Barcelona, 13 April 2011 - 25th Anniversary Chernobyl Conference

Changing The Way The World Works

Presentation by Walt Patterson

I owe my career to nuclear power. In Canada I took a postgraduate degree in nuclear physics, but I knew nothing about nuclear power. I knew about the beta-ray spectrum of iridium-192, and that was not enough. I dropped nuclear physics and spent nearly a decade trying to find something else. Then, in the late 1960s, something called 'the environment' burst into my life. Suddenly I was concerned about everything - air pollution, water pollution, waste management, resources, land use, and what came to be called energy. I became editor of the first environmental magazine in the UK. In June 1972 I attended the United Nations Conference on the Human Environment, and helped to publish the first-ever independent conference newspaper, with colleagues from a new organization called Friends of the Earth, or FOE.

A month later I joined the staff of FOE in London. FOE invited me to Washington DC. The US Atomic Energy Commission, then one of the most powerful agencies in the US, was holding hearings about the safety of nuclear reactors - the American water-cooled designs. FOE published a newspaper about the hearings, and about many other aspects of nuclear power. I researched and wrote a 2000-word article every two days. My nuclear physics degree meant that I spoke the language; but I was learning the engineering hour by hour. What I learned was far from reassuring.

Back in the UK I wrote an article for the *New Scientist* magazine, about the possibility of a major accident in a water-cooled reactor. You can find the article on my website archive Walt Patterson On Energy, www.waltpatterson.org . It makes alarming reading, especially so after the events in Japan from 11 March this year.

In 1973 the UK electricity authorities announced that they proposed to abandon UK gas-cooled reactor designs and build American water-cooled reactors. A furore ensued, with FOE and me in the thick of it. Within a matter of weeks I was FOE UK's first 'energy campaigner', specializing in nuclear power.

Although FOE's original concern had been with safety, we gradually began to realize that all was not as advertised with nuclear economics, either. We had all heard the quote from the then chairman of the US Atomic Energy Commission, that nuclear power would produce 'electricity too cheap to meter'. The UK authorities were claiming that their nuclear plants produced the cheapest electricity on the system. But the numbers did not add up. When Penguin Books commissioned me to write my book *Nuclear Power,* I included a chapter I called 'Nuclenomics', to indicate that whatever it was it was not economics as we otherwise understood it. The most recent edition of *Nuclear Power*, published a week before they blew up Chernobyl, is now available as a free download on my website archive Walt Patterson On Energy, www.waltpatterson.org. Although it's now 25 years old it gets downloaded more than 2000 times a month. What it says is still relevant - maybe more so.

The economic evidence began to mount up. In the US, home of the water reactors, the surge of orders in 1973-74 abruptly faded. After 1978 no US electricity company ordered any further nuclear plant. They were becoming far too expensive. They cost too much and took too long to build, and many did not even work properly. Every plant ordered after 1974 was subsequently abandoned, some when more than 95 per cent completed.

People would frequently ask us 'If not nuclear power, what?' We would answer 'If not nuclear power, *not nuclear power*'. We meant that if governments did not divert so much time, effort and money to nuclear power, other better options would have more chance. Nuclear advocates thought every nuclear question was 'Yes/no' - 'Do you do this nuclear thing or not?' We knew that the question was really 'Either/or' - 'Do you do this nuclear thing or do something else instead?' Even in the 1970s we were promoting other, better ways of generating electricity and delivering energy services. That was to become a dominant theme. The inadequacy of nuclear power impelled us to think ever harder about what might be better.

In the mid-1970s, however, our attention was preoccupied not with reactors but with reprocessing and the plutonium-fueled fast breeder reactor. At that time this was the dominant vision of the nuclear future for the planet, endorsed by governments everywhere and lavishly supported with taxpayers' money. It made nuclear waste management, already a daunting problem, effectively insoluble. It meant shipping plutonium, nuclear weapons material, all over the planet by the hundreds of tonnes. The whole package scared me. It still does. The book I wrote about it, called *The Plutonium Business,* is by far my darkest book. If you're interested you can find it, too, as a free download on my website.

Fortunately, however, after four decades of effort and many billions of dollars of public money in many countries, both oxide-fuel reprocessing and fast breeders proved to be a technical challenge too far - frighteningly expensive and precariously unreliable, creating far more problems than they solved. Yet even now nuclear proponents advance these ideas all over again. Just last month a former chief scientist to the UK government published a report advocating renewed reprocessing and plutonium fuel. I sometimes think these people live in a different universe.

In March 1979 we were at hearings in Germany, on an international panel reviewing German plans for reprocessing and plutonium, when Three Mile Island took us all by surprise. Most of us had almost forgotten reactor safety as a nuclear issue. Many commentators now claim that the Three Mile Island accident stopped nuclear power in the US. They are wrong. US electricity companies gave up on nuclear power for economic reasons at least a year before Three Mile Island. But Three Mile Island did not help. Its costs underlined the extreme risk - the *financial* risk - posed by nuclear power.

Undeterred by Three Mile Island, the new UK government of Margaret Thatcher later that same year once again proposed a programme of US-model water reactors. We continued to challenge the claims of nuclear advocates, especially about the economics. After a long-running hearing, to no one's surprise the government gave the go-ahead for the first pressurized-water reactor in the UK. Then the Soviet operators blew up Chernobyl 4. Caesium-137 from Chernobyl reached north Wales. Today, 25 years later, Welsh sheep farmers still have to test their stock for radioactive contamination before taking it to market.

The free-market ideology of the Thatcher government soon collided head-on with nuclear economics. The government announced plans to sell the state-owned electricity system to private investors - so-called 'privatization' in English. To the chagrin and embarrassment of the government, financiers in the City of London declared that if the nuclear plants were part of the sale package private investors would not buy it. They did not like the risks, uncertainties and long-term liabilities of nuclear power. Mainstream investors were now saying what we had been saying for fifteen years. The government was forced to remove the nuclear plants from the sale.

I was delighted, and relieved. I had become bored with the sound of my own voice, reiterating the same arguments over and over again for nearly two decades. I was eager to move on to more interesting, more positive work, and soon thereafter I did. My concern about nuclear power had long prompted me to seek out and promote more acceptable alternatives. I now found myself immersed in electricity itself as a policy issue. Something exciting was starting to happen with electricity.

For more than a century electricity all over the world has been based on the same technical model. Large remotely-sited central-station generators produce electricity and send it out to users over networks of wires including long high-voltage transmission lines. Most of the large central-station generators operate either intermittently or at only partial load most of the time. The central-station generators that use fuel waste two-thirds of the fuel energy before it even leaves the power plant. The system necessitates long lines of network, in which line losses cost another significant fraction of the energy flowing. The configuration is inherently vulnerable to disruption, by mishap or malfeasance, over a wide area and almost instantaneously.

It assumes that every load is essentially equivalent, requiring the same high quality of electricity. The system produces and delivers high-quality electricity as required by sensitive loads. Much of this electricity is then used for undemanding services such as heating and cooling. The generators are almost all thousands, more often millions of times larger than most of the loads on the system. Most of the loads are inherently intermittent or variable; but the system's large fuel-based generators are inherently inflexible. The most extreme example of this traditional electricity is nuclear power.

The mismatch is so complete you'd think we planned it that way. Yet probably the single worst feature of this arrangement is that the rest of the system is selling electricity to the user by the measured unit. The more the user has to buy, the more revenue for the seller. The seller therefore wants the user to have inefficient lamps, inefficient motors and other inefficient user-technology. This perverse incentive to poor overall system performance has persisted ever since the invention of the electricity meter some 125 years ago.

By the 1990s, as I struggled free of nuclear entanglements, traditional electricity was already long overdue for change. By that time, an additional and progressively more alarming factor was the realization that human energy use is disturbing the climate of the planet. Changing the way we produce and use electricity seemed to be a good place to start.

In the early 1990s I began work on a book I was going to call *Transforming Electricity*. Then I had a bad fall at my home, that put me out of action for nearly two years. It proved, however, to have one beneficial effect. Early drafts of *Transforming Electricity* had talked about all the exciting innovations that might happen. By the time I returned to work on the book, the innovations were already happening. Instead of mere possibilities, the book was able to describe real practical examples of innovative electricity, not just hypothetical but actual.

*Transforming Electricit*y was written for general readers, but it didn't sell them many copies. To my surprise, however, many people in the electricity industry bought it. My friends explained why. Electricity used to be managed by engineers. Since liberalization, however, it is now being managed by lawyers, accountants and stockbrokers. They bought my book, said my friends, to find out how electricity actually works.

By the time *Transforming Electricity* appeared, in 1999, developments were speeding up. The more you think about electricity, the more possibilities you find. I tried repeatedly to draft a book to take

the analysis farther; but I kept underestimating how far the transformation might beneficially run. I had to keep redrafting and redrafting, to work out the implications.

We already seeing dramatic changes in the type, scale and number of generators on an electricity system - many more generators, much smaller and more numerous, much closer to users, often on the same site or nearby. We are also going to see corresponding changes in networks, their configuration and operation. That in turn means changes in the technical operation of the system, especially as information and control technology allow generators and loads to communicate actively and directly with each other.

However, changes in technical operation also imply, indeed require, changes in management of the system, not just moment to moment and day to day but extending through business and business relations, investment and even ownership of system assets - a fundamental reorganization of every aspect of electricity in human society.

Once you start thinking hard about nuclear power, your thinking can carry you a long way, much farther than you might originally imagine. It doesn't even stop with electricity.

After eight years of work I at last succeeded in completing a book I called *Keeping The Lights On: Towards Sustainable Electricity*. The UK and other countries were by now promoting what they called an 'electricity market'. This so-called 'market' tries to treat electricity as though it were a commodity like natural gas. But the UK has thus far tried three times to organize its electricity market, and all three attempts have failed to meet the criteria set for them. The UK is now trying yet a fourth time for 'electricity market reform'. This latest version is complicated and convoluted, with so much government intervention it hardly qualifies for the term 'market'. Many people, including me, suspect that this latest consultation is mainly a smokescreen to disguise another huge subsidy for nuclear power. The big international electricity companies have been saying for years that they want to build new nuclear plants in the UK. But they are waiting until they know they can put their hands deep into UK taxpayers' pockets when they need to.

In any case, my book *Keeping The Lights On* challenges the whole idea of electricity as a commodity. It is not a commodity. You cannot store it and withhold it from the market until you get the price you want. Electricity is a *process*, a process in technology. Indeed without technology electricity as we use it does not even exist.

That much is already clear. What is now becoming equally clear is that this applies not only to electricity in particular but to energy in general. My current project, which I hope will become another book, is called *Managing Energy: Rethinking The Fundamentals*. My website already includes three working papers exploring the implications.

Human energy use of every kind is also a process - a process in technology. What matters most is the technology - the buildings, fittings, appliances, vehicles and other user-technology that delivers the services we actually want. To focus as we do on commodity fuel and metered units of electricity, in this so-called 'energy market', misses the most important part of our energy systems, our user-technology and user-infrastructure. The key competition is not between suppliers of electricity. It is between fuel and user-technology. The better the user-technology, the less fuel it needs to deliver the service. Don't call this 'energy efficiency', or even 'fuel efficiency'. What matters is not how well the technology uses fuel, but how well it delivers the desired service - what we ought to call 'energy performance'.

For almost any user-technology the available room for improvement is substantial. For buildings alone it is vast, as study after study confirms. However, today's energy companies still make their money by selling fuel or electricity by the measured unit: the more they sell the more their revenue. It is in their interest for the rest of us to use technology with mediocre performance, requiring us to buy and pay for more fuel and electricity. This simple, perverse incentive is the biggest single obstacle between us and a more secure, healthier planet.

We need to change the ground-rules, so that the companies become true *energy* companies, making money by upgrading and improving everyone's buildings and other user-technology. Energy business should become more and more a matter of investment not in yet more supply technology but in continually improving user-technology. That means not commodity markets but contract markets. It also means transforming company business plans accordingly. In the UK, for example, the Green Deal concept now endorsed and promoted by the government links investment in upgrading buildings and other user-technology to the property rather than to the user, creating mutual benefits, with a low risk and guaranteed return for companies and users alike. Governments, themselves major energy users, should take the lead and show the way, as enlightened and demanding customers for this new form of energy business.

Two of the most urgent issues now facing policy-makers, energy security and climate change, arise primarily because of society's dependence on fuel - not 'energy' but quite specifically fuel. A 'low-carbon' future means a low-fuel future. The first way to reduce our use of fuel is to boost energy performance. The second way starts by recognizing that human society uses two different kinds of electricity. One we generate using the stored energy in fuel, such as coal, natural gas or uranium. The other we generate using technology to convert natural ambient energy - hydro, wind, photovoltaic, solar thermal, wave, tidal and geothermal - into electricity. This electricity *does not use fuel*. Most people call it 'renewable'; I prefer to call it 'infrastructure electricity'. It is created and delivered by the function of physical assets, not by combustion or any other reaction. Once the assets are in place and functioning, whenever the natural ambient energy is available the infrastructure converts it into electricity, for us to use however we wish.

Using fuel the way we do threatens the security of our energy services and the climate of the only planet we have. Of all the ways we use fuel, generating electricity is the easiest to change. To get better, more reliable, more universally available and sustainable electricity services, we should be aiming to move as rapidly as possible away from fuel-based electricity to infrastructure electricity, for every feasible application, all over the world.

It will not happen rapidly. But it might happen more rapidly than many now expect. A coherent vision of a low-carbon, low-fuel future led by innovative electricity looks ever more appealing. My overriding concern about nuclear power for decades has been its opportunity cost. Let's not let the false promise of nuclear power deny us the real promise of innovative electricity for a healthier, more stable planet.

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