MacroPlus
Comment

Batteries not included

- *One major limitation of renewable technology is energy storage*
- *For power supply the issue is intermittency; for electric vehicles it is range*
- *Batteries offer applications in many sectors, but lack capacity*
- *A major battery breakthrough would transform the situation and solve a slew of problems*
- *Clever people can achieve extraordinary things, so the future could well be electric*

The storage barrier

Storage is a major limitation for renewable energy

Although there have been massive advances in renewable technology, penetration is being hampered by one major limitation – storage. Storage limitations range across many sectors, but in particular in power and transport. For renewable power the issue is separating generation from consumption over the cycle, be it daily, weekly, or longer. For electric vehicles the main issue is range.

Age-old hydroelectric storage dominates

A number of storage options are currently available: mechanical (e.g. pumped hydropower, compressed air energy storage, and flywheels); electrochemical (e.g. batteries and supercapacitors); and thermal (e.g. molten salt). Notwithstanding, decades-old pumped hydroelectric storage still accounts for around 98% of the power sector's installed capacity (Figure 1), suggesting that other technologies are not yet commercially attractive, and/or scalable. Moreover, only some hydroelectric storage eases intermittency problems associated with renewable technologies. Batteries by contrast, do.

Better batteries would provide a comprehensive solution

Improved battery technology would enable peak demand to be met at low cost, facilitate wind and solar generation, and provide distributed energy to remote areas and to small-scale applications. A comprehensive storage solution will likely have to involve batteries.

Electric dreams

The transport sector is driving battery development

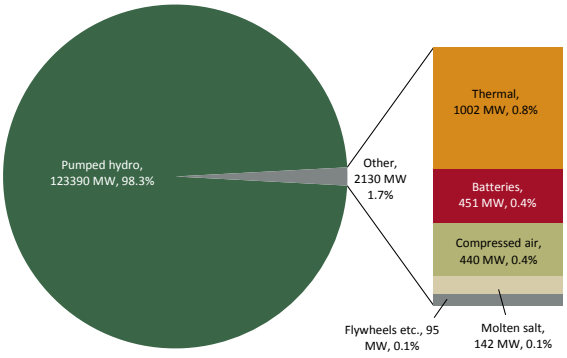
Interestingly, it is technological advances outside the power sector that are driving battery development. Batteries for electric vehicles – plug-in hybrid and battery-electric vehicles – have made significant advances: since 2010 battery costs have almost halved, while energy density volume has almost doubled.[1]

The electric car market is in its infancy, however

Electric vehicles are likely to be increasingly attractive as a clean and quiet energy source, particularly in densely populated areas where noise and air quality costs are rising, often rapidly. Continued urbanisation is likely only to make such matters worse. Increasing demand for electric vehicles, therefore, stands to accelerate battery development, improving the cost-effectiveness, and range of applications, for the power sector.

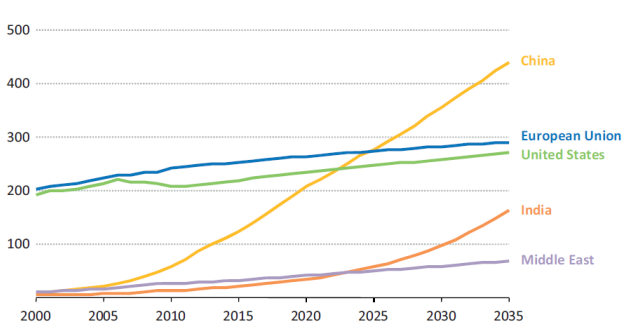
The market for electric cars, however, is still in its infancy. In 2012 a mere 100,000 were sold

Figure 1: Estimated global installed storage capacity



Source: California Energy Storage Alliance (2010)
Notes: Thermal includes energy storage for cooling only.

Figure 2: PLDV vehicle fleet growth by region, million vehicles



Source: IEA World Energy Outlook (2013)
Notes: PLDV: Passenger light-duty vehicles. New Policies Scenario.

globally, according to the IEA.[2] A key limitation of battery-electric vehicles has been range. The Nissan Leaf, for example, has a range of only 124 miles,[3] more 'luxury' models such as Tesla's cars stretch to 300 miles.[4] If range is improved, charge times would likely become less of an issue too: at-home charging for current battery-electric vehicles typically takes hours; superchargers, which can supply a half-charge in around 30 minutes are however available in certain locations.

Making a breakthrough

Lithium-ion batteries may be near their limit

The cost of lithium-ion batteries is expected to fall further, which would help bring longer-range luxury models closer to the mid-priced market. Tesla, for example, has announced plans for a 'gigafactory' which is aiming, through mass production, to reduce lithium-ion battery costs by up to one-third. Notwithstanding such developments, however, many researchers consider that lithium-ion batteries may be approaching their energy-density limit: electric vehicles with lithium-ion batteries may never achieve the 500-mile range of a petrol tank.

A game-changing technology is needed …

The world needs a breakthrough in battery technology to improve energy density markedly, reduce costs dramatically, and to transform the situation. Without such a breakthrough it is difficult to see battery-electric vehicles being the car of choice over the coming decades, particularly given that the majority of new car sales are expected to be in non-OECD countries, notably India and China (Figure 2), where cost considerations are likely to be central, and infrastructure a further limitation.

… to solve a slew of problems

With such a breakthrough electric vehicles could become dominant, perhaps globally. Power sector applications could transform the take-up, and the economics, of solar and wind power. Phone and tablet functionality could be improved markedly, providing many days of charge, and perhaps enabling the development of lighter more flexible devices too.

Given the size of, and potential for, the battery market, it is not surprising that there is increasing collaboration and funding availabilitity for R&D. The US Joint Centre for Energy Storage Research,[5] for example, has a $120m grant from the Department of Energy, and has the aim of making batteries that are five times more powerful, five times cheaper, within five years.

New technologies are being developed

New types of battery, including lithium-air and multivalent-ion, are in development. The technologies are not there yet. The former is difficult to recharge and is highly flammable. The latter will likely require new materials to improve the movement of ions. Lithium-sulphur batteries may be closer to market: material costs are low and energy density could be up to five-times that of Lithium-ion, but the reaction between lithium and sulphur can cause problems during charging and discharging, potentially limiting the number of charging cycles.

The future could well be electric

But technologists and scientists can achieve extraordinary things when they put their minds to a problem. It is necessary only to look at the massive fuel efficiency gains that have been achieved in Formula 1 over the past three years (a 30% reduction in engine size, a 40% reduction in fuel consumption, yet no reduction in available power) to see that major breakthroughs and step-changes in performance are achievable in relatively short timeframes. Who knows whether similar, or even greater, gains will be made with batteries? If massive improvements are achieved, however, the future could well be electric.

Charging indicators

Against this background there are four broad developments which would be of significance were they to happen:

- Successful trials of new battery materials and chemistries achieving commercial numbers of recharging cycles.
- Commercialisation of new battery technologies (i.e. beyond economies of scale cost reductions).
- Dramatic range improvements in lower-priced battery-electric vehicles.
- Successful, and scalable, wind- and solar- to battery projects. ■

Disclaimer

[1] U.S. Department of Energy, 2014. *EV Everywhere Grand Challenge: road to success*. See p5
[2] IEA, 2013. *World Energy Outlook 2013*. OECD publishing. See p520
[3] http://www.nissan.co.uk/GB/en/vehicle/electric-vehicles/leaf/charging-and-battery/range.html
[4] http://www.teslamotors.com/goelectric#range
[5] http://www.jcesr.org/