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Energy 21: Making The World Work

By Walt Patterson

The time has come for me to reveal an embarrassing secret. Some twenty-five years ago, at the end of the 1970s, I wrote a book. I gave it the title *Energy and Purpose*. By 'purpose' I meant 'what we humans want from energy, and how we try to get it'. A reputable publisher gave me a modest advance. I worked on the book for two years, eventually accumulating about 100 000 words of text. But the longer I worked on it the less I liked it. I finally had to confess to myself that I didn't know what I was talking about. I didn't understand enough about energy and purpose to say anything I considered useful or persuasive. I gave the publisher back the advance, piled the typescript in a cardboard box and stashed it in my archive, along with the unpublished novel, the unpublished textbook and the unproduced musical.

I now propose to return to the scene of my failure so long ago, to talk again about energy and purpose - what we humans want from energy, whether we can get it and if so how. I have an alarming sense of deja vu, knowing I have been here before, and wondering whether I can do any better this time. Wish me luck.

Why talk about energy and purpose? The short answer is that we're making a mess of it. The world isn't working well enough. More than two billion people - one-third of humanity - have no access to the kinds of energy benefits the rest of us take for granted; and the proportion of 'energy have-nots' is increasing, not decreasing. Worse still, the key fuels and energy technologies of the 'energy haves', like us - fossil fuels, large dams, nuclear power - all face problems that may become insuperable. If that doesn't worry you, I'm wasting your time. I hope I'm not wasting your time.

What do YOU want from energy? You probably never gave the matter a moment's thought. That's as it should be. Almost everything you get from energy you get without even noticing. It doesn't involve a meter; you don't get billed for it. You get surroundings whose temperature mostly stays within limits your body can tolerate. You get sunlight processed by green leaves, that store up the solar energy in a form you can eventually eat, for your muscles to use. As a byproduct from the green leaves you get the oxygen you breathe to process the food; and so on. You are immersed in - and indeed you are a part of - natural energy systems of astonishing complexity and variety; and you take them all for granted.

You are also, however, immersed in energy processes that you yourself, and other people, initiate and control - what we can call human energy systems. Some you take for granted as completely as you take natural energy systems for granted. I'll bet you can't remember the last time you turned on a light. Some human energy systems you

notice, at least some of the time - particularly when they fail. When you turn the key in the ignition, or flip the light switch, and nothing happens, you notice. You also notice when you get a bill. That may be part of the problem. In the last three decades we have come to think of energy as something you get a bill for. I propose to argue here that this should change.

Let's start with this word 'energy'. When you think of energy, you probably think of oil, coal, natural gas, electricity. I don't. By training, I'm a hard scientist. I used to call myself a lapsed nuclear physicist. I am also, as my family and friends will testify, a pedant. I'm obsessively fussy about language. The language we now use to talk about energy drives me crazy. It's wrong, wrong, wrong. If we can't even describe the issues and options correctly we'll never get the policy right.

How many times have you heard some energy specialist refer to 'energy production' or 'energy consumption'? These people are supposed to be experts. Haven't they heard of the First Law of Thermodynamics, the law of conservation of energy? NO ONE produces energy. NO ONE consumes energy. The amount of energy in THE WHOLE UNIVERSE remains the same. That's what makes energy such a valuable and important concept for understanding how the world works. We don't have to conserve energy. Nature does it for us.

Why, then, do we talk this way? The answer is simple. When we talk about energy production, energy consumption and energy conservation, we don't mean 'energy'. We mean 'energy carriers' - that is, fuels and electricity. The confusion dates back only about 35 years. Until the early 1970s governments had 'fuel policy'. They had Ministries of Fuel, or perhaps of Fuel and Power - 'power' meaning electricity. Then, in October 1973, the Organization of Petroleum Exporting Countries suddenly quadrupled the world price of oil, and plunged the world into a panic. Governments everywhere launched a frenzied search for a 'substitute' for oil. Within weeks all the different fuels, plus electricity, were swept together and called 'energy', as if they were all potential substitutes for one another, all more or less interchangeable. 'Fuel policy' became 'energy policy'. Governments exhorted their citizens to 'conserve energy'. Ministries of Fuel became Departments of Energy. Oil companies, coal companies, gas companies and electricity companies all became 'energy companies'. Here in the UK the Institute of Fuel became the Institute of Energy.

So what? Everyone knows that specialists talking about 'energy' really mean 'energy carriers' - oil, coal, natural gas, electricity. Lumping them all together and calling them 'energy' is just a convenient shorthand. Does this quirk of language really matter, except to pedants like me?

I think it does. It distorts our understanding of what we are actually doing with energy; and here I mean 'energy', not 'fuels and electricity'. Worse still, this misleading language obscures crucial options we now have - ways for us to use energy much better.

Note that I'm talking about 'using' energy. That's what we do with energy. We don't consume it, we use it. Humans have been using energy on purpose since long before the beginning of recorded history. Our human ancestors began using energy by intervening intentionally in natural energy flows, or what I like to call 'ambient energy' - energy that is there for us to use, with no meter and no bills to pay. The first 'energy technologies' that our human ancestors hit upon were clothing and shelter. In cold weather clothing reduces the loss of heat energy from your body; in hot weather it protects you from too much solar energy. Shelter provides an enclosed space, reducing energy flows and keeping the temperature inside more stable than that outside; inside the shelter you are more comfortable.

You may not usually think of clothing and shelter as energy technologies. But if you really want to understand how we humans use energy, clothing and shelter are fundamental. Note, too, that clothing and shelter are physical materials. You don't measure or pay for the energy flows involved; the clothing and the shelter manage the energy flows for you. Keep that in mind. It's important.

Humans were probably manipulating ambient energy in these basic but fundamental ways long before they learned to control fire and use fuel. Fire and the fuel to feed it opened many new possibilities. Nevertheless, intervening in ambient energy remained an important aspect of using energy on purpose. In many parts of the world, for instance, humans developed increasingly subtle and ingenious ways to design the energy technologies we call buildings. They selected materials and erected structures to use the ambient energy of sunlight, moving air and human bodies for comfort, light and ventilation. They also developed technologies including sails, windmills and watermills, to use the ambient energy of wind and water for human purposes.

Ambient energy is all around us, whether or not we explicitly want to use it. Fuel, by contrast, is a material containing energy that we can release on purpose, when and where we want to use it. The word 'fuel' comes from old French 'fowaille', which comes in turn from low Latin 'focale' and Latin 'focus', meaning 'fireplace'. Etymologically, a fuel is 'material for a fireplace'. Historically, a fuel is a material you can burn, to release its stored energy as heat. This creates a local high temperature, in which you can cook food, fire ceramics and smelt metals. But the real potential of fuel only emerged less than three centuries ago, with the invention of the steam engine.

The steam engine could convert the heat energy from a burning fuel into mechanical energy - a source of controlled force and motion much more powerful than human or animal muscles, and more predictable than wind or water. The steam engine tipped the balance. Since the advent of the steam engine, giving us this potent additional way to use fuel energy, we have gradually forgotten about using ambient energy. Instead we have concentrated our attention on fuel energy - usable energy stored in a form that can be stockpiled, transported, and released in concentrated form, when and where we want to use it.

Note one important corollary. Fuel energy is comparatively easy to measure and quantify - so many tons of firewood or coal, barrels of oil, cubic metres of natural gas. Because it can be stored, it can be possessed - someone can take title to it and own it. It can therefore be bought and sold. Nobody can buy or sell ambient energy, because nobody owns it - not yet, at any rate. Keep the distinction between ambient energy and fuel energy in mind. It's important.

The steam engine, and all the numberless energy technologies that have come after it, also demonstrate another key point. At its simplest, fuel energy can be released directly from the fuel and used as it comes - say from a bonfire. However, precisely because it is being released intentionally, for a human purpose, fuel energy is usually released in the context of some sort of physical hardware - an energy technology designed to control and direct the conversion of the fuel energy.

For example, my wife and I have a little house on a remote hillside on a Greek island. The house is heavily insulated - roof, walls, windows and floor - in order to take maximum advantage of the ambient energy, whatever the temperature outside, to keep us cool in summer and warm in winter. In northern Greece, however, winters can be pretty cold. Rather than lighting a bonfire on the kitchen floor we have a black potbellied stove. It is essentially a metal canister with a lid, a small front door into which we put the fuel, and a pipe to channel the smoke of the fire out the back of the house. We burn dead heather branches from the hillside, scrap planks from the builders, cardboard packaging, essentially anything combustible. It converts the energy from the fuel into radiant heat energy that saturates the structural material of the house. If it's cold outside, a short burst of heat from the stove fine-tunes the temperature inside, and keeps us cosy for hours. Of course a lot of the heat from the stove escapes out the chimney, and the emissions would probably get us into trouble in London. As an energy technology our potbellied stove could scarcely be more basic. But we have fallen in love with it.

Our potbellied stove, however, illustrates another significant aspect of human energy use. Precisely because the stove is such basic energy technology, it can use the most basic fuel - whatever we can lay our hands on to burn. The only processing the fuel requires is to break or cut it into pieces small enough to put in the stove. Although we bought and paid for the energy technologies we use - the house itself, and the stove in the kitchen - we don't have to buy the fuel. We can gather and cut it up ourselves. It costs us our own time and effort, but doesn't take any expertise.

In that respect, our stove is no longer a typical energy technology, at least in this part of the world. Over the past three centuries, the interaction between fuels and energy technologies has become ever more specialized. A particular technology requires a particular fuel, and vice versa. The specifications of both the technology and the fuel have become steadily more stringent. Your car engine probably demands not petroleum, not even plain 'petrol', but unleaded premium petrol. As my wife and I now know, a cooker designed for natural gas will not work safely on bottled propane; and so on.

That's the main reason why looking for a 'substitute for oil' in the 1970s was misconceived. You can't change the fuel without changing the energy technology that uses it. Preparing, delivering and supplying fuels appropriate for their corresponding energy technologies now requires not only high levels of expertise, but elaborate organization of all the necessary skills and competences, with all that that implies. You can't collect the fuel on a hillside. Just as you buy and pay for the energy technology, you also have to buy and pay for the fuel. The companies you buy the fuel from used to be similarly specialized - oil companies, coal companies, gas companies. That, however, is now changing rapidly – as we shall see.

Within the past century, the human use of energy in much of the world has come to depend not merely on separate individual fuels and technologies, but on entire intricate human energy systems, complex and interconnected. To fulfil our many purposes these human energy systems use a combination of ambient energy and fuel energy not merely in individual energy technologies but in a vast human energy infrastructure. Enormous aggregations of buildings are expanding into megacities. The buildings are filled with other energy technologies, and linked by roads, pipes, cables and other interacting connections, extending human energy processes not only across entire continents but even bridging the oceans.

As well as natural energy systems, we now have a human energy infrastructure that also covers the planet. Much of this human energy infrastructure delivers the energy services we all want - comfort, cooked food, illumination, motive power, information handling and so on. However, a substantial part of this infrastructure is now devoted to collecting, preparing and delivering fuel energy to run the rest of the infrastructure. Making substantial changes to the delivery infrastructure can take as long as making substantial changes to the energy-service infrastructure, and cost at least as much.

Among the specialized and complex energy systems we have created, perhaps the most specialized are those that function with an energy carrier quite different from fuel. I mean of course electricity. No matter what you may hear from politicians and others, electricity is not a fuel. A fuel is a physical substance. You can store it until you want to use it or sell it. Electricity, in the form in which we use it, cannot be stored. Electricity is not a physical substance; it is a physical process, happening simultaneously throughout an entire interconnected system; it has to be generated more or less exactly as it is being used. Fuels and electricity also differ in another fundamental way. A fuel such as natural gas comes out of a hole in the ground at a particular place. If you want to use it somewhere else you have to carry it there. Electricity, by contrast, you can generate anywhere, at a price. Just ask the person with the hissing headphones sitting next to you on the bus.

Because electricity can't be stored, whenever you use it you have to have the entire system in place and operating. The person with the headphones, for example, is carrying the whole system. Back in the 1870s, the first systems for electric light were likewise local; generator, cables, and lamps were all on the same site. Some generators used ambient energy, with a water wheel; others used fuel, with a steam engine. The arrangement was reassuringly expensive; only the wealthiest and most

ostentatious could afford electric light. At the beginning of the 1880s, however, Thomas Edison had a bright idea. He scaled up the entire system, to reduce the unit cost of lighting individual lamps; and he enlisted subscribers on sites all around his central generating station on Pearl Street in lower Manhattan, charging them according to how many lamps they used. Edison was selling electric light - what his customers actually wanted. To keep the cost of the electric light as low as possible Edison had to optimize the entire system - generator, cables and lamps.

Soon thereafter, however, came a critical change in the arrangements - the introduction of the electricity meter. From that time on, Edison, his contemporaries and their successors were no longer selling electric light; they were selling electricity, by the metered unit. The advent of the electricity meter had an additional consequence. If you are selling electric light, you want the whole system producing the light to be as efficient and cost-effective as possible. If, on the other hand, you are selling units of electricity as measured by an electricity meter, someone using less efficient lamps has to buy more electricity from you to get the same level of illumination. From the point of view of you, the seller, inefficiency on your customer's premises is good for your business. This perverse incentive has underpinned the electricity business for a century.

The introduction of the electricity meter made electricity analogous to fuel in one key respect. If you used electricity from a central-station system you bought the electricity by the unit, just like fuel. In other respects, however, electricity evolved as a distinct and specialized form of energy carrier. As an energy carrier electricity proved extraordinarily versatile. It could even be used to collect and convert for use ambient energy from concentrated sources – even as dramatically concentrated as Niagara Falls. But electricity demanded highly skilled specialists to design the interconnected system and operate it continuously in real time, responding immediately whenever some electricity user threw a switch. It also involved what eventually became staggering amounts of capital investment in the electricity infrastructure itself. Nevertheless Edison's crucial idea, of scaling up the system to lower the cost of the services it could provide, succeeded magnificently. In my book *Transforming Electricity* I declared that 'Electricity systems may be the most spectacularly successful technology of the twentieth century. They work so well that those who most rely on them hardly notice them'.

Remember, however, that you can generate electricity anywhere, at a price. The whole point of traditional central-station electricity systems following Edison is to lower the cost of delivering electric light and the many other services electricity technologies provide. But electricity by itself is useless. Electricity just carries energy; the energy has to be converted into a useful form by an energy technology such as a lamp, a motor or a computer. When it is being used, the energy technology involved - lamp, motor, computer - becomes a functioning part of the electricity system. In this respect electricity as an energy carrier is fundamentally different from any fuel. The whole system - generators, networks and end-use technologies or 'loads' - is part of the human energy infrastructure, operating continuously in real time. You can keep a stack of wood, a pile of coal, a tank of oil or even a canister of compressed natural gas

on site, ready to use when you wish. But if you want to use electricity from a traditional system the whole system - that vast array of capital assets - has to be operating with you, in real time.

In that respect, oddly enough, using electricity has a lot in common with using ambient energy, and the link is going to get steadily closer. Like electricity, ambient energy is delivered continuously. Ambient energy can't be stored, except as low-grade heat. To use ambient energy on purpose, you need physical assets - a building, a water turbine, a wind turbine, a photovoltaic panel - that is, physical infrastructure. For some purposes, such as comfort - probably the single most important human purpose for using energy - if you make the physical infrastructure good enough, ambient energy may well suffice, with no resort to fuel energy. In much of the world, however, we have accumulated a built infrastructure whose performance with ambient energy all too often seems wilfully poor, making fuel energy essential if we are to get the comfort we want. When I first arrived in Britain from Winnipeg in Canada four decades ago, I could not believe the buildings in Britain. The heat inside barely slowed down before it escaped outdoors.

We also settle for poor performance from the energy technologies inside and around the buildings. When I arrived in London I lived in a bedsitter in Bayswater. The bath was in a sort of greenhouse over the front door. The boiler was in the basement. The hot water pipe from the boiler ran up the exterior wall. Not only was it not lagged, it was painted black – the best colour for radiators. As you can imagine, the water running into the tub was barely tepid. I couldn't understand why they bothered.

That may sound like an extreme example, but it's not. Countless reports and analyses have underlined the inadequate performance of lighting, motive power and other energy technologies in many parts of the world, and deplored the missed opportunities for so-called 'energy efficiency' - another expression I have come to avoid. Many reasons have been suggested. I'm sure you've all read the meticulous and detailed lists of 'barriers to energy efficiency' that have been pouring out since the 1970s, and they are all true. But the single underlying reason why our human energy infrastructure does not perform better is that most of us can't be bothered. We have other things to think about. If we are ever going to make the sweeping improvements in human energy use long since readily available, if we are ever going to make the world work better, someone has to want to - someone who can make it happen.

By now you're probably thinking 'What about costs? How can he talk so long without mentioning costs?' Let's talk about costs. Energy itself costs nothing. However, if you want to use ambient energy you have to design and fabricate the technology to do so. If you want to use fuel energy you have to produce and process the fuel, and deliver it to where it is to be used; and you have to design and fabricate the technology to use the fuel. Once you get beyond the mud hut and the bonfire, all these activities have become variously part of a financial economy, carried out in transactions mediated by money. The skills, competences, responsibilities and risks involved have been divided up and apportioned out in ways that once appeared to make sense, but now look

profoundly unsatisfactory, because of what they have done to human energy infrastructure.

Consider, for instance, the two parts of this infrastructure I mentioned earlier. One part delivers the energy services we want. The other part delivers the fuels and electricity to run the first part. Both parts represent investments in physical assets. Because the fuels and electricity are to be sold by the unit to users, the investment in all of this part of the infrastructure generally receives favourable tax treatment, as business investment. An investment, say, to increase the generating capacity of an electricity system, is allowed against tax; whereas investments in, say, more efficient refrigerators to make extra generation unnecessary are not. This one single anomaly, replicated across all the energy infrastructure, skews the pattern severely, in favour of more investment in delivering fuels and electricity, and less investment in delivering better energy services. Tax regimes thus tend to encourage investment in infrastructure that makes money, rather than in infrastructure that delivers the energy services we citizens want.

Using ambient energy does not make money – not at the moment. But fuel energy can be stored and sold, by the unit. What costs money is not the energy, but storing it, carrying it to where it is to be used and converting it. We use fuels and electricity to have energy available where, when and in what form we want; and we pay for the privilege. Policy people call this 'commercial energy', as if paying for it makes it better. Commentators scrutinize the prices of fuels and electricity, and analyze their movements minutely. However, in our modern interconnected society the prices of fuels and electricity by the unit have long been essentially artificial, shaped by preferential tax regimes, subsidies and cross-subsidies, cartels and outright monopolies, as in the case of electricity networks. With this in mind the highly respected chairman of Ireland's Electricity Supply Board, Patrick Moriarty, once remarked succinctly 'The price of electricity is what the government wants it to be'. Much the same can be said of fuels. Except for short-term advantage, price is not a good enough criterion.

If we were stuck with these traditional arrangements for using energy on purpose, concentrating on selling fuels and electricity by the unit at more or less arbitrary prices, we would have little chance of making the world work better. Fortunately, however, within the past decade or so something remarkable has begun to happen. I don't really understand it yet, and I'm not alone. But if I'm reading it right we may at last be starting to move in the right direction.

I noted earlier that if we really want to change human energy infrastructure to make it work better, someone has to want to - someone with the clout to make it happen. Well, now someone wants to - and not just a single someone but a rapidly lengthening catalogue of some of the biggest players in the game. As some of us foresaw, the apparently modest and constrained measures originally billed merely as 'privatization and restructuring' of traditional electricity industries in the UK and elsewhere have acquired a headlong momentum, far beyond the expectations of those who set the changes in motion. Major companies are redefining the business they are in, and the

relationship they want to have with their customers. Their focus is shifting steadily away from selling fuel and electricity by the unit. Instead they are offering to sell the energy services that their customers actually require, bringing both expertise and financial resources to bear on the energy service infrastructure itself. These big players can overcome the 'hassle factor', the 'can't be bothered' factor that keeps the rest of us from making energy work better; and they can do so for sound commercial reasons.

How this is going to work out in practice no one yet knows. But here are some possibilities you might like to ponder. In the sort of world we may be moving towards, big companies will do the short-term trading, not only in fuels and electricity but also in all the requisite energy hardware. This is happening already; the internet is humming with deal-making of every kind. But relations between companies and energy users will be on the basis of service contracts – contracts to supply whatever comfort, illumination, motive power, information handling or other energy services customers desire, at fixed contract prices over stated periods of time. For energy users, units of fuel and electricity will disappear from the picture.

Big companies will out-source a vast amount of their on-site activities; they will need plenty of staff and contract employees to install, maintain, service and upgrade energy technologies for their customers. They will also enter alliances, to bring together skills and competence hitherto separate and disconnected, from architects and designers through to electronics, control and network specialists, pooling their expertise and sharing responsibility to get the whole service system right. Financial links with customers need not include outright sale of hardware; leasing and other contractual arrangements may be more appropriate when technology is evolving so rapidly.

Governments, in turn, will have to revise and reshape company law to foster these activities, and to ensure that big players deal fairly with each other, with employees, with smaller players and with customers. Energy service contracts, even those with individual householders, will have to be enforceable in law, with penalties for failure. Governments will also have to reorganize tax regimes and fiscal structures. They must shift the balance away from expanding fuel and electricity delivery infrastructure, in favour of upgrading the energy service infrastructure. Governments will set an example and prime the pump for energy service business, by calling for tenders and contracting for their own requirements, especially for their own extensive stock of buildings. Governments will have to take explicit responsibility to make energy services available to the poorest and most vulnerable in society, by tenders and contracts for services, paid for out of government social service budgets.

For years we've been talking about 'sustainable energy'. In my more hopeful moments I think we may at last be seeing the initial stages of the evolution that will get us there – not just just those of us among the 'energy haves', but also the two billion people who are still waiting. In the course of this new century we may even manage to make human energy systems work like natural systems, continually delivering the services we want while most of us don't even notice. Can human

energy systems converge toward natural energy systems? I find the vision appealing and exhilarating.

I know all too well that energy is only one of the fundamental issues that challenge us. But if we don't get energy right the other issues will be insoluble. The most difficult piece of writing I've ever done was a 'millennium essay' written for Chatham House and published at the end of 1999. I called it *Running The Planet*. As this modest title indicates, the essay was an attempt to reassess the fundamentals of human life on earth, from first principles. As you might imagine, I lay awake night after night for many months, wrestling with it. If you're interested you can still download the essay from the Chatham House web site. *Running The Planet* proved to be a distillation of my own world-view. Since writing it I have found that I read newspapers and watch the TV news in a very different way.

One key aspect that emerged is my profound conviction that we humans cannot long survive as a species, on this interconnected planet we share, unless we can rectify the gaping disparities that divide us. As I said in *Running The Planet* 'The co-existence of opulent luxury and desperate poverty, sometimes within the same urban area, is not a recipe for stability'. Nor can we keep borrowing from our descendants.

If we are to meet this challenge, we have to get energy right. We have to make the world work better, and I think we can. But I must close with the closing lines of *Running The Planet*:

'No one knows all the answers. We may not even be asking the right questions. We're all in this together, and we'll need all the help we can get.'