DOWNLOAD PDF NUCLEAR POWER TECHNOLOGY

Chapter 1 : Nuclear Power | Union of Concerned Scientists

Nuclear power has reliably and economically contributed almost 20% of electrical generation in the United States over the past two decades. It remains the single largest contributor (more than 70%) of non-greenhouse-gas-emitting electric power generation in the United States.

To earn a Nuclear Power Technology degree a student will decide on one of two tracks; non-licensed operator or instrumentation and control technician. All students will need to complete the Nuclear Uniform Curriculum Program NUCP courses; then, depending on their specialization, four specific courses are required. The instrumentation and control technician track will include: Offered entirely online, students in both tracks are trained in industry-required fundamentals needed for their respective field. Students will learn about all phases of nuclear power generation, including equipment, systems and safety culture. Both careers provide students the opportunity to find entry-level positions at nuclear or other modern power plants. Preparation A background in math, physics and chemistry is highly recommended. Knowledge of electronics, mechanics or instrumentation is helpful. Prospective students should be prepared for the physical demands of entry-level technician positions. Job applicants also may be required to pass a drug screen and eye exam, including the ability to distinguish between colors accurately. Program Requirements Students who complete the curriculum requirements receive a Program Certificate or Associate in Applied Science degree. Required program entrance scores: Career Opportunities Industry forecasts a strong job market for job applicants in nuclear energy due to an aging workforce, plant license renewal and growing interest in nuclear power. Graduates find employment as entry-level instrumentation and control or non-licensed operators. Graduates can also find entry-level employment as radiographers, operators, radiation monitors, and decontamination workers. They may also work in health care. Technicians with the necessary skills can become instructors who train new workers or technical writers who prepare operating or repair manuals. The BAS is designed for individuals interested in supervisory and management positions in the energy industry. The BAS builds on the foundation laid in an AAS degree and includes general education classes, core management courses, and energy specific management courses. Energy Secretary Samuel W. This official designation recognizes BSC as the premier national center of education and training for operators and technicians in the energy industry.

Chapter 2 : Course Details - Certificate and AAS in Nuclear Power Technology - Details | EPCE

Nuclear News - Nuclear Power Daily brings you daily news on nuclear energy science and technology.

How Nuclear Power Works Principles of nuclear power Atoms are constructed like miniature solar systems. At the center of the atom is the nucleus; orbiting around it are electrons. The nucleus is composed of protons and neutrons, very densely packed together. Hydrogen, the lightest element, has one proton; the heaviest natural element, uranium, has 92 protons. During fission, a neutron bombards a uranium atom, releasing more neutrons and triggering a chain reaction. Because uranium atoms are so large, the atomic force that binds it together is relatively weak, making uranium good for fission. In nuclear power plants, neutrons collide with uranium atoms, splitting them. This split releases neutrons from the uranium that in turn collide with other atoms, causing a chain reaction. This chain reaction is controlled with "control rods" that absorb neutrons. In the core of nuclear reactors, the fission of uranium atoms releases energy that heats water to about degrees Farenheit. This hot water is then used to spin turbines that are connected to generators, producing electricity. Mining and processing nuclear fuels An open pit uranium mine in Namibia. One pound of uranium has as much energy as three million pounds of coal. Radioactive elements gradually decay, losing their radioactivity. The time it takes to lose half of its radioactivity is called a "half life. Uranium is found in a number of geological formations, as well as sea water. To be mined as a fuel, however, it must be sufficiently concentrated, making up at least one hundred parts per million 0. Wyoming and the Four Corners region produce most U. The mining process is similar to coal mining, with both open pit and underground mines. It produces similar environmental impacts, with the added hazard that uranium mine tailings are radioactive. Groundwater can be polluted not only from the heavy metals present in mine waste, but also from the traces of radioactive uranium still left in the waste. Half of the people employed by the uranium mining industry work on cleaning up the mines after use. The Department of Energy estimates that the U. American power plants are using over 40 million pounds of uranium fuel each year. Much more uranium is likely to be available beyond our proven reserves. Uranium comes in two forms, U and U As found in nature, uranium is more than 99 percent U; unfortunately, U is what is used in power plants. U can also be processed into plutonium, which is also fissionable. Once mined, the uranium ore is sent to a processing plant to be concentrated into a useful fuel. There are 16 processing plants in the US, although eight are inactive. Most uranium concentrate is made by leaching the uranium from the ore with acids. Sometimes the concentrate is made underground, without removing the uranium ore. When finished, the uranium ore is turned into U_3O_8, the fuel form of uranium, and shaped into small pellets. The pellets are then packed into foot long rods, called fuel rods. The rods are bundled together into fuel assemblies, ready to be used in the core of a reactor. Nuclear reactors There are currently 99 commercial nuclear reactors in operation in the United States. Over a dozen commercial reactors have been shut down permanently, with more retirements likely to be announced in coming years. Most of the plants in operation are "light water" reactors, meaning they use normal water in the core of the reactor. Different reactor technologies are in use abroad, such as the "heavy water" reactors in Canada. In a boiling water reactor, shown below, the water is allowed to boil into steam, and is then sent through a turbine to produce electricity. In pressurized water reactors, shown below, the core water is held under pressure and not allowed to boil. The heat is transferred to water outside the core with a heat exchanger also called a steam generator , boiling the outside water, generating steam, and powering a turbine. In pressurized water reactors, the water that is boiled is separate from the fission process, and so does not become radioactive. After the steam is used to power the turbine, it is cooled off to make it condense back into water. Some plants use water from rivers, lakes or the ocean to cool the steam, while others use tall cooling towers. The hourglass-shaped cooling towers are the familiar landmark of many nuclear plants. For every unit of electricity produced by a nuclear power plant, about two units of waste heat are rejected to the environment. Commercial nuclear power plants range in size from about 60 megawatts for the first generation of plants in the early s, to over megawatts. Many plants contain more than one reactor. The Palo Verde plant in Arizona , for example, is made up of three separate reactors, each with a capacity of 1, megawatts. Some foreign reactor designs use coolants other than water to carry the heat of fission away from the core. Canadian reactors use water loaded with deuterium called "heavy water" , while others are gas cooled. One plant in Colorado , now permanently shut down, used helium gas as a coolant called a High Temperature Gas Cooled Reactor. A few plants use liquid metal or sodium. Nuclear waste Experimental tunnels at the Yucca mountain waste repository site. Nuclear Regulatory Commission By the end of , over 67, metric tons of highly radioactive waste had been produced by American nuclear reactors. That increases by about 2, metric tons every year. Before the mids, the plan for spent uranium was to reprocess it into new fuel. Since a by-product of reprocessing is plutonium, which can be used to make nuclear weapons, President Carter ordered the end of reprocessing, citing security risks. Reprocessing also had a difficult time competing economically with new uranium fuel. Since then, the Department of Energy has been studying storage sites for long-term burial of the waste, especially at Yucca Mountain in Nevada. Although Yucca Mountain has yet to be officially chosen, there are no other sites being considered. Meanwhile, radioactive waste is being stored at the nuclear plants where it is produced. The most common option is to store it in spent fuel cooling pools , large steel-lined tanks that use electricty to circulate water. As these pools fill up, some fuel rods are being transferred to large steel and concrete casks, which are considered safer. In addition to the spent fuel, the plants themselves contain radioactive waste that must be disposed of after they are shut down. Plants can either be disassembled immediately or can be kept in storage for a number of years to give the radiation some time to diminish. Most of the plant is considered "low level waste" and can be stored in less secure locations. Currently, only two sites accept low level waste: Barnwell in South Carolina and Hanford in Washington. A number are in storage awaiting decommissioning at a future time. The rise of nuclear power The principles of nuclear power were formulated by physicists in the early 20th century. In , German scientists discovered the process of fission, triggering a race with American scientists to use the incredible power of fission to create a bomb. Through the intense effort of the Manhattan Project, the atomic bomb was created by , and used to destroy Hiroshima and Nagasaki at the end of World War II. After the war, "great atomic power" was seen as a potential new energy source. As late as the s, bombs were being set off above and below ground to test different ideas. That job would be done with H-bombs having a total power of 42 megatons. To build it with conventional explosives would cost nearly six billion dollars -- using nuclear blasts just a little over two billion. Excavating, which took almost 20 years for the old Canal, might take only five for the new one. A more successful use of atomic power was in nuclear reactors. Admiral Hyman Rickover guided the development of small reactors to power submarines, greatly extending their range and power. The USS Nautilus was launched in By the late s, nuclear power was being developed for commercial electric power, first in England. Morris, Illinois, was the site of the first U. A plant at Shippingport, Pennsylvania, went on line in , but was not commercially owned. The head of the Atomic Energy Commission, Lewis Strauss, said in that "it is not too much to expect that our children will enjoy in their home electrical energy too cheap to meter. As a result, many of the early safety concerns about nuclear power were suppressed. Any consideration of the long-term effects and hazards were downplayed. This started a trend of "turnkey" nuclear plantsâ€”plants that were sold to utilities only when fully completed. Such turnkey plants enabled the nuclear industry to get off the ground, with plant orders booming in the late s. The fall of nuclear power After absorbing as many losses as they could, manufacturers ended turnkey offers. By the s, about plants were built, under construction or planned. But a number of factors conspired to end the nuclear boom. Interested in your local nuclear reactor? Use our database to research nuclear safety issues in your area. First, cost overruns revealed the true cost of nuclear plants. Once utilities began building the plants as their own projects, their lack of experience with the technology, the use of unique designs for every plant, and a "build in anticipation of design" approach led to enormous cost overruns. Because construction took years to complete, utilities found themselves with huge amounts of money invested in a plant before any problems developed. Yet the utility canceled construction of the plant in

Chapter 3 : nuclear power | Definition, Issues, & Facts | blog.quintoapp.com

Nuclear power is a type of nuclear technology involving the controlled use of nuclear fission to release energy for work including propulsion, heat, and the.

Pinterest A comparison of small nuclear reactors left with a traditional reactor at a nuclear power plant today. At a time when many existing nuclear power plants are struggling financially from competition from low natural gas prices and subsidized wind and solar projects, the nuclear industry sees hope in this next-generation technology. Grecheck said scientists are studying other ways to improve nuclear technology. Can our need for a carbon-free future override our fears of nuclear energy? Startup companies working on using spent uranium fuel include the Bill Gates-backed TerraPoweras well as Transatomic and Terrestrial Energy. Another start up, Oklo, seeks to create 2-megawatt reactors that fit inside shipping containers to provide electricity for remote off-grid locations. Many small nuclear reactor companies have yet to line up customers. One exception is Oregon-based NuScale Power, whose technology has been tapped for the project by the Utah consortium in Idaho. NuScale plans to apply for certification from the US Nuclear Regulatory Agency later this year, a step that all nuclear engineering firms must take before their designs can be used to build power plants. Even if the small reactor remains within estimated costs, it will be pricey, at least initially, next to subsidized wind and solar. Like solar and wind, McGough said he expected the prices would decrease over time as more utilities build small nuclear reactors. Read more The Utah consortium, like power companies across the country, is under increasing pressure from state and federal regulations such as the Clean Power Plan to cut its emissions. Nuclear fits that need, but the size of traditional plants is too big, said LaVarr Webb, spokesman for the Utah consortium. Current nuclear plants are designed to produce electricity without interruption; adjusting the levels of energy output quickly in response to any sudden increase or drop of renewable energy generation is difficult to do. Small reactors can operate independently, allowing a plant to vary its output more dynamically, McGough said. The Utah consortium will hire Washington state-based Energy Northwest to operate and maintain its 12 reactors in Idaho if they are built. The Utah group expects the project to come online by The initial high prices mean these tiny nuclear reactors will likely be built in the near future in states that allow utility monopolies, such as California, Utah and Washington. Are they cheaper to build? Do we have any experience doing it?

Chapter 4 : Nuclear power - Wikipedia

Nuclear technology is a major base-load power-generating source and accounted for % of global power generation in as per GlobalData, a leading data and analytics company. News Hitachi selects partners to construct Wylfa Newydd nuclear power plant.

An ionization smoke detector includes a tiny mass of radioactive americium , which is a source of alpha radiation. Two ionisation chambers are placed next to each other. Both contain a small source of Am that gives rise to a small constant current. One is closed and serves for comparison, the other is open to ambient air; it has a gridded electrode. When smoke enters the open chamber, the current is disrupted as the smoke particles attach to the charged ions and restore them to a neutral electrical state. This reduces the current in the open chamber. When the current drops below a certain threshold, the alarm is triggered. Food processing and agriculture[edit] In biology and agriculture , radiation is used to induce mutations to produce new or improved species. Another use in insect control is the sterile insect technique , where male insects are sterilized by radiation and released, so they have no offspring, to reduce the population. In industrial and food applications, radiation is used for sterilization of tools and equipment. An advantage is that the object may be sealed in plastic before sterilization. An emerging use in food production is the sterilization of food using food irradiation. The Radura logo, used to show a food has been treated with ionizing radiation. Food irradiation [8] is the process of exposing food to ionizing radiation in order to destroy microorganisms , bacteria , viruses , or insects that might be present in the food. The radiation sources used include radioisotope gamma ray sources, X-ray generators and electron accelerators. Further applications include sprout inhibition, delay of ripening, increase of juice yield, and improvement of re-hydration. As such it is also used on non-food items, such as medical hardware, plastics, tubes for gas-pipelines, hoses for floor-heating, shrink-foils for food packaging, automobile parts, wires and cables isolation , tires, and even gemstones. Compared to the amount of food irradiated, the volume of those every-day applications is huge but not noticed by the consumer. The genuine effect of processing food by ionizing radiation relates to damages to the DNA , the basic genetic information for life. Microorganisms can no longer proliferate and continue their malignant or pathogenic activities. Spoilage causing micro-organisms cannot continue their activities. Insects do not survive or become incapable of procreation. Plants cannot continue the natural ripening or aging process. All these effects are beneficial to the consumer and the food industry, likewise. The specialty of processing food by ionizing radiation is the fact, that the energy density per atomic transition is very high, it can cleave molecules and induce ionization hence the name which cannot be achieved by mere heating. This is the reason for new beneficial effects, however at the same time, for new concerns. The treatment of solid food by ionizing radiation can provide an effect similar to heat pasteurization of liquids, such as milk. However, the use of the term, cold pasteurization, to describe irradiated foods is controversial, because pasteurization and irradiation are fundamentally different processes, although the intended end results can in some cases be similar. Detractors of food irradiation have concerns about the health hazards of induced radioactivity. Food undergoing irradiation does not become any more radioactive than luggage passing through an airport X-ray scanner or teeth that have been X-rayed. There is a worldwide industry for processing by ionizing radiation, the majority by number and by processing power using accelerators. Food irradiation is only a niche application compared to medical supplies, plastic materials, raw materials, gemstones, cables and wires, etc. Nuclear and radiation accidents and Nuclear safety Nuclear accidents, because of the powerful forces involved, are often very dangerous. Historically, the first incidents involved fatal radiation exposure. Marie Curie died from aplastic anemia which resulted from her high levels of exposure. Two scientists, an American and Canadian respectively, Harry Daghlian and Louis Slotin , died after mishandling the same plutonium mass. Unlike conventional weapons, the intense light, heat, and explosive force is not the only deadly component to a nuclear weapon. Approximately half of the deaths from Hiroshima and Nagasaki died two to five years afterward from radiation exposure. Most common are nuclear leaks that expose workers to hazardous material. A nuclear meltdown refers to the more serious hazard of releasing nuclear material into the surrounding environment. The earthquake and tsunami on March 11, caused serious damage to three nuclear reactors and a spent fuel storage pond at the Fukushima Daiichi nuclear power plant in Japan. Military accidents usually involve the loss or unexpected detonation of nuclear weapons. The Castle Bravo test in produced a larger yield than expected, which contaminated nearby islands, a Japanese fishing boat with one fatality , and raised concerns about contaminated fish in Japan. In the s through s, several nuclear bombs were lost from submarines and aircraft, some of which have never been recovered. The last twenty years[when?

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Chapter 5 : Nuclear Power Technology (NUPT) < Bismarck State College

This nuclear reactor in France is shown being sprayed with water to keep cool. Small nuclear reactors, in contrast, use passive cooling means like gravity and convection - one benefit of the new.

Overview of Nuclear Energy Credits: FALL In this course the student will study the history of nuclear power, the basic principles of reactor design and operation at commercial nuclear electrical generating facilities. It includes an examination of nuclear waste issues, a study of important events which occurred at commercial nuclear plants, and a look towards the future of the electrical generating industry. Nuclear Mathematical Fundamentals Credits: FALL This course will review basic math, including basic arithmetic functions, fractions and decimals. The course will continue by covering scientific notation, dimensional analysis, algebra, basic geometry and trigonometry. Control charts and graphs, logarithms and exponential functions, and rate concepts will also be covered. FALL This course is designed to introduce students to classical physics. Engineering Drawings, Diagrams and Schematics Credits: FALL This course will introduce students to engineering drawings, diagrams, and schematics that are used in nuclear operations. Students will learn how to read and decipher the various nuclear symbols, components, systems, and legends found on diagrams, drawings, and schematics. Direct current and alternating current electrical circuits, generators, motors, and other components along with their applications will be covered. Single-phase AC circuits and three-phase AC circuits will be discussed. Inductance, capacitance, impedance, and resonance will be covered along with construction of conductors, insulators, and relays. Instrumentation and Control Prerequisites: FALL This course will cover the construction, operation, and failure modes of basic sensors and detectors used in nuclear generation. Included in this are gamma and neutron core power detector construction, operation and effects. Various control systems will be covered including failure symptoms and troubleshooting techniques from an operational perspective. SPRING This course will cover the basic function, design, and operation of mechanical components and equipment which are an integral part of nuclear facilities. Pumps, heat exchangers, valves, diesel engines, compressors, and filters will be included as well as some mechanical systems such as cooling towers and refrigeration. SPRING This course will tour the topics that comprise the fundamentals of nuclear science, giving the students an appreciation of theory and principles that govern nuclear processes involved in an operating reactor. This course covers the fundamental atomic structures, nuclear nomenclature, binding energy and nuclear decay reactions. Nuclear Plant Chemistry Prerequisite: SPRING This course covers basic chemistry fundamentals relating to maintaining water purity in primary and secondary systems. This course also covers chemistry concepts for both pressurized water reactors and boiling water reactors. Principles of water treatment, hazards and safety requirements will also be contained in the course. FALL This course covers heat transfer, fluid flow fundamentals, and the basics of thermodynamics. It begins with a discussion of temperature and heat, and progresses into heat capacities, sensible and latent heats. The laws of thermodynamics and related terms are introduced. The student will learn to perform energy balances, and understand thermodynamic processes and cycles. Properties of fluids and descriptions of their behavior are discussed. Topics covered include density, static head, hydraulics, buoyancy, and fluid flow. Centrifugal pumps are studied as well as closed system operation. FALL This course provides the student with a basic understanding of the structure of metals and how those structures are affected by various processes. The properties of metals and their applications are also covered along with thermal stress and shock. Ductile and brittle fractures will also be covered along with selecting materials for specific use in the industry. Lastly, students will discuss how important pressure and temperature curves are and why they are used when heating up and cooling down plant equipment. This course starts with classification of the types of neutrons, and the neutron life cycle. Other topics include reactivity which provides an understanding of what criticality means in terms of reactor operation. Lastly, a discussion of reactor shutdown operation and decay heat removal and significant reactor events. Science of Radiological Protection Credits: Reactor Safety Design Credits: SPRING This course will provide the student with a broad, in-depth knowledge of reactor safety design and protection principles. Conduct of Facility Operations Credits: This document contains best operating practices found in the commercial nuclear fleet, and as such can be looked at as a summary document for candidate utility workers. SPRING In this course, the student will be exposed to advanced instrumentation and control concepts pertinent to technicians working in the nuclear industry. The course will delve into the theory of operation for a number of digital components and systems, and explain important systems common to all nuclear power plants that employ these concepts. The course will also delve into the certain mechanical and electrical processes to demonstrate how these relate to the instrumentation and control systems governing them.

Chapter 6 : Nuclear Power Technology

Nuclear Power Technology AAS This program is designed to prepare students for entry level employment in the nuclear/power generation industry and will provide the academic and technical competencies required.

See Article History Nuclear power, electricity generated by power plants that derive their heat from fission in a nuclear reactor. Except for the reactor, which plays the role of a boiler in a fossil-fuel power plant, a nuclear power plant is similar to a large coal-fired power plant, with pumps, valves, steam generators, turbines, electric generators, condensers, and associated equipment. The first nuclear power plants, which were small demonstration facilities, were built in the s. That percentage remained stable through the s and began to decline slowly around the turn of the 21st century, primarily because of the fact that total electricity generation grew faster than electricity from nuclear power while other sources of energy particularly coal and natural gas were able to grow more quickly to meet the rising demand. This trend appears likely to continue well into the 21st century. Department of Energy , has projected that world electricity generation between and will roughly double from more than 15, terawatt-hours to 35, terawatt-hours and that generation from all energy sources except petroleum will continue to grow. In more than nuclear reactors were in operation in 30 countries around the world, and more than 60 were under construction. The United States has the largest nuclear power industry, with more than reactors; it is followed by France, which has more than Of the top 15 electricity-producing countries in the world, all but two, Italy and Australia, utilize nuclear power to generate some of their electricity. The overwhelming majority of nuclear reactor generating capacity is concentrated in North America , Europe, and Asia. The early period of the nuclear power industry was dominated by North America the United States and Canada , but in the s that lead was overtaken by Europe. The EIA projects that Asia will have the largest nuclear capacity by , mainly because of an ambitious building program in China. A typical nuclear power plant has a generating capacity of approximately one gigawatt GW; one billion watts of electricity. At this capacity, a power plant that operates about 90 percent of the time the U. The predominant types of power reactors are pressurized water reactors PWRs and boiling water reactors BWRs , both of which are categorized as light water reactors LWRs because they use ordinary light water as a moderator and coolant. Issues affecting nuclear power Countries may have a number of motives for deploying nuclear power plants, including a lack of indigenous energy resources, a desire for energy independence, and a goal to limit greenhouse gas emissions by using a carbon-free source of electricity. The benefits of applying nuclear power to these needs are substantial, but they are tempered by a number of issues that need to be considered, including the safety of nuclear reactors, their cost, the disposal of radioactive waste, and a potential for the nuclear fuel cycle to be diverted to the development of nuclear weapons. All of these concerns are discussed below. Safety The safety of nuclear reactors has become paramount since the Fukushima accident of The lessons learned from that disaster included the need to 1 adopt risk-informed regulation, 2 strengthen management systems so that decisions made in the event of a severe accident are based on safety and not cost or political repercussions , 3 periodically assess new information on risks posed by natural hazards such as earthquakes and associated tsunamis, and 4 take steps to mitigate the possible consequences of a station blackout. The four reactors involved in the Fukushima accident were first-generation BWRs designed in the s. Newer Generation III designs, on the other hand, incorporate improved safety systems and rely more on so-called passive safety designs i. Traditionally, enhanced safety systems have resulted in higher construction costs, but passive safety designs, by requiring the installation of far fewer pumps, valves, and associated piping, may actually yield a cost saving. Economics A convenient economic measure used in the power industry is known as the levelized cost of electricity, or LCOE, which is the cost of generating one kilowatt-hour kWh of electricity averaged over the lifetime of the power plant. For nuclear power plants, busbar costs are dominated by capital costs, which can make up more than 70 percent of the LCOE. As a result, the cost of electricity from a nuclear plant is very sensitive to construction costs and interest rates but relatively insensitive to the price of uranium. Indeed, the fuel costs for coal-fired plants tend to be substantially greater than those for nuclear plants. Even though fuel for a nuclear reactor has to be fabricated, the cost of nuclear fuel is substantially less than the cost of fossil fuel per kilowatt-hour of electricity generated. This fuel cost advantage is due to the enormous energy content of each unit of nuclear fuel compared to fossil fuel. Costs for decommissioning and waste disposal are included in fees charged by electrical utilities. At the beginning of the 21st century, electricity from nuclear plants typically cost less than electricity from coal-fired plants, but this formula may not apply to the newer generation of nuclear power plants, given the sensitivity of busbar costs to construction costs and interest rates. Another major uncertainty is the possibility of carbon taxes or stricter regulations on carbon dioxide emissions. These measures would almost certainly raise the operating costs of coal plants and thus make nuclear power more competitive. Radioactive-waste disposal Spent nuclear reactor fuel and the waste stream generated by fuel reprocessing contain radioactive materials and must be conditioned for permanent disposal. The amount of waste coming out of the nuclear fuel cycle is very small compared with the amount of waste generated by fossil fuel plants. However, nuclear waste is highly radioactive hence its designation as high-level waste , or HLW , which makes it very dangerous to the public and the environment. Extreme care must be taken to ensure that it is stored safely and securely, preferably deep underground in permanent geologic repositories. Despite years of research into the science and technology of geologic disposal, no permanent disposal site is in use anywhere in the world. In the last decades of the 20th century, the United States made preparations for constructing a repository for commercial HLW beneath Yucca Mountain, Nevada, but by the turn of the 21st century, this facility had been delayed by legal challenges and political decisions. Pending construction of a long-term repository, U. Some other countries using nuclear power, such as Finland, Sweden, and France, have made more progress and expect to have HLW repositories operational in the period â€” Proliferation The claim has long been made that the development and expansion of commercial nuclear power led to nuclear weapons proliferation, because elements of the nuclear fuel cycle including uranium enrichment and spent-fuel reprocessing can also serve as pathways to weapons development. However, the history of nuclear weapons development does not support the notion of a necessary connection between weapons proliferation and commercial nuclear power. The first pathway to proliferation, uranium enrichment, can lead to a nuclear weapon based on highly enriched uranium see nuclear weapon: Principles of atomic fission weapons. It is considered relatively straightforward for a country to fabricate a weapon with highly enriched uranium, but the impediment historically has been the difficulty of the enrichment process. Since nuclear reactor fuel for LWRs is only slightly enriched less than 5 percent of the fissile isotope uranium and weapons need a minimum of 20 percent enriched uranium, commercial nuclear power is not a viable pathway to obtaining highly enriched uranium. The second pathway to proliferation, reprocessing, results in the separation of plutonium from the highly radioactive spent fuel. The plutonium can then be used in a nuclear weapon. However, reprocessing is heavily guarded in those countries where it is conducted, making commercial reprocessing an unlikely pathway for proliferation. Also, it is considered more difficult to construct a weapon with plutonium versus highly enriched uranium. More than 20 countries have developed nuclear power industries without building nuclear weapons. On the other hand, countries that have built and tested nuclear weapons have followed other paths than purchasing commercial nuclear reactors, reprocessing the spent fuel, and obtaining plutonium. Some have built facilities for the express purpose of enriching uranium; some have built plutonium production reactors; and some have surreptitiously diverted research reactors to the production of plutonium. All these pathways to nuclear proliferation have been more effective, less expensive, and easier to hide from prying eyes than the commercial nuclear power route. Nevertheless, nuclear proliferation remains a highly sensitive issue, and any country that wishes to launch a commercial nuclear power industry will necessarily draw the close attention of oversight bodies such as the International Atomic Energy Agency.

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Chapter 7 : Nuclear technology - Wikipedia

Level II Certificates. Non-Licensed Operator. Electrical Technician. Instrumentation & Control Technician. The Non-Licensed Operator, Electrical Technician, or Instrumentation & Control Technician certificates are standalone or may be used as specialty enhancements to existing related degrees: Nuclear Power Technology, Process Technology, Manufacturing Technology or other AAS Degrees by.

Today most people are aware of the important contribution nuclear energy makes in providing a significant proportion of clean electricity. The applications of nuclear technology outside of civil electricity production in power plants are less well-known. Radioisotopes Isotopes are variants of a given chemical element that have nuclei with the same number of protons, but different numbers of neutrons. The first practical application of a radioisotope was made by a Hungarian man named George de Hevesy in At the time de Hevesy was a young student working in Manchester, studying naturally radioactive materials. Not having much money he lived in modest accommodation and ate his meals with his landlady. He began to suspect that some of the meals that appeared regularly might be made from leftovers from the preceding days or even weeks, but he could never be sure. To try and confirm his suspicions de Hevesy put a small amount of radioactive material into the remains of a meal. Several days later, when the same dish was served again, he used a simple radiation detection instrument â€" a gold leaf electroscope â€" to check if the food was radioactive. History has forgotten the landlady, but George de Hevesy went on to win the Nobel prize in and the Atoms for Peace award in His was the first use of radioactive tracers â€" now routine in environmental science. ETRR-2 in Egypt forthcoming: Over half of the Mo has been made in two reactors: Output from each varies due to maintenance schedules. The targets are then processed to separate the Mo and also to recover I However, in medical imaging, the cost of Mo itself is small relative to hospital costs. Mo can also be made by bombarding Mo with neutrons in a reactor. This is still about two days from the end of irradiation, so some , TBq must be made in the reactor to allow for cooling, processing, and decay en route to the users. See also information paper on Research Reactors. Radioisotopes and radiation used in food and agriculture are helping to reduce these figures. As well as directly improving food production, agriculture needs to be sustainable over the longer term. Plant mutation breeding Plant mutation breeding is the process of exposing the seeds or cuttings of a given plant to radiation, such as gamma rays, to cause mutations. The irradiated material is then cultivated to generate a plantlet. Plantlets are selected and multiplied if they show desired traits. A process of marker-assisted selection or molecular-marker assisted breeding is used to identify desirable traits based on genes. The use of radiation essentially enhances the natural process of spontaneous genetic mutation, significantly shortening the time it takes. Countries that have utilised plant mutation breeding have frequently realised great socio-economic benefits. In Bangladesh , new varieties of rice produced through mutation breeding have increased crops three-fold in the last few decades. During a period of rapid population growth, the use of nuclear techniques has enabled Bangladesh and large parts of Asia in general, to achieve food security and improved nutrition. Fertilisers Fertilisers are expensive and if not properly used can damage the environment. Insect control Estimates of crop losses to insects vary, but are usually significant. One approach to reducing insect depradation in agriculture is to use genetically-modified crops, so that much less insecticide is needed. Another approach is to disable the insects. SIT involves rearing large populations of insects that are sterilised through irradiation gamma or X-rays , and introducing them into natural populations. The sterile insects remain sexually competitive, but cannot produce offspring. The SIT technique is environmentally-friendly, and has proved an effective means of pest management even where mass application of pesticides had failed. At present, SIT is applied across six continents. Since its introduction, SIT has successfully controlled the populations of a number of high profile insects, including mosquitoes, moths, screwworm, tsetse fly, and various fruit flies Mediterranean fruit fly, Mexican fruit fly, oriental fruit fly, and melon fly. The most recent high-profile application of SIT has been in the fight against the deadly Zika virus in Brazil and the broader Latin America and Caribbean region see also Insect control within the section on Medicine below. The function of many common consumer products is dependent on the use of small amounts of radioactive material. One of the most common uses of radioisotopes today is in household smoke detectors. These contain a small amount of americium which is a decay product of plutonium originating in nuclear reactors. The Am emits alpha particles which ionise the air and allow a current between two electrodes. If smoke enters the detector it absorbs the alpha particles and interrupts the current, setting off the alarm. This problem is particularly prevalent in hot, humid countries. Food irradiation is the process of exposing foodstuffs to gamma rays to kill bacteria that can cause food-borne disease, and to increase shelf life. In all parts of the world there is growing use of irradiation technology to preserve food. More than 60 countries worldwide have introduced regulations allowing the use of irradiation for food products. In addition to inhibiting spoilage, irradiation can delay ripening of fruits and vegetables to give them greater shelf life, and it also helps to control pests. Its ability to control pests and reduce required quarantine periods has been the principal factor behind many countries adopting food irradiation practices. Industrial racers Radioisotopes are used by manufacturers as tracers to monitor fluid flow and filtration, detect leaks, and gauge engine wear and corrosion of process equipment. Small concentrations of short-lived isotopes can be detected whilst no residues remain in the environment. By adding small amounts of radioactive substances to materials used in various processes it is possible to study the mixing and flow rates of a wide range of materials, including liquids, powders and gases, and to locate leaks. Inspection and instrumentation Radioactive materials are used to inspect metal parts and the integrity of welds across a range of industries. For example, new oil and gas pipeline systems are checked by placing the radioactive source inside the pipe and the film outside the welds. Gauges containing radioactive usually gamma sources are in wide use in all industries where levels of gases, liquids, and solids must be checked. They measure the amount of radiation from a source which has been absorbed in materials. These gauges are most useful where heat, pressure, or corrosive substances, such as molten glass or molten metal, make it impossible or difficult to use direct contact gauges. The ability to use radioisotopes to accurately measure thickness is widely utilised in the production of sheet materials, including metal, textiles, paper, plastics, and others. Density gauges are used where automatic control of a liquid, powder, or solid is important, for example in detergent manufacture. Carbon dating Analysing the relative abundance of particular naturally-occurring radioisotopes is of vital importance in determining the age of rocks and other materials that are of interest to geologists, anthropologists, hydrologists, and archaeologists, among others. Desalination See also information paper on Nuclear Desalination. Potable water is a major priority in sustainable development. Where it cannot be obtained from streams and aquifers, desalination of seawater, mineralised groundwater, or urban waste water is required. Most desalination today uses fossil fuels and thus contributes to increased levels of greenhouse gases. The feasibility of integrated nuclear desalination plants has been proven with over reactor-years of experience, chiefly in Kazakhstan, India, and Japan. Large-scale deployment of nuclear desalination on a commercial basis with reactors built primarily for that purpose will depend on economic factors Medicine See also information paper on Radioisotopes in Medicine. Many people are aware of the wide use of radiation and radioisotopes in medicine particularly for diagnosis identification and therapy treatment of various medical conditions. In developed countries about one person in 50 uses diagnostic nuclear medicine each year, and the frequency of therapy with radioisotopes is about one-tenth of this. Diagnosis Diagnostic techniques in nuclear medicine use radiopharmaceuticals or radiotracers which emit gamma rays from within the body. These tracers are generally short-lived isotopes linked to chemical compounds which permit specific physiological processes to be scrutinised. Dependent on the type of examination, radiotracers are either injected into the body, swallowed, or inhaled in gaseous form. The emissions from the radiotracers are detected by the imaging device, which provides pictures and molecular information. The superimposition of nuclear medicine images with computed tomography CT or magnetic resonance imaging MRI scans can provide comprehensive views to physicians to aid diagnosis. An advantage of nuclear over X-ray techniques is that both bone and soft tissue can be imaged very successfully. The most widely used diagnostic radioisotope is technetiumm, with a half-life of six hours, and which gives the patient a very low radiation dose. Such isotopes are ideal for tracing many bodily processes with the minimum of discomfort for the patient. They are widely used to indicate tumours and to study the heart, lungs, liver, kidneys, blood circulation and volume, and bone structure. Therapy Nuclear medicine is also used for therapeutic purposes. Most commonly, radioactive iodine I is used in small amounts to treat cancer and other conditions affecting the thyroid gland. The uses of radioisotopes in therapy are comparatively few, but important. Cancerous growths are sensitive to damage by radiation, which may be external using a gamma beam from a cobalt source , or internal using a small gamma or beta radiation source. Short-range radiotherapy is known as brachytherapy, and this is becoming the main means of treatment. Many therapeutic procedures are palliative, usually to relieve pain. A new field is targeted alpha therapy TAT , especially for the control of dispersed cancers. The short range of very energetic alpha emissions in tissue means that a large fraction of that radiative energy goes into the targeted cancer cells once a carrier, such as a monoclonal antibody, has taken the alpha-emitting radionuclide to exactly the right places. Sterilisation Hospitals use gamma radiation to sterilise medical products and supplies such as syringes, gloves, clothing, and instruments that would otherwise be damaged by heat sterilisation. Many medical products today are sterilised by gamma rays from a cobalt source, a technique which generally is much cheaper and more effective than steam heat sterilisation. The disposable syringe is an example of a product sterilised by gamma rays. The benefit to humanity of sterilisation by radiation is tremendous. It is safer and cheaper because it can be done after the item is packaged. The sterile shelf life of the item is then practically indefinite provided the package is not broken open. Apart from syringes, medical products sterilised by radiation include cotton wool, burn dressings, surgical gloves, heart valves, bandages, plastic and rubber sheets, and surgical instruments. Insect control In addition to agricultural pest control see Agriculture section above , SIT has found important applications in the fight against disease-carrying insects. The most recent high-profile application of SIT has been in the fight against the deadly Zika virus in Brazil and the broader Latin America and Caribbean region. Following its outbreak, impacted countries requested urgent support from the IAEA to help develop the established technique to suppress populations of disease-carrying mosquitoes. The IAEA responded by providing expert guidance, extensive training, and by facilitating the transfer of gamma cell irradiators to Brazil. IAEA Transport Nuclear-powered ships Nuclear power is particularly suitable for vessels which need to be at sea for long periods without refuelling, or for powerful submarine propulsion. The majority of the approximately ships powered by small nuclear reactors are submarines, but they range from icebreakers to aircraft carriers.

Chapter 8 : How Nuclear Power Works | Union of Concerned Scientists

By the late s, nuclear power was being developed for commercial electric power, first in England. Morris, Illinois, was the site of the first U.S. commercial reactor, the Dresden plant, starting in

Nuclear Power Reactors Updated October Most nuclear electricity is generated using just two kinds of reactors which were developed in the s and improved since. New designs are coming forward and some are in operation as the first generation reactors come to the end of their operating lifetimes. This paper is about the main conventional types of nuclear reactor. A nuclear reactor produces and controls the release of energy from splitting the atoms of certain elements. In a nuclear power reactor, the energy released is used as heat to make steam to generate electricity. In a research reactor the main purpose is to utilise the actual neutrons produced in the core. In most naval reactors, steam drives a turbine directly for propulsion. The principles for using nuclear power to produce electricity are the same for most types of reactor. The energy released from continuous fission of the atoms of the fuel is harnessed as heat in either a gas or water, and is used to produce steam. The steam is used to drive the turbines which produce electricity as in most fossil fuel plants. These were in rich uranium orebodies and moderated by percolating rainwater. The 17 known at Oklo in west Africa, each less than kW thermal, together consumed about six tonnes of that uranium. It is assumed that these were not unique worldwide. The less numerous boiling water reactor BWR makes steam in the primary circuit above the reactor core, at similar temperatures and pressure. Both types use water as both coolant and moderator, to slow neutrons. Another type uses heavy water, with deuterium atoms, as moderator. Components of a nuclear reactor There are several components common to most types of reactors: Uranium is the basic fuel. Usually pellets of uranium oxide UO2 are arranged in tubes to form fuel rods. The rods are arranged into fuel assemblies in the reactor core. Usually this is beryllium mixed with polonium, radium or other alpha-emitter. Alpha particles from the decay cause a release of neutrons from the beryllium as it turns to carbon Restarting a reactor with some used fuel may not require this, as there may be enough neutrons to achieve criticality when control rods are removed. Material in the core which slows down the neutrons released from fission so that they cause more fission. It is usually water, but may be heavy water or graphite. These are made with neutron-absorbing material such as cadmium, hafnium or boron, and are inserted or withdrawn from the core to control the rate of reaction, or to halt it. Secondary control systems involve other neutron absorbers, usually boron in the coolant â€" its concentration can be adjusted over time as the fuel burns up. These are crucial in enabling a chain reacting system or reactor to be controllable and to be able to be held precisely critical. A fluid circulating through the core so as to transfer the heat from it. In light water reactors the water moderator functions also as primary coolant. Except in BWRs, there is secondary coolant circuit where the water becomes steam. See also later section on primary coolant characteristics. Pressure vessel or pressure tubes. Essentially a heat exchanger like a motor car radiator. Since over PWR reactors have had their steam generators replaced after years service, 57 of these in USA. Each structure weighs up to tonnes and contains from to 16, tubes about 2 cm diameter for the primary coolant, which is radioactive due to nitrogen N, formed by neutron bombardment of oxygen, with half-life of 7 seconds. The secondary water must flow through the support structures for the tubes. Tubes which fail and leak are plugged, and surplus capacity is designed to allow for this. Leaks can be detected by monitoring N levels in the steam as it leaves the steam generator. The structure around the reactor and associated steam generators which is designed to protect it from outside intrusion and to protect those outside from the effects of radiation in case of any serious malfunction inside. It is typically a metre-thick concrete and steel structure. There are several different types of reactors as indicated in the following table. Nuclear power plants in commercial operation or operable Reactor type.

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Nuclear power, electricity generated by power plants that derive their heat from fission in a nuclear reactor. Except for the reactor, which plays the role of a boiler in a fossil-fuel power plant, a nuclear power plant is similar to a large coal-fired power plant, with pumps, valves, steam.

History Origins The Nuclear binding energy of all natural elements in the periodic table. Higher values translate into more tightly bound nuclei and greater nuclear stability. Iron Fe is the end product of nucleosynthesis within the core of hydrogen fusing stars. The elements surrounding iron are the fission products of the fissionable actinides e. Except for iron, all other elemental nuclei have in theory the potential to be nuclear fuel, and the greater distance from iron the greater nuclear potential energy that could be released. However, he and other nuclear physics pioneers Niels Bohr and Albert Einstein believed harnessing the power of the atom for practical purposes anytime in the near future was unlikely, with Rutherford labeling such expectations "moonshine. Experiments bombarding uranium with neutrons led Fermi to believe he had created a new, transuranic element, which was dubbed hesperium. They determined that the relatively tiny neutron split the nucleus of the massive uranium atoms into two roughly equal pieces, contradicting Fermi. This work became part of the Manhattan Project , a massive secret U. The United States would test an atom bomb in July with the Trinity test , and eventually two such weapons were used in the atomic bombings of Hiroshima and Nagasaki. In August , the first widely distributed account of nuclear energy, in the form of the pocketbook The Atomic Age, discussed the peaceful future uses of nuclear energy and depicted a future where fossil fuels would go unused. Nobel laureate Glenn Seaborg , who later chaired the Atomic Energy Commission , is quoted as saying "there will be nuclear powered earth-to-moon shuttles , nuclear powered artificial hearts , plutonium heated swimming pools for SCUBA divers, and much more". This was followed by the Amendments to the Atomic Energy Act which allowed rapid declassification of U. The controllability of nuclear power reactors depends on the fact that a small fraction of neutrons resulting from fission are delayed , which makes the reactions easier to control. These are neutrons emitted by the decay of certain fission products. AEC, forerunner of the U. Nuclear Regulatory Commission and the United States Department of Energy spoke of electricity in the future being " too cheap to meter ". AEC itself had issued far more realistic testimony regarding nuclear fission to the U. Congress only months before, projecting that "costs can be brought down First connected to the national power grid on 27 August and officially opened by Queen Elizabeth II on 17 October The Shippingport Atomic Power Station in Shippingport, Pennsylvania was the first commercial reactor in the United States and was opened in One of the first organizations to develop nuclear power was the U. Navy , for the purpose of propelling submarines and aircraft carriers. Navy submarine fleet is made up entirely of nuclear-powered vessels, with 75 submarines in service. As of the Russian Navy was estimated to have 61 nuclear submarines in service; eight Soviet and Russian nuclear submarines have been lost at sea. Several serious nuclear and radiation accidents have involved nuclear submarine mishaps. Army also had a nuclear power program , beginning in The SL-1 was a U. It underwent a steam explosion and meltdown in January , which killed its three operators. The Soviet government kept this accident secret for about 30 years. The event was eventually rated at 6 on the seven-level INES scale third in severity only to the disasters at Chernobyl and Fukushima. Installed nuclear capacity initially rose relatively quickly, rising from less than 1 gigawatt GW in to GW in the late s, and GW in the late s. Since the late s worldwide capacity has risen much more slowly, reaching GW in Between around and , more than 50 GW of capacity was under construction peaking at over GW in the late s and early s â€” in , around 25 GW of new capacity was planned. More than two-thirds of all nuclear plants ordered after January were eventually cancelled. In the s U. The project was cancelled in and anti-nuclear success at Wyhl inspired opposition to nuclear power in other parts of Europe and North America. Several site occupations were also attempted. In the aftermath of the Three Mile Island accident in , some , people attended a demonstration against nuclear power in Bonn. Health and safety concerns, the accident at Three Mile Island , and the Chernobyl disaster played a part in stopping new plant construction in many countries, [42] although the public policy organization, the Brookings Institution states that new nuclear units, at the time of publishing in , had not been built in the United States because of soft demand for electricity, and cost overruns on nuclear plants due to regulatory issues and construction delays. Eventually, more than reactor orders in the United States were ultimately cancelled [52] and the construction of new reactors ground to a halt. A cover story in the February 11, , issue of Forbes magazine commented on the overall failure of the U. However, changes were made in both the reactors themselves use of a safer enrichment of uranium and in the control system prevention of disabling safety systems , amongst other things, to reduce the possibility of a duplicate accident. Opposition in Ireland and Poland prevented nuclear programs there, while Austria , Sweden and Italy influenced by Chernobyl voted in referendums to oppose or phase out nuclear power. In July , the Italian Parliament passed a law that cancelled the results of an earlier referendum and allowed the immediate start of the Italian nuclear program. It is the first EPR design, but problems with workmanship and supervision have created costly delays which led to an inquiry by the Finnish nuclear regulator STUK.