# ENERGY LITERACY

understanding and communicating energy issues

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As the world heads towards peak oil, and the UKs ageing nuclear power stations come to the end of their lives, important questions arise about where we will be getting energy from in the near future. There is the threat of climate-wrecking sources of energy such as tar sands or coal, sources such as biofuels that can take food out of people's mouths or destroy entire ecosystems, and other questionable options such as nuclear energy or hydrogen fuel. At the same time there is the promise of fulfilling energy needs through energy efficiency, reduced consumption of material goods and renewable energy sources such as wind, sun and tidal power. Decisions about our energy future are made by people all the time, in choosing how much energy to use, where to purchase energy from, and what kind of energy to support and promote in debates. It is essential, then, that these decisions are made with the maximum understanding of issues surrounding energy, and that the concept of energy is communicated as accurately as possible.

'Energy' is a concept that is precise and mathematical when treated from a pure science perspective. It is, however, a word that we use in more common everyday contexts, which whilst appearing 'scientific and technological' treat the word in a far less precise way, leading to confusion and lack of understanding when learners switch between the two contexts.

This chapter looks at four dimensions of 'Energy Literacy', first the qualitative, exploring how we talk about energy, and balancing this with the quantitative – exploring the scale of the problem through energy units. Systems perspectives are advanced as a way of picking apart the hard and soft aspects of problems relating to energy, and 'feedback' is introduced as a key concept.

## Language, Nomenclature and Energy

One of the challenges of energy literacy is to communicate issues clearly that are complex and nuanced. Language provides many pitfalls, often serving to obfuscate rather than illuminate the true meaning of processes. Inaccurate use of language in relation to the range of energy issues we face is commonplace and serves to further confuse the energy debate. Our predicament as a society is often presented as a single problem - one of 'energy'; however, this fails to recognise the array of distinct, complex and multifaceted issues we face, from the impact of energy sources on climate change to the peaking of oil. There are many parallels and interconnections between this array of issues; however, they are not interchangeable.

There is often confusion about the different types of energy used by humans. The computer on which I am writing this chapter requires electricity in order to operate, whilst the car on the road outside requires high octane unleaded petrol – both are distinctly different carriers of what is refered to by the single word 'energy', and have very different properties and environmental impacts.

The terms energy and power are often used inaccurately. Energy is, of course, the 'capacity to do work', whilst power is the rate at which 'work' is done. The 'power' that a battery can deliver is the instantaneous measure of energy flow it can provide; whereas the 'energy' that battery contains can be expressed as the total of all the power supplied over the time that the battery is capable of supplying the energy. Each has their own set of units, however, these are commonly confused by learners (and journalists) alike! When we talk about a '1MW' wind turbine, for instance, we refer to the *power* that turbine is capable of producing at any one time when the wind blows at a particular speed. However, over the course of a year, if a wind turbine produces 3.9 million kWh *energy*, this is determined by the power produced over time, which in turn is a combination of how hard and often the wind blows. It is not uncommon to see statements such as 'The wind turbine produces 3.9 million kW' or the real example, 'the average energy saving in just one hospital would be over 24000 kW [sic] of energy, or 36 million kW [sic] of energy if fitted in all hospitals' from a press release by a hand dryer manufacturer. Both these examples show flagrant disregard for understanding of energy and power.

### *Energy Language: Reinforcing The Status Quo*

The way we talk about energy reveals 'hidden acceptance' of norms and paradigms that have been embraced by society in a period of 'energy abundance'. When we talk about units of energy that embrace a particular fuel type – MTOE, millions of tonnes of oil equivalent, or MCOE, millions of tonnes of coal equivalent, we subconsciously endorse a particular worldview of abundant fossil fuels. Using the neutral turn of phrase and units such as gigajoules or kilowatts that do not ally themselves to any particular energy source is a more neutral way of discussing energy matters, and converting between units is a relatively simple affair.

Also, the way we talk about 'renewable' resources, influences our perception of them. The term 'alternative' verges on the pejorative, with an inference that power from ambient energy sources is somehow a second option, an alternative – rather than the main agenda. Some, including the energy commentator Walt Patterson, prefer the descriptive term 'ambient' energy to either 'renewable' or 'alternative' – it is a notion that re-enforces the fact that we are harnessing the earth's natural energy flows, that are all around us, and using them for our own disposal. The term 'ambient' reinforces the fact that this energy is omnipresent.

### Using Services vs. Using Energy

In teaching skills for sustainability literacy, we need to challenge traditional views of how goods and services are provided, and highlight alternative models of delivering human well-being – whether than be through different business models or a change in perception and awareness.

Moving into the 21st century, in some quarters the paradigm is slowly changing. Energy suppliers in many countries are encouraged to deliver reductions in demand whilst maintaining a profitable business. As the demand for new services increases, the traditional way to respond to that demand is to build more power generating capacity to meet that demand. We can change *how* we provide power to users, choosing cleaner technologies and better systems: this is known as 'Supply Side Management', however, it fails to address the root of the problem – our growing demand for energy.

'Demand Side Management' is a strategy that says – rather than just accepting an increase in demand, the utility providing that power can respond by helping the user of energy to meet their demand for services in ways that are more efficient – for example, by giving away free light-bulbs. DSM challenges the year-on-year growth of energy consumption, by addressing the problem from the consumers end and challenging the need for increased energy consumption.

**A problem of scale**

The problem is a multi-scalar one. In order to beginning to tackle to problem, we need individuals to be able to perceive the problem on a personal, community, regional, national and international level.  Whilst we can understand the different scales of the problem in terms of organisational, institutional and political challenges on different levels; it is helpful to grasp the quantities of energy that we are talking about and differentiate between different units of energy and power. This goes hand in hand with understanding energy units and SI prefix scalars, included in the appendix to this chapter. A firm grasp of these combines with a sound understanding of basic units and how these relate to each other will be invaluable in understanding the relative scales of 'problems' and 'solutions'.

These issues of scale are particularly timely when engaging in the debate between 'centralised traditional energy generation' vs. 'decentralised *renewable* energy generation'. The size of generating units in centralised thermal power stations and small renewable installations vary enormously, and it is hard to engage in this debate meaningfully without an awareness of the scales of different solutions. We can start to pick apart debates such as "How many 'domestic micro-wind' turbines might we need to substitute for a large coal-fired power station" with an understanding of how units of energy and power are scaled.

**Energy and Systems**

Systems thinking is a central part of Education for Sustainability. Van Huis & Van den Berg (1993) advance a model of systems thinking for use in 'teaching energy'. Our perception of the mechanisms through which energy is produced and consumed needs to move beyond simplistic understandings of provision and consumption, to more complex systemic understandings of energy as a process of transformation, with multiple inputs and outputs.

At the moment we perceive energy transformation as a process of 'consumption' – a uni-directional flow from producer to consumer, with perhaps some intermediate refining, processing, extraction or other transformation process..

One way to bring the teaching of energy units to life is to use meaningful examples of applications – this is something that can readily be accomplished with plug-in energy meters. Learners could compare the amount of energy used to make a cup of tea with the power required to run a laptop computer, for example. This gives one side of the 'human' dimension of energy – consumption.

The side learners are less likely to be aware of, at least directly, are the human costs associated with energy production. Looking at the 'death rates' for different methods of power production is illuminating, if a little macabre. What are the risks associated with power generation – an evaluation of the effect of coal mining on a locality, or discussion of the Chernobyl accident and how its effects spread beyond the borders of Ukraine, affecting such distant groups as the North Wales sheep farming community (whose meat still needs to be tested for radiation levels) can help to illuminate the far reaching impact of power production. On a local level, opposition to local power developments, whether that be the planning of a new power station, wind farm or incinerator can help give energy a personal and emotive connection, grounding the subject in real issues and showing its relevance.

Many students understand energy as a process of production and consumption – energy is produced at a power station and consumed by customers; this is partly a result of the current socio-technical paradigm of energy consumption and production in the developed world. We see power stations, oil rigs and coal mines as producers of power, and view ourselves as passive consumers.

Our modern industrialised energy provision removes any responsibility for the provision of energy from the consumer, and with this lack of awareness comes disinterest and apathy. As users embrace the process of generating their own power, they become connected to and interested in the process and conscious of the conservation and efficient use of energy.

**Feedback – The Key in Understanding Energy Usage**

If learners are asked how much petrol they use in a week's average driving, and how much electricity and gas their house uses in a week, the chances are they'd be able to come up with a reasonable estimate of the former, and probably be clueless about the latter. Why? These are both activities where we are consuming energy, and deriving benefits from the services they provide, so why should our understanding differ? The answer lies in feedback. With a small fuel tank, your car requires regular refuelling. As you pay for the energy in small chunks, you are cognisant of the cost of the resource you fill your car with, and sensitive to its price fluctuations. Most drivers have a relatively good understanding of the cost of a gallon of fuel, and how this translates into the number of miles they can travel for that amount of energy; however, when it comes to the cost of a unit of power, and an understanding of the amount of useful work we can extract for it the response is less clear.

Unless learners pay for their electricity using a pre-payment key or card meter, the chances are that they receive little feedback of their domestic energy consumption. Their electricity usage and gas usage is recorded by an inconspicuous meter, probably hidden in a cupboard under the stairs where it rarely gets looked at. The figure from this meter is read infrequently, and they are billed invisibly by direct debit on a quarterly basis.

Learners need to investigate their 'hidden' energy consumption, and how much it is costing them, and then search for creative ways to restore feedback. If clear feedback on use is available then it is far easier to realise how much money is wasted and what changes in lifestyle can contribute to reduced use of energy.

**Exercises:**

**Ex.1**

We are going to practise conversion of energy units, using tables one and two, we should be able to convert between different types of unit, and different orders of magnitude.

- The nuclear power station at Sizewell A produced 110TWh (Tera-Watt hours) of power over it's 40 year lifespan. How many tons of oil contain an equivalent amount of energy.
- A single person's Household Electricity Consumption might be 3084kWh every year, whereas a family of two adults two children use around 5480kWh every year. What would their respective energy consumption be if measured in gigajoules?
- Although the unit "therm" is still largely used in the wholesale UK gas market, in the retail UK gas market, the term "kilowatt-hours" is more commonly found on bills. An average domestic dwelling in East Refrewshire in 2007, might use an average of 24 101kW of gas a year. However, the occupants want to compare their gas consumption, to an older bill from 1995, where the units are given as therms. Can you help them?

**Ex.2**

Look at the table three of the "carbon content of different fuels":

- Discuss why the impact for Biogas, Bioethanol, Biodiesel & Wood might differ from some of the other fuels in the table? *Hint: Explore "The Carbon Cycle".*

- Look at the "carbon content" of UK 'Grid Electricity', discuss what factors might lead to this figure? For interesting case studies use the internet to research carbon content of grid electricity from Canada and France – Contrast this against the UK.

**Ex.3**

Look at the table four "average employment for different energy technologies":

- Imagine you are a government minister in charge of energy. There is a recession and unemployment figures are increasing. A large Magnox power station, which produces an average of 420MW electrical power needs to be decommissioned. You need to replace this capacity with an alternative (or range of alternatives) from the list.
    - Discuss the employment opportunities that could be created by each technology.
    - Discuss the barriers and opportunities in terms of "employment", skills, training, workforce that each of these choices would create.
    - What other barriers do you see to the implementation of your plan?

**Ex.4**

Buy a "plug-in" energy meter, and compare the amount of power drawn by a range of household devices. Note how much power they draw. Prepare a "guesstimate" of how much power these devices might draw over the course of a year's use – considering how often they might be used. Now monitor a devices energy consumption over a week using the meter, multiply this figure by 52, and compare this to your estimate. How accurate were you?

**References:**

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**Appendix**

Table 1. Commonly Used SI Prefixes When Talking About Energy:

| Factor | Name | Symbol | Number of Zeros |
|---|---|---|---|
| $10^{18}$ | exa | E | 000 000 000 000 000 000 |
| $10^{15}$ | peta | P | 000 000 000 000 000 |
| $10^{12}$ | tera | T | 000 000 000 000 |
| $10^{9}$ | giga | G | 000 000 000 |
| $10^{6}$ | mega | M | 000 000 |
| $10^{3}$ | kilo | k | 000 |

Table 2. Useful Conversion Matrices:

| From: | To: multiply | | | |
|---|---|---|---|---|
| | Thousand toe | Terajoules | Gigawatt hours | Million therms |
| Thousand tonne of oil equivalent | 1 | 41.868 | 11.630 | 0.39683 |
| Terajoules (TJ) | 0.023885 | 1 | 0.27778 | 0.0094778 |
| Gigawatt hours (GWh) | 0.085985 | 3.6000 | 1 | 0.034121 |
| Million therms | 2.5200 | 105.51 | 29.307 | 1 |

| From: | To: multiply | | | |
|---|---|---|---|---|
| | Tonnes of oil equivalent | Gigajoules | Kilowatt hours | Therms |
| Tonnes of oil equivalent | 1 | 41.868 | 11,630 | 396.83 |
| Gigajoules (GJ) | 0.023885 | 1 | 277.78 | 9.4778 |
| Kilowatt hours (kWh) | 0.000085985 | 0.003600 | 1 | 0.034121 |
| Therms | 0.0025200 | 0.105510 | 29.307 | 1 |
| | | | | |

Table 3. Carbon Content of Different Fuels:

| Fuel | Carbon Content - kg/GJ | Calorific Value (Net) – MJ / kg |
|---|---|---|
| Coal | 26 | 29 |
| Oil | 20 | 42 |
| Petrol | | 44 |

| | | |
|---|---|---|
| Diesel | | 42.8 |
| Bioethanol | | 27 |
| Biodiesel | | 37 |
| Natural Gas | 14 | 52 |
| LPG | 17 | 49.7 |
| Biogas | 28 | 20 |
| Wood (Chips) | 27 | 14 |
| Wood (Pellets) | 26 | 17 |
| Electricity (UK National Grid) | 35 | N/A |

Table 4. Average employment for different energy technologies

| Energy Technology | Average employment over lifetime of facility jobs / MWa* | | |
|---|---|---|---|
| | Construction, Manufacturing, Installation | Operation, Maintenance and Fuel Processing | Total Employment |
| PV (1) | 6.21 | 1.2 | 7.41 |
| PV (2) | 5.76 | 4.8 | 10.56 |
| Wind (1) | 0.43 | 0.27 | 0.71 |
| Wind (2) | 2.51 | 0.27 | 2.79 |
| Biomass (High Estimate) | 0.4 | 2.44 | 2.84 |
| Biomass (Low Estimate) | 0.4 | 0.38 | 0.78 |
| Coal | 0.27 | 0.74 | 1.01 |
| Gas | 0.25 | 0.70 | 0.95 |
| Figures from: Kammen, D.M., Kapadia, K., & Fripp, M., "Putting Renewables to Work", UC Berkeley<br>MWa refers to average installed megawatts de-rated by the capacity factor of each technology. | | | |