Flexibility of Advanced Nuclear Energy

Summary

- Future electricity grids will need to incorporate high levels of variable renewable energy and manage concerns about grid reliability and resilience in the face of extreme and changing weather.
- Advanced reactors are well suited to provide firm, flexible and resilient electricity supply in future energy grids.
- Advanced reactors can supply energy for industrial requirements and enable co-production of hydrogen and desalination, helping to decarbonize other energy-intensive economic sectors and mitigate the impacts of climate change.

Electricity markets require closely matching electricity supply to demand on an instantaneous basis. Power system operators "dispatch" or adjust the production of power from electric generating units so that total generation matches demand as it varies throughout the day, season, and year. As the share of variable renewable energy continues to grow, the rest of the electric grid must feature increased flexibility to economically balance energy requirements while maintaining reliability. As economies grapple with how to balance variable renewables, advanced reactor developers can provide the zero-carbon on-demand power needed when renewable generation is unavailable, and work in tandem with renewable energy and energy storage to decarbonize energy systems.

Flexibility and compatibility with renewable energy have been part of advanced reactor designs from the start. Advanced reactor designs will be able to change their power level rapidly to complement variable levels of wind and solar generation. Some designs will even be able to ramp down to and up from 40% in 12 minutes to match fluctuating. In addition, most designs consist of multiple units that can be managed separately to meet fluctuating supply or demand. In fact, it's a common misperception that nuclear reactors aren't compatible with renewables. Existing reactors were originally licensed to also modify their output to match changing energy demand (called load following to help maintain the stability of the electric grid) but have not typically done so in the United States because in the past, it has been more economically efficient for them to operate continuously at full power (i.e., as a "baseload" electricity resource).

In addition to their ability to vary their output, some advanced reactor designs incorporate power storage capability, to save power when there is a lot of renewable energy available, and provide it later, when it's needed. TerraPower's Natrium reactor can increase its output by about 45% for 5.5 hours using thermal storage. Holtec's SMR-160 also can be paired with an energy storage system.

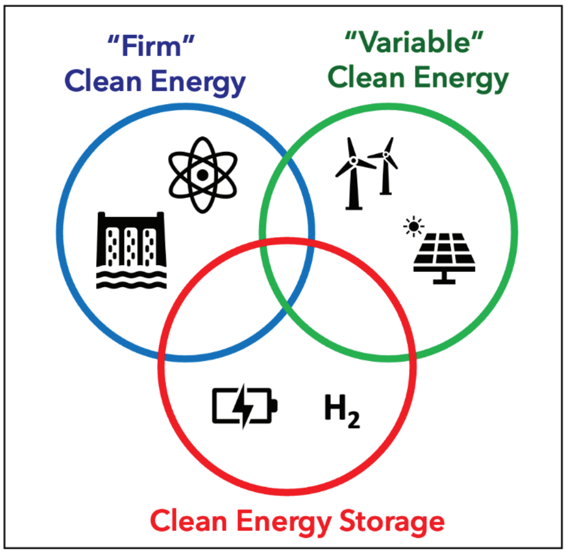

Figure 1: Simplified visualization of how grid flexibility can be achieved using clean energy sources

Figure 2: Range of applications that advanced nuclear can decarbonize. Source: Modified from X-energy presentation

Advanced reactor technologies are also capable of supplying [high-temperature output for industrial requirements], and of powering hydrogen production and decarbonizations. The ability to provide energy for industrial productions will be critical to achieving decarbonization objectives. Furthermore, it may be feasible to use some of these additional energy requirements to balance the production of electricity for the grid, providing an additional source of flexbility for energy generation.

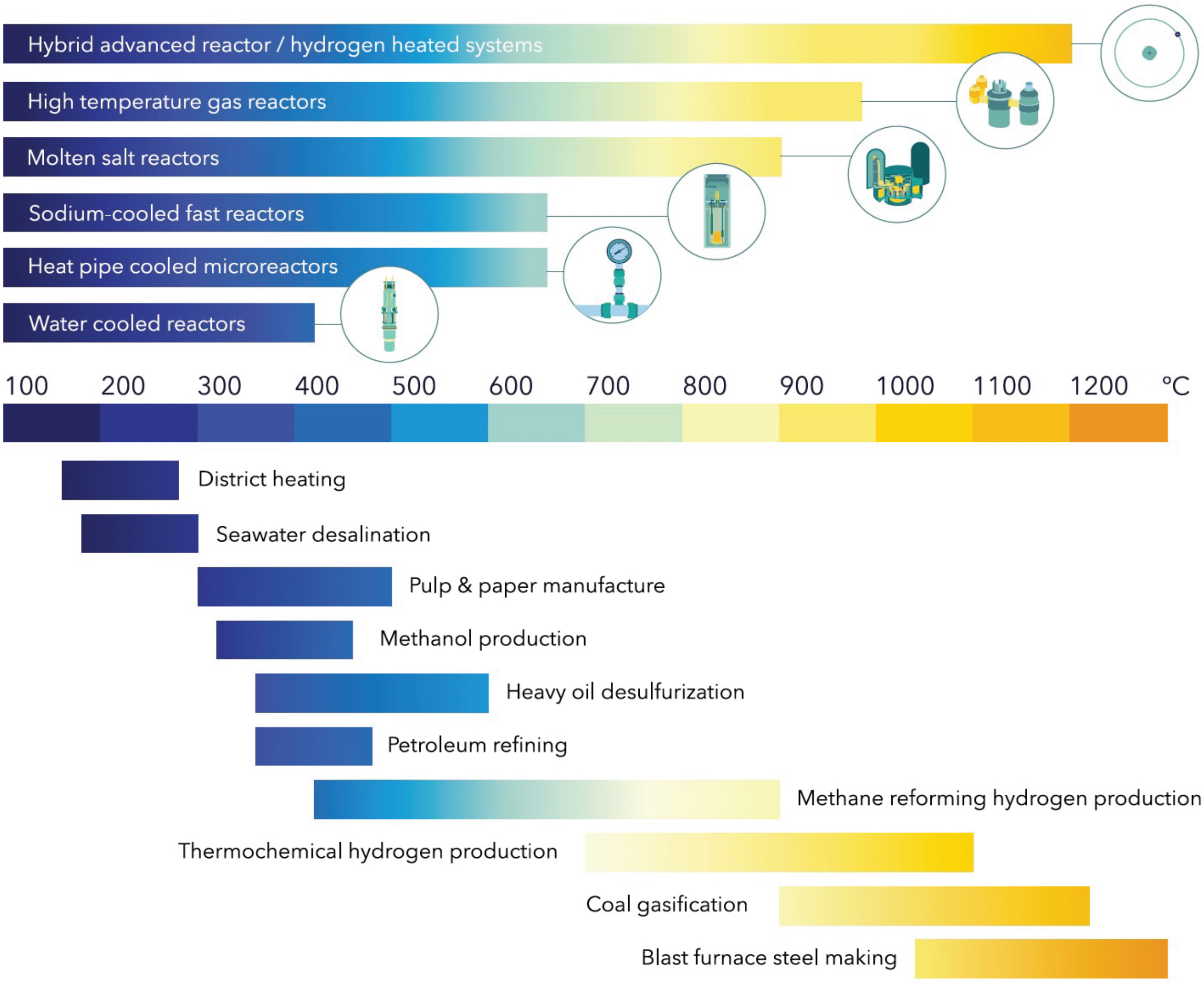

Figure 3: Temperature ranges for several industrial processes and reactors operating ranges. Source: NIA

Including nuclear power gives the world the best chance to table climate change and energy security. A study conducted by Princeton's Net Zero America analyzed the ability and affordability of five distinct technological pathways, all using technologies known today, to decarbonize the United States' economy. Out of the five pathways, all but one used nuclear energy and the pathway which used the largest amount of nuclear energy was also [the most affordable]. While it is impossible to predict the exact energy mix necessary to fully decarbonize the world's economy by 2050, nuclear energy will likely play a significant part.