Conference on the Assessment of Future Energy Systems, Calgary, 3-4 November 2011
Making Electricity Sustainable

Presentation by Walt Patterson

Why are we assessing future energy systems? The short answer, as those of us here all know, is that our present energy systems, our human energy systems, are failing us. Nearly two billion of us, a quarter of humanity, still do not have electric light. Those of us who do are worried about keeping the lights on. What politicians call 'energy security' is now a pressing issue even in the richest countries. The best available scientific evidence now indicates ever more urgently that the way we use energy is upsetting the climate of the only planet we have. If our future energy systems don't do better than this we are in deep trouble.

However, let's be clear about this, and more precise. Despite all you hear to the contrary, the problems we face with security and climate are not about energy. They are quite specifically about *fuel*. We've almost forgotten the word 'fuel'. We now say 'energy', when we really mean 'oil', or 'coal', or 'natural gas', or even 'electricity'. They are not the same. They are not interchangeable. Smearing them all together like this is misleading and dangerous. The differences are essential. Indeed the difference between fuel and electricity is one of the the keys to a sustainable energy future, as I hope to show you. But first let's clarify what we're talking about.

Politicians around the world declaiming about 'energy security' *could* mean secure - that is, reliable and affordable - provision of what we really want: energy *services*, such as comfort, illumination and motive power. But they don't. They mean secure provision of fuel, particularly oil and natural gas, and more particularly *imported* oil and natural gas. Why is this an issue? It is because all over the planet we already have a vast array of user-technology - buildings and their contents, industrial plant, vehicles and so on - that use fuel to deliver the services we desire. Interrupting fuel supply may interrupt essential services. That makes politicians jumpy.

But fuel is only part of the story. Oil by itself is almost useless. Natural gas by itself is downright dangerous. Once you get beyond the bonfire, fuel is useful only because of the user-technology that actually delivers the service. Yet we mostly take user-technology for granted. Instead we focus only on the fuel passing through it, as though the user-technology were irrelevant for policy and decision-making.

We need to change our approach. As the title of this conference says, we should be thinking not of fuel alone but of systems. An energy system does not stop at the filler-cap or the wall-socket. Once we recognize that, we notice something profoundly important. Recent energy policy has laid great stress on competition, as the way to optimize our energy systems. What policy-makers mean by 'competition' is that different suppliers of fuel or electricity compete for our custom. Within our energy systems, however, much the most important competition is between *fuel and user-technology*. The better the user-technology, the less fuel it needs to provide the service we actually

desire. Fuel and user-technology *compete directly* with each other. Key competitors for ExxonMobil are not Shell nor BP but Toyota and Volkswagen. Here in Alberta competitors for AltaGas may be the manufacturers and installers of thermal insulation. Competitors for Enmax and Epcor may be the suppliers of compact fluorescent and LED lamps; and so on.

Within our energy systems, our dependence on *fuel* is the reason for our concern about supply security, and for the mounting alarm about disrupting the climate. The obvious rational response must be to reduce our dependence on fuel. That means, first of all, shifting the balance within our energy systems away from fuel toward better user-technology. We know how; we've known how for decades, especially for the most important energy technology of all - buildings. Governments and policymakers have long given lip service to what they call 'energy efficiency'. Then, however, they turn to what they're really interested in - supplying more fuel and electricity. That's understandable. Our suppliers of fuel and electricity earn their revenue by selling us their products. The more we have to buy, the more they earn. The way we have organized our systems means that fuel and electricity suppliers *benefit* from us living in poorly-insulated buildings, using inefficient lamps and motors and driving inefficient vehicles.

From a system point of view this is a cockeyed arrangement. When Thomas Edison set up his first central-station electricity system in lower Manhattan in 1882 he charged his customers according to how many lamps they used. He was selling *illumination*, the service they actually wanted. He had to optimize the *whole system*, to keep the cost of illumination tolerable. Then, in the mid-1880s, came the electricity meter. Suddenly Edison and his competitors were no longer selling illumination. They were selling electricity by the unit. Suddenly they no longer *wante*d to optimize the whole system. They were happy to have customers using inefficient lamps and motors. Today's electricity suppliers *still are*, however much they protest to the contrary. The companies doing very well out of today's cockeyed arrangement will continue to resist any significant change, because it is against their interest - unless we change the groundrules.

We need to rethink the system framework for business and finance, to remove the perverse incentive to inefficiency and poor system performance. What we now call 'energy companies' should once again want to optimize our energy systems, to deliver services as reliably and affordably as possible - and to make money doing it. That will mean investing *everywhere on the system* - not only in fuel and electricity production facilities but also in user-technology and infrastructure, where we have the most headroom for improvement.

The first strand in reducing our dependence on fuel ought to be upgrading existing buildings and other user-technology - the top priority for real *energy* policy, around the world. The second strand is electricity. While we are improving the performance of user-technology, we shall still require either fuel or electricity to run it. This is where electricity will make the difference. We use two kinds of electricity. One kind we generate using fuel, such as coal, oil, natural gas or uranium. The other kind we generate by harvesting natural ambient energy flows and turning them into electricity, including hydroelectricity, wind power, solar thermal power, solar photovoltaic power, geothermal power and marine power. Most people call it 'renewable'. I prefer to call it 'infrastructure electricity'. This electricity *does not use fuel*. You invest in a physical asset - perhaps a wind turbine or a photovoltaic array. Once in place, a piece of infrastructure, it delivers electricity, for you to use as you please. The implication is obvious. Of all the ways we use fuel, generating electricity is the easiest to change; indeed it is already changing, at a breakneck pace. To reduce our dependence on fuel, as well as upgrading user-technology we should also be aiming to move as swiftly as possible away from fuel-based electricity to infrastructure electricity.

If we were starting now to electrify global society, with what we *now know* about technology, finance, institutions and environment, and about popular expectations, our electricity systems would look unrecognizably different from the systems that keep our lights on today. More than a century ago, the economies of scale of water power and steam power established the common technical model of electricity system that still prevails today. It is based on large remotely-sited central-station generators, most of which 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 which 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 mismatch is so complete you'd think we planned it that way.

It is long overdue for dramatic change; and the change is under way. We know now that we can generate electricity in much smaller, cleaner units, much closer to users. We can control system behaviour continuously and automatically, with loads and generators both participating in real-time dynamic interactions, stabilizing the system autonomously. We can establish integrated, optimized local systems including both generation and loads. Moreover, generating much of our electricity locally means that we shall be much more careful with it, ensuring that we use it in high-performance loads, especially buildings and other user-technology. Decentralized local systems in turn can be coupled with much less need for long high-voltage transmission; and we can upgrade long lines to high-voltage direct current, doubling and even tripling the capacity on the same conductors and wayleaves.

We already have the technology, both to upgrade user-performance and to move to infrastructure electricity. Further technological innovation will help, but is not critical. The critical innovation we really need is about finances, institutions and social behaviour. Both upgrading user-technology and installing infrastructure electricity generation require a distinctively different framework for finance and business. That is, at least in part, because of the role of fuel in fuel-based systems. In a fuel-based system, whether it be a building or, say, a gas-fired combined-cycle plant, you invest a modest amount in the flimsy building or the low-cost plant, on the basis that you will then continue for many years to buy enough fuel to keep the building comfortable or the plant producing electricity. On the one hand you take the risk that the cost of fuel will rise, making running the building or the plant more expensive. On the other hand, in the case of the building you may choose the cheapest available fuel; better still, someone else, a new owner or a tenant, may have to pay the bills. In the case of the generating plant you have the option of not producing electricity when fuel cost would make it uneconomical. In a fuel-based system the fuel gives you flexibility in managing the risks of future developments.

What happens when you reduce the use of fuel, by upgrading user-technology and installing infrastructure electricity generation? In each case, what is entailed may be a substantial initial investment, after which the subsequent running cost is modest to minimal. But if the cost of fuel goes down, you have already tied up substantial capital in your initial investment. You do not have the option of reducing running cost, because it is already minimal. Staying comfortable in your building costs more than it would with a flimsy building and fuel. Similarly, generating your infrastructure electricity also means capital carrying charges you can't reduce, that may make your

electricity more expensive than someone else's fuel-based electricity. Moreover your electricity output will depend on the vagaries of natural ambient energy flows. The wind may not blow, or cloud may cover the sun.

Reducing the use of fuel in our energy systems therefore removes flexibility and complicates risk management. If our future energy systems are to use less fuel, as they must, they will therefore require a different financial framework - different ways to provide flexibility and manage risk, both for users and for providers of energy services. Let me give you a striking example. At least one global insurance company is now offering weather insurance not only against a hurricane but also against a flat calm. Every individual wind farm operator is at the mercy of the weather; a flat calm means no generation and no revenue. But the insurer can build a portfolio of insured wind farms to spread the risk, allowing each farm operator a guaranteed minimum income whatever the weather.

Such financial and business innovation has enormous potential for future energy systems. We're beginning to see hints of what's needed. In the UK, for instance, we are just launching something called the Green Deal; in the US they have so-called Property Assessed Clean Energy or PACE bonds. Companies are invited to invest to upgrade customers' premises, and to earn a guaranteed return on the investment through a surcharge on fuel or electricity bills, or on local rate bills. The upgrade, however, reduces the bill; customer and company both benefit. The investment, moreover, is tied not to the customer but to the premises. Even if it changes hands the guaranteed return on investment continues. It ought to be an attractive business proposition; we shall see.

My friend and colleague Ian Temperton of the financial services company Climate Change Capital in London is just publishing a remarkable series of essays on climate, finance and information. I was given an early sight of them; I commend them strongly to your attention - just google 'Temperton climate'. If you can't wait for the complete publication online, email me and I'll send you the full series, which ought to be read as a whole.

Ian's essays explore incisively the traditional frameworks for energy investment, and the changes we must make to elicit a dramatic redirection of investment into upgrading user-technology and switching to infrastructure electricity. The essays challenge much of the conventional wisdom that now guides climate policy and electricity policy, including cap-and-trade, feed-in tariffs and other official measures, re-examining and redefining their proper roles and functions. I've no doubt the essays will be intensely controversial. To me, however, they represent a welcome jolt to the stultifying stasis now gripping climate policy worldwide.

Much of this stasis, of course, arises because powerful interests, not just corporations but entire countries, are currently doing very well out of our present fuel-based energy systems and the traditional arrangements that support them. At the moment, quite understandably, they have little desire to see these arrangements change. Indeed some have been exerting significant and largely successful effort to thwart any changes. That places the onus squarely on our various governments. If they accept that our present energy systems are failing us, governments have the power and the responsibility to make the requisite changes. However, I suggest that the most potent leverage available to governments may not be through legislation, nor through regulation. As well as being legislators and regulators, governments at every level - national governments, provincial and state governments, municipal and city governments - are major energy *users*. They themselves can redirect energy investment and redefine energy business - and take the energy companies with them.

In their role as energy users, they themselves can change not only the discourse but the practice. As clients and contractors they can change the ground-rules for the *business* of energy. They can launch

- and *publicize*, not just at the outset but on a continuing basis, as public education - major long-term strategic programmes to upgrade their own buildings, fittings and other user-technology, and to add innovative decentralized supply technologies for their own sites, including heat pumps, gas-fired microcogen and infrastructure electricity generation. The contracts entailed would prime the pumps for the new breed of energy service company we need, persuading the major energy players to create effective and profitable energy service companies to bid for and carry out the work. Such programmes would create skilled jobs all over the country, bring down the unit cost of innovative materials and technologies, and provide vivid practical examples to the private sector. Best of all, if properly organized and managed, they would save us taxpayers money. In the aftermath of the global financial mess, we've heard repeatedly about 'green stimuli' and a 'green economy'. The opportunity is obvious. Governments should stop *telling* the rest of us what to do, and start *showing* us. Imagine what such programmes could achieve worldwide.

I concede immediately that I don't expect to be around to see us get very far along in this process. The obstacles are all too obvious and obtrusive. The traditional mindset, the way we think about electricity and energy in society, is built into our institutions and social organization, our decisions and governance, individually and collectively. Governments, regulators and corporate planners see their roles in energy in particular ways. So do energy users. That will not be easy to change. We may encounter physical constraints of resource availability, not for commodity fuels but for infrastructure materials, including rare metals and other minerals of critical importance for high-performance technology and controls. The change I'm suggesting, away from fuels and toward infrastructure electricity, will create global constituencies of winners and losers; and the losers will not go quietly. Somehow I can't see the oil companies, the coal companies, the OPEC countries or indeed Alberta, taking kindly to a low-fuel future. If the energy transition is to happen, and happen in time, all the key players must see more opportunities than threats. That's why we have to change the groundrules, the business models and the mindsets.

Where is this transition heading? When assessing future energy systems, we need a vision. What do we think a future system *ought* to look like? How might it function, not only technically but financially and indeed socially? I can see at least the vague shape of a system that would make sense to me. I hope I've outlined it sufficiently clearly for you to see it too. Of course, even if my outline of a future energy system proves persuasive, we also have to devise a way to get there from here. But I am ever more convinced that the key to a sustainable energy future for our only planet will be sustainable electricity. Let's go for it.