NICE Future

Nuclear Innovation: Clean Energy Future

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Integrated Energy Systems: Maximizing Clean Energy for Industry, Transportation and the Grid

As communities explore new options to combat climate change, nuclear and renewables, such as wind and solar, play big roles by providing carbon-free electricity to the grid. But there's no one-size-fits-all solution to every energy challenge.

Currently, more than 20% of global carbon emissions come from industry, primarily from processes that burn fossil fuels on site for high temperature heat or electricity.

Nuclear fission produces high-quality, carbon-free heat — heat that is typically converted to electricity.

New technologies allow nuclear plants to direct their heat and electricity to support non-grid industrial needs.

For example, integrated energy systems would coordinate the distribution of heat and electricity from multiple generators, such as nuclear and renewables.

Integrated energy systems

As part of integrated energy systems, current and future nuclear reactors would continue to generate electricity when demand is high. But when demand is low, or when ample electricity is available from renewables, those reactors could divert excess energy in the form of heat, steam or electricity to a wide range of applications — from purifying water and heating greenhouses to producing hydrogen and manufacturing steel.

A few nuclear plants are demonstrating early versions of these systems to support hydrogen production, while others already support desalination to produce potable water. Integrated systems, combined with higher temperature heat that would be produced by many of tomorrow's advanced nuclear reactors, could support a wide range of applications with even greater efficiency.

Clean energy parks of the future will coordinate the distribution of heat and electricity from multiple generators, such as nuclear and renewables.

Image courtesy of GAIN and Third Way, inspired by the Nuclear Energy Reimagined concept led by INL.

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How integrated energy systems work

An integrated energy system would generally include one or more power generation source, storage, heat transfer systems, a control system, and industrial heat and/or electricity consumers.

Such systems may integrate multiple generation sources (e.g., a nuclear plant, a wind farm and a concentrated solar power station) and sell the energy for multiple uses (e.g., the electrical grid, a hydrogen production plant and a water desalination plant). To reduce heat losses, industrial users could be located adjacent to the power plant.

An integrated energy system would coordinate this heat and electricity distribution in response to loads on the electrical grid, balancing electricity generation to match changing demand and responding to the availability of variable renewables such as wind and solar.

These systems aren't limited to large scale applications. Microreactors, which provide anywhere from a few to tens of megawatts of energy, could supply heat and electricity to remote locations, such as villages or mining operations.

Potential uses for carbon-free heat

Integrated energy systems can help meet heat and electricity demands while reducing the typical carbon emissions for industrial processes. They can also free resources such as coal for uses other than power generation, including manufacturing useful industrial or consumer products like carbon fiber or chemicals. Integrated systems can support social justice by ensuring the economic viability of communities that currently rely on fossil fuels by using those resources as feedstock for higher-value products. They also promote environmental justice by providing these communities with clean energy.

Additionally, thermal energy from a nuclear plant can be used in district heating systems. These systems distribute heat from a centralized source to residential and commercial buildings through a network of pipes that convey steam, hot water, or other mixtures to provide space heating.

INDUSTRIES THAT CAN BENEFIT FROM CARBON-FREE NUCLEAR HEAT

Bioenergy and bioproducts
Heat can dry and process biomass into more useable forms for making biofuels, biopower and bioproducts, or for upgrading biofuels into higher value products.

Hydrogen
Heat and electricity can be used to make clean hydrogen, avoiding the carbon dioxide generated by today's techniques (steam methane reforming). Carbon-free hydrogen can be stored and turned back into electricity, burned as a clean transportation fuel or converted to valuable chemicals such as ammonia, a key ingredient in fertilizer.

Water
Heat and electricity can power desalination plants that convert salty or brackish water to potable water for drinking or agriculture, or to clean industrial wastewater.

Agriculture
Heat can be used for greenhouses, soil warming or to help dry and process crops. Nuclear energy can also support production of fertilizer, herbicides, and pesticides, all of which require significant process heat to produce.

CO_2 capture
Heat and electricity can power chemical reactions that convert CO_2 from fossil fuels or biofuels into useful chemicals, such as carbon monoxide and methane. These chemicals can then be used to produce any number of products including plastics, polymers, other chemicals and carbon-based fuels, especially syngas. When that CO_2 is captured from a nearby fossil fuel plant, it can be combined with hydrogen to produce "synfuels" that can be burned in a standard gasoline engine.