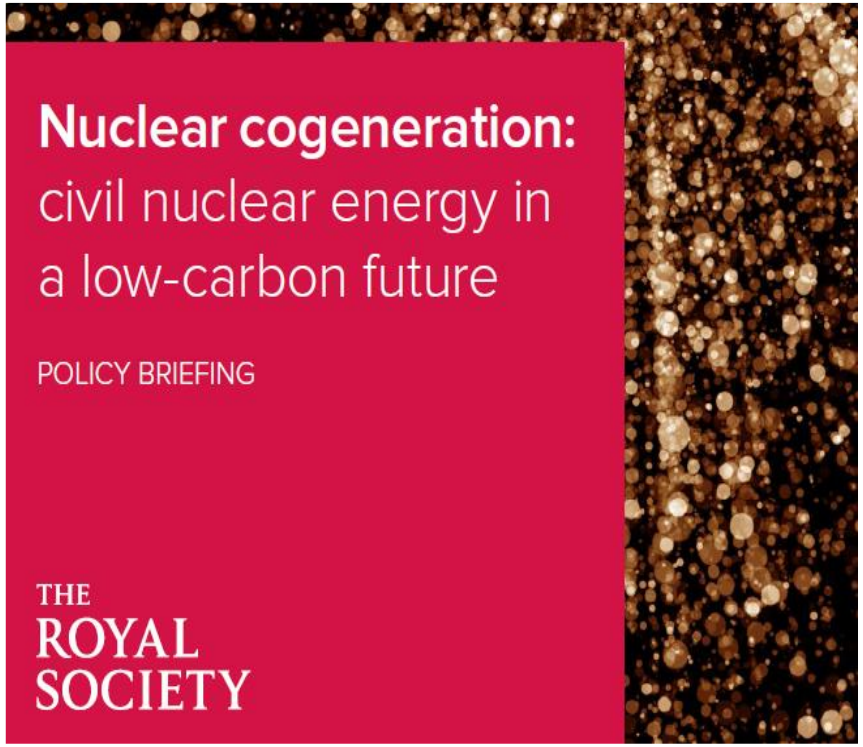
Nuclear cogeneration:
civil nuclear energy in a low-carbon future

Policy Briefing:
Part of the Low Carbon Energy Programme

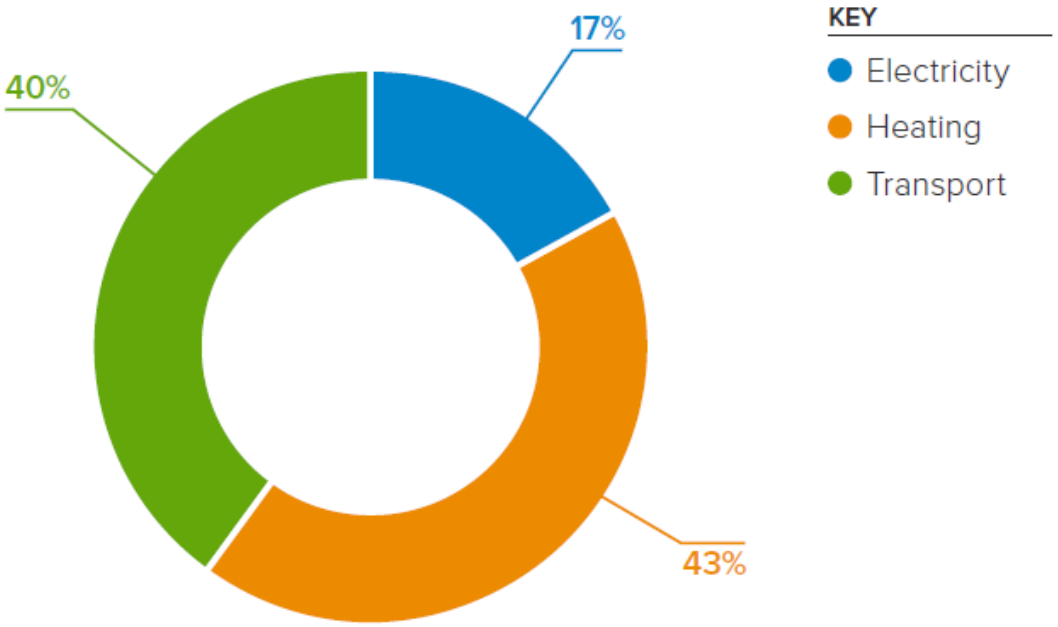
https://royalsociety.org/topics-policy/projects/low-carbon-energy-programme/nuclear-cogeneration/

07 October 2020

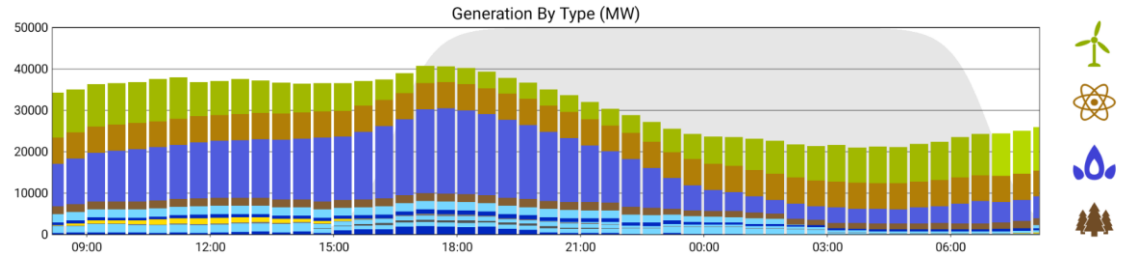


We need to double electricity generation to meet Net Zero. It needs to be decarbonized, and able to turn on and off quickly.

Current UK energy consumption:



Renewables are intermittent. Today, we manage these fluctuations with gas:



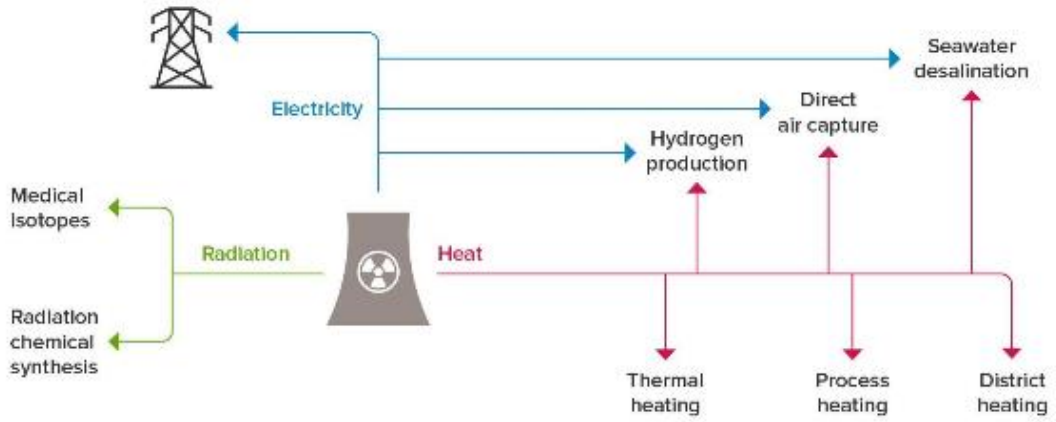
- Nuclear has provided reliable low carbon power for over 60 years.
- “Gigawatt build” nuclear plants provide baseload contribution (brown above), but have not managed fluctuations well, and will not be the solution to manage intermittency.
- Gas (blue above) currently manages intermittent fluctuations in electricity demand.

Figure captured from GridCarbon app 4/11/20

One advantage of new nuclear is the potential for co-generation to contribute to Net Zero

65% of energy generated by nuclear is lost as “waste heat”.

That wasted energy can be used: to heat buildings, to support industrial processes, including the production of hydrogen via electrolysis.

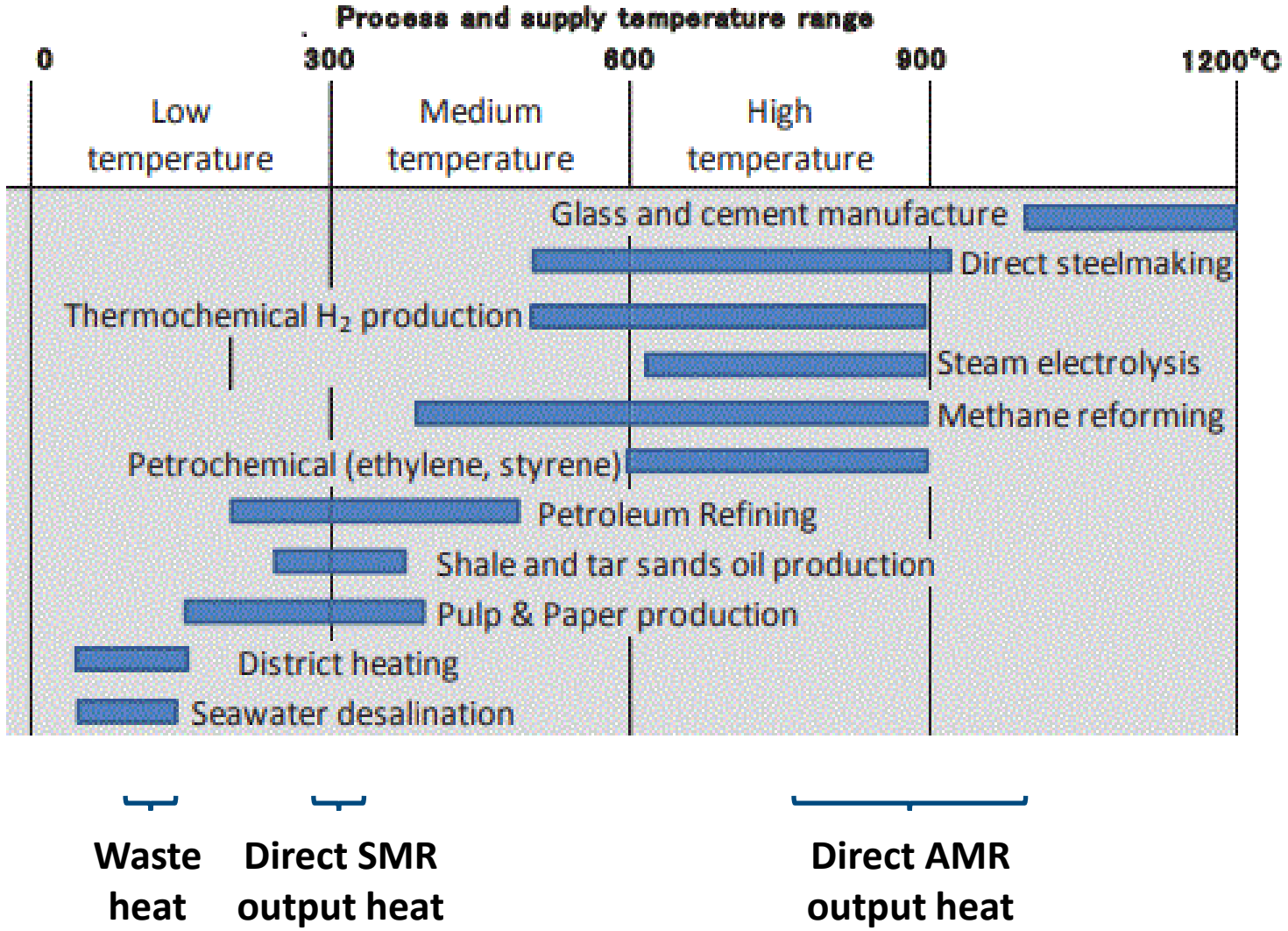


Current nuclear generation is <u>not</u> designed to utilise its waste heat. It could be but this would be inefficient and expensive.

Next generations of nuclear power – Small Modular Reactors (“Generation III”) and Advanced Modular Reactors (“Generation IV”) – are designed in part with co-generation in mind

But it is not really about waste heat. Using heat <u>directly</u> is more efficient in meeting Net Zero: we require a range of solutions to decarbonising sectors: surface transport, aviation and industrial processes.
We need a range of temperature output options for co-gen…

Temperature Ranges of Heat Application Processes



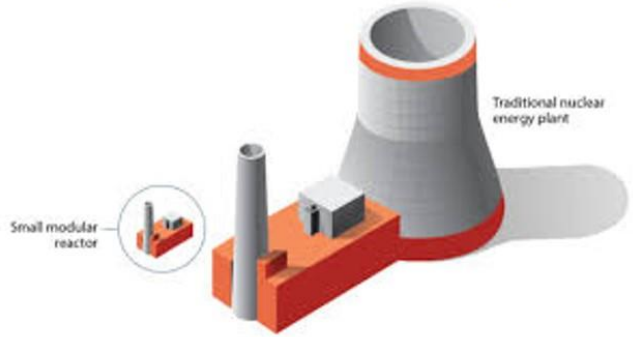
- Electricity when electricity is needed – eg when renewables generate less.
- Other ‘products’ when electricity needs are met by renewable
- <u>But</u> products that contribute to those ‘hard to reach’ areas of decarbonisation

SMRs and AMRs – what are they?

Small Modular Reactors (SMRs):

The next generation of current nuclear plants

Smaller than current nuclear plants



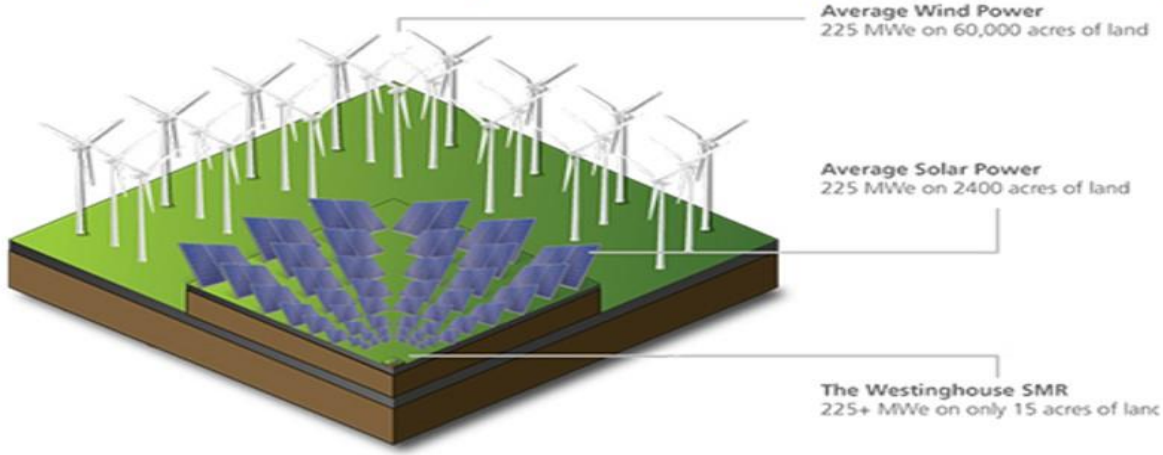
Already being built and there is high confidence they can produce electricity at competitive prices.

Advanced Modular Reactors (AMRs):

A further generation again, using novel fuel types and specifically designed for co-generation

Have been built, but further demonstrators are required to show they can produce electricity at competitive prices.

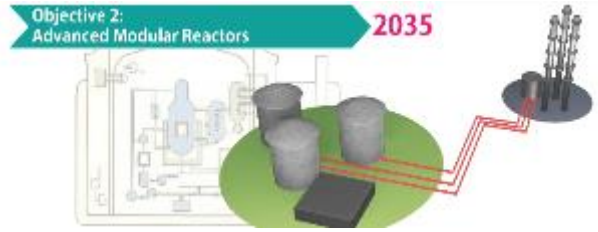
SMRs and AMRs are space-efficient per unit of energy



Where is it all coming from?

EDF GW builds

SMR builds



AMR builds

Fuel	Currently via Areva (now Orano)	Opportunity to use UK supply chain (e.g. Westinghouse Springfields)	Builds on world-leading UK expertise in advanced nuclear fuels.
Reactor Vessels	No UK manufacturing capacity. Producers in Japan and Korea.	Opportunity to use UK supply chain (e.g. Sheffield Forgemasters)	Opportunity to use UK supply chain (e.g. Sheffield Forgemasters)
Reactor Components	Majority of components through French (EDF) supply chain.	Majority of components through UK (including Rolls Royce) supply chain.	UK world-leading experience in using graphite in nuclear reactors (evidenced by our current AGR fleet)
Engineering benefits	UK civil engineering workforce utilised in large-scale builds and complex engineering challenges on nuclear facilities.	Civil engineering PLUS mechanical and electrical engineering expertise retained in UK	Extension of – and reliance upon – SMR benefits. Builds on export potential in product, skills and services.

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Key Points:

Electricity production will increase dramatically as we proceed towards the 2050 net zero target ⇒ increased requirement for zero carbon base load electricity

While renewables is a crucial element it brings with it the challenge of intermittency ⇒ nuclear must be able to address the intermittency challenge

Net zero 2050 also demands decarbonisation of transport and heat beyond that provided only by electricity ⇒ requirement for zero carbon high temperature heat

Gigawatt (GW) nuclear will contribute but is optimised to provide base load capacity.

Small modular reactors offer greater flexibility, develop a UK nuclear manufacturing supply chain but like GW do not offer heat hot enough to deliver many important industrial processes

Advanced modular reactors offer the right high temperature heat but are a decade+ away – they require us to further develop a UK supply chain if we are to benefit.

The Road-Map

GW production

Continues to provide the “stable baseload” electricity requirement

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Manages intermittency + some co-generation

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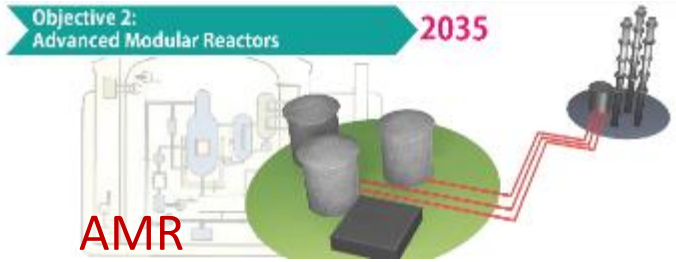

Significant co-generation