Which energy technologies are going to keep us to 1.5°C?

With the window to keep global temperature rises to 1.5°C quickly closing, *Marc Height* looks at the pace and scale of technology deployment needed to keep us below the limit.

The Paris Agreement on climate change, reached in 2015, has a goal of limiting the world's average temperature rise from global warming to 'well below 2 degrees Celsius above pre-industrial levels'. But it also stretches its ambition in a slightly more precise manner than that, stating an aim to 'pursue efforts to limit the temperature increase even further to 1.5 degrees.'

This outcome, not expected as negotiations in Paris began, was a positive surprise for many in the climate change community, but then led to questions of how, or perhaps if, the goal could be achieved. The Intergovernmental Panel on Climate Change (IPCC) was spurred into action to produce a special report on 1.5°C, due in 2018. At the same time the UK's Met Office and others reported that in 2015 global temperatures had already touched the milestone of 1°C above pre-industrial levels.

More recently, a study published in *Nature Geosciences* generated a glut of headlines, some more accurate than others, with its assertion that we may actually have slightly longer than had been previously thought to cut global greenhouse gas emissions enough to stay below 1.5°C.

The study provides an updated estimate of the carbon budget for 1.5°C – the total amount of carbon dioxide emissions that can be emitted while staying below the limit. It estimates the budget to be around 20 years' worth of current emissions rates, totalling between 700bn to 900bn tonnes of carbon dioxide. If we keep within that limit that would give us a two-thirds chance of keeping temperature rises to 1.5°C by the end of the century, says the paper. This compares with earlier estimates of only around four years, using data from the IPCC's 2014 assessment report.

But the *Nature* paper concludes that, despite this sliver of good news, given the challenge ahead the 1.5°C window is still narrow and to reach the target will be a daunting policy challenge – with emissions needing to peak in the next year or so and then rapidly decline year-on-year to reach zero by around 2050.

Hitting 1.5°C is not, as the study authors call it, a 'geophysical impossibility', but there is a great deal of work to do to remain below it.

Smoke and steam emissions at Grangemouth

Photo: Shutterstock, cornfield

COP 23

Negotiators at the imminent United Nations Framework Convention on Climate Change (UNFCCC) twenty-third Conference of the Parties (COP 23) will no doubt be cognisant of the 1.5°C number, not least because, despite the conference being held in Bonn, it is being presided over by Fiji – an archipelago of over 330 low-lying islands in the Pacific, which are at the forefront of vulnerability to climate change impacts.

A climate action statement from the leaders of the Pacific Small Island Developing States, issued from the COP 23 Fiji Secretariat in July this year, reiterated the group's call for the world to focus on the more ambitious target from the Paris Agreement of limiting warming to 1.5°C – a position they have held since 2009.

Fiji is the first Small Island Developing State to preside over a COP, and Fiji's Prime Minister, Frank Bainimarama, told a separate UN climate meeting in Bonn earlier this year that, while remaining impartial, he will be bringing his own perspective to the negotiations from a region of the world 'that is bearing the brunt of climate change'.

'The rising seas, extreme weather events or changes to agriculture... threaten our way of life and in some cases, our very existence,' he said. To tie into Pacific social traditions while injecting some symbolism into COP 23, a traditional Fijian canoe, or drua, will be displayed in the conference's main hall throughout the talks.

COP 23's negotiations are designed to keep things ticking over as Parties continue to discuss how 2018's 'Facilitative Dialogue', taking place at COP 24, will work.

The Facilitative Dialogue is an important step in the Paris Agreement process. It will act to take stock of collective efforts to reduce emissions set out in each Party's emissions reduction plan, known as Nationally Determined Contributions (NDCs).

Its aim also is to identify ways to enhance the ambition of Parties' mitigation pledges. This is in preparation for when the NDCs are due to be updated in 2020, and is part of a ratcheting process in which countries will continue to be encouraged to increase their emissions reduction ambitions over time.

In the 1.5°C context, this ratcheting process is particularly important. As various reports indicate, including the most-recent United Nations Environment Programme *Emission Gap* report, current NDC pledges as they stand are likely to add up to somewhere between 2.9°C and 3.4°C of warming. To get to the 2°C target the world will need to shave an extra 12 to 14 gigatonnes of carbon dioxide equivalent emissions off the current trajectory by 2030, it says. To reach 1.5°C means being even more ambitious.

It is therefore key that the Facilitative Dialogue process is effective in encouraging deeper emissions reduction plans.

What does this mean for energy?

There is a relative lack of scientific analysis focusing on the mitigation efforts needed to stay below 1.5°C compared to 2°C, mainly as 1.5°C has, until now, been seen as something of a political impossibility. But what is clear is that remaining within the carbon budget for 1.5°C will require rapid decarbonisation and a transformation of the energy system at a radical pace never seen before.

Professor Jim Skea FEI, Chair in Sustainability at Imperial College London, tells me that the debate around carbon budgets brought up from the aforementioned Nature Geosciences paper 'doesn't affect in any way the urgency with which you need to actually reduce emissions, if you are going to keep to anything towards 1.5°C or 2°C.'

'That will only happen with extreme decarbonisation starting now, because you still need to get to net zero emissions during the century to do it,' he says. 'For the science community, the 1.5°C number that emerged from Paris came as something of a surprise. They did not have model runs ready off the shelf to answer the question. So it's only now that you're seeing papers beginning to emerge that start to talk about the implications of 1.5°C.'

Hitting 1.5°C means 'more of the same [for 2°C] but faster', says Skea. 'It does need absolutely everything. There is no magic bullet.'

Emissions need to start declining rapidly right now. As well as the obvious – a phase out of fossil fuel power, increased renewable energy capacity, and a switch to low carbon electricity for heating and transport – a number of technologies will be necessary to get there. And, as analysis from Climate Analytics and the Climate Action Tracker consortium indicates, the next ten years will be critical.

Smart, renewable power

Let's start with the obvious – electricity grids will need to be further decarbonised, and this means that the electricity climate villain, coal power, will have to disappear from power systems entirely. Climate Analytics analysis indicates that coal will need to be phased out entirely world-wide by mid-century (see **Figure 1**), and earlier in Europe, with countries having to retire existing coal plants early and stop building new capacity.

Climate Action Tracker's study, *The ten most important short term steps to limit warming to 1.5°C*, says that, from now, no new coal-fired power plants can be built. Anywhere. It says emissions from current coal plants must drop by 30% by 2025 and 65% by 2030.

The global power system needs to be fully decarbonised by 2050 under a 1.5°C pathway. Continuing price drops for renewable energy technologies, along with enabling technologies for a smarter grid, including electricity storage, will help form the electricity systems of the future.

As the International Energy Agency's (IEA) recent *Renewables 2017* report indicates, renewables, particularly solar power, are dominating new power capacity additions and are predicted to continue to do so. The proliferation of smarter grid technologies will allow renewables to further thrive. And as renewables become more affordable, the ability for developing countries to 'leapfrog' growth based on fossil fuelled energy becomes more realistic.

Energy efficiency

Energy efficiency is well known as one of the cheapest methods to reduce emissions from energy use and supply, and one with a great deal of potential. The UK's Carbon Trust has also said that energy efficiency is essential to keep the door open to remaining below even 2°C of warming.

Yet there is still a need for supporting policies to increase investment in efficiency and to mine this enormous area of untapped emissions reduction. However, the IEA's recent *Energy Efficiency 2017* report unhelpfully indicates that the implementation level of new policies that cover energy efficiency is actually slowing down. Countries should now focus on targeting the 68% of global energy use that isn't covered by energy efficiency standards, it says.

The Climate Action Tracker report says that the pathway to stay below 1.5°C (see **Figure 2**) demands a complete phase-out of direct emissions from electricity and heat use in buildings by 2050. Today's new builds should be future-proofed in terms of efficiency, but tackling new buildings is not enough – retrofit rates for existing buildings will need to at least triple from the current level in order to transform the entire current building stock by 2050.

One point made recently by DNV GL is that the move towards renewable energy technologies will itself aid energy efficiency goals, through avoiding thermal losses in coal and gas-fired power generation.

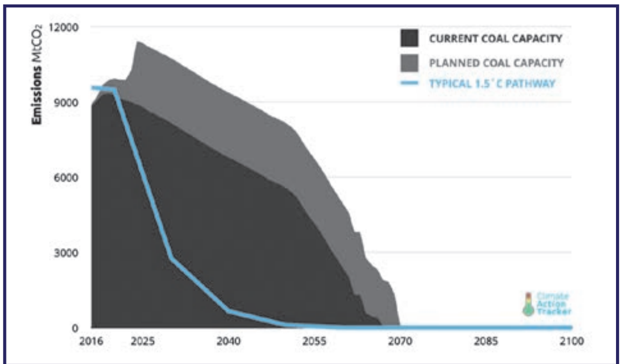

Figure 1. Emissions from coal will have to drop to zero by mid-century to reach 1.5°C *Graph: Climate Action Tracker*

Tackling transport

Electrifying the transport sector is a key element of 2°C and 1.5°C scenarios. There has been a spate of activity in this space recently, with car manufacturers announcing big electrification plans and governments announcing target dates to phase out fossil fuelled vehicles.

If we're serious about 1.5°C, the world's very last fossil fuelled car will need to be sold by 2035

But, regardless of these targets, Climate Action Tracker's pathway says if we're serious about 1.5°C, the world's *very last* fossil fuelled car will need to be sold by 2035. Electric vehicles powered by renewable electricity are the current favourite zero-emission vehicle technology to replace these conventional cars.

Freight transport is a whole different ball game, and a tricky area (see *Energy World* November 2016). Land freight movement will have to shift as much as possible from road to rail, while trucks will need to tap into low carbon electricity – either via overhead wires on highways, or through the use low carbon synthetic fuel produced using renewables.

We will have to fly less, and for what air travel is deemed necessary the aviation sector will need to use efficient planes and

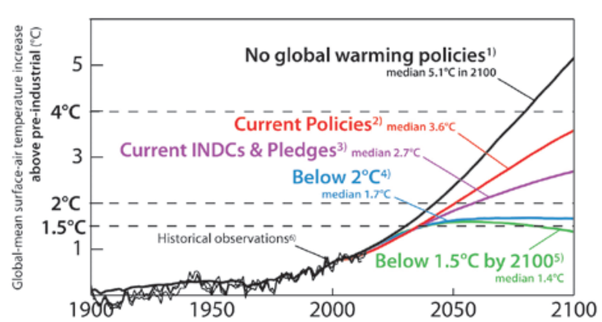

Figure 2. Comparison of 1.5°C to other emissions pathways
Graph: Climate Analytics

biofuels to eventually get its emissions down to zero. If the aviation and maritime sectors – currently outside the scope of the COP process – are unable to get to zero emissions, new technologies to actively take carbon dioxide permanently out of the atmosphere will be needed to offset these.

In fact, so-called negative emissions technologies, in some form, are basically essential to meet 1.5°C.

Negative emissions technology

The bulk of future energy and climate scenarios bank on future technologies being developed that can directly reduce the atmospheric concentration of carbon dioxide. It is common in 2°C scenarios that emissions 'overshoot' the total budget and then have to be 'sucked' back in from the atmosphere at a later date. Cut to a 1.5°C budget, and this becomes more important.

The Climate Action Tracker study says that 'due to the insufficient emissions reductions realised to date, negative carbon dioxide emissions will unfortunately be necessary at scale from mid-century to limit warming to 2°C, and even more for 1.5°C.'

'It is certainly the case that you cannot do 1.5°C unless you are willing to take carbon dioxide out of the atmosphere,' says Skea. 'That has to be part of the set.'

Carbon capture and storage (CCS) alone will be important if the world's energy systems are to continue to rely to an extent on large, centralised fossil fuel generators. And it is also argued as one of the only ways to decarbonise industrial emissions in the future, as well as a route to low carbon heat through hydrogen production.

But, in tandem with burning biomass for power, bioenergy and CCS, or BECCS, is one potential route towards negative emissions. Growing biomass will draw carbon dioxide out of the atmosphere, and using this for thermal power generation, then capturing and storing the carbon dioxide from this process underground, will mean atmospheric carbon dioxide is 'captured' and then permanently stored.

Negative emissions technologies are not confined to BECCS. Other routes include Direct Air Capture, with companies like the Swiss Climeworks developing machines to suck carbon dioxide directly from the atmosphere. Plant matter can be turned into biochar to be sequestered in soil.

BECCS is perhaps the most focused on, but it has its critics, not least because end-to-end CCS projects are rare and not yet commercially viable.

The vast majority of 2014 IPCC scenarios with a likely chance of staying below 2°C rely on BECCS – with most of these stating that BECCS would account for a whopping 20% of world primary energy by 2100. Scenarios indicate that to keep to 1.5°C, as well as pushing every other low carbon technology to its limit, negative emissions technologies will need to be deployed at scale from 2040 onwards.

But BECCS is not without its problems from a bioenergy supply perspective.

Dr Joana Portugal Pereia, Research Fellow at Imperial College London, says that 'there are still some questions around the technology feasibility, land-use change and effects on ecosystem services through using BECCS.'

'The scale and the potential sustainability consequences [of negative emissions technologies] are quite large,' says Skea. 'You're getting into a zone where you are looking at competition for land or food versus fuel issues. It ties into many other factors, like what is going to happen to people's diets, and later improvements in agricultural productivity... There's a very large number of uncertainties in that mix.'

Could a reliance on future negative emissions technologies result in less immediate mitigation efforts now, as some research suggests, due to complacency and holding out for a future magic solution?

'The only consistent message I would give is that [achieving 1.5°C] is such a challenging and difficult thing to do, there isn't any kind of choice or and/or about it,' says Skea. 'You need to make rapid progress on all things if you want to take 1.5°C remotely seriously.'

'We cannot put all the golden eggs in the same basket,' says Portugal Pereia. 'Countries around the world need to align their climate policy based on a wide range of technological and non-technical strategies. BECCS and other greenhouse gas removal technologies by themselves won't be the solution.'

> ***'It is certainly the case that you cannot do 1.5°C unless you are willing to take carbon dioxide out of the atmosphere'***
>
> **Professor Jim Skea, Imperial College London**

Half a degree difference

There are no two ways about it – keeping to below a 1.5°C temperature rise is going to be hard. But there will also, clearly, be huge benefits to remaining below it, in terms of avoiding damaging climate change impacts, particularly to vulnerable nations like Fiji.

This means making some fundamental wider decisions on how we value emissions. 'To get carbon dioxide removal you do need to place some kind of value on carbon dioxide for it to be worthwhile,' says Skea. 'That means carbon taxes or power purchase agreements for bioenergy with CCS, or something like that. And these ultimately would be reflected in electricity bills, or if it was paid for through the public purse it would have to come via the taxpayer.'

This all isn't to say that a world exposed to 1.5°C of warming will avoid detrimental climate change impacts. A 2015 study in *Earth System Dynamics* analyses the difference between impacts for 1.5°C and 2°C of warming, and indicates that 1.5°C will still result in significant temperature extremes, weather extremes, crop yield reduction risks, coral reef bleaching and sea-level rise.

But these risks will increase substantially between 1.5°C and 2°C, says the study – particularly for heat extremes, tropical crop yield reductions and subtropical water scarcity. End-of-century sea level rise would be 10 cm lower, at 40 cm, under 1.5°C of warming. The half a degree means potentially tipping from the upper limit of today's climate variability into a new climate regime under 2°C.

For nations like Fiji, 1.5°C means that the risks of sea-level rise and the loss of surrounding coral reefs – which provide ecosystem services and coastal protection – are reduced.

It is both physically and economically feasible to limit warming to 1.5°C, says Climate Analytics. But action is needed now.

As Fiji's Prime Minister Bainimarama told a Berlin conference earlier this year, tying into the country's symbolic addition to the talks, the drua, 'we are all in the same canoe together'.

Our planet's geography means some of us are closer to the edge of that canoe than others. Only by acting seriously now can we avoid them bearing the brunt of the swell. ●