricity.

As the international dimension of electricity expands, national governments will need to identify the specific and explicit roles and responsibilities they still retain towards electricity within their borders. They will also need to identify the mechanisms available to them to exercise these responsibilities, within the constraints imposed by the international dimension.

Taxation: The ability to levy and collect taxes is one of the defining attributes of a national government. Taxes imposed on fuels, enterprises, labour, pollution, land, materials, wastes and water will determine the economic status of different options, and be a critical factor in shaping electricity regimes. Recent developments in so-called 'eco-taxation' or 'green taxes' are attracting increasing interest. But the international dimension of taxation as it affects electricity as yet raises some difficulties. The concept of a 'carbon tax', for instance, has been attacked as disturbing the international competitive status of industry. If national governments wish to take advantage of the obvious potency of this or other eco-taxation to influence policy, including electricity policy, some form of international harmonization will be necessary. To date, negotiations to this end have been largely fruitless; but they are still on the international agenda, and may yet succeed. Another international aspect of taxation now emerging is the reluctance of the new foreign owners of electricity facilities to accept some forms of taxation, such as the 'windfall tax' imposed by the new Labour government in the UK. This may be only a transitional problem, arising from the novelty of foreign ownership in the context of electricity. On the other hand, it may be a symptom of deeper problems facing national governments, as their national tax regimes come under pressure from globalization of business and industry. If so, electricity will not escape the general turmoil.

Standards: National governments can establish and enforce many types of standards relevant to electricity, for instance for the performance of system components including end-use equipment. Many standards are already agreed internationally. Others, however, such as minimum standards for efficiency, may be challenged under rules such as those of the World Trade Organization, as barriers to international trade. As national governments impose tighter standards, particularly in the effort to fulfil international environmental commitments such as those under the Framework Convention on Climate Change, they may provoke international objections and encounter further international constraints on their actions.

Access to information: National governments have widely differing policies about access to information, including information about electricity systems and their performance - technical, financial and environmental. Two directly opposed trends are already evident. Some national governments that are liberalizing their electricity regimes now require system owners to publish much more comprehensive and detailed data than were historically available under government ownership. On the other hand, mergers and acquisitions, including those involving system entities recently privatized, are now reducing the flow of data into the public domain, as activities hitherto transacted in public become internalized into merged entities. This problem is aggravated by international and foreign ownership; indeed some relevant data about a particular system may no longer be held under the jurisdiction of the national government.

Research and technology development: Most national governments regard RTD in general as properly a government concern, at least to the extent that it may lead to commercially valuable developments for the national economy. In the context of electricity, however, liberalization and privatization have substantially reduced support for RTD, either from governments or from the new private owners of electricity entities. Paradoxically, the most conspicuous government-funded energy RTD remains that into nuclear fusion, whose prospects as an electricity technology recede ever further into the remote future. Nuclear fusion indeed demonstrates what may be a universal truth, that the enthusiasm for international cooperation in RTD is inversely proportional to the likelihood that anyone will ever make any money out of it. Be that as it may, new electricity technologies with better environmental performance and other desirable attributes, including advanced coal technologies, fuel cells, various renewables and others, still require support for the requisite RTD to achieve commercial credibility. Some analysts suggest that the process ought now to be called 'industry development'. Mechanisms available to governments now include not only direct financial support - much reduced - but also indirect support through subsidized premium prices and long-term contracts, of which the so-called 'Non-Fossil Fuel Obligation' or NFFO in the UK is a salient example. Whether national governments can continue to support such RTD over the longer term, in the context of liberalized competitive electricity systems, remains nevertheless a matter for doubt.

Subsidies: National governments around the world have a long history of distorting the financial structure of electricity systems by granting or mandating subsidies and cross-subsidies of various kinds. They have subsidized investment, through tax relief, grants and other mechanisms. They have subsidized fuels for electricity generation, either

directly or by requiring electricity systems to pay domestic fuel suppliers prices higher than those on world markets. Above all they have cross-subsidized preferred categories of user, by controlling the tariffs charged. Some subsidies are egregious, where for political reasons governments set tariffs too low even to cover the cost of supply. Some support minimal tariffs for electricity-intensive industries such as aluminium smelting, to keep their output competitive on world markets. Others are more subtle, such as the tacit cross-subsidization that leads to a uniform residential tariff across an entire system, even though supplying scattered rural users is much more expensive than supplying concentrated clusters of urban users. For electricity systems operating as isolated fiefdoms, subsidies are a purely national matter; this aspect will be considered in subsequent Working Papers. But the international dimension of electricity also calls into question some aspects of subsidies. For instance, as already noted, an international company may face an invidious situation if it wishes to build an IPP unit on a system otherwise heavily subsidized. The company will want to charge an appropriate commercial rate for its output; but this rate will be higher than that charged by the subsidized generation elsewhere on the system, leading to political controversy and opposition. Governments that insist on subsidizing electricity tariffs may therefore find difficulty in attracting foreign capital and technology. Subsidies tend to thrive in circumstances where financial arrangements are opaque. The transparency required by international tendering and bidding will sit uneasily with a regime of subsidies. International funding sources such as the World Bank are taking an increasingly adamant stand against subsidies, and may grow steadily more reluctant to participate in projects on systems whose finances are thus distorted. In due course, the international dimension of electricity may be incompatible with the subsidies hitherto widely taken for granted.

Government procurement: Governments themselves frequently represent a substantial load on the electricity system, in the form of office buildings, military establishments, and facilities for other government departments including schools, hospitals, prisons and so on. The electricity services a government requires for its own use are clearly amenable to direct government intervention, even in a liberalized international context, for purposes of demonstration and pump-priming as well as enhanced government efficiency and reduced burden on taxpayers. Other Working Papers will consider this aspect of government involvement in electricity. But it does raise one international issue of potential interest. Will a government inviting bids to supply electricity services for its own facilities offer equitable treatment to foreign bidders competing with domestic bidders? The question is not trivial, especially in the context of the following subhead.

Social welfare: What responsibilities does a national government have for the social welfare of its citizens? How should it exercise these responsibilities? In the 1990s these questions are among the most challenging that national governments face, and they will become more so. To a significant extent, especially in OECD countries but also elsewhere, responsibility for social welfare represents the converse of taxation. An elected government whose citizens demand reduced taxation - as has recently become a political cliché, at least within the OECD - has less money available to devote to social welfare, however defined. The issue goes to the heart of political science, and cannot be addressed here, except to note one specific aspect of it. Until very recently, in most parts of the world, electricity has been seen as a 'public service', provided under the direct or indirect auspices of government at some level. In many places, ranging from

municipalities in the midwestern US to the whole of France under Electricité de France, it still is; indeed the claim that electricity is a public service is one of the most widespread counterarguments used against liberalization. One issue in particular cannot be avoided: if an electricity system is liberalized, what responsibility will a government still have to ensure that the poor have access to electricity services? How will it exercise this responsibility? These difficult questions will be explored at greater length in Working Paper 2 on *Liberal Futures*. But it brings one possible international corollary. In a liberal international setting for electricity, governments that accept the responsibility to provide essential electricity services to the poor may contract with private companies to supply them. Foreign companies already contract with governments in many countries to provide a wide variety of goods and services. Will governments also contract with foreign companies to supply electricity services for social welfare? The possibilities are intriguing, and will be explored further in subsequent papers.

International agreements: Perhaps the single activity that most clearly defines a national government is its ability to enter into international agreements. As the international dimension of electricity expands, national governments will have to sign, ratify and implement the agreements that create the requisite international framework. These agreements will be numerous and multifarious: bilateral agreements on cross-border electricity activities, multilateral environmental agreements affecting electricity, even the possible implementation of global measures to control climate change and foster sustainable development, such as tradeable permits for greenhouse gas emissions.

The relationship between electricity systems and governments is changing, almost certainly irreversibly. In the years and decades to come, the traditional electricity fiefdom within national borders, in stable symbiosis with the national government, will become less and less common. For most of the world, electricity is now an international issue, and will become more so. Nevertheless national governments will continue to play a crucial role in transforming electricity. Each national government will guide the process within its own borders; and the scope and nature of international agreements between national governments will be a key factor in the future evolution of electricity worldwide.

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