Supplementary Information

Could we build sufficient IFRs quickly enough to meet climate-agreement targets?

In the MiniCAM CCSP Reference (no new policy) scenario [1] total primary energy increases from 498 exajoules (EJ) in 2010, thru 849 EJ in 2050 to 1288 EJ in 2100. Now, suppose we want to get to a near-zero carbon energy economy by the year 2100. Note that previous work by one of us (TMLW) showed that we could "allow" some CO_2 emissions (ECO_2) in 2100 and still meet the Paris 1.5°C target, provided we allow a long period of temperature overshoot [2]. So, going to zero in 2100 means that the estimated amount of integral fast reactors (IFRs) needed, as a silver bullet, will be more than required by the Paris 1.5°C scenario.

Even without using the above-cited Paris result we could have non-zero ECO_2 in 2100 if all emitted CO_2 were removed by carbon-capture-and-storage (CCS). The MiniCAM data could be used to estimate how much CCS might be possible by 2100. The other issue is the effect of end-use efficiency improvements. These have the effect of reducing the estimated primary-energy increases. For the scenarios in [1], the policy cases derived from different Integrated Assessment Models have (quite widely) different magnitudes for the end-use efficiency effect. As one example, primary energy in 2100 in the MiniCAM Level-1 (stabilization) scenario is 1047 EJ, so that end-use efficiency changes reduce the primary energy requirements in the Level-1 case by 241 EJ.

To take a worst case, we will ignore CCS and end-use efficiency effects. This will significantly increase the number and growth rate of IFRs required. (It would be easy to consider other scenarios.) In this case, however, we need to go from 498 EJ in 2010 to 1288 EJ in 2100 using, by 2100, only IFRs—a total eventual addition of 790 EJ. Further, we need to eliminate the fossilfuel component of the original 498 EJ, which is 406 EJ. (This, of course, is a simplification, because retiring CO_2-free plants will have to be replaced.) As such, we need to have approximately 790 + 406 = 1196 EJ provided by IFRs by 2100.

Consider the PRISM design for the IFR, which provides 311 MWe of power. To provide 1196 EJ of final energy using only modular IFRs, we would therefore need the PRISMs in 2100 to provide 37899 GWe, which means we would need 37899/0.311 = 121,862 PRISM modules worldwide. This implies building PRISMs at an average rate of 1354 per year. Of course, the build rate would not be constant, and we can make assumptions about how build rate might vary over time, but this is still a useful indicator of the required effort, and for reference to historical benchmarks.

This may seem like a large IFR build rate, but it should be realized that, in the MiniCAM Level 1 scenario (widely judged to be a realistic, cost-effective policy scenario) the same carbon-free energy target is met by a mix of technologies, including technosolar options that, because of their far lower capacity factors, require a substantially higher nameplate capacity to deliver an equivalent amount of energy to an IFR. All we are doing in these calculations is substituting this realistic future energy mix with a single, replicable and 'self-contained' technology.

References

1. Clarke, L.; Edmonds, J.; Jacoby, J.; Pitcher, H.; Reilly, J.; Richels, R.; Parson, E.; Burkett, V.; Fisher-Vanden, K.; Keith, D.; et al. *Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations*; Department of Energy, Office of Biological & Environmental Research: Washington, DC, USA, 2007.
2. Wigley, T.M.L. The Paris warming targets: emissions requirements and sea level consequences. *Climatic Change* (in press).