A New Vision for Bioenergy:
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Embedded Bioenergy - Issues and Prospects
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Ladies and gentlemen - Please brace yourselves. I am about to say two words that may strike terror to your hearts.

Natural gas.

In fact I'm going to say them again. *Natural gas.*

By now you're probably regretting that you invited me. What can I possibly mean, standing here in front of you as your guest and invoking your worst nightmare? Am I just ill-mannered, or positively sadistic? Neither, I hope, at least not intentionally. On the contrary - I'm here as a conciliator and peacemaker, to suggest that despite the fierce competitive challenge it represents, natural gas is actually the natural ally of bioenergy. Indeed I'm convinced that natural gas is perhaps the biggest single factor shaping a bright future for bioenergy.

That probably sounds perverse, but please bear with me. I intend to elucidate. At the moment, to be sure, Britain is not a good place for bioenergy. I see no point in pretending otherwise. The main reason is little to do with bioenergy in itself. It is the existing, and expanding, surplus of generating capacity already in operation in Britain, at a time when Britain's electricity use has almost stopped increasing. So much new generating capacity has been built in the 1990s that even some of these new plants, the earliest of the combined-cycle gas turbine plants, are now in trouble, stuck with comparatively expensive gas-supply contracts and comparatively inefficient turbines, trying to sell electricity in a competitive market where prices continue to get lower and lower, and competition gets ever more fierce.

Doesn't that mean that natural gas is to blame for the problems facing bioenergy? Not at all - not as I see it, at any rate, or only very superficially. I've been asked to speak today about 'embedded bioenergy - issues and prospects'. The obvious first question is 'embedded in what?' The answer to that question is the reason why natural gas is - or at any rate will be - good for bioenergy. I'm sure the organizers of today's conference were using the word 'embedded' as it is commonly used these days, to indicate that a bioenergy plant may be connected to the rest of the electricity system at a voltage lower than transmission voltage. But that severely understates the import of what is actually happening. We can address the issues and prospects for 'embedded bioenergy' adequately only if we start by giving a much more careful and detailed answer to the question 'embedded in what?'

In fact, the 'new vision for bioenergy' proclaimed in the title of today's conference is 'embedded' - that word again - in a new vision for electricity. This new vision is already beginning to emerge, not only here in Britain but across much of the world. In February next year Earthscan will publish my latest book, entitled *Transforming Electricity*. The book describes what I see happening to world electricity and why. It's written for general readers, that great majority of people who take electricity completely for granted - who assume without thinking about it that when they throw the switch the light will come on. But I think the book may also interest specialists like yourselves, your colleagues and your competitors, because of what it says about the business you're in and how this business is going to change.

In a short presentation today I can only outline some of the key arguments from *Transforming Electricity*. I'll be happy to try to respond to questions afterwards, and I've also brought along some propaganda about the book, for any of you who may want to watch for it when it's published. In the mean time you might want to check out the web site of the Energy and Environmental Programme at the Royal Institute of International Affairs. The URL for the RIIA site is <www.riia.org>. On the site you'll find a series of five Working Papers I wrote as preliminary analysis for *Transforming Electricity*. The series is called *Electric Futures*; each of the five Working Papers is available as a file you can download and print out. I should warn you that together they're the length of a short book themselves; but I think you'll find them thought-provoking.

Transforming Electricity starts from the premise that the technical configuration of electricity systems all over the world has been shaped by a single fundamental factor: the economies of scale associated with water turbines and steam turbines. As a result, throughout most of the past century, almost every electricity system of any size anywhere in the world has come to conform to a common technical model, in which electricity is generated in large-scale central stations remote from users, and delivered to users over a network including a substantial length of high-voltage transmission lines, in the form of synchronized alternating current. To maintain the stability of the synchronized AC network, generators connected to it must be under some form of central control or dispatching. The necessity for a network, and the requirements of central control, in turn meant that until only a decade ago almost every electricity system operated as a franchised monopoly under the auspices of government. A franchised monopoly delivering an essential good to captive customers has a guaranteed revenue stream. In such a context, financing enormous generating stations, that may take six years or more to come into operation and may then have to operate for two decades or more to cover the investment and earn a return, is not a problem. The captive customers will eventually pay whatever the stations cost. The captive customers also pay for recondite but essential system services like reactive power and frequency control, as well as for all the redundancy of generation and networks that ensure system stability even under serious fault conditions.

In the late 1980s, however, first in Chile, then in Britain and subsequently in an expanding wave reaching from Argentina to Finland, and from Poland to New Zealand, governments around the world began to liberalize their electricity systems. Privatization of assets formerly owned by governments was the original intention; but soon liberalization extended even to introducing competition into systems previously operated as monopolies. Nevertheless, even as they were overturning the institutional arrangements that had prevailed for most of the century, politicians and governments appeared to expect that electricity systems would continue to look much the same and function much the same way into the indefinite future. They were wrong.

Much to the surprise of the politicians, who had no such expectations in mind, a new fuel and a new technology for electricity generation burst on the scene: natural gas, and the gas turbine. In the 1950s natural gas was a nuisance and a hazard in oilfields. By the late 1970s it was a premium fuel too valuable to burn in power stations. In the 1990s its burgeoning abundance in more and more parts of the world has made it the fuel of choice for power generation wherever it is available. At the same time the gas turbine, once too inefficient and expensive to use for any but peaking applications on an electricity system, has become the generating technology of choice.

The advent of natural gas and gas turbines for electricity generation has changed the fundamental premise that shaped electricity systems for more than a century. Although gas turbines exhibit some significant economies of scale, they also - and more importantly - exhibit dramatic economies of series manufacture, with a rapid learning curve for improvements. A gas turbine station, even one

that also uses steam turbines in combined cycles, can be ordered, built and brought into operation in under three years, sometimes well under, making it easier to finance, even in a competitive context. A gas turbine station is modular, expanding by replicating modules as required. Moreover, a gas turbine station is easy to site. It is clean and comparatively quiet, and requires no on-site storage of fuel or waste. Accordingly it can be built close to users, and indeed even on a user's site. If the user requires both electricity and heat, gas-turbine cogeneration is even more attractive.

You know all this already. But what I want to underline is the effect these developments are having on the technical configuration of electricity systems. Gradually, and in some places not so gradually, the traditional shape of the electricity system has begun to change. Not so long ago, a better power station was always considered to be a bigger power station, usually farther away. Now a better power station is likely to be a smaller power station, probably closer. The traditional centralized configuration is giving way to a steadily more decentralized configuration, with more and smaller generating units much more uniformly distributed around the network.

At the same time, as novel arrangements for network access come into play, the traditional redundancy on the system is diminishing. In a competitive context, every generator wants to operate at base load. A station that is not dispatched earns no revenue, and is likely to be summarily shut down, as so many British stations have been in the 1990s. Even load-following becomes unpopular. In Britain the review of technologies for electricity generation published this past summer revealed that the CCGT stations, although inherently much more flexible than coal-fired or nuclear stations, refuse to load-follow, for their own very good financial reasons. In due course this state of affairs is going to make system stability an issue, and companies and other users will grow increasingly unhappy about power quality and reliability. With transients sloshing around the AC network, an AC spike can fry all the chips in a database in an instant. Having your own generation on site and under your own control becomes an appealing alternative. Power electronics, including AC-DC-AC links, can decouple sites from synchronized control, providing voltage support while blocking transients.

The most exciting developments in generating technology are now not at the large end of the scale, but at the small end. Major gas turbine manufacturers are already demonstrating mini- and micro-turbines in sizes down to tens of kilowatts - small enough to power individual factories and office buildings. Fuel cells, too, are improving rapidly, cheaper, more reliable, more efficient and more versatile. At the same time, the capabilities of information technology for system management and control are leaping ahead at breath-taking speed. The opportunities for complete local systems, in which generation and use of electricity are optimized together for both economic and environmental benefit, become appetizing - for perfectly sound business reasons. In short, within the next two decades I expect the traditional shape of electricity systems to evolve almost beyond recognition in many parts of the world, as I discuss in much more detail in *Transforming Electricity*.

You understand, therefore, that when you invite me to talk about 'embedded bioenergy' I want to know 'embedded in what?' I hope you're also beginning to understand my cryptic comments earlier about natural gas. Natural gas and gas turbines are changing the traditional shape of the electricity system, towards a decentralized configuration much more congenial to bioenergy than the traditional system, with its gigawatt-scale generating units, could ever be. The most obvious characteristic of biomass power units is that they have to be comparatively small, to avoid long-distance transport of fuel with low energy density. Accordingly, an electricity system consisting of many small decentralized generating units is going to be a much more comfortable context for biomass power of all kinds. It is not going to arrive overnight; but I suggest that it is going to arrive a lot faster than most people yet realize.

The first phase will be swift expansion of cogeneration, on more and smaller sites. Bioenergy is already successful for cogeneration in appropriate industrial contexts; it will become more so, especially as the technologies for advanced biomass utilization prove themselves. Many of the arguments in favour of cogeneration using natural gas apply equally to cogeneration using biomass, notably the advantage of having your own on-site generation under your own control. Moreover, many of the technologies now under development to use natural gas for on-site generation and cogeneration, including mini- and micro-turbines and fuel cells, may be readily adaptable to use fuel gas from biomass - another example illustrating why you should not think too harshly of natural gas. The crucial technological research the bioenergy community itself must pursue is into gasification in its various forms, for every variety of biomass feedstock, to produce fuel gas suitable for the innovative small-scale generating technologies.

Among renewable energy sources, biomass has one distinct and valuable attribute. It is a true fuel, and can be stored. That means that it can play a key role in local systems based entirely on renewables. In combination with, for example, local wind generation and photovoltaics, bioenergy offers the assurance of reliable continuous delivery of energy, even at night or in a calm, with no need for backup from a grid and without resort to batteries.

I stress this concept of local systems, because I'm increasingly convinced that they will become steadily more common not just in rural areas of developing countries but all over the world, including OECD countries. Local systems, and the whole-system thinking they foster, will give rise to fascinating alliances of different abilities and specializations, particularly to optimize the combination of efficient, economic generation and efficient, economic end-use of electricity.

As you know, this week the world's governments are meeting in Buenos Aires, at the fourth Conference of Parties to the Framework Convention on Climate Change. Two of my colleagues from RIIA are at the conference. The conference is meeting against a background of ever more alarming news about the world's weather - hurricanes, floods, droughts, heatwaves, with 1998 the warmest year ever recorded. Unfortunately, despite the mounting evidence that something gravely serious may be happening to our only planet, I'm not really expecting the conference to make significant progress. I nevertheless consider electricity the brightest hope in an otherwise gloomy prognosis. It is one sector of the global economy where finance and environment are now pointing in much the same direction, toward smaller-scale generation closer to users, and to local systems optimized for high performance and high efficiency - better electricity services with lower adverse effects on the environment, local and global.

In the course of my research on *Transforming Electricity*, I found myself wondering what 'sustainable electricity' might look like, and how to get there from here. I now think we're on the right track. Liberalization, natural gas and gas turbines have given us the initial breakthrough we needed. We must now take advantage of the new frameworks emerging for electricity, and push the desired changes farther and faster.

Natural gas, for all its attractions, is still a fossil fuel. Biomass emits no net carbon dioxide. I yield to no one in my admiration for natural gas. On behalf of the planet, however, I still like biomass better.