

TECHNOLOGY FUTURES



Introduction: The Energy System

The world's energy system is currently dominated by fossil fuels. Modern society as we know it cannot function without electricity from power stations or liquid fuels, all of which are derived from coal, gas and oil – hugely concentrated sources of energy.

In the home, lights rely on electricity. Central heating boilers work with gas. So do kitchen ovens. A wood-burning stove can do a good job of heating and cooking but it can't power the lights or TV.

We are, in short, dependent on fossil fuels at the moment. If power stations tried to replace coal, gas or oil with fresh firewood as their energy source, the amount of power generated would be drastically reduced. There would be brownouts (partial blackouts) and power cuts, and the economy would grind to a halt.

Trains run on electricity, either generated on board by burning diesel oil, or through wires or rails connected to the grid. There is no going back to the age of steam and the appalling smoke pollution caused by shovelling logs or coal into a fiery furnace.

Cars burn fuel to create mechanical energy, or rely on stored electricity that has been generated by burning fossil fuel. "Burning firewood to commute is not an alternative option."

"Wood burning aircraft just won't fly."

Fossil fuels are just old biomass. Plant and animals grew, died, decayed and compacted over millenia to form hugely concentrated energy sources such as coal, oil and gas. Burning these concentrated resources releases a lot of very useful heat but also releases greenhouse gases like carbon dioxide that were previously locked away.

The natural concentration process that creates fossil fuel takes a very long time - millions of years. That's precisely why reserves are running out, and getting harder to find. The trick is to find new ways of extending the life of fossil fuel or to develop enough alternative energy sources that can compete with fossil fuels and meet the future scale of demand. The challenge is for these alternatives to achieve mass-market impact quickly enough to satisfy rapidly growing demand.

This Technology Futures report focuses on emerging technologies outside the fossil-fuel industry, and so does not discuss in detail those technologies that aim to secure more oil, gas or coal-based energy.



The Current Energy System

Energy is the ability to do work. The energy industry is concerned not with the *creation* of energy resources but rather the *conversion* of primary energy sources like crude oil and sunlight into a form that consumers can more readily use – such as liquid hydrocarbons and electricity – for a range of needs such as transport or providing heat and light for homes. Converting primary energy into usable forms is a process that requires energy itself and is often inefficient: as energy is converted, some is lost as heat, for example.

The energy system refers to the complex interaction of all potential sources of energy, conversion technologies, distribution routes and end-use activities.

The global energy system currently relies mainly on hydrocarbons such as oil, gas and coal, which together provide nearly 80 per cent of energy resources. Traditional biomass – such as wood and dung – accounts for 11 per cent and nuclear for 6 per cent, whilst all renewable sources combined contribute just 3 per cent.

Energy resources, with the exception of nuclear, are ultimately derived from the sun. Non-renewable resources such as coal, oil and gas are the result of a process that takes millions of years to convert sunlight into hydrocarbons. Renewable energy sources – such as biomass, wind, wave, tidal, sea currents, hydro-electricity, solar energy and geothermal – convert solar radiation, the rotation of the earth and geothermal energy into usable energy in a far shorter time.

Primary energy resources are converted into a number of different energy carriers: oil into liquid hydrocarbons, coal into solid hydrocarbon fuels, wind into electrons, gas into liquids, or into hydrogen. As energy carriers differ in characteristics, they are measured in different ways (barrels, tonnes, watt-hours). The critical factor is the amount of energy available for use; so a common measure – joules – is used that allows comparison of energy efficiency across different carriers.

When comparing energy sources or carriers, it is important to consider a number of factors. These include: their “capacity factor” – the relation between average power delivered over a year and installed peak power; their dispatchability – the ability to start and stop generation at will; the ease of storing the energy carrier; and other characteristics such as end-use efficiency.

When assessing the relative performance of energy carriers, it is also necessary to consider other inputs required to produce usable energy (such as raw materials, labour, land, water), the amount of contamination they may cause (waste water, radioactive waste, CO₂, etc.), and the associated amount of energy needed to deal with this contamination.

The complexity and cost of the infrastructure needed to use a given energy is perhaps the main factor that will determine whether and how fast a technology can develop to unlock additional energy resources and achieve mass-market impact. For example, hydrogen fuel, solar power and wind power all require different infrastructure investments before they can deliver significant amounts of usable energy. ■



The Energy System - Today¹

35%



Oil

21%



Gas

25%



Coal

10%



Biomass

6%



Nuclear

3%



Renewables

Liquids



Gaseous

Solid Fuel



Power Generation



Mobility



27%

Agriculture, Industry, Services



46%

Residential



27%

Note 1: All data sources for charts and a glossary of abbreviations can be found on page 140

Global Warming

The ice ages in the distant past prove that climate can change by itself, and radically. Though not new, the belief that human activity can change the climate is a more recent understanding.

In 1896, Swedish scientists published a new theory called the “greenhouse effect”. It argued that, as humanity burned fossil fuels that released carbon dioxide (CO₂) into the atmosphere, the planet’s average temperature would rise. This is because the CO₂ absorbs heat radiated from the sun, trapping it in the Earth’s atmosphere. Despite accepting the theory, the greater scientific community believed that major climate change would take tens of thousands of years to materialise.

By the 1930s, people realised that the United States and North Atlantic region had warmed significantly during the previous half-century. Scientists believed this was just a phase of some mild natural cycle, with unknown causes. Only one lone voice, G.S. Callendar, insisted that greenhouse warming was on the way.

In the 1950s, Callendar’s claims provoked new studies that showed that carbon dioxide could indeed build up in the atmosphere and lead to global warming. Painstaking measurements drove home the point in 1961, by showing that the level of CO₂ was in fact increasing year by year.

A 1967 calculation suggested that average temperatures might rise a few degrees within the next century. However, with the next century far off, the calculations were plainly speculative. Scientists reviewing the issue saw no need for any policy actions.

Over the following decade, curiosity about climate turned into anxious concern. Study panels began to warn that future climate change might pose a severe threat and research activity accelerated.

Programmes were organised on an international scale and the world’s governments created the Intergovernmental Panel on Climate Change in 1988. By 2001 this panel managed to establish a consensus, announcing that it was much more likely than not that our civilisation faced severe global warming.

Since 2001, the abundance of data has strengthened the conclusion that human emissions are very likely causing serious climate change. Depending on what steps people take to restrict emissions, the planet’s average temperature might rise between 1.4 and 6 °C by the end of the century. Although only a small fraction of this warming has happened so far, predicted effects are already becoming visible – more deadly heat waves, rising sea levels, more frequent severe floods and droughts, the spread of tropical diseases and the decline of species sensitive to temperature changes.

