Powerful choices

Solar and wind power look set to be the two dominant technologies for ***clean power generation***

Heat pumps will become the ***key means of providing heat***

Electric vehicles will become the dominant means of ***affordable clean transport***

And the rest is hydrogen

Nigel Aylwin-Foster, business development director at ReEnergise Ltd, says that two questions are often asked by governors when discussing their school's pursuit of net-zero and, in particular, the introduction of renewable heat technologies into school estates. They are: 'How do we know some new technology will not come along that renders this technical solution obsolete'? Then 'What about Hydrogen'?

▲ Hydrogen will need to be reserved for niche roles, it will not be the silver bullet hoped for by some

Underlying these questions is a broader issue: how can we be sure which technologies, if any, are going to be key to the successful pursuit of net-zero?

So, I thought it might be helpful in this edition of Bursar's Review to address those two questions and sweep up the broader issue at the same time, by describing what the future net-zero energy system is probably going to look like and which technologies will be key. I'm conscious that any essay on this topic constrained to just a few pages is bound to leave loose ends requiring further discussion but readers should regard this contribution as a starter.

For the avoidance of doubt, the terms of the deal are that the end result for net-zero – globally, nationally and for schools and any other energy users – must be an energy system which is not only cleaner than the fossil fuel era but also at least as affordable, as reliable and ideally, somewhat cheaper. A worthy cause is a good thing, but history shows that it's the money that matters in the end and there's no reason why our collective progress towards net-zero is likely to be any different. So we don't want a solution that relies on us all using much less energy, using it intermittently and, in winter months, going to bed with extra socks on or sitting in classes wearing arctic operations gear from the local British Army surplus store. I am not belittling the current drive in many schools to become more energy efficient. That is essential and common sense, but the point of these measures is to achieve the same quality of life using less energy, not to suffer a reduction in quality of life.

10 years ago it would have been difficult to answer this with any assurance, but armed with access to several assessments of what is going on globally we now know that all the relevant ingredients are in plain sight – they are either already developed, or developing with such momentum that they are now effectively unstoppable. In case this sounds too grandiose a claim, I am not laying claim to it in my own right; I am merely summarising the work of others[1]. And the sum of the general message is that net-zero is not only going to offer an energy system that is cheaper, as reliable, and much cleaner than the outgoing fossil fuel regime but that the transition to it is now inevitable: it's no longer 'if' but 'when'.

1 The most recent assessment I've read, and one which covers the subject with convincing clarity but in an easy conversational style is *The Future of Energy* by Richard Black, published by Melville House UK in 2024. I'd recommend this short book to all readers and every aspiring estate director should keep a copy handy.

Information technology

The first key ingredient in the transition is information technology. This might seem counter-intuitive in an article about energy, but it is recent developments in the way we manage data that will provide the foundation for a cost-effective, reliable net-zero energy system.

Smart controls and automation derived from advances in information technology mean that national energy systems that once used to rely on centralised control can increasingly become decentralised, both in a physical and a commercial sense. This in turn allows for the development of a market that allows energy users at all levels and right across the market to trade with other energy users, rather than us all buying all of our energy from a few providers; and it allows for a system in which there can be many local energy generators and the consumer can become a local provider as well as being a user. Note the use of the present tense in describing this; and please hold that thought while we review the other ingredients of the future net-zero energy system.

The second key ingredient is Wright's Law. Using the first definition I could find in an internet search[2]:

Wright's Law

Wright's Law, often mentioned in the context of technological advancement and cost dynamics, posits that for every cumulative doubling of units produced, costs fall by a consistent percentage. This principle, also known as the 'learning curve' or 'experience curve,' suggests that the more a company produces, the more efficient it becomes, thereby reducing the cost per unit of its products.

Note that Wright's Law stands up to scrutiny in commercial technology markets; mass production, enabled by modularity and high demand, does indeed bring down prices[3]. For example, look how the cost of LEDs has plummeted since they first started being promoted to the independent education sector, while quality has gone up. Solar PV is following the same route, although a few years behind. We can reasonably expect that other technologies that are suitable for mass production will also follow the same trajectory, if they catch the selector's eye. Conversely, energy systems that cannot be mass produced do not offer the same commercial benefits. One example is nuclear power, where the whole-life levelised cost of electricity has seemingly not reduced in real terms over the decades[4]. Another technology that is unlikely to reap the rewards of Wright's Law is carbon capture and storage (CCS). CCS systems under development are large and ●▶

▼ Very few buildings cannot be heated by heat pumps and in whole-life terms, heat pumps are already achieving cost-parity with the oil or gas systems they are replacing. N.B. School systems will be much larger than this domestic example.

2 Courtesy of Quickonomics at Wright's Law Definition & Examples - Quickonomics.

3 I recognise that there is scope for an article in its own right on the relationship between mass production and pricing, and precisely how the various enablers work.

4 I've looked at several studies on nuclear generation costs and the picture is murky but the debate seems to be about the rate at which nuclear costs are increasing, as opposed to how fast they are falling. This is in marked contrast to LED and solar prices. Some experts argue that small modular reactors (SMR) are set to change the dynamic and the EU has recognised SMRs as a relevant decarbonisation technology in the EU Green Deal. However, SMRs are proving stubbornly resistant to proliferation at present.

> Net-zero is not only going to offer an energy system that is cheaper, as reliable and much cleaner than the outgoing fossil fuel regime, but the transition to it is now inevitable.

bespoke for each situation and seem likely to remain that way. I'd suggest that UK government policy on CCS is an area to watch closely; and be ready with that letter to your MP.

Also note that Wright's Law does not apply ad infinitum. For any mass-produced commodity logic tells us that there will be an eventual point when the commercial benefits stall, whether due to market saturation or some other factor. Market data to date tends to bear this out, although it's still too early to tell for LEDs and solar installations when that point will be reached.

Electrification

The third key ingredient is electrification. According to the Cambridge Dictionary[5] electrification is defined as *the process of making a machine or system operate using electricity when it did not before*. In the context of the transition to net-zero this means, for example, that where we used to burn a fuel to generate heat, we will instead run a machine powered by electricity (e.g. a heat pump) to achieve the same function. EVs are another example. Why is this so helpful? Because electrification will introduce a degree of commonality into the energy system that renders systems integration more commercially viable[6]. In conjunction with our first ingredient – smart controls and automation – electrification will mean that energy providers and consumers can more easily switch roles and consumers can more easily switch sources in order to harness whatever happens to be the cheapest or most accessible option of the moment.

Flexibility

For the third ingredient to work to its maximum value we need a fourth; a power network that can meet changing demands and balance out peaks and troughs. This is known as flexibility. According to National Grid[7]:
Flexibility is one of the solutions to the changing use of the power networks. Fundamentally, flexibility is about reducing loads on the network by using customers' ability to change their usage patterns by either switching on generators or reducing consumption. Managing peak load through flexibility helps reduce costs to all customers because it means we don't have to invest in a permanent upgrade to meet a temporary spike in demand.

Flexibility on the UK power grid is set to proliferate at the domestic scale as consumers buy into the commercial opportunities on offer from providers such as Octopus Energy. No doubt it will take time but if Wright's Law has anything to do with it then before long it will be the norm. The workings of network flexibility merit a separate article but in the meantime those readers with spare time in their working day (!) will find a helpful guide on the National Grid website.

To summarise the argument so far, the foundation for a future, affordable net-zero energy solution is a mix of smart controls and automation; technologies that are compatible with mass production; the electrification of our power, heat and transport functions; and network flexibility.
All of which already exists and is in commercial operation in the UK.

So, returning to the anecdotal school governor's two questions, which technologies can best exploit that foundation?

Clean power

Solar and wind power look set to be the two dominant technologies for clean power generation. Other options are available but solar and wind power are now so far down the mass production/relative price reduction track[8] that it seems unlikely that any other technology will overtake them for the foreseeable future. Naturally (no pun intended) volatility in generation is a challenge, but electricity storage working in tandem with network flexibility will overcome this.

Heat pumps

Heat pumps will become the key means of providing heat. Here again, they are compatible with mass production. School staff often worry about them

5 ELECTRIFICATION | English meaning – Cambridge Dictionary
6 No doubt readers can offer other advantages of electrification but I think that it is the prospect of more commercially effective diversification that will prove the key, if we accept that achieving net-zero is primarily about affordability.
7 **https://www.nationalgrid.co.uk/smarter-networks/flexibility-and-flexible-power**
8 The metric here is not absolute price but price relative to other options.

on the grounds of heating capacity in poorly insulated buildings, and their affordability. But in practice – working in the net-zero energy sector – we find very few buildings that could not be heated by heat pumps and we know that in whole-life terms heat pumps are already achieving cost-parity with the oil or gas systems they are replacing. That downward price trend, says Wright's Law, will continue until the issue is beyond doubt. Note, however, that it is absolutely critical that they be specified and installed correctly and the evidence – in the UK schools' market at least – is that this requirement is still not being met consistently.

EVs

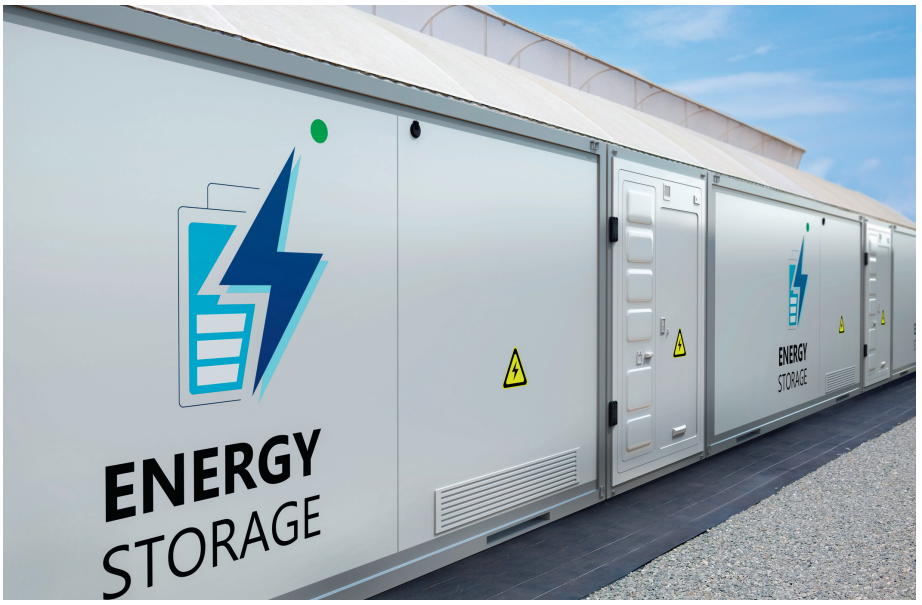
Electric vehicles (EVs) will become the dominant means of affordable clean transport, most often powered up by local solar or wind installations. When not in use they will double up as battery storage. If in doubt, look at the rising demand for EVs and the relatively stagnant demand for rival transport technologies[9].

Electricity storage

Electricity storage will be vital to compensate for the volatility of solar and wind power and some experts argue that battery storage will become the dominant means. Other options exist, but their argument is that it's battery storage that is likely to plummet in price as Wright's Law takes effect.

Hydrogen technology

And hydrogen – yes, hydrogen – will play an essential role. This will not be for heating homes and other buildings, contrary to what the current fossil fuel lobby is trying so hard to persuade us. It must be clean hydrogen, produced via electrolysis and using electricity that has been generated cleanly[10].



▲ Electricity storage will be vital to compensate for the volatility of solar and wind power and some experts argue that battery storage will become the dominant means

That rules out the more abundant option of relatively cheap hydrogen produced via combustion (unless you accept the current UK Government argument about combining this with CCS, but I don't – see above). However, clean hydrogen does not make the cut commercially for heating buildings – it's much more expensive than heat pumps driven by solar or wind power and working in concert with electricity storage. Rather, clean hydrogen will be essential for meeting those roles that are not commercially viable or physically achievable using the other technologies listed above. For example, this will include various manufacturing processes that require heat at temperatures well above those easily achievable using heat pumps. In short, hydrogen will need to be reserved for niche roles: it will not be the silver bullet hoped for by some.

Summary

Any reader kind enough to accept these arguments in principle – high level as they are – will still be left wondering 'when is it the right time for my school'? In answer, that still requires a separate discussion because it entirely depends on the situation at each school and the opportunities offered by each school estate. However, at least now in answer to those two opening questions, we can reasonably assert that:

- The key technologies required for the affordable achievement of net-zero in schools are already known.
- Developments in the foreseeable future will undoubtedly lead to incremental improvements in those technologies, but we don't expect a silver bullet to appear.
- Clean hydrogen has a key role to play, but definitely not in the heating of schools.

9 According to a report on 6th January 2025 from the Society of Motor Manufacturers and Traders (SMMT), EVs accounted for almost one in five car registrations in the UK during 2024, with a record 382,000 sold.

10 Known as 'green Hydrogen' in energy circles.

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