# Small Modular Reactors

- A wave of near-term innovation in nuclear energy promises to revolutionise nuclear safety and economics and open up new applications in hard-to-abate sectors
- Small modular reactor (SMR) designs under development offer different value propositions, with a variety of sizes and temperatures intended for different applications
- SMR reactors are expected to be commercialised within the next decade
- A rapid SMR uptake could help avoid 15 Gt of carbon emissions by 2050

## SMRs are reinventing nuclear energy

### Small

SMRs are smaller, both in terms of power output and physical size, than conventional gigawatt-scale nuclear reactors. SMRs are nuclear reactors with power output less than 300 megawatts electric (MWe), with some as small as 1-10 MWe.

### Modular

SMRs are designed for modular manufacturing, factory production, portability, and scalable deployment.

### Reactors

SMRs use nuclear fission reactions to create heat that can be used directly, or to generate electricity.

### Safety

SMR designs build on lessons learnt from over 60 years of experience in the nuclear energy sector to enhance safety and improve flexibility. Many SMR designs incorporate the concept of passive safety, meaning they do not require active interventions or backup power to safely shut down.

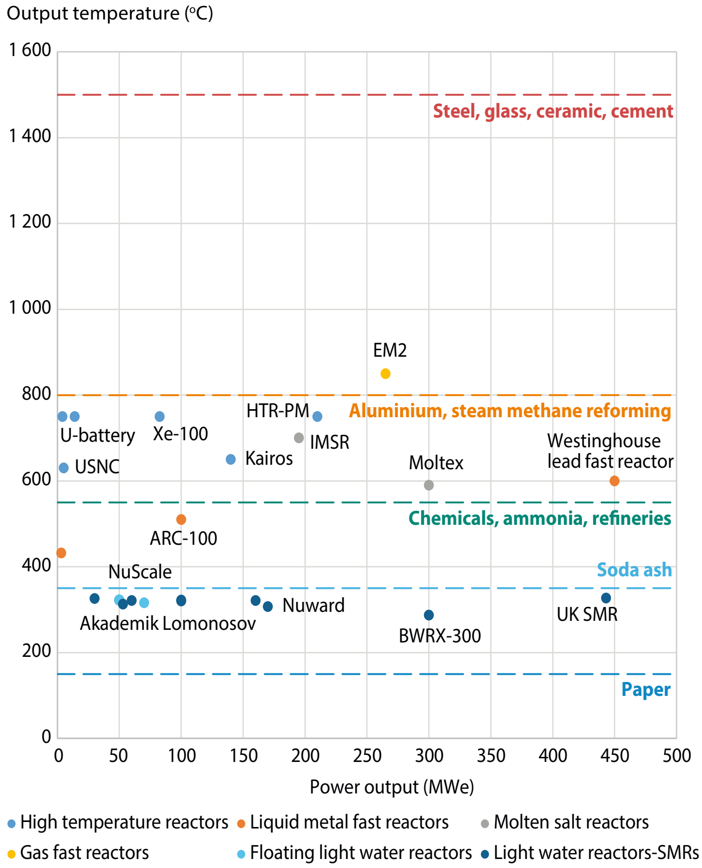
### Flexibility

SMRs are designed to integrate into energy systems, offering much needed flexibility to enable high shares of variable renewable energy.

### Fuel cycle

Some SMR designs seek to recycle waste streams from existing reactors to produce new useful fuel and minimise waste volumes requiring long-term management and disposal.

Figure 1: Near-term SMRs could decarbonise heavy industries with combined heat and power




Source: NEA, forthcoming.

## The first SMR demonstration units are being deployed today

Competition between designs is fierce as the first SMRs are expected to be commercially deployed within five to ten years.

## Range of sizes and temperatures

Some SMRs are based on existing commercially deployed technologies, while others are based on advanced design concepts, offering a range of sizes – from 1 to 300 MWe – and a range of temperatures – from 285°C to more than 850°C.

## SMRs are positioned to open up new markets and applications for deep decarbonisation

### On grid

Larger SMRs (around 200-300 MWe) are designed primarily for on-grid power generation. This size is especially well suited for replacing coal power plants.

### Off grid

Smaller SMRs could create an alternative to diesel generation in remote communities and at mining sites. SMRs could be used to provide power as well as heat for various purposes such as district heating or mine shaft heating.

### Heat

Many SMR designs will operate at higher temperatures, creating opportunities for the decarbonisation of hard-to-abate sectors. High-temperature SMRs could create the first real non-emitting alternative to fossil fuel cogeneration by offering combined heat and power solutions for industrial customers.

### Marine shipping

SMRs could provide a non-emitting alternative for merchant shipping.

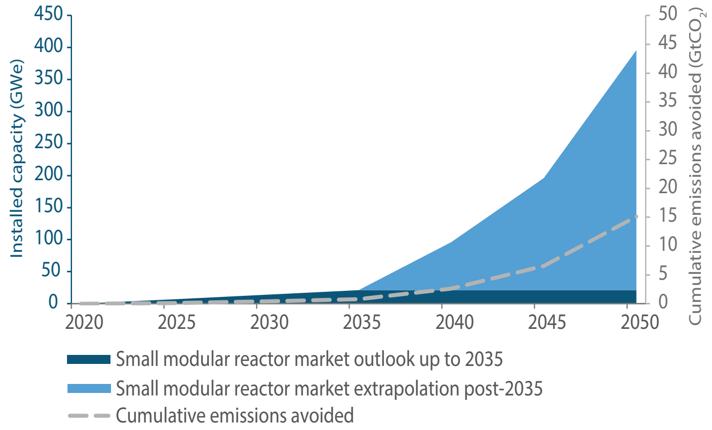
## Near-term deployment of SMRs could avoid 15 gigatonnes of carbon dioxide emissions between 2020 and 2050

Forthcoming NEA analysis will identify the potential contribution of nuclear energy to clean energy capacity and emission reductions between 2020 and 2050, taking into consideration the potential contributions from power and non-power applications of nuclear technologies.

The NEA estimates that the global SMR market could reach 21 gigawatts by 2035. A rapid increase in build rate can be envisaged with construction between 50 and 150 gigawatts per year. Assuming a build rate that reaches 75 gigawatts per year by 2050, up to 375 gigawatts of installed capacity would be built over the next three decades. This would translate into avoiding 15 gigatonnes of cumulative $CO_2$ emissions.

Taken together, the contributions of SMRs, along with long-term operation, new builds of existing large-scale nuclear technologies, nuclear hybrid energy and hydrogen systems begin to reveal the full extent of the potential for nuclear energy and nuclear innovations to play a significant and growing role in pathways to net-zero by 2050. NEA projections forecast that if all options are implemented, some 87 gigatonnes of cumulative emissions between 2020 and 2050 will be averted, the equivalent of more than two years of global carbon emissions at 2020 levels and a critical contribution towards meeting Paris Agreement targets.

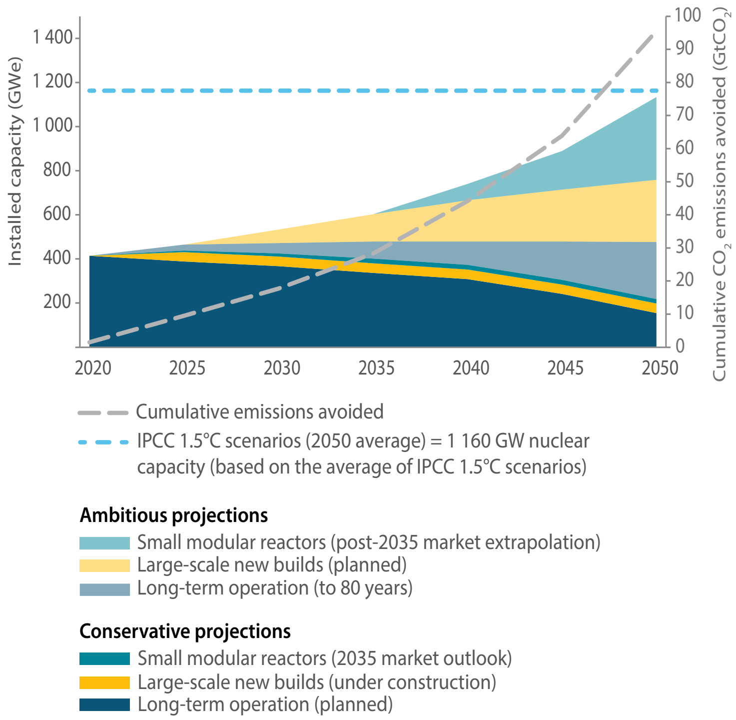
Figure 2: **SMR installed capacity and cumulative emissions avoided**




Source: NEA, forthcoming.

Note: It is assumed that nuclear power (12 g $CO_2$eq/kWh) is displaced by gas with a carbon footprint of 490 g $CO_2$eq/kWh (Bruckner, 2014). SMR 2035 market outlook based on NEA (2016). Extrapolation post-2035 based on SMR build rate envisaged by McKinsey & Company (2018) "Nuclear deep decarbonization scenario". By 2050, 25% of nuclear reactors are used for nuclear heat applications, also displacing gas. By 2050, nuclear reactors operate with a 90% availability factors with 60% of the power used to supply electricity and 30% to supply hydrogen. Hydrogen produced with nuclear power will displace steam methane reforming (10 kg $CO_2$ per kg of $H_2$).

Figure 3: **Full potential of nuclear contributions to net-zero**




Source: NEA, forthcoming.

## Further reading


NEA (forthcoming), *Meeting Climate Change Targets: Projecting the Potential Role of Nuclear Energy*, OECD Publishing, Paris.