PERSPECTIVE

From knowledge comes power

For a faster, more secure transition, low-carbon energy should become an integral part of the knowledge economy, says **Roger Fouquet**.

Major phases of economic growth are inextricably linked to the emergence of new sources of energy. In the late eighteenth century, use of coal instead of wood in iron production ushered in the Industrial Revolution. Iron steam engines, fuelled by coal, reduced the cost of power to the benefit of other industries, such as textiles, stimulating economic growth and development into the nineteenth century. In the twentieth century, the combination of electricity and mass production, and of oil and the internal combustion engine, created mutual markets for each other's products, achieving economies of scale and bringing down costs. Energy transitions both depend on economic change and enable economic transformation.

Some argue that these industrial and technological interconnections are crucial to expansion and market dominance. Notably, infrastructure enhances this dominance by creating a network effect — reducing the cost of related technologies. The growth of the railways, for instance, helped developers travel to expand the telegraph network; increased use of telegraph services made it profitable to set up new railway tracks. Compatible technologies co-evolve and are likely to experience faster cost reductions, have more market success and remain dominant for longer than isolated technologies. Indeed, one reason why the global economy struggles to leave the fossil-fuel energy system behind is that there are strong interconnections between the coal and natural-gas industries and electricity production, and between the petroleum and car industries, which have allowed fossil fuels to dominate.

Over the past two decades, the global economy has been transformed, most notably by the growth of the 'knowledge economy', founded on information and communication technology (ICT). The 2012 World Bank report *ICT for Greater Development Impact* estimates that in developing countries, a 10% increase in the amount of people who can connect to the Internet could boost economic growth by up to 1.4%. Economic growth, in turn, drives the uptake of computing and Internet-based activities. Until recently, energy had not been central to the ICT explosion. The businesses in the knowledge economy have a low energy intensity — individually, they do not require a lot of energy to operate. As they increase in number, however, they account for a growing share of electricity demand, which makes energy an increasingly important consideration. If low-carbon energy can become tightly connected with the knowledge economy, it could start to outcompete fossil fuels and become locked-in.

There are early signs that this integration might happen. In the knowledge economy, energy expenditure is relatively low per dollar generated. Hence many ICT businesses are willing to pay a little more for renewable energy without greatly influencing their production costs. For instance, Google is one of the leading corporate consumers of renewable power in the world. By the end of this year, it will be powered entirely by renewable energy. Microsoft, Apple and Intel already source nearly 100% of their electricity from renewable sources such as solar, wind, small-scale hydropower and biogas. There are historical precedents in which the power preferences of an economic elite have shaped the wider adoption of technologies: for example, exclusive shops, restaurants and theatres in New York, London and Paris in the late nineteenth century helped to spread electric lighting.

The rise of smart meters also reflects the growing integration between renewable energy and ICT. The devices provide a detailed two-way flow of information: power companies can learn what households use power for and when, while customers gain an understanding of market price fluctuations and can adjust their consumption accordingly. These benefits are not unique to green energy, but this flow of information could prove particularly useful in tackling some of the challenges specific to renewable energy. Wind and solar power, for example, are greatly affected by weather conditions, making for a volatile electricity market. If smart meters could signal to users and appliances that they should reduce electricity consumption in periods of low solar or wind activity, they could help to match demand with the fluctuating supply, thus stabilizing electricity prices.

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Smart meters are also important for the expansion of small-scale renewable-energy generation, such as households with solar panels. In the long run, these producers are likely to provide an important share of renewable energy. Producers need to signal the amount of electricity they wish to supply to the grid — or to small, local energy networks — using a smart meter to communicate with the electricity market. Thus, demand for intelligent control systems will increase as distributed renewable electricity generation takes off, with ICT at the centre.

For consumers who prefer to buy green electricity, and regulators who need to accredit green power, the origin of the electricity is crucial. The solution here might be blockchain technology, which is most closely associated with Bitcoin. Blockchain enables all past transactions to be formally identified, and so assures trust in the source of the power, thus improving certification schemes and small-scale trading.

The knowledge economy does not have to be low carbon, but there are signs that a mutually beneficial relationship between ICT and renewable energy could emerge, binding them together on an upwards trajectory to positions of dominance. To cement this relationship, governments can encourage partnerships between ICT companies and renewable-electricity suppliers, as the US Environmental Protection Agency has done. Governments can also support the roll-out of technologies such as smart meters. The next phase of economic growth is under way. Now is the time to ensure it is fuelled by renewable power. ■

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