Tim Radford 14 October 2014

As populations multiply, so do the planet's problems. A quarter of the world's available farmland is degraded so to feed the extra mouths by 2030, farmers must do more with less. They have to deliver 50% more food, most of it by increasing yields, according to Olivier Dubois of the UN Food and Agriculture Organisation. That means finding 40% more water and 40% more energy. But 30% of the world's energy already goes into food supply, and 30% of that food is lost to pests, poverty, poor resources or just sheer waste, along with 30% of that invested energy. In a world threatened by climate change as a consequence of greenhouse gas emissions from fossil fuel use, future generations could be materially poorer.

But, as the Fourth World Materials Summit was repeatedly reminded as it met in Strasbourg 14 and 15 October, materials science could go some way to meet the challenges, by developing technologies, engineering solutions and new fabrics that could enhance lives, save energy and feed nations. The agribusiness accounts for around 33% of greenhouse gas emissions, so the challenge is to use energy more efficiently.

But the scale of the challenge, and the directions engineers, chemists and materials scientists might take to confront it, were outlined in daunting detail at the summit. Sébastien Candel, of the French Academy of Sciences, and of the Ecole Centrale in Paris, reminded his listeners that in the past 40 years coal use had increased 2.6 times, natural gas 3.3 times: fossil fuels provided 80% of the world's energy and there were no signs of any levelling off. So there was increasing pressure on scientists and engineers to find ways of using the same energy more efficiently. He took as an example advances in aviation, where materials science really had made a significant difference, by reducing engine weight, enhancing engine performance and optimizing aircraft structure.

But as aircraft became more efficient, with better ratios of fuel per passenger-distance, so did other challenges soar: as fuel consumption fell, engine temperatures rose, along with pollution from oxides of nitrogen. He set his audience a small challenge: how long would it take to recharge a 28 kwh battery using renewable resources, for example 10 square meters of solar panels? The answer is 280 hours, or 11 days. The implication is that there are power problems that renewable resources cannot solve.

But, according to Jean-Paul Reich, director of research at GDF/Suez, there were ways of meeting the challenge. Renewable energies could only use wind or solar energy as it became available: sometimes it could not meet demand; on other occasions supply would far exceed demand, so there was a strong case for using surplus electricity to make gas that could serve as an energy store. Because under those circumstances energy prices would be low, engineers could use electrolysis techniques to produce large quantities of combustible gas – methane or hydrogen – to serve as a store for the moment when demand was high.

By 2050, surplus production could reach 75 terawatt hours a year, and on this basis synthesis of methane or production of hydrogen could reach 20 twh a year. This is about 7 per cent of natural gas consumption in France. The economics depended on the development of cost effective technologies but there were already more than 50 active projects to achieve successful power-to-gas systems in Europe and other parts of the world. Peter Röttgen of the energy giant Eon – as did many others – reminded those who attended the summit, organized by the European Materials Research Society, that it would take a mix of solutions to confront the problems of fluctuating energy supply but cost effectiveness and public acceptance were vital for all of them.

Other contributors outlined many of the problems that the energy industry – and materials science – faces now and in the future. Supplies of vital rare earth metals are unevenly distributed, difficult to identify and rarely available in easily extracted quantities. The nuclear industry faced a series of engineering challenges to maintain sustainability; advances in photovoltaics and condensed solar power – in which the sun's rays are focused to generate heat – were still energy systems in development; chemists had just begun to appreciate the value of captured and stored carbon dioxide as potential fuel, or an energy storage resource, and the manufacture of synthetic fuels, sometimes from carbon dioxide, presented a suite of still-to-be resolved difficulties.

But it remained to David MacKay, of the University of Cambridge to put the looming energy challenge in the widest perspective. For example, could biofuels be an answer? He asked his audience to consider how much land would have to be devoted to biomass if the fuel was to be grown alongside a motorway to provide for the cars on one lane of that motorway.

Suppose this one lane of cars was spaced at distances of 80 metres, was travelling at 60 miles an hour, and consumed fuel at 30 miles per gallon? Suppose the land delivered 800 litres of biofuel per hectare, how wide would that parallel strip of land need to be? The answer, he told everybody, was 8 kilometres. Professor MacKay is the author of a free online book called Sustainable Energy: Without the Hot Air,www.withouthotair.com. The book has now been translated into French, Hungarian, Polish, Slovenian and Chinese. "This is a book full of back-of-the-envelope calculations that help people understand the energy options for the future." He was then appointed chief scientific adviser to the UK government Department of Energy and Climate Change and introduced a web tool *2050-calculator-tool.**decc**.gov.uk/* built for public instruction with the co-operation of science, the energy industry and environmental campaigners.

He also reminded his audience of the significance of the latest report of the Intergovernmental Panel on Climate Change, and the long history of increasing carbon dioxide levels. "Temperature rise depends on the cumulative emissions," he said. "And so if we want to limit global temperature rises, we need to limit the emissions rate to zero. Zero emissions is where humanity has to be going."