Energy Costs and Issues

As a break from the political turmoil of 2016 we took some time to consider some issues in the field of energy in our blogs. From some ideas around costs to the benefits of energy in economic development, here's some thoughts.

What is happening to energy costs?

A recent article in Science Direct looks at a range of 53 technologies and find that their costs follow a generalized version of Moore's law, i.e. costs tend to drop exponentially, at different rates that depend on the technology.

http://www.sciencedirect.com/science/article/pii/S0048733315001699

The authors formulate Moore's law as a correlated geometric random walk with drift, and apply it to historical data on 53 technologies. They derive a closed form expression approximating the distribution of forecast errors as a function of time. Based on hind-casting experiments the authors show that this works well, making it possible to collapse the forecast errors for many different technologies at different time horizons onto the same universal distribution. This is valuable because it allows forecasts for any given technology with a clear understanding of the quality of the forecasts.

The practical demonstration which caught our eye was the forecasts at different time horizons for solar photovoltaic modules, which are used to estimate the probability that a given technology will outperform another technology at a given point in the future.

The prediction says that it is likely that solar PV modules will continue to drop in cost at the roughly 10% rate that they have in the past. A forecast for the full cost of solar PV electricity requires predicting the balance of system costs, for which there is a lack of consistent historical data, and unlike module costs, the full cost depends on factors such as insulation, interest rates and local installation costs. As solar PV grows to be a significant portion of the energy supply the cost of storage will become very important.

Current levelized costs for solar PV power plants in 2013 were as low as 0.078–0.142 Euro/kWh (0.09–0.16$) in Germany and in 2014 solar PV reached a new record low with an accepted bid of $0.06/kWh for a plant in Dubai. In "Clean Disruption of Energy and Transportation" by Tony Seba, he forecasts a tariff of 3.4 US cents (2p) /KWH for solar power in California by 2020. My current tariff is 14p/KWH.

It is useful to compare this to two competitors, coal-fired electricity and nuclear power.

An analysis of coal-fired electricity, breaking down costs into their components and examining each of the trends separately shows that while coal plant costs (which are currently roughly 40% of total cost) dropped historically, this trend reversed circa 1980. Even if the recent trend reverses and plant construction cost drops dramatically in the future, the cost of coal is likely to eventually dominate the total cost of coal-fired electricity. As mentioned before, this is because the historical cost of coal is consistent with a random walk without drift, and currently fuel is about 40% of total costs. If coal remains constant in cost (except for random fluctuations up or down) then this places a hard bound on how much the total cost of coal-fired electricity can decrease. Since typical plants have efficiencies the order of 1/3 there is not much room for making the burning of coal more efficient – even a spectacular efficiency improvement to 2/3 of the theoretical limit is only an improvement of a factor of two, corresponding to the average progress PV modules make in about 7.5 years. Similar arguments apply to oil and natural gas.

Because historical nuclear power costs have tended to increase, not just in the US but worldwide, even a forecast that they will remain constant seems optimistic. The projected cost of $0.14/kWh in 2023 for the Hinkley Point nuclear reactor, it appears that the two technologies already have roughly equal costs, though of course a direct comparison is difficult due to factors such as intermittency, waste disposal, insurance costs, etc.

As a final note, skeptics have claimed that solar PV cannot be ramped up quickly enough to play a significant role in combating global warming. A simple trend extrapolation of the growth of solar energy (PV and solar thermal) suggests that it could represent 20% of the energy consumption by 2027.this is significantly higher than the “hi-Ren” (high renewable) scenario of the International Energy Agency, which suggests that PV will generate merely 16% of total electricity in 2050, i.e. taking 25 years longer than the historical trend.

The authors conclude that the example of solar PV modules illustrates that differences in the improvement rate of competing technologies can be dramatic, and suggest that, given the urgency of limiting greenhouse gas emissions, it is fortuitous that a green technology also happens to have such a rapid improvement rate, and is likely to eventually surpass its competition within 10-20 years.

Gill Ringland, SAMI Fellow and CEO, published 9 March 2016.

What are the benefits of energy?

Energy is an essential pillar of economic development. This appears so obvious, that it seems almost banal to say it. Indeed, few would question the need for increasing access to energy, and UN initiatives such as Sustainable Energy for All have successfully embedded the idea into the Sustainable Development Goals for 2030.

But as soon as we ask 'how much energy is needed for a country to develop', we hit a problem. The empirical evidence is surprisingly thin. We know the historical record of 19th Century's reliance on coal, and the global political struggles of the 20th Century over the oil and gas needed to sustain our energy-intensive economies. But beyond these historical narratives, the analysis proving a causal link between energy access and economic development is largely missing, especially at a micro-economics level. We need to better understand this if we are to develop a forward-looking narrative for the energy story in the 21st Century, and understand what type of support will be needed from policy-makers.

This question is particularly pertinent for countries not already committed to heavy industrialisation pathways. Sub-Saharan Africa together with India and Bangladesh are the new frontier of this debate. New energy business models are emerging to provide energy to households based on micro-credit or pay-as-you-go, enabled by new communication technologies and a precipitous decline in solar energy costs. The financial sector serving this market is still small and niche, but is getting positively frothy at the prospect of serving this huge untapped market.

However, the questions remain; what are the benefits of energy access, and therefore, how much support should be given? Evidence from case-studies and data reported by practitioners and industry bodies show a range of positive socio-economic benefits including health, education, welfare and gender impacts (e.g. IEG 2008, GOGLA 2016, ODI 2016). But academic literature reviews find more mixed results. Whilst the IEG 2014 review supports the case for educational benefits, they find evidence is thin regarding economic, health and gender impacts. A World Bank review also concludes that in the literature there is "a complete lack of agreement concerning the nature of the causal link (if any) between energy and GDP". Systematic literature reviews by Attigah 2013 and Torero 2014 also show mixed evidence on economic impacts, noting examples of both positive and negative impacts depending on country context and the kind of investment being made. One recent example is in Kenya where the social benefits of grid electrification were found to be smaller than the costs, leading to overall negative social welfare impacts (Lee, 2016). Peters 2015 finds that in the short run at least, energy access in low consumption environments such as rural Sub-Saharan Africa can be as effectively served by low-cost solar alternatives.

This evidence suggests that simply providing higher levels of energy access will not necessarily drive more development if other growth factors are not in place. In some circumstances, basic access will deliver a high proportion of the achievable benefits, whereas in other circumstances, development benefits will only accrue if high-level access is available. This variation in the impact of energy access depends on what binding constraints apply in different circumstances, factors such as income levels, human capital, physical capital, natural resource endowments, technological status etc. Energy access is only one of these constraints, so providing more energy does not necessarily lead to a proportionate increase in development. Getting energy access decisions wrong may lead to huge opportunity costs in terms of inappropriate spending, or delayed benefits.

Research funded by DFID is currently underway to understand the relationship between energy and development for both centralised and decentralised systems. Intuitively it seems likely that causality works in both directions between energy and growth, the classic chicken-and-egg problem. Planning energy systems in this context will require a deeper understanding of the linkages between energy and other growth factors. Energy policy needs to come out of its silo and work towards building coordinated strategies that tackle the SDGs in a holistic way.

Written by William Blyth, SAMI Associate, published 9 November 2016.