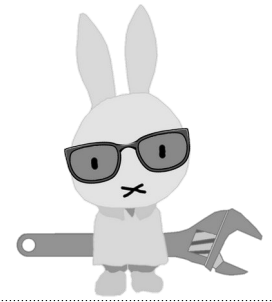


Lithium-ion batteries versus potatoes in the battle for energy storage:

Are potatoes better energy storage devices than lithium-ion batteries, and what does that mean for technological society?

Paul Mobbs, *The 'Meta-Blog'*, issue no.16, 28th August 2021



Oh no! Not that [stupid clickbait article](#) again! *Stoners!* Even without the questionable quality of the drugs they consume these days, you have to wonder about their credulity: “*Hemp Batteries are Eight Times More Powerful than Lithium, Scientists Discover*”?

The problem is people really don't understand energy in general, and electrical power in particular: How it is made, how it can be stored; and more importantly, they really don't get [energy density](#) and [embodied energy](#).

My response to that article?: ‘*Did you know that, weight-for-weight, potatoes can store more energy than lithium-ion batteries?*’

How energy has been portrayed by politics and the media is inseparable from progress and [technocracy](#). From [consumer bling](#), to [nuclear energy propaganda](#), people are taught to only think about energy only in terms of ‘more’: More of it to use; and, more ‘stuff’ to use it with. That whole framework for perceiving the world is willing ignorant of the physical realities energy is based upon.

The reason that clickbait article keeps doing the rounds isn't the psychoactive effects of THC. It's the impact of a far more powerful drug: [Consumerism!](#)

The pseudo-science of ‘more’

What is consumerism? It has political and economic definitions, but I prefer the psychological:

‘The basic inability of a person to critically discern their needs from their wants under a systematised psychological assault on their freedom to choose.’

After three centuries of research we have a fairly good understanding on how energy ‘works’. The [Laws of Thermodynamics](#) underpin all the sciences, and to an extent, even the pseudo-science of economics. But when businesses market commodities to the public, or governments the solutions to the ecological crisis, the public's credulity on the physics of energy is willingly abused.

The impacts of the more than seventy-year psychological assault of consumerism are numerous. What they have in common is that, at all levels of society, they reinforce the values of affluence and wealth; in turn, helping to drive their power and influence at the heart of this system. Or as a pioneer of [ecological footprinting](#) analysis, William E. Rees, [observed last year](#), “*More disturbingly, many ordinary citizens are all too willing to go along for the ride, trusting their leaders, buying into trivial mitigating pursuits as solutions, and thus becoming both victims and perpetrators of eco-destruction.*”

Nowhere does this compromised view – and the [cognitive dissonance](#) it gives rise to – manifest itself more nefariously than in the environment movement. Of late, a backlash has arisen over the mainstream movement's [compromise over consumer values](#); and the dichotomy of [words versus actions](#) it gives rise to. More and more research demonstrates that [this agenda does not](#) ‘*save the planet*’; it merely seeks to prop-up the consumer lifestyle against [the inevitability](#) of ecological collapse.

One of the best recent explorations of this is the film, [‘Bright Green Lies’](#). It describes, with many clear examples, how environmentalism has become a front for a global industry – *renewable energy*. As one of the film's ‘[deep green](#)’ critics of mainstream environmentalism, [Derrick Jensen](#), says:

“It's extraordinary what you can get by when you have a claim to virtue... I've seen environmentalists, mainstream 'bright green' environmentalists, applauding the production of a gigantic battery factories in Nevada simply because they're for the production of electric automobiles. And it's nuts. Environmentalists, in general, have historically been pretty decent on being opposed to electronics; and historically environmentalists have been pretty strong on being opposed to automobiles. But somehow, if you combine electronics and automobiles, then suddenly it's a good idea. That's crazy.”

Burning the planet to make bulk foodstuffs

OK, what has this all got to do with potatoes? When pundits or the media talk about 'energy', what they mostly talk about is electrical power. The fact is globally, and in most developed states, electrical power is only a fifth to a third of total energy consumption. And so immediately you're ignoring three-quarters of the 'energy problem'.

Food is energy: It takes energy to grow it; it takes energy to harvest and process it; and then, when you eat it, you get energy back as food calories.

In nature any animal that gets less calories from its food than it takes to find will die; and the more stark that differential, the more quickly it will die. That iron rule of nature does not (currently?) apply to modern humans, however.

We've feasted upon the Earth's 'inedible' natural resources; **turning oil, gas, and phosphate rock**, into food using intensive agriculture. It's that 12,000-year-old process – the contemporary of our first use of metals, and the founding of technological society – which has been at the root of creating the global ecological crisis.

It's strange that this issue **is arising now** as I worked on it almost twenty years ago – and no one seemed particularly keen back then. I stopped talking about it around 2010 because, in the wake of 'The Crash', people really didn't need any more angst to heap on their more precarious lifestyles.

This issue of food and energy density first came to light about thirty years ago. Researchers began to look in detail at how much energy and resources are involved in maintaining our daily lives; and the **results were not good**. Everyday consumer prod-

ucts, for example the **eponymous 'Big Mac'**, took way more resources to produce than were delivered to those eating them; a lot more (see *diagram below* – from **one of my presentations** circa. 2008).

In the book, '**Bright Green Lies**', Jensen says, "It can be fun thinking about "energy density," which, if you recall, is the amount of energy per unit mass you can store in some material. Here's what's funny about it: Bright greens are excited because lithium-ion batteries can store 1 MJ/kg, and they hope to someday reach 5 MJ/kg. But fat already can store 37 MJ/kg, and protein and carbohydrates store about 17 MJ/kg. We think we're so smart as we destroy the world so we can make a battery with less than one-third the energy density of a potato."

There is a reason for this 'bright green excitement': Today, campaign groups are not working to 'save the planet', but to 'save our affluent lifestyle'. They might talk about climate change, but their dialogue is dominated by projects or policies that replicate affluent consumption patterns; but that in turn **do not significantly change** their ecological impact.

People obsess about electricity, and the technologies to make it. Seldom, though, do they think about something as hum-drum as their food – which is where Jensen's statement makes a stinging point.

Thing is, while I know Jensen's statement embodies the truth, *I know it's not accurate*. That's because he falls into the same analytical trap as so many other commentators; looking 'what's in' the commodity, not the footprint of how it is made.

The situation is way more complex than is readily apparent. Yes, batteries store electrical power, and potatoes store food calories. But it also takes energy to build the battery, and of course it takes energy to produce the potatoes.

More critically, how do you compare something that can be recharged and reused many times, to something that is only eaten once?

Comparing lithium batteries and potatoes as energy storage devices

All batteries, from old-fashioned lead-acid to the latest lithium-ion (Li-ion) cells, **have a 'storage density'**: A measure of how much electrical energy they can store per unit of volume or weight.

Embodied Energy: The Big Mac®

The BigMac, without inputs such as packaging and running the store, requires between 3.2 and 8.1 (av. 5.7) calories per calorie of food energy delivered.

The BigMac – 210g serving (UK), 493kcal/2.1MJ

Av. EE, 11.8MJ (hi 16.7, lo 6.6) = density 56kJ/g. Inputs 1941g (inc. waste/feed)

Lettuce

25g, 1.98MJ, 72kJ/g

Dried onion

1.5g, 0.08MJ, 53kJ/g

Pickles

6.6g, 0.04MJ, 6kJ/g

Dressing, 17.8g



Bread

66g, 2.95MJ, 45kJ/g

Meat

80g, 7.11MJ, 89kJ/g

Cheese

13.3g, 0.64MJ, 48kJ/g

Based upon: *Energy Use in the Food Sector: A data survey*, Annika Carlsson-Kanyama, Environmental Strategies Research Group, 2001

The Energy Beyond Oil Project



What is so often overlooked is that it also takes energy to make the battery – a figure called ‘*embodied energy*’ – in addition to charging the battery.

In the same way, food has a certain amount of ‘energy storage’ as food calories. And to get those from potatoes we have to grow them, then [cook them](#), using various energy sources.

Though it is said potatoes store more energy than lithium batteries, it’s more complicated than that.

The figures must be expressed the same way. The big difference is the number of times you can do this: A lithium-ion battery can be recharged maybe 3,000 times; you can only eat a potato once.

More importantly, batteries only ‘*store*’ energy; meaning energy must be put into them first. As charging never gives back what it took, overall rechargeable batteries do not supply energy, they consume energy on each cycle.

We need a figure for [the ‘net energy’ of each cycle](#) – how much energy is output on each cycle, less [how much embodied](#) and expended energy goes into each cycle.

Reviewing various journal papers, the [energy characteristics](#) of a lithium-ion cells (rounding the figures up/down to the nearest 100) are shown in the table above. Yes, lithium-ion batteries consume a lot of energy in production, but assuming they’re recharged 3,000 times, each cycle only ‘costs’ a fraction of that figure. Overall then, each cycle supplies **-450kJ to -1,000kJ/kg**.

“*Hang on*”, you say. “*How can a battery supply a negative value of energy*”. Well, it can’t. The system supplies it – *the hidden consumption of resources which media pundits never take into account*.

The calculation for [shop-bought potatoes](#) are shown in much the same way. Take [the calories supplied](#), and as we eat them only once just subtract the energy used in production, plus the energy used in cooking. This gives a figure of **-5,200kJ/kg**.

“*Hang on*”, you say. “*How can a potato supply a negative value of energy*”. Well, it can’t. The system supplies it – *the hidden consumption of resources which media pundits never take into account*.

	Lithium-ion battery	Shop-bought potatoes	Own-grown potatoes
Stored energy, kJ/kg	300 to 700 <i>electric power</i>	3,300 <i>food calories</i>	3,300 <i>food calories</i>
Embodied energy of ‘cell’ production, kJ/kg	1,300,000 to 2,900,000	7,000	330 [#]
Cycle energy input, kJ/kg	315 – 735 [^] <i>charging</i>	1,500 <i>boiling</i>	1,500 <i>boiling</i>
Number of use cycles	3,000	1	1
Net energy per cycle, kJ: <i>stored – ((embod. ÷ cycles) + cycle en.)</i>	-448 to -1,001	-5,200	+1,470

* Expressed in kilo-Joules (kJ) as equivalent for potato & li-ion battery data:
1 Watt-hour (Wh) is equivalent to 3.6kJ; 1 kilo-calorie (kCal) is equivalent to 4.2kJ.
Input:output calories of subsistence agriculture, 1:10, assumed from other studies.
^ Assumes 95% cell charging efficiency

The last column is ‘own-grown’ potatoes. This assumes hand-digging and harvesting, saving and reusing seed, and not adding artificial nutrients. Rather than use a ‘0’, it assumes a [~1:10 calories input/output ratio](#) for subsistence farming. These potatoes produce an actual surplus of **+1,470kJ/kg**.

“*Hang on*”, you say. “*How can a harvested potato supply more than energy than goes into it; that violates the laws of physics!*” Well, it can’t. What’s happened in this case is that the solar energy of photosynthesis, and the nutrients supplied by living organisms – so called ‘[ecosystem services](#)’ – have provided that additional energy in put naturally.

Modern farming, producing bulk commodities for supermarkets, uses large amounts of fossil fuels and other inputs. For example, around [2% of the world’s energy supply](#) goes into making fertiliser. Then there’s processing and transport on top, often spread across continents. A recent study found that perhaps [40% of global carbon emissions](#) are tied up with agriculture – *this is why!*

While environmentalists obsess about EVs and battery technology, [their ‘modern’ lifestyle](#), and especially food supply, often demands more energy, calorie per calorie, than cycling an EV battery, watt-hour per watt-hour. If they’d stop buying from supermarkets, and grew food [locally using low-tech methods](#), their diet might transform into supplying a truly ‘renewable’ energy surplus.

If we do a more exacting analysis of Derrick Jensen’s claim, the results show not only that he is right; but the full answer is far closer to the point he is trying to advance. The problem is not batteries versus potatoes; it is that ‘low tech.’ potatoes are far better than their resource-intensive counterparts.

'I Want to Believe'

Oh, the article about hemp batteries? I'm not even [going to examine that](#) here because it's so absurd. Why that article is important is that represents one of the key features of all technological debates in consumer society – as so distinctly put in the series, 'The X-Files' – "[I Want to Believe](#)".

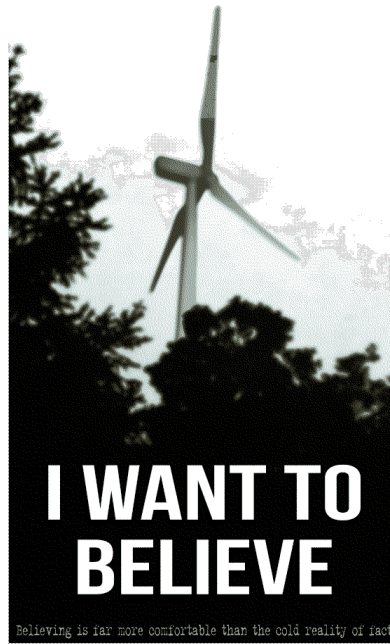
People are no longer permitted to explore [or to act independently](#):
"Political agency is no longer defined by interest groups seeking out the levers of state power, because these levers are seen to be largely impotent or politically suspect".

Much of politics and the media takes this as an accepted fact. It requires people 'believe' what they are told, and not demand evidence from politicians, or pundits, that confirms the claims being made. In that context, how do people battle an existential crisis? For example, is it any wonder Extinction Rebellion get so little coverage?

Consumer society must disempower the individual to function effectively. You have the freedom to choose a particular job, but in a consumer society you are forced to work in order to survive. That's because to survive you must consume, and to be a consumer you must have the money to pay for goods, perpetuating the cycle of consumption.

It is that [virtuous circle of economic exploitation](#) that gives corporations and the modern state their power. Ameliorating the impacts of that with [green technology won't change](#) the nature of that. The only way to break that system is to break the cycle of exploitation through our essential daily needs.

The simplest way to do that is not to consume what is offered, but to produce the vital goods for your daily life yourself – *especially food*. Of course, that's where it gets difficult, as you butt-up against



the regulatory restrictions that consumer society has enacted to facilitate its daily operation:

Land – the essential precursor to living more independently of this system – is hard to come by cheaply. Even if you have land, regulatory barriers prevent you easily living a simple lifestyle upon it – as the regulation of everyday life takes a dependency upon that system of exploitation to be the norm.

That is why this system is going to fail; it is intolerant towards any proposals for change that expose its irrational, meaningless, and most brutal flaws. Or, as William Rees' paper ([noted earlier](#)) put it:

"The over-arching question is whether society will be willing/able to organize globally to abandon the myth of 'perpetual-growth-with-decoupling' and articulate a compelling new social-construct-for-survival that will override, rather than reinforce, peoples' innate myopia and expansionist tendencies."

There is sparse evidence that this is possible. The ongoing national stalling [over climate change](#) being an exemplar of these systemic failings.

Consumer society cannot be 'reformed' because the types of physical change required dismantle its fundamental reason for existence – allowing people to be affluent consumers. This has been so since Thorstein Veblen wrote [one of the first books](#) on the minority of affluent consumers in the late Victorian era. [That situation hasn't changed](#) in the interim, it's become habituated across most of the population.

Thus it will always be until it drives the world to ecological collapse. We cannot hope to reform consumer society from within. At best, we can only try to escape it. To do without the lithium-ion batteries, as well as the intensively grown potatoes, and instead 'grow our own' energy storage devices.

At its simplest, consumerism works by: Separating the mass of people [from the land](#) which could sustain them; then charging a premium to buy those goods made from the land via economic middle men. Basically, it's a more modern, 'civilised' form of ['indentured servitude'](#). If you have no belief that this system can survive the realities of ecological collapse, then you need to find your route to the exits as quickly as possible. In reality, that means being able to have a space to grow your own potatoes!