TECHNOLOGY APPRAISAL

the ability to evaluate technological innovations

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Consumers are being increasingly bombarded with so-called 'green-innovations' - devices that claim to have enhanced environmental performance, offer superior benefits over their competitors, or claim some kind of eco-advantage as the result of innovation. Indeed, in these fast-moving times of sustainable innovation, there is a plethora of devices, widgets and technologies all vying for the consumers' attention. Sustainable technologies, however, have not yet been codified into standards, and there is insufficient performance data to evaluate their 'real world' performance.

The ability to look at a new product, and, with some knowledge of the underpinning technologies, make a judgement on how well it is likely to work, how useful it is and whether it is an efficient solution that society should adopt is likely to become an increasingly useful skill as the traditional orthodoxies of dominant technologies are challenged by new, more sustainable alternatives.

It is essential for all learners, not just those in technical disciplines, to gain skills in the appraisal of technologies, since everyone makes choices about which technologies to employ in their personal and professional lives, and must be able to see through the flashy marketing literature and unearth the true nature of claims made for devices. There is not space for a comprehensive discussion of the many aspects necessary for adequate technology appraisal, so this chapter describes a few examples as catalysts to engage learners in discussion, and for educators to create active learning exercises around. Through active exploration of the kinds of issues described in this chapter, learners can begin to develop a skill that is likely to become increasingly relevant as a smörgåsbord of competing technologies vie for their attention.

The role of materials in making a 'green' product

Often a product or technology will justify its superior environmental performance based on the fact that it is made from materials that are in some way environmentally benign, recycled or repurposed. In assessing the products claim to green-ness, learners need to first consider the product itself and the worldview it embraces. The new Honda hybrid car for instance, has seeds embedded in the cover of its information booklet and the speedometer glows green when the driver is light on the throttle, but is none-the-less a large, heavy machine for transporting very few people at a time. By the time it rolls off the production line it has already used up a large amount of energy in the mining and manufacturing of its materials and parts, the transportation of those parts around the world and the final assembly. If learners have a clear idea of embodied energy they can question innovations such as hybrid cars and compare them with smaller, lighter diesel cars or with alternative forms of transport such as trains.

An important question is: what are the product designers' motivations for choosing alternative materials? Are they subtly used to replace other materials where they can offer similar performance but with reduced impact, or are they brazenly displayed to add novelty to a product? Do they constitute the bulk of the product, or are they a thin veneer of eco-minded propaganda over an otherwise unsustainable product? Learners also need to question how the use of materials affects the users' perception of the product – does the fact it is covered with an 'environmentally benign' material make it more acceptable to the user to throw it out and replace it than if it was made from a conventional material?

Bolt-on renewables

There is a current vogue in green product design for 'bolt on renewables' as a solution to the energy crisis. By being able to generate (sometimes a tiny fraction) of the energy required to run the product from within itself, the product somehow lays claim to being 'greener' than the alternatives.

A useful example for learners to investigate is that of a 'conversion kit' marketed to drivers of hybrid cars. The kit allows the roof of the car to be coated in solar photovoltaic material, which will trickle-charge the batteries of the vehicle. To the bystander with no technical knowledge, this may create the deceiving impression of a solar powered car, whilst at best the clean energy provided by the solar panels will be sufficient to run the lights or the radio of the car for a relatively short amount of time rather than producing enough energy to produce vehicle motion. Whilst some would still praise this as a noble attempt to 'green up' the vehicle, it is eco-façadism - a ploy to *appear* green without any real substance. If we enquire further, we could surmise that the vehicle's aerodynamic performance decreases as a result of the retro-fitted solar surface, the surface adds weight to the vehicle adding to the bulk the engine must carry around, and the solar material is unlikely to be perfectly oriented towards the sun for optimal efficiency, particularly when parked in the shade or in a garage. A far better use of the photovoltaic material would be to create a static array on the garage roof, with optimum orientation for solar collection which would also be able to collect solar energy for the duration the sun was in the sky rather than relying on fortuitous parking.

This mentality of bolting on renewables to add instant green credentials extends thorough all layers of society, with prominent politicians jockeying for enhanced green credentials by 'bolting on' micro wind turbines to their residences – save for the fact that turbulence in urban areas often means that the energy returned by small wind turbines in low wind regimes is disappointing – to the extent of not always displacing the energy used in the turbine's manufacture over its entire lifecycle. A working knowledge of Energy Return On Investment (EROI) will help students calculate whether and how soon devices generate more energy than their embodied energy, i.e., the energy that went into making them in the first place.

A question of scale

The underlying message of the work of E.F Schumacher is often misunderstood as being 'Small is beautiful' - a catchy title appended by his publisher to his originally entitled work

Economics as if people mattered. However, the thrust of Schumacher's argument, is, in fact that 'There is an appropriate scale for any human endeavour', and the same can be said of technologies. For any technological endeavour, there is a scale at which it makes the best economic, social and environmental sense.

Small scale solutions carry a certain allure to some environmentalists who believe that solutions should be decentralised as far as possible. It is possible to take this too far, however, and ignore basic economies of scale, physical reality and practicality. Solutions on a scale that is too small are futile, requiring undue duplication to produce questionable results.

There are often basic physical factors that underpin the performance of many engineered solutions. For example, with a solar array, as the area is doubled, so the power output of that array (all other things being equal) should double. Twice as many panels will cost twice as much – however, there are also 'fixed costs' that accompany such an installation, the cost of labour, and inverters and ancillary equipment. There is a scale at which the array becomes so small, that the 'fixed' costs drown out the benefit of any valuable energy generated by the array – and as the scale of the endeavour increases, so the fixed costs appear smaller in comparison to the cost of purchasing panels.

Likewise, with wind power, the physical relationships between size of turbine, speed of wind and power output are not linear relationships. In fact the capture area of a turbine, the area its blades sweep, is πr^2, and the amount of energy in the wind is a cube relationship – double the speed and you multiply the amount of energy by eight. Increasing the diameter of a wind turbine from nine feet to ten results in a twenty-three percent increase in swept area. Suddenly, the economy of smaller wind machines begins to look dubious in contrast to the utility-scale counterparts, and investment in a community wind turbine looks a sounder investment than every homeowner bolting a turbine to the side of their house. Whilst some people might cherish notions of their own micro-generation keeping their lights on as their neighbours enter a blackout, for reasons of technology and economy the development unit that makes sense may require the cooperation and pooling of resources among members of communities.

Technology lock-in

There is an element of 'path dependency' in the selection of technologies. Decisions will need to be made in the evolution of new sustainable technologies, and standards will have to be selected and codified – either by national bodies, or informally selected by consumer decision making and current public perception. These decisions and choices will doubtless result in increased energy and vigour being channelled into developing those initially selected solutions into versions with iterative improvements. However, there is ample evidence to suggest that neither the market, nor official bodies are always right in their initial selection of standards.

The standards that 'win', are not always the standards that are technologically superior. In the βetamax vs. VHS formats war, VHS was the eventual winner even though βetamax offered higher horizontal resolutions, less video noise and less crosstalk between channels. A combination of factors, marketing availability and price led to the widespread adoption of

VHS, which shaped videoplayer technology until the end of the 20^{th} century when video tapes themselves were superseded.

We will inevitably see a degree of competition as sustainable technologies compete for market share, for subsidies and for recognition. Choosing the most suitable technologies involves an element of forecasting, looking not only at our present technology needs but also ensuring that if we pursue a particular path there are no unhelpful dependencies or lock-ins.

A good example of how this will be played out in the next several decades is looking at the transition to alternative vehicles and fuels. Many technologies are vying for recognition as the answer to fuelling our transportation needs in a post-petroleum world. At the moment, no one solution emerges as a clear winner, partly because of the presently intractable nature of storing energy in the small weight and volume presently afforded by liquid hydrocarbons. Competing technologies – electric vehicles and hydrogen fuelled vehicles, not to mention advanced biofuels – pertain to offer a solution at some point in the indeterminate future. Selection of any one of these technologies however, will result in the creation of path dependencies. Adoption of new vehicle technologies is heavily reliant on the provision of infrastructure, which is costly to develop. It is also necessary to consider undesirable side-effects related to scale - for example, the impact on ecosystems of providing biofuels on a very large scale, or the contribution to climate change if electricity from coal fired power stations is used to create hydrogen or power electric cars. In making decisions that will have a real impact on the future trajectory of green innovation, we need to ensure that learners are equipped to make sound, resilient technology choices today.

A question of necessity

All kinds of devices from aeroplanes to mobile phones are labeled 'green' or 'ecological' simply because they use slightly fewer resources in their manufacture or consume slightly less power than alternatives. However, learners need to compare these minor gains with the scale of energy reduction needed to cope with climate change and peak oil, and ask themselves whether small savings like these are of the right order of magnitude. They will need to consider the rebound effect, where efficiency savings result in more money available to spend in further energy consumption, such as reduced plane ticket prices due to fuel savings resulting in people flying more often. Cars are a good example of a technology which has become far more efficient over the years, while the overall energy use has increased significantly since there are simply more of them and people drive further in them.

Often, the only solution is not a slightly more efficient version of the same technology, but an entirely different technology. If the problem is restated from 'what's the greenest kind of car I can buy' to 'how can I best fulfil my transport needs' then walking, bicycles or trains might be the most appropriate technology for people in particular situations. In general, green advertisements attempt to convince people that by purchasing a slightly more efficient product they can continue to live their lives in exactly the same way as before but without the guilt. Learners need the ability to resist such messages and search for ways to change their lifestyle and business practices so that their needs can be fulfilled using significantly less energy. Without skills in doing so, they are unlikely to survive and thrive in a world where the use of energy is increasingly constrained by limitations on fossil fuel extraction and environmental legislation.

Activity

Learners could engage in active learning exercises where they write down lists of the services they receive from energy-intensive technological devices. They could then search for available or possible ways of making the technology less environmentally damaging. A starting point may be considering advertisements for 'green' alternative products and estimating how much energy would be saved over the expected product lifetime, taking embodied energy into consideration. Going beyond that, however, they could think laterally about whether an entirely different form of technology could provide the same service if they changed their lifestyle in particular ways. For example, learners might write that they get the service of 'exercise' through using jogging machinery in a heated and lit indoor gym, but the same service could be supplied for free by running outdoors or even gardening with friends. They get 'entertainment' from the latest video games, MP3 players, chatting on the internet, and watching plasma televisions, but 'entertainment' could equally be provided through alternative, less energy-intensive ways that could, ultimately, be healthier and more fulfilling. Learners could calculate savings both in terms of energy and money, and think of ways of avoiding the rebound effect by channeling the money saved into something more meaningful than additional consumption.

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