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Electricity Vs Fire

When you say 'energy', what do you mean? Do you ever think about it? You should. My international colleagues and I are members of the Seoul International *Energy* Advisory Council. Yesterday we took part in the third Seoul International *Energy* Conference. But think about this word 'energy'. I looked up the Korean equivalent and found 'ghee'. But I don't think that's what we've been talking about. For what we've been discussing, the Korean language seems to use the imported english word 'eneoji'. Beware of this english word. It can be very misleading.

In English, we use the word 'energy' all the time. But we are careless about its meaning. Too many of us say 'energy' when we really mean coal, or oil, or natural gas, or electricity. They are not the same, not interchangeable. But lumping them all together and calling them all 'energy' makes too many people, especially politicians, think they are the same - that one can substitute for another. We talk about 'energy supply', when we really mean 'oil supply' - not the same as gas supply or electricity supply.

I am a lapsed nuclear physicist, and a pedant. I'm very fussy about language. I think the language we use to talk about 'energy' is profoundly misleading. I know what 'energy' really means. Energy makes the universe go round. When you talk about 'energy' you have to talk about whole systems, and what they do.

No one wants 'energy'. When did you last put 'energy' on your shopping list? Until just over forty years ago, no one except scientists and engineers talked about 'energy'. Politicians, governments and the media talked about 'fuel and power' - 'power' meaning 'electricity'. They did so because of what people wanted to do, and how they wanted to do it. Fuel and electricity were, and are, essential. But they are only part of the system, and not the most important part.

In physical terms, everything we humans do, everything we have ever done, amounts to just six activities. First, we control heat flows. Second, we adjust local temperatures up or down. Third, we make light. Fourth, we exert force. Fifth, we move things - by exerting force, but the activity is so important it deserves a separate category. Sixth, we manage information - now probably the most important activity of all.

We do all these activities with whole systems. In my new book, *Electricity Vs Fire: The Fight For Our Future*, I call them human activity systems. These systems are made up of <u>things</u> - physical artefacts such as buildings, lamps, motors, vehicles, and electronics - and they use two processes - fire, and electricity. Of the two processes, fire still dominates. Fire predates *homo sapiens.* Our Neanderthal precursors had fire. We have evolved with fire. We think of fire as cosy, welcoming, hearth and home. But fire is actually a violent, extreme process. Fire produces heat at a temperature so high it's dangerous. Fire turns resources rapidly into waste. Much of this waste is pernicious, locally or globally. Why can't you breathe in Beijing? Fire, and what it pours into Beijing air. Why are governments fighting over the Arctic seabed? Fire, the worldwide craving to feed fire. Why are we alarmed about what's happening to our weather? Fire, and the carbon dioxide it pumps into the atmosphere. Not only have we let fire get out of control, we ourselves are fanning the flames.

For more than a century, however, in the systems that do what we do, electricity has been supplanting fire. We make light with electric lamps and electricity. We exert force with electric motors and electricity. We manage information with computers, smartphones and so on, using electricity. Fire is a chemical process. Electricity is not. Electricity is a physical process. Electricity under human control does not destroy what it happens in. Electricity does not produce pernicious waste. Try a thought experiment. Suppose we already had electricity, and then discovered fire. Once we saw how damaging and dangerous fire was, we would almost certainly ban it.

Electricity, therefore, can save us from fire - except, of course, for one awkward detail. We still make most of our electricity using fire. We don't need to. We've known since the earliest days of electricity how to make it without using fire. We can make useful electricity, for instance, from chemical batteries and by harnessing natural forces such as wind, moving water and more recently sunlight. However, we have convinced ourselves that making electricity with fire is less costly than these other methods. Because we evolved with fire, we have never accurately costed its pernicious consequences. We still think, for instance, that coal-fired electricity is cheap, even as coal fires suffocate our cities and exacerbate ever fiercer weather. Because our cost comparisons are wildly inaccurate, our governments continue to allow us to resort preferentially to fire, rather than the many much less dangerous forms of electricity not based on fire.

Moreover we have come to treat electricity as though it were fire, with government ground-rules and regulations to match. We buy and sell electricity as though it were a a fuel, a physical commodity, in short-term batch transactions where what matters is the price per kilowatt-hour. But electricity is not a fuel or physical commodity. It is a process, happening instantaneously throughout an entire system - including most particularly the things that do what we want to do - the lamps that make light, the motors that exert force, the electronics that manage information, and so on.

Unfortunately, however, the invention of the electricity meter in 1885 broke up the electricity system and fractured the electricity process. It's as if you put a meter between the engine and the wheels of your car. Since then, electricity suppliers sell us electricity by the unit. Their revenue streams depend on selling us electricity by the unit - the more electricity, the more revenue. It is therefore in their interest for us to use inefficient things - lamps, motors and other user-technology, because to do what we want to do we have to buy and pay for more electricity. This perverse incentive still prevails - a key reason why our user-technology is so extravagantly wasteful.

We need urgently to revise our assumptions about electricity. We need to recognize explicitly that electricity is not a commodity but a whole-system process in infrastructure. What really matters is not short-term trading in some putative 'electricity market' but long-term investment in this system infrastructure. The most important place for such investment, moreover, is at the point where the system is doing for us what we want to do - the things, the lamps, motors, electronics and other user-technology, and especially the buildings. But we need investment everywhere, in the innovative technical options now burgeoning, especially decentralized generation and smart networks, to replace traditional generation and networks.

What's wrong with traditional electricity? Think about it. Traditional electricity is based on large central-station generators, most of which operate either intermittently or at only partial load most of the time. The central-station generators based on fire and fuel, not to mention the even more violent and extreme process of nuclear fission, waste two-thirds of the fire energy before it even leaves the power plant. Because the huge stations have to be built far away from users, this configuration of 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. It can shut down over a wide area and almost instantaneously, even in rich countries, as we see all too frequently.

Traditional electricity assumes that every load is essentially equivalent, requiring the same high quality of electricity. The system therefore produces and delivers high-quality electricity as required by sensitive loads, much of which we then use 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 generators based on fire and fuel are inherently inflexible. The mismatch is so complete you'd think we planned it that way.

Fortunately - and not a moment too soon - this traditional arrangement, outdated, obsolete and dangerous, is now changing. It is not, however, changing fast enough. To speed up the transition we need new investment, new regulation, new business models and new revenue streams. What we have is outmoded, unable to cope with the transformation now under way. Many network operators, for instance, face a mounting threat from decentralized generation that does not pay, or pay enough, for network access. Yet the more you have to pay for the network the keener you are to leave it and install your own generation, as is now happening hectically in Australia, the southwestern US and elsewhere.

In Denmark systems for electricity and heat now often belong to local communities under local control. In Hvide Sande, in northwestern Denmark, I was thrilled to stand on a North Sea beach in a force 8 gale under three 135-meter wind turbines turning majestically, that belong to the town and keep its lights on. In Germany the feed-in tariff and other regulatory innovations have dramatically altered the balance between local generation, now often owned by communities and individuals, and traditional large-scale remote generation owned by the major German companies. The companies are now in trouble, opposing Germany's 'Energy Transition' or 'Energiewende' while they struggle frantically to adapt. One of the biggest German companies, called E.On, has announced that it is splitting into two separate companies. The company keeping the name E.On will now concentrate on providing its customers with efficiency and renewable, fire-free electricity - what E.On's management sees as the future.

Regulatory models are breaking down. We need to reshape electricity regulation and electricity business away from its traditional focus on selling units of electricity, away from short-term commodity trading, back toward the model Thomas Edison originally used. At the outset he charged his customers according to how many lamps they had, whether they were using them or not. The customers were paying to have electric light available, whether they used it or not - just as, for instance, you pay rent to have the comfort of a house available, whether you are in it or not. Edison's customers were paying not for a commodity but for access to the process. Edison in turn had to optimize the entire system - not only the steam engine, generator and cables, but also the lamps - to keep the total cost tolerable. He was selling light, and access to light - what his customers actually wanted. Unfortunately, in 1885 the electricity meter broke up the system, and we've been paying the cost in inefficiency ever since.

For whole human-activity systems, therefore, what matters is not short-term transactions in commodities to use up. What matters is process, and access to process. Optimizing whole systems should once again become the guiding principle of regulation, and the objective of genuine energy policy and energy business. That time is still some way off. Fortunately, nevertheless, we are already seeing the gradual emergence of innovative regulation and innovative business, in many parts of the world. It is evident, for instance, in the rise of microgrids and integrated optimized local

systems serving the immediate neighbourhood, such as universities, hospitals and small communities, both in the US and much more widely in northern Europe, where local community ownership and operation of entire systems is increasingly widespread. Perhaps Korea University ought to explore the possibility of its own microgrid.

Traditional centralized systems based on very large, remote generation and very long high-voltage transmission lines are already evolving toward much more decentralized systems, in which loads and generation are closer to each other both in location and size. Decentralization reduces the vulnerability of systems to large-scale failure. It increases their resilience and ability to recover from damage, whether from extreme weather or malevolence, both categories of threat unhappily ever more evident.

Not everyone, of course, favours these changes. Traditional centralized electricity with generation based on fire still dominates. Powerful adherents in politics and the media defend its role and its advantages. Chief among its advantages is our stubborn failure to cost accurately the pernicious consequences of fire, local and global. Adherents of fire-based electricity therefore claim vehemently that it is the cheapest; and users paying electricity bills under our prevailing ground-rules tend to agree. Efforts over the years to apportion costs more accurately to fire and fire-based electricity have had at best limited success. Legislation and regulation seem unable to cope.

Yet even as we fail to account for the true cost of fire, the cost of fire-free electricity continues to fall. Many analysts now expect, for instance, that solar photovoltaic electricity will achieve so-called 'grid parity' - that is, that it will cost no more than traditional fire-based generation - before 2020 in many parts of the world. Coupled with battery storage, solar PV can turn any individual building into its own power station. Advances in battery technology such as the 'gigafactory' that Elon Musk's Tesla Energy is building in Nevada, could alter spectacularly the fundamental assumptions that underlie society's use of electricity, within a very few years.

Moreover, even as the economic case against fire and for fire-free electricity gains in strength, more and more influential voices are stressing the moral dimension of the issue. Even Pope Francis has weighed in, with his powerful encyclical *Laudato Si*. Campaigners, notably many students at universities, are calling for withdrawal of investment from companies devoted to feeding fire, saying we should no longer try to profit from the damage fire causes. In purely economic terms these divestment campaigns might appear doomed to failure. But they cast a dark shadow over the companies involved. Companies exist only because society allows them to. Company managers may soon have to ask themselves - is our business increasing the fire risk? If global society decides that we need to put out the fire, the companies devoted to feeding fire will be in dire trouble.

The implications go even further. Apart from food, fuel to feed fire is the only product we make that is intended to be consumed continuously, needing continuous replacement. Everything else we make - clothing, footwear, furnishings, tools, vehicles, buildings - is, or should be, durable, something that lasts. But we seem to have stumbled into a global economy modeled on fire and its consequences - a 'Fire Economy', what we call a 'consumer society', in which you and I are consumers, whose central function appears to be to turn resources into waste as fast as possible. The oxymoron 'consumer durables' succinctly pinpoints the paradox. From this perspective, moving away from fire as the model for human activities will entail changing the model of our global economy, moving beyond this Fire Economy - a daunting but exhilarating challenge.

One key will be to establish financial and institutional ground-rules and incentives to make fire-free electricity the norm, and phase out electricity based on fire. That can start - indeed has already

started - with governments. National governments are laggards. But city governments around the world, like the municipal government here in Seoul, are already showing the way. For city government the most effective leverage may not be legislation or regulation. It may be their role as major users of fire and electricity - highly desirable customers, who can define the business they want to do and the contracts they offer. As we have already seen here in Seoul, a local government can upgrade its own buildings. It can replace public lighting with LEDs. It can install local electricity generation and cogeneration, heat networks, private-wire networks and microgrids. And it can publicize these and similar projects as demonstrations, enlisting support and participation from private industry and private citizens.

The crucial innovation we need is a new mindset, a new way to think about what we do and how we do it. We need a new story to tell. This year, as I mentioned earlier, I have at last published a book that tries to tell this story. The book is called *Electricity Vs Fire: The Fight For Our Future*. It describes what we do, how we do it and how we can do better. Unfortunately it is not available in Korean. But I think those of you who read English would find it easy to read. I gave a copy to my irreplaceable housekeeper in England. Two weeks later she told me 'I read the whole book, I really enjoyed it - and I understood everything' - the best testimonial I could possibly receive. If you're interested, just google my name, and you'll find my website archive, with lots more information.

As my book says, we are in a fight for our future. This year, to my surprise, I'm beginning to think we may win it. I won't be around long enough to see what happens. But you will. Go for it.

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