Future Power: Looking ahead in electricity generation technology
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Upgrading electricity

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Do you remember when a mobile phone looked like a brick, and felt like one? It was not that long ago. It was an early, primitive version of what was to come. In 2008 the evolution of the mobile phone is faster than ever, and still accelerating. Telecoms experts have remarkable visions of what the mobile phone may soon become.

When the organizers invited me to talk to you this morning, they suggested I speak about 'distributed generation' of electricity. Whenever I hear the phrase 'distributed generation', it reminds of the mobile phone that looked like a brick. Like the brick mobile phone, 'distributed generation' is a primitive precursor of what is to come, technically, economically and socially, for electricity in human society. We used to have an electricity industry. I've not heard it called that for years. It's now the electricity business. Do those of you in this electricity business know where your business is going? Have you a vision of what may become of it, within your working lives? Like the mobile phone, electricity is changing, and changing fast. You are going to see it change almost beyond recognition. If you are not ready for it, the change will leave you behind.

Even before 'distributed generation' we had 'embedded generation'. The meaning was clear. Embedded generation was generation in the wrong place on the system - not the traditional place for generation, which is as far as possible from users and loads. But have you ever stopped to think about this traditional electricity system, that we all take for granted worldwide? It's based on criteria from the 1890s, a common technical model whose essentials are now more than a century old. It arose because of the economies of scale associated with water power and steam power, the only two options then available to drive electricity generators. Traditional electricity is still based on large central-station generators. Most of them operate either intermittently or at only partial load most of the time. Those that use fuel waste two-thirds of the fuel energy before it even leaves the plant. The system has to have long lines of network. Line losses waste another significant fraction of the energy flowing. The system is inherently vulnerable to disruption, by mishap or by malice, over a wide area and almost instantaneously. We see the resulting blackouts all too often, all over the world, rich as well as poor.

The arrangement assumes that every load is essentially equivalent - that all loads require the same high quality of electricity. But we then use most of this high-quality electricity for undemanding applications such as heating and cooling. The generators are almost all at least a hundred times, and more often ten or a hundred thousand times, larger than most of the loads on the system. Most of the loads, such as lamps, motors and computers, are inherently intermittent or variable; but the system's large fuel-based generators are inherently inflexible. The mismatch is already so complete you'd think we planned it that way. But it does not have to be like this. We can do much, much better - and we have already begun to. But it is not going to be easy. Innovative technologies and innovative system design now offer cleaner,

more robust and more reliable electricity services. But legacy systems, legacy institutions and - especially - legacy mindsets make upgrading electricity a daunting challenge.

If we were starting from scratch today to create electricity systems all over the world, using what we now know about technologies, applications, finances, business models, resources, environment and society, the systems would look utterly different, as other speakers at this conference will tell you. Our main problem, however, is that we cannot start from scratch. All over the world billions of people already rely on traditional electricity to keep their lights on. We cannot scrap it and start over. The transition from nineteenth to twenty-first century electricity must be gradual. But gradual does not and must not mean slow. The process of upgrading electricity must be coherent, focused and directed, toward a credible long-term vision of the future of electricity in our human society.

What vision do you have of the future of electricity? Do you have one? If you think about it at all, do you visualize more of the same, more or less indefinitely? If you do, I have to tell you that you're wrong. The pressures for change are inexorable - financial, environmental and political. So are the opportunities for imagination and innovation, to deliver electricity services that are more reliable, cleaner and cheaper. I don't have to tell you that the traditional model of electricity faces major problems - getting wayleaves for transmission; siting large-scale power plants; cutting emissions; finding finances in the face of serious market risk and political risk; coping with environmental constraints, public opposition and public expectations... At the same time we have a rapidly expanding catalogue of innovative technological options, with attributes very different from the traditional.

Smaller-scale generation can be cleaner and more efficient. It can be sited close to loads, even on the same site, reducing losses and vulnerability to disruption. Technologies such as gas engines, Stirling engines, microturbines and fuel cells can also offer cogeneration and even trigeneration, producing electricity, heat and cooling from the same amount of fuel. They can be heavily instrumented and remotely monitored, requiring no on-site staff or maintenance. The catalogue of innovative technologies also includes ground-source heat pumps, wind turbines of every size and kind, solar water heating, solar thermal power generation, solar photovoltaics, and a lengthening list of marine technologies - you can all tick the familiar boxes along with me. But innovation is not just about generation, about producing and delivering electricity. Upgrading electricity means changing the fundamental nature of the system, its role and function in society - not only how we make, use and pay for electricity, but how we think about it.

Ever since the introduction of the electricity meter in the mid-1880s we have thought of electricity as a commodity, that we sell and buy by the measured unit. The notion of electricity as a commodity was central to government plans when they began to liberalize electricity, some two decades ago, and created the so-called 'electricity market'. It is a bizarre and arbitrary construct. The reason they have not yet got it right is because electricity is not a commodity - it is a process. Selling electricity by the unit of measured flow is ultimately as sensible as selling by the unit the kinetic energy passing from the drive shaft of a car engine to its wheels. What matters is the whole system through which electricity is flowing. Electricity by itself is useless. It only exists in infrastructure. As I told a conference of schoolchildren a couple of weeks ago, what is important about electricity is that we use it to *run stuff*. What matters is the *stuff we run*, the technology and the infrastructure that deliver the services we actually want. Upgrading electricity depends above all on upgrading this stuff - the lights, motors, chillers, electronics, and especially the buildings, that provide all these services.

For those of you in what you think of as the electricity business, this is the biggest challenge and the biggest change you face - how to make money not just by selling units of electricity but by upgrading the entire system, and particularly the end-use technologies. Steve Holliday of National Grid, speaking to the FT last year, put it neatly. He asked the regulator, OFGEM, 'Help us to sell less electricity'. In other words, help us to devise business models that reward us for doing what wider society wants us to do - to deliver better services more reliably, more economically and more sustainably.

That requires whole-system thinking, and a whole-system approach, which is much easier if the whole system is of manageable size - say a single building, a single village, a single neighbourhood. That is one of the key advantages of smaller-scale local generation close to loads: you can optimize the whole system, using real-time controls to match local generation to high-performance end-use technologies delivering all the services desired. If you want to know how well that can work, just google 'Woking energy', to learn about the vivid example that town in Surrey has demonstrated since electricity liberalization in 1990.

Such optimized local systems ought to be the business of so-called 'energy service companies'. As yet, however, even when they are offshoots of major energy companies, energy service companies still struggle to succeed. To get over this hurdle I have two suggestions you may want to ponder. One relates to a stumbling block that has long deterred energy service companies from investing - as they ought to - in upgrading the premises of their customers. Companies making such investments want to earn an appropriate return. They can do so by a modest increase in the price per unit of electricity. Since the upgrade investment means better services while using less electricity, the customer's bill still goes down, even while the company is earning back its investment with interest. But what if the customer moves, or switches suppliers? Does the company lose its investment? Under present supply contracts, which are made between company and customer, it might. Recall, however, that the company already has the use of a permanent continuous physical connection to the premises. An appropriate amendment to the supply contract could link the investment not to the customer but to the premises in which the investment is made, no matter who uses the premises or on what basis. The details need careful thought, but such a change might remove a major obstacle and foster exciting new business.

The second suggestion is immediate and obvious. In the grip of a global financial crisis the UK government, like many others, is trying desperately to inject fresh confidence and fresh funds into the economy. As Nick Stern and other commentators have pointed out, this is a dramatic opportunity to upgrade our energy systems and infrastructure. The UK government should stop telling the rest of us what to do and show us instead. The Sustainable Development Commission, the National Audit Office, and most recently the Environmental Audit Committee of the House of Commons have all pointed out that the UK government uses tens of thousands of buildings - everything from schools to prisons. Most are inadequate, and many are appalling.

To inject funds into the UK economy the government should immediately launch programmes to upgrade its own facilities to much higher standards - better insulation, better doors and windows, better lighting, better controls, better appliances and electronics, and - especially - complete local systems using on-site generation of electricity, heat and cooling. Government upgrade programmes would persuade major energy players to create effective and profitable energy service companies to bid for and carry out the work. They would create skilled jobs everywhere. They would also offer a vivid example to the private sector. Bulk orders for upgrades would bring down the unit cost of innovative materials and technologies. Such programmes would dramatically accelerate the upgrade of electricity

into the twenty-first century. Best of all, properly managed, government upgrade programmes would save all us taxpayers money.

Upgrading our energy systems could save the global financial system. It might even save the planet. Let's start with electricity, and let's start now.