Modern Methods of Obtaining Electricity from Nuclear Energy

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A B S T R A C T

At present, the work on obtaining electricity from nuclear power plants is in full swing. Nuclear power plants play an important role as the largest energy source of our century. this article discusses modern methods of obtaining electricity from the atom.

A R T I C L E I N F O

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Nuclear power is the use of nuclear reactions to produce electricity. Nuclear power can be obtained from nuclear fission, nuclear decay and nuclear fusion reactions. Presently, the vast majority of electricity from nuclear power is produced by nuclear fission of uranium and plutonium in nuclear power plants. Nuclear decay processes are used in niche applications such as radioisotope thermoelectric generators in some space probes such as Voyager 2. Generating electricity from fusion power remains the focus of international research.

Civilian nuclear power supplied 2,586 terawatt hours (TWh) of electricity in 2019 (around a tenth of all global electricity generation), and was the second-largest low-carbon power source after hydroelectricity, with 28% of global low-carbon power in 2019 supplied by nuclear. As of September 2021, there are 444 civilian fission reactors in the world, with a combined electrical capacity of 396 giga watt (GW). There are also 53 nuclear power reactors under construction and 98 reactors planned, with a combined capacity of 60 GW and 103 GW, respectively. The United States has the largest fleet of nuclear reactors, generating over 800 TWh zero-emissions electricity per year with a very high average capacity factor of 92%. Most reactors under construction are generation III reactors in Asia.

Nuclear power is the safest energy source. Coal, petroleum, natural gas and hydroelectricity each have caused more fatalities per unit of energy due to air pollution and accidents. Accidents in nuclear power plants include the Chernobyl explosion in the Soviet Union in 1986, the Fukushima nuclear disaster in Japan in 2011, and the more contained Three Mile Island accident in the United States in 1979.

There is a debate about nuclear power. Proponents, such as the World Nuclear Association and Environmentalists for Nuclear Energy, contend that nuclear power is a safe, sustainable energy source that reduces carbon emissions. Nuclear power opponents, such as Greenpeace, Scientists for Future and NIRS, argue that nuclear has not been proven to be safe and should be supplemented with other ideas, such as wind and hydroelectric energy. The nuclear industry also includes nuclear medicine, including applications involving diagnosis and treatment of tumors.

Decarbonization to create a CO_2-neutral global economy requires decarbonizing *all* sectors that largely rely on fossil fuels today. These include heating, industrial processes that require combustion and transport, especially heavy duty, maritime and air transport. Nuclear energy generates about 10 per cent of the world's electricity, and after hydropower, it is the world's second largest source of low-carbon power, according to the International Energy Agency (IEA). Nuclear can also be utilized to decarbonize non-electric applications.

What are non-electric applications?

There are many applications beyond electricity generation that can use nuclear power. These applications, which require heat, include seawater desalination, hydrogen production, district heating and process heating for industry (glass and cement manufacturing, metal production), refining and synthesis gas production. As the global community strives to meet climate goals, expanding nuclear's role in these applications could be key to a successful clean energy transition.

Learn how nuclear can replace coal as part of the clean energy transition.

The heat produced by nuclear power plants is used to create steam, which drives electricity-generating turbines. Existing nuclear fleets today reach operating temperatures in the range of 300°C, while district heating and seawater desalination processes require about 150°C. By design, nuclear power plants currently convert one third of the heat produced into electricity because of technological reasons mostly related to material properties and performances. The remaining heat is usually released to the environment.

Instead of releasing this heat, it could be utilized for heating or cooling, or as an energy source towards the production of fresh water, hydrogen or other products, such as oil or synthetic fuel. These products may be produced by existing power plants, in what is referred to as cogeneration. Nuclear cogeneration is the simultaneous production of electricity and heat or a heat-derivative product. By using heat for cogeneration, the thermal efficiency can be improved up to 80 per cent.

What is nuclear energy, and how does a nuclear power plant work? Read about the science of nuclear power.

Nuclear power and hydrogen production

Hydrogen can replace fossil fuels across multiple sectors to potentially enable zero or near-zero emissions in chemical and industrial processes, clean energy systems and transportation. Hydrogen is produced today from the steam methane reforming process, an energy-intensive process that emits around 830 million tonnes of CO_2 per year, equivalent to the CO_2 emissions of the United Kingdom and Indonesia combined, according to the IEA. There are several methods to use nuclear energy, as a source of electricity and heat, to produce hydrogen efficiently and with little to no CO_2 emissions.

Nuclear power and district heating

District heating relies on a centralized energy plant for the distribution of heat to residential and commercial buildings. In nuclear district heating, steam produced by a nuclear power plant serves to heat regional heating networks. This practice has been implemented in several countries – Bulgaria, China, Czech Republic, Hungary, Romania, Russia, Slovakia, Switzerland and Ukraine.

The Akademik Lomonosov, the world's first floating nuclear power plant that began commercial operation in May 2020, provides heat to the Chukotka region in far northeastern Russia. Since 1983, Switzerland's Beznau nuclear power plant has been providing heat for municipalities, private, industrial and agricultural consumers totalling about 20 000 people. The main heating network has a length of 31 km, from which heat is transferred to secondary networks with a total length of 99 km.

In China, the Haiyang Nuclear Energy Heating Project is expanding. The heating network using steam from Haiyang's two reactors became operational at the end of 2020, and the first phase of the project is expected to avoid the use of 23 200 tonnes of coal annually and the emission of 60 000 tonnes of CO_2. The Heating Project is an example of how nuclear energy can play a role in decarbonizing residential heating, as well as the added value of operating a nuclear power plant in cogeneration mode. The project will provide heat to the entire city of Haiyang, a coastal city in Shandong province that has a population of about 670 000, by the end of 2021.

Nuclear power and desalination

Desalination of seawater can help to meet the growing demand for potable water, while alleviating water shortages in many arid or semi-arid coastal areas. Desalination plants require energy in the form of heat for distillation or electrical/mechanical energy to drive pumps for pressurization of seawater across membranes to separate salt from saline waters. Currently most of this energy is derived from fossil fuels. Nuclear desalination is a low-carbon alternative that utilizes the heat and electricity from a nuclear reactor. Desalination techniques can be coupled with different types of nuclear power plants to produce water and electricity concurrently.

The feasibility of integrated nuclear desalination plants has been proven with over 150 reactor-years of experience, mainly in India, Japan and Kazakhstan. The Aktau nuclear reactor in Kazakhstan, on the shore of the Caspian Sea, produced up to 135 MWe of electricity and 80 000 m3/day of potable water for 27 years until it was shut down in 1999. In Japan, several desalination facilities linked to nuclear reactors produce about 14 000 m3/day of potable water. In 2002, a demonstration plant coupled to twin 170 MWe nuclear power reactors was set up at the Madras Atomic Power Station, in southeast India. This is the largest nuclear desalination plant based on hybrid thermal and osmotic technology using seawater and low-pressure steam from a nuclear power station.

Initiatives for non-electric applications

Though only about 1 per cent of nuclear energy is currently used for non-electric applications, there are initiatives around the world from the United Kingdom and France to Russia, Japan and beyond, to pave the way for broader adoption. This includes the H2-@-Scale initiative, launched in 2016 by the United States, which examines the prospects for hydrogen production via nuclear power. In Canada, the Canadian Nuclear Laboratories (CNL) are planning to launch the Clean Energy Demonstration, Innovation, and Research (CEDIR) Park, which will serve as a testing site for cogeneration applications using small modular reactors (SMRs).

In China, a high-temperature gas cooled SMR, is slated to begin operation by the end of 2021. The reactor is designed to support electricity generation, cogeneration, process heat and hydrogen production. Japan restarted its High-Temperature Engineering Test Reactor (HTTR) in July 2021. The heat produced by the HTTR has applications for power generation, desalination of seawater and hydrogen production via thermo chemical process.

In the range of 250-550°C, the European heat market represents more than 100 giga watts-thermal (GWth), and there is an opportunity for nuclear to address this market. Poland relies 100 per cent on fossil fuel for heat production; however, the deployment of nuclear for heat is included in the country’s development strategy.

References:

1. Conca, James. "How Deadly Is Your Kilowatt? We Rank The Killer Energy Sources". Forbes. Retrieved 2022-02-16.
2. "What is the Safest Energy for the Future? | AltEnergyMag". www.altenergymag.com. Retrieved 2022-02-16.
3. "Reactors: Modern-Day Alchemy - Argonne's Nuclear Science and Technology Legacy". www.ne.anl.gov. Retrieved 24 March 2021.
4. Wellerstein, Alex (2008). "Inside the atomic patent office". Bulletin of the Atomic Scientists. 64 (2): 26–31. Bibcode:2008BuAtS..64b..26W. doi:10.2968/064002008.
5. "The Einstein Letter". Atomicarchive.com. Retrieved 2013-06-22.
6. "Nautilus (SSN-571)". US Naval History and Heritage Command (US Navy).
7. Wendt, Gerald; Geddes, Donald Porter (1945). The Atomic Age Opens. New York: Pocket Books.
8. Mirzayev A. T., Mirinoyatov M. M., Stepanov V. A., Molekulyarniegazovielazeri s poperechnimvisokochastotnimvozbujdeniyem, M., 1979; 3 vel to O., Prinsipilazerov [per. s angl.], 2-izd., M., 1984.A’zam Mirzayev