Abundance

a new approach to energy sustainability

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This white paper outlines a transformative approach to sustainability, focusing on the way renewables offer opportunities of abundance and the way this could lead to a radical transformation of industry and life.

When we think of energy and sustainability, of carbon footprints and global warming, the normal environmental response is to think about saving energy, reducing demand, the psychology of scarcity. That is our focus is negative, on things we do not do. The variability of renewable energy makes this worse, not just reducing overall demand, but needing to deal potential of periods of time when energy is extremely scarce.

This is important, but variability also offers opportunities, times of scarcity, but also times of abundance. When there are periods when energy is available, cheap, free or maybe even negative cost, our whole conception of environmentally friendly industry and transport is transformed – uses that would normally be regarded as wasteful or uneconomic, become positive uses of otherwise lost resources.

1. Background

1.1 On demand vs. on supply

In 2013–2014, the OnSupply project looked at issues of public awareness of renewable energy using the island of Tiree as an example. The project was set within the local context of an island with its own community turbine, and within the national and international context of work on smart grids and smart meters to enable better use to be made of variable renewable supply.

Part of the idea of smart grids is to enable non-urgent uses, for example, washing clothes, to be time shifted to periods where there is greater availability of electricity. To some extent off-peak rates and storage heating already do this, shifting power use to times of (on average) lower demand. However, by and large, the electricity industry is oriented to ensure that energy is available *on demand*: when the customer flips the switch, energy is expected to flow.

This approach has always had problems, notable the Coronation Street effect: when the popular soap finishes the nation turns on its electric kettles. The industry is aware of some of these surges in demand, but needs sufficient capacity of electricity generation that can be ramped rapidly to full power,

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requiring specific types of generation capacity that are not otherwise the most efficient.

The growth of renewable energy supplies make this worse as renewable sources have their own variability: the wind blows and the sun shines when they will, not when Coronation Street finishes! In response to this, smart metering starts to create a change of emphasis; instead of providing energy *on demand*, can consumers shift their use if energy to when it is available, consuming *on supply*.

1.2 Supply on Tiree

This variability of supply and demand was particularly clear in Tiree when the undersea cable to the mainland power grid was broken. As well as a 950KW community owned wind turbine, Tilley, there is a 3.5Mw backup diesel generator, which comes into operation if the grid connection is disrupted. As well as being far more expensive to run, the fuel filled the ferry causing knock-on problems for other freight.

However, during these times, just when Tilley's electricity would be most useful, it has to be held back to a 'ticking over' 50kw mode, because the diesel generator cannot cope with the potentially rapid changes of power when the wind drops.

The average island use is close to the 1Mw that Tilley produces at full power … and Tiree is a windy island, so it often does! Of course, this demand has peaks and troughs above and below that and in particular the normal peak point at around 1.5Mw is at 4am in the morning … not the time one would normally expect.

This peak is because approximately 2/3 of island homes uses some form of electrical hearting, and about half of these are on 'Total Control' a metering system that is rather like a conventional off-peak 'white meter', but gives the electrical supplier more control over when (far cheaper) power is provided. Total control guarantees a certain number of hours of night time, and afternoon electricity, which is then used to power storage heaters, but gives the electricity board the choose as to when this is provided. A radio signal is used to trigger these times. Over Scotland as a whole this will undoubtedly be staggered, but all of Tiree homes receive the same signal, hence the 4am surge.

However, this did suggest that if the 'Total Control' were switched at a finer scale and under more local control it could allow Tilley to be used more effectively.

Imagine an automatic system that monitored Tilley's output, and simply directed the majority of this directly to storage heating. That is, only turned on the Total Control heaters when Tilley was producing electricity, and just the right number to balance its output. If the wind dropped suddenly then the heaters could equally quickly be turned off , unlike the slow ramp up time required for the diesel generator.

In practice, such a system would have some extra features to deal with longer-term variability: filling in storage heating from diesel generation if there were insufficient wind and feathering back wind production if the island storage heating were saturate. A more sophisticated version could use weather data to predict what proportion of wind power was reliable, in the sense that wind would not drop below this level too rapidly for the diesel to compensate, hence allowing it to be used for non-storage uses.

Disruption to the grid connection is only an exceptional event, especially since the subsea cable has been upgraded, so it would not be worth the investment in infrastructure, but this productive use of storage heating as much to deal with excess production suggests a broader principle.

2. From Variability to Abundance

Recapitulating, variability of renewable energy sources form wind, wave and sun, is seen as problematic, because it may not synchronise with demand. In contrast, current energy supply aims to always satisfy need as it arises. In the case of the electricity supply switching power stations and pumped storage, in the case of direct fossil fuels for heating and transport, ensuring there are sufficient stocks to provide for demand.

If renewables are to form a substantial part of power provision they need to be able to deal with peak demand, including when they are at minimum.

To deal with gaps due to high demand, this may mean:

S1. *Combine* – Combining renewables with less carbon-friendly power sources that are only used as fillers, e.g. coal or oil

S2. *Store* – Using energy store excess from periods of high production to fill in gaps (e.g. batteries, hydrogen production)

S3. *Reduce* – Reducing demand (e.g. paying factories not to use electricity)

The opposite problem occurs when supply exceeds demand. When this happens you can

T1. *Turn Off* – For example, the way Tilley stops producing. In the UK wind farms are sometimes paid to stop producing electricity to avoid overloading the grid.

T2. *Store* – Charge batteries, crack hydrogen, pump water, etc.

T3. *Waste* – Domestic and minor industrial windmills send excess power into banks of heaters that are then rapidly air cooled … if these fail the generator overloads and catches fire! One could imagine having heating cables under large bodies of water, or similar ways to throw away excess power if this is easier, cheaper, faster or more reliable than switching off the power source.

T4. *Use* – If you are going to throw away power, maybe it can be put to discretionary use. On Tiree we considered that if there were an open-air swimming pool it could be heated (not boiling!) as a way to discard electricity.

Energy shifting, such as using a smart meter to control a washing machine can be seen as a combination of S3+T4: *reducing* use during periods of high demand and instead *using* otherwise wasted power in periods of high supply.

The Total Control storage radiators on Tiree can be viewed as a form of storage (S2+T2), or as a shift.

However, this move from *waste* to *use* (T3 to T4) opens up the question as to whether there could be other ways to use power that would otherwise be wasted, but uses that would otherwise be seen as frivolous, or uneconomic.

In the days before international transport of food, crops came in season. Some, such as potatoes, could be stored for periods, whereas others were only available for a short period. In many ways a harvest represents a 'problem' rather like over supply of renewable energy, but the idea of 'harvest' suggests images of *abundance*, an opportunity to feast and celebrate.

In some ways the 'problem' was still there, excess food needed to be stored (in one's own body, animals, siloes or barns) or transformed into more easily stored forms (jam, bacon). However, the abundance of harvest is fundamentally about opportunity not problem.

Can the abundance of energy be a similar creative resource?

One example, that is already being persued by an energy company, is to have small hydrogen production facilities at local service stations for hydrogen-powered vehicles (Levene, 2005; ERP, 2016, fig 3.1;). During times of cheap electricity they would create and store hydrogen, which would then be available to fill vehicles. In one way this is just another example of storage, but is more radical as the local production means there is less need to transport large volumes of liquid hydrogen, which can be dangerous. In addition, this means that less fuel is needed to transport the liquid hydrogen. With catalytic conversion this could also be used to replace liquid fuels (FCB, 2016).

In this example, there may be a net saving of energy, but if electricity is free or even with negative cost then new opportunities arise that may include not simply moving existing energy demand, but actually using more energy, so long as it can be done dynamically during times of peak production.

3. Application Ideas

3.1 Heating: swimming pools and polytunnels

As noted, domestic and small commercial wind turbines often deal with excess generation by having relays switch on additional load in the form of heaters on the open air. Instead of wasting this by heating air, it could be used productively. The Total Control heating system effectively already does this by using storage heating, although the aim is more to store the hear for later use (shifting demand). More radical uses are where the thing being heated would not otherwise have been economical, but by by being heated has extra value.

One example would be outdoor swimming pools. Heating water is very costly, especially for an outdoor pool, but if a pool were warmed then it would attract more swimmers with knock on health and well-being benefits. As the pool would not always be warm, this would need to be combined with some sort of community awareness system (social media notifications, public displays) to let people know when they can expect warm water!

Greenhouses for high value crops often include some form of soil heating, but this is not usually economic for lower value crops. However, with very low cost or free electricity, soil cables could be placed under permanent polytunnels. If the soil is heated then the crops will either mature sooner, hence attracting higher prices, or at the normal time bit with higher yields.

3.2 Batch processes

Factories are already sometime asked to stop using electricity at times of high demand or low availability. This is usually seen as a form of exceptional emergency response, but suggests the potential for switchable factories to be common. Many processes from assembly plants and chemical industries are designed to work continuously; breaks in production are costly.

However, many of the earliest forms of assembly and chemical process were batch oriented, creating a single artefact or a vat of chemical. Could factories more generally move back to this kind of production?

For chemical production, this might require radical re-envisioning of processes as certain forms of chemical reaction would behave badly if, say, heating were removed. However, if combined with other forms of short-term demand balancing, weather forecasts could allow factories to plan production so that critical processes are completed during times of high-availability.

There is already a move towards more flexible, short-run manufacturing with low set up costs, so in many ways industry is already shifting in an appropriate direction. Furthermore, unlike some chemical intermediate products, half-manufactured goods are unlikely to suffer damage from being left temporarily on the production line.

This all fits well the FabCity concept with its multiple loops of production and recycling at local, city and national levels (Diez, 2016)

3.3 Intermittent Transport

We have already seen the example of local hydrogen production. However, this is more a clear way of supporting 'business as usual'. More radically we could imagine driverless trains on a goods-only tracks that carry non-perishable goods and are only powered when there is excess power. Trains could stop entirely simply run more slowly. In the Netherlands the electric passenger rail network is already '100%' powered by wind, although this currently means 'on average' not moment-to-moment production. Rather than trying to make power delivery more average through storage, non-passenger rail use could itself adapt. Customers could pay different rates depending on the urgency of delivery, in effect augmenting current standard and fast delivery options with slow delivery. This would be particularly powerful when combined with plans for track-side soar generation feeding directly into the track power network (Holder, 2017; O'Neill, 2017).

4. Challenges and Potential

Most of these example concepts involve capital investment that many only be used intermittently. For example, when installing soil heating cables in a polytunnel, even if the electricity is free the additional value of earlier or higher yield vegetables needs to exceed the interest and depreciation costs of the installation. Similarly a batch-oriented factory may be in operative for substantial periods,

We already noted that certain chemical processes may not be are to cope with periods where intermediary reagents are left to stand. Similarly intermittent transport would not be suitable for perishable goods. In general, if goods decay or perish, then any forms of intermittent power use may be problematic.

Synchronising work with energy availability requires greater labour flexibility. Of course as automation increases this may well be less of an issue, but an abundance-focused society may need quite radical shifts of working patterns, just as the whole community would have shifted to the land at harvest time in pre-industrial days.

For longer-term variations, this may mean more seasonal and weather directed working, as already happens in the building industry, rural areas, or with inshore fishing and historically was common, for example, for dock labour. In the UK climate this is not helped by the fact that days off would end up being non-sun days.

Such flexibility at the employer's behest has often been to the detriment of workers security and this has become a major issue in the UK with the proliferation of zero hours contracts. The history of technological change is littered with industrial disputes, sometimes due to fear of change, but often when owners use it as an excuse to exert greater control. So, while not insurmountable, this is a major issue to consider while looking for workable solutions.

For shorter day-to-day and within-a-day flexibility, we could imagine workplaces including both automated and hand-labour elements. For example, hand finishing off of 3D printed products. Craftwork that would normally be deemed uneconomic in a developed country might become so in a richer manufacturing ecosystem, and jobs become more enriching as a consequence.

This last example demonstrates that the challenges of abundance-focused working could offer opportunities beyond the immediate environmental and energy advantages. Experiences of cradle-to-cradle design have shown that when given fresh objectives designers and engineer are able to create novel solutions, which have often saved money as well as having substantially reduced environmental footprints (McDonough, 2002).

Abundance offers a new design turn offering similar potential for innovation that substitute for existing goods a services in more sustainable ways, or offer completely novel products and processes that would otherwise appear impractical or superfluous.

5. Acknowledgements

This White Paper draws on conversations with many people, but in articular members of the OnSupply project (2013–2014).

6. References

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