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A Critical Look at Nuclear Energy in Colorado

Overcoming Our Past to Secure Our Future

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EXECUTIVE SUMMARY

Colorado has played a pivotal role in the history of nuclear research and technology. Being the first state to produce uranium and later having a near monopoly on the global radium trade, the Centennial state's complex relationship with nuclear materials highlights both its contributions to the field and the resulting controversies. Despite Colorado's significant impact on the U.S. nuclear industry, early mining and weapons manufacturing practices have left a legacy of skepticism toward the use of nuclear energy in the modern age.

KEY HIGHLIGHTS:

➤ **Pioneering Uranium Mining and Radium Production:**

- Colorado was the first state in the U.S. to mine uranium in 1881, with the Western Slope becoming the hub of uranium and radium production during the early 20th century.
- The high demand for radium during World War I propelled Colorado to global prominence, with the state's mines contributing significantly to the war effort.

➤ **Environmental and Health Challenges:**

- A combination of wartime urgency and a lack of regulatory precedence resulted in health and environmental issues, such as high levels of radon exposure in miners, which were not understood at the time.
- In the early atomic age, the long-term effects of radiation exposure were unknown, resulting in unsafe material handling practices such as using contaminated mill tailings in western slope building construction.

➤ **Rocky Flats and Public Controversy:**

- The Rocky Flats Plant near Denver, a major site for nuclear weapon components production, experienced widespread criticism and an FBI raid for environmental mismanagement, negatively affecting the perception of nuclear technology in Colorado.

➤ **Nuclear Energy Perception and Fort St. Vrain:**

- Colorado's first and only nuclear power plant was limited to low power operations due to design issues but operated safely before its decommissioning in 1989. Its failure contributed to public skepticism about nuclear energy in the state.
- Misunderstandings about the events at Chernobyl, Three Mile Island, and Fukushima Daiichi stained nuclear power's reputation, despite Chernobyl and Fukushima Daiichi being the only major reactor accidents in over 20,000 reactor-years of civil reactor operations globally.

➤ **The Begay v. United States Case:**

- Filed in 1979, this landmark lawsuit involved uranium miners, including those in Colorado, who argued the government failed to protect them from hazardous radiation levels. Although the case highlighted serious health issues, the court ruled that the government was immune due to national security concerns, negatively impacting public trust and the public's perception of the nuclear industry.

Colorado's nuclear history reflects a dual narrative of groundbreaking contributions and enduring controversies. While the early ages of domestic uranium mining and nuclear weapons production advanced national interests, they left environmental damage and public health challenges behind. Colorado's cultural and political stance on nuclear energy has been significantly influenced by events at sites unrelated to nuclear energy production, such as Uravan and Rocky Flats. Moving forward, acknowledging these historical concerns while utilizing modern computational technologies could offer a path to a cleaner, more reliable state energy future.

INTRODUCTION

Since the dawn of time, humans have been learning about the workings of our universe by interacting with it and using that knowledge to change or adapt to our environment. Such is the definition of technology: the ability of us humans to manipulate nature.[1] Technological advancements and scientific discoveries come with tradeoffs that shape society and shift culture, and the development of nuclear technology is a prime example. When the atom was first split in the early 20th century, so was history. With powerful applications in both energy and war, nations, including the United States, raced to be the first to harness it. To that end, Colorado and the rest of the American West were instrumental.

Global conflict forced the march into the atomic age to be hurried, without time to learn the hazards of long-term radiation exposure. Unlike a child touching a hot stove, humanity's "lesson learned" didn't occur immediately. The side effects of long-term radiation exposure took years to manifest in those engaged in early radiological work, and the importance of minimizing the spread of contamination wasn't common knowledge to the miners who tossed contaminated tailings into lakes and rivers.

Nuclear pioneers, including geniuses like Marie Curie, worked according to the standard practices of their time. Others operated under the threat of war. They aren't to blame for nuclear technology issues but rather a lack of precedent, political turmoil, and public misinformation of days past. These core issues contributed to the controversy surrounding anything "nuclear," and between mining the first American uranium ore to operating Cold War era nuclear weapon facilities, no state in America has been involved in it for as long as Colorado.

We now know that radon gas and uranium mill tailings are biological hazards. However, that wasn't always apparent. In 1970, it was revealed that builders in western Colorado had been given mill tailings to use in place of sand during construction for over 15 years, resulting in heavily contaminated towns such as Uravan and Grand Junction.[2] The men who poured residential home foundations that emitted radon gas weren't careless or cavalier. They didn't have today's knowledge.

Colorado first mined uranium in 1881, only five years after gaining statehood. The following decades saw numerous mills spawn across the Western Slope, despite uranium's limited value until World War II.[3] Early mills primarily processed vanadium and radium, often leaving radioactive mill tailings on site without containment. It wasn't until 97 years later (1978)—three years after the formation of the Nuclear Regulatory Commission—that Congress passed the Uranium Mill Tailings Radiation Control Act to manage these sites.[4]

Colorado's uranium mining past has impacted its present. In 2009, Elise Jones, then executive director of the Colorado Environmental Coalition and current executive director of the influential anti-nuclear Southwest Energy Efficiency Project (SWEEP), told the Denver Post, "We believe that the best energy future for Colorado is a clean energy future…Nuclear energy is not clean." Jones's justification? Colorado's past. "Western Colorado is still home to toxic waste from the uranium mining of decades ago," she added.[5]

Like the issues regarding legacy mining sites, nuclear weapons are erroneously conflated with nuclear power. While they both utilize the same fundamental physics to achieve their desired results, that's where their similarities end. Major differences in their construction and fuel mean that commercial nuclear reactors cannot, under any circumstances, explode like an atomic weapon.[6]

"…the only byproduct an operating reactor releases to the environment is clean, non-radioactive steam."

Additionally, as evidenced by Rocky Flats, their waste products are different. Unlike nuclear power plants, past nuclear weapon manufacturing byproducts included heavy metals, toxic chemicals, and radioactive material – leaving behind a complex combination of radiologically controlled (RADCON) and hazardous material (HAZMAT).[7] In contrast, the only byproduct an operating reactor releases to the environment is clean, non-radioactive steam.

By design, U.S. nuclear power plants can't cause nuclear explosions. In fact, in over 18,500 cumulative reactor-years of commercial nuclear power operation in 36 countries around the world, there have only been two major reactor accidents: Chernobyl and Fukushima Daiichi. Both incidents are classified as major accidents because they "resulted in radiation doses to the public greater than those resulting from the exposure to natural sources."[8]

To mitigate that risk, modern nuclear power plants are equipped with a containment structure designed to minimize the spread of contamination in the extremely low likelihood that a reactor accident occurs. The Chernobyl disaster occurred for many reasons, all documented thoroughly by countless dedicated studies; however, it became an international issue mainly because the Soviet reactor design did not have a containment structure. In the case of Fukushima Daiichi, despite suffering a triple meltdown and damage to the containment structure by post-tsunami flooding, there were no fatalities or serious radiation doses to anyone, even to first responders.[9]

It should also be noted that while nuclear power plant incidents are media sensations, their continued safe operation doesn't garner the same attention. This can be seen

in ports all over the world. Every aircraft carrier and submarine in the U.S. Navy is nuclear-powered, and in total, the Navy has steamed over 166 million miles on the atom, spanning 7,100 reactor-years of operation without a single reactor accident.[10] As of October 1, 2019, the Naval Nuclear Propulsion Program was operating 98 reactors, most of which were in the bellies of naval vessels with open access to over 50 foreign countries and 150 ports globally.[11]

Recent polls in the United States indicate an interest in nuclear energy across the country, with the strongest support observed in Western states.[12] A majority of respondents expressed favorable views toward constructing new nuclear power plants and extending the licenses of existing facilities; specifically, 66 percent of surveyed adults supported building additional nuclear power plants, while 87 percent favored renewing the licenses of nuclear plants that meet federal safety standards.[13]

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Most Coloradans agree with their fellow Americans. According to an Independence Institute commissioned Cygnal poll, Colorado likely voters "favor nuclear energy more than 2:1." Fifty-four percent said they want nuclear power included in Colorado's clean energy mix by 2040. Nuclear energy enjoys bipartisan support from Coloradans, including 65 percent of Republicans, 52 percent of Unaffiliates, and 48 percent of Democrats.[14]

Despite favorable public opinion, a longstanding history of safety, and a regulatory structure that minimizes risk, Colorado – the state that first produced American uranium – has no nuclear power. Why is that? Perhaps the answer lies in the history of Colorado's long relationship with nuclear energy and how events at sites such as Uravan, Rocky Flats, and Fort St. Vrain Nuclear Generating Station have shaped Colorado, influencing both the centennial state's culture and energy infrastructure.

THE PAST

THE AGE OF DISCOVERY: 1800S TO 1914

One hundred fifty years ago, the world was amidst a period of unprecedented growth and discovery. Europeans, enabled by their recent discovery of quinine's antimalarial properties, could finally venture into the heart of Africa, exploring territories previously locked away by disease. Meanwhile, the Spanish-American War raged across the Atlantic, reshaping global power and influence. The upstart state of Colorado had just joined the Union, bringing a wealth of natural beauty and resources that contributed to the "Second Industrial Revolution," including significant improvements to steel, chemicals, usable electricity, mass production, and the transportation industry. Railways and steamboats allowed the transfer of people and goods around the country faster than ever before. The invention of the radio and the telegraph, combined with improvements to newspaper production, did the same for information.[15]

It was during this period, in 1895, that a German physicist named Wilhelm Roentgen stumbled upon something extraordinary. When electrons traveled through a vacuum tube, they emitted a mysterious type of radiation he called "X-rays."[16] This unseen energy, hidden until then, would change the face of medicine and science forever. The following year, his work piqued the interest of several other scientists during an academic expo in Paris. The scientific community of the time was under the impression that X-rays were related to the ability of some materials to absorb light from the sun and re-emit it, also known as luminescence. To test that theory, one scientist began experimenting with a luminescent material that happened to contain uranium. He discovered that the material did not emit X-rays; it emitted something else entirely, despite being locked in a dark drawer for nine months.[17] While this phenomenon was not luminescence, the type and source of energy produced by this material remained a mystery, and Roentgen moved on to other studies.

At this same time, Marie Curie was searching for a subject suitable for her doctoral research. Her husband, Pierre Curie, was an established physicist who had recently gained notoriety for his works on piezoelectricity and magnetism, and Marie aimed

to forge her own path. The discovery of these mysterious "uranic rays" had just been announced, but there was one issue: no one could accurately monitor or measure the emission of these rays. Noticing an opportunity, Mrs. Curie repurposed her husband's experimental electrical equipment, creating what was possibly the first nuclear instrument.[18]

Through her tests, she determined that some elements with high atomic weights, such as uranium, spontaneously emitted energy without the need to first absorb it from the sun. This breakthrough created a new branch of science, alluring her husband away from his research on magnetism to join her. On July 18, 1898, the term "radioactive" first appeared in scientific literature as they announced the discovery of a new element named polonium.[19] Five months later, the Curies announced the discovery of radium, which would later have a profound economic impact on the American West.

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That very same year, a Frenchman named Charles Poulot was living in Colorado while on contract with a French organization. He was a recent graduate of the Paris School of Mines, and although he had been living in the Mountain West for two years already, he remained unsuccessful in his one goal: to find and retrieve uranium.[20] That is until an American copper company hired him to build and manage a smelting plant at the Cash-In copper mine on La Sal Creek just south of the Paradox Valley in Montrose County.

Local miners questioned Poulot about the canary yellow, powdery mineral they'd found all over the La Sal and Roc Creeks. Poulot could not determine its exact makeup without the proper equipment, so he returned a sample to the Paris School of Mines. There, it was determined that the mysterious Colorado ore contained more than uranium. The discovery of "carnotite," named after the French inspector of mines Marie-Adolphe Carnot, was announced two months after the Curies discovered radium. The Curies concurred with the Paris School of Mines: Colorado's carnotite contained uranium, vanadium, and trace amounts of radium.[21] The discovery of radium in the ore did not immediately impact the industry but would play an important role in the future.

In 1900, Poulot and an associate opened a uranium and vanadium extraction plant in the Paradox Valley. Due to diminishing returns, their mill became unprofitable, and they were forced to close. However, that didn't stop several others from buying and reopening the Poulot mill several times. Throughout this process, no one attempted to recover radium from Colorado carnotite, and it was left in the tailings around mill sites.[22] Though Poulot was unsuccessful, his mill was just the beginning. The eastern section of the Paradox Basin quickly became known as the Carnotite Mineral Belt, encompassing Mesa, Montrose, and San Miguel counties. This belt, centered around the Dolores River and its tributaries, came to include the mining districts of Hydraulic, Uravan, Paradox Valley, and McIntyre – all areas that began to churn out uranium and vanadium by the ton.[23]

WORLD WAR I AND WORLD WAR II: 1914-1945

Medical research over the following years indicated that radium could be effective at treating cancer, causing demand for the exceedingly rare and radioactive element to explode. That incentivized western miners to extract as much as possible; at one point, the market price ranged from $120,000 to $160,000 per gram.[24] While the Colorado mining industry attempted to shift practices to improve radium recovery, Austria was the world's leading exporter. Soon, the political turmoil of World War I restricted Austria's economic trade, giving the U.S. a monopoly on radium—thanks to Colorado.[25]

"As demand for radium surged and Austrian supplies dwindled, a new industry took shape on Colorado's Western Slope."

As demand for radium surged and Austrian supplies dwindled, a new industry took shape on Colorado's Western Slope. Companies set up mills to process local carnotite ores and ship them to Europe for radium extraction. Before the U.S. entered the war, concern that most American carnotite was being exported prompted the establishment of the National Radium Institute in Denver to boost domestic radium production and reduce reliance on Europe. The Institute quickly built facilities near Naturita and Denver, turning the latter into the "radium capital of the world," with Standard Chemical Company dominating production.[26]

World War I only increased the importance of the Colorado carnotite industry. By the time Austria's supply lines were cut off, global demand for radium was soaring, driven in part by the need for luminous aviation and military instruments. By 1917, most radium production shifted to support the war effort, with vanadium—once considered a waste product—gaining value as a steel alloy. Companies like Standard Chemical and the Radium Company of Colorado led operations in what became known as the Uravan Mineral Belt, extracting relatively large quantities of vanadium, and uranium as a byproduct.[27]

Western dominance in radium production was short-lived. After World War I, demobilization reduced demand, metal prices fell, and the industry on the Western Slope was in decline. By the 1920s, the cheaper radium exports from the Belgian Congo undercut domestic supply, effectively ending the local industry. Over this brief period, Colorado's mines produced 67,000 tons of ore, yielding 202 grams of radium and 500 tons of vanadium; the uranium was left around mill sites as a worthless byproduct.[28]

While Colorado miners pulled vast quantities of ore out of the Earth, scientists overseas were making further progress on the Curies' discoveries. One year before the Wright brothers took flight at Kitty Hawk, it was discovered that radioactive decay changed the atomic makeup of a material.[29] In other words, a different element remains behind when an element decays.

Soon after, Albert Einstein published his most famous discovery, formally establishing a link between mass and energy. The existence of "radionuclides," or radioactive elements that have several different atomic forms (isotopes) all with the same chemical properties, became commonly accepted. All these groundbreaking discoveries culminated in a desire to change the atom by human means. The stage was set to begin physical experiments, that is, smash a bunch of particles together.

In 1932, two weeks after the discovery of the neutron, a pair of physicists had assembled a particle accelerator at the University of Cambridge in the UK and were transforming atoms by shooting protons at them.[30] By 1939, researchers were launching neutrons at targets, artificially prompting nuclear fission. Humans had split the atom for the first time in history, releasing massive amounts of energy. Exact details on how to accurately replicate, improve, and continue the fission process were finalized and published in a scientific paper only days before Nazi Germany invaded Poland.[31] Prompted by growing concerns over an Axis nuclear weapon program, the U.S. developed its own.

"On a frigid December day in 1942, a team at the University of Chicago conducted the groundbreaking Chicago Pile-1 experiment, creating the world's first self-sustaining nuclear chain reaction."

It's understandable but unfortunate that people equate nuclear energy with nuclear bombs. However, before the bomb, there was a reactor. On a frigid December day in 1942, a team at the University of Chicago conducted the groundbreaking Chicago Pile-1 experiment, creating the world's first self-sustaining nuclear chain reaction. The highly unorthodox experiment consisted of a 20-foot-tall stack of graphite bricks interspersed with uranium and cadmium-coated wooden rods. Removing the rods initiated controlled fission, proving that the atom could be weaponized. The experiment cost roughly $1 million at the time (about $16 million today) and was closely monitored using instruments named after the storybook characters Pooh, Piglet, and Tigger.[32] Upon pulling control rods (by hand), graduate students, nicknamed the "suicide squad," were stationed atop the reactor to pour a cadmium solution over it in case of failure. Fortunately, the reactor worked as expected.

With fission finally attainable, The Army Corps of Engineers was tasked with developing the atomic bomb – otherwise known as the Manhattan Project – though they struggled to find a suitable supply of uranium. The Colorado Plateau, with its discarded uranium tailings, was exactly what they were looking for. Companies like U.S. Vanadium reprocessed old tailings, and the Manhattan Project built a mill near Grand Junction in 1943 to extract uranium for bomb production, operating until 1946.[33]

THE COLD WAR: 1946-1970S

As the power of the atom became apparent, a postwar America saw something which has never happened before or since: a federal government-induced "mining rush" to secure as much uranium as possible. In August 1946, the Atomic Energy Commission (AEC) was established, taking over uranium oversight from the Manhattan Project. Tasked with addressing the limited uranium resources in the U.S., the AEC signed contracts with producers, though initially, low prices failed to promote new mill development. Existing companies benefited the most by establishing new mills in Naturita, Grand Junction, Rifle, and the Uravan area. Pressure from small operators and Colorado senators, combined with the start of the Korean War in 1950, led the AEC to significantly raise the price of uranium oxide, kicking Colorado uranium production into high gear.[34]

Despite record-breaking production, the government demanded more. With the AEC's Grand Junction Operations Office aiming to quadruple uranium production, field camps were established, airstrips built, and roads improved to support exploration. By the mid-1950s, around 800 additional mines were brought into operation on the Colorado Plateau, establishing Colorado as the nation's top uranium producer.[35] With substantial government backing, the industry transitioned from bands of small-scale operators to a few major companies with superior capital and technology, which quickly dominated production.

While the number of mines continued to grow, so too did concerns over radiation safety and mining-related cancer. On August 25, 1949, Colorado and U.S. Public Health Service (PHS) officials met to explore radiation safety in the mines and mills.[36] The Colorado Department of Health formed an advisory panel consisting of federal, state, and uranium industry representatives to guide a detailed study and requested more data on the medical risks associated with uranium mining. During that meeting, the health department, Colorado Bureau of Mines, and U.S. Vanadium Company formally requested the Public Health Service to conduct the study, which the PHS agreed to do.[37]

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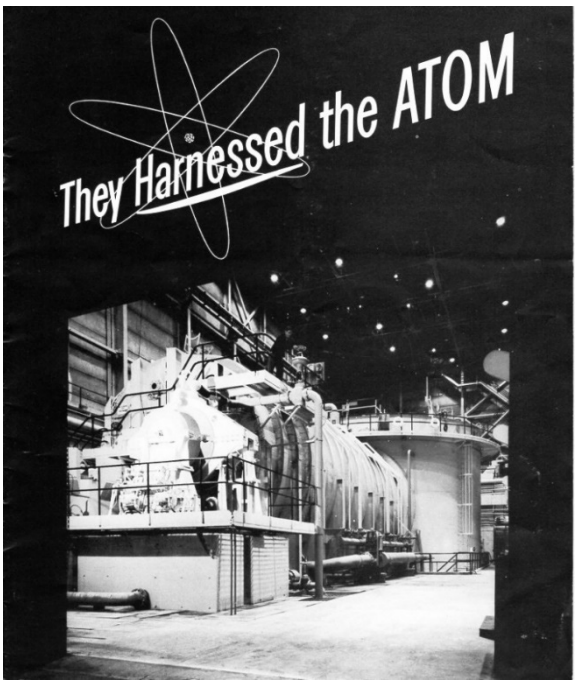
From 1949 to 1951, PHS inspectors took air samples in mines across Colorado and found high levels of radon gas.[38] On a survey of four mines on the Navajo reservation, one inspector reported that while he "anticipated that the samples would show high radon concentrations, the final results were beyond all expectations." The levels of radon showed a "rather serious picture," and he concluded "that a control program must be instituted as soon as possible in order to prevent injury to the workers."[39]

The PHS and other officials had no authority to enter the privately owned mines, however. In a court testimonial conducted decades later, that same inspector would recall that to access the mines in the first place, an agreement was made with the mine owners not to tell any of the miners the findings of the studies so as to "not alarm them."[40] The full PHS report was then distributed on a "restricted" basis to state, federal, and civilian mining officials until 1952, when a public press release on the report declared that "no evidence of health damage from radioactivity had been found."[41]

One official at the National Cancer Institute, Dr. Hueper, had previous experience with mining-related cancer and policy development in Europe.[42] During this investigation into Colorado mines, he was invited to speak to the Colorado Medical Society in 1952 but declined to attend when the Atomic Energy Commission requested that he not mention "the observation of lung cancer in from 40 to 75 percent of the radioactive ore miners in . . . [Europe] although these occupational cancers had been reported repeatedly since 1879."[43] An AEC member declared that references to the hazards of mining-related cancer were "not in the public interest" and "represented mere conjectures."[44] Another member of the AEC wrote to the National Cancer Institute requesting that Dr. Hueper be dismissed; though, instead of being let go, he was forbidden from traveling west of the Mississippi for research purposes.[45]

In 1960, ten years after those initial air samples were taken, the Public Health Service (PHS) presented evidence to the governors of western mining states that showed a clear link between uranium mining and lung cancer. The data revealed that miners experienced lung cancer rates over four times higher than expected, with a less than 5 percent chance of error. Additionally, a comparison study of 371 mines over a one-year period showed growing radon levels.[46] Despite these findings, the federal government left radon regulation and enforcement to the states for mines not owned by the AEC. Meanwhile, the AEC, PHS, and state authorities continued their studies and discussions without any decisive action.

At the same time, other uses for the incredible heat generated by fission were being developed. President Dwight D. Eisenhower gave his famous "Atoms for Peace" speech in which he called for the world to embrace the use of nuclear energy and de-escalate nuclear conflict. His words did little to ease global tensions, and the need for a strong Navy was apparent as the Cold War loomed on the horizon.



THE NAVY GOES NUCLEAR

The U.S. Navy established the Naval Nuclear Propulsion Program, almost entirely at the direction of Admiral Hymen G. Rickover. The Navy entered into contracts with Westinghouse to develop a land-based prototype reactor for naval use and General Dynamics to build the first nuclear-powered submarine. Competition with the Soviets drove both the test reactor and the real thing to be constructed concurrently.

In March 1953, the Submarine Thermal Reactor (STR) Mark I prototype plant successfully went critical at what is now the Idaho National Laboratory, and less than a year later in January 1954, the first nuclear-powered submarine (USS Nautilus)

launched.[47] Even today, the U.S. Navy owes its entire aircraft carrier and submarine fleet to Hymen Rickover and the STR plant.

COLORADO'S ROCKY FLATS

The U.S. wasn't the only nation gearing up for war. Once the Soviets developed and tested their own atomic bomb, the race to stockpile them was on. With national security at risk, the Department of Defense drove large-scale production of nuclear weapons, establishing facilities across the country, including one familiar to Coloradans: Rocky Flats.

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When the site began operations in 1952, there were just over 100 personnel employed there by Dow Chemical—though only a few knew the nature of their work. It wasn't until 1955 that the plant's production became linked to nuclear weapons; previously, it had been called an "atomic plant," giving the idea that it was the energy they were producing, not weapons components.[48]

A few years later, it was discovered that radioactive waste was leaking from drums left in an open field, though it wouldn't be admitted until 1970 when winds blew contaminated soil over the Denver metro area.[49] By the late-60s, more waste had been discovered leaking around the site. On one of the storage pads, more than 3,500 drums of plutonium-contaminated machining lubricants and chlorinated solvents were found to be leaking, spreading into the surrounding areas via soil and wind.[50] Despite this, it wasn't until 1970 that the Rocky Flats site established its first waste management group, and another two years later, Congress finally approved the purchase of a 4,600-acre "Buffer Zone" around the facility.[51]

Before the buffer was officially carved out, the Colorado Department of Health discovered tritium in Walnut Creek and the Great Western Reservoir, the town of Broomfield's water supply.[52] The contaminant had come from radioactive scrap material delivered to Rocky Flats from Lawrence Livermore Laboratory in California. Being a multi-jurisdictional incident, the newly formed Environmental Protection Agency (EPA) and Atomic Energy Commission (AEC) launched an investigation, eventually implementing some corrective measures which are considered standard practice in today's industry, such as performing routine radiation monitoring on-site buildings and testing water before releasing it off-site.[53]

Governor Richard Lamm and Congressman Tim Wirth assembled a citizens' task force to "prepare a report on the public and employee safety issues surrounding Rocky Flats" shortly after being appointed to office. Over the next several years, thousands of protesters descended on the site, nearby landowners sued over property contamination, and during the controversy, the AEC dissolved. Responsibility for the Weapons Complex Facilities now rested with the newly created Energy Research and Development Administration (ERDA), which would soon be rebranded as the Department of Energy.[54]

THE CULTURE WAR: 1960S-1990S

Rocky Flats wasn't the only site in Colorado involved with nuclear devices. On September 10, 1969, a 40-kiloton nuclear bomb – more than twice as powerful as the weapon used on Hiroshima – was detonated outside of Rulison, Colorado in the depths of the Piceance Basin.[55] The goal was to use nuclear energy for fracking, to release oil and gas from shale underground, which it successfully did. However, the unintended side effects were jars flying off shelves in peoples' homes and the oil and gas becoming too radiologically contaminated to use.[56] Ultimately, the project was considered a failure, and if Colorado wants to detonate a nuclear device again, it must now get voters' permission first.[57]

American culture was beginning to shift, marked by war protests and a push for environmentalism. The first Earth Day, observed on April 22, 1970, saw approximately 20 million Americans attend events nationwide to protect nature. Republican President Richard Nixon responded with the National Environmental Protection Act (NEPA), which established the EPA.[58]

As one of the two major superpowers of the time, the U.S. needed energy to fuel its economy and battle the Soviets during the decades-long Cold War. However, actions in the Middle East posed huge issues on U.S. soil. The 1973 Oil Embargo, imposed by Arab OPEC members in response to U.S. support for Israel during the Arab-Israeli War, exposed the vulnerabilities of the U.S. economy's dependence on foreign oil. The embargo banned oil exports to the U.S. and other pro-Israel nations, cut oil production, and caused global oil prices to skyrocket, first doubling and then quadrupling. In response, the Nixon administration launched Project Independence to secure American energy independence, created the Strategic Petroleum Reserve, and even established a national 55-mile-per-hour speed limit on highways.[59] In addition, the Energy Reorganization Act of 1974 was passed, creating the Nuclear Regulatory Commission (NRC) to supersede the controversial AEC.[60] The need for clean, abundant, and domestic energy was clear – but where did nuclear power fit in?

"While plenty of support for nuclear power existed, as evidenced by groups such as Citizens for Energy and Freedom, so did plenty of opposition."

By this point, several commercial reactors had been adapted from naval designs and were already online producing power. While plenty of support for nuclear power existed, as evidenced by groups such as Citizens for Energy and Freedom, so did plenty of opposition. Some likely associated the decades of health and environmental issues with both uranium mines and Rocky Flats to be also attributed to nuclear power. Others opposed it for different reasons. The scientific community was split, and as commercial reactors were still relatively new, sufficient data was lacking to bolster claims on either side.

In 1975, a scathing report from Paul R. Ehrlich, a Stanford-educated ecologist, compared humanity's use of nuclear power to a Faustian bargain. In further developing nuclear technologies to generate usable power from fission, he claimed we risk "the destruction of the ecological systems that are essential to the persistence of civilization."[61] Ehrlich

also stated that "giving society cheap, abundant energy at this point would be the moral equivalent of giving an idiot child a machine gun."[62]

Other notable figures, such as Colorado's own Amory Lovins, opposed nuclear power and his influence in the energy sector meant that his criticisms certainly shaped others' opinions in the field. In the paper that jumpstarted his career – "Energy Strategy: The Road Not Taken?"—Lovins' position was that nuclear power was too expensive to be practical for the end user and that scaling up nuclear energy production increased the risks of global nuclear weapon proliferation.[63]

Both the economy and national infrastructure have changed so much since the 1970s that it's challenging to agree with all of Lovins' statements today. However, his anti-nuclear opinions likely influenced the local population when he moved to Snowmass, Colorado, and founded the influential Rocky Mountain Institute in 1982.

Along the Front Range, the federal government established the National Renewable Energy Laboratory (NREL) in 1977. Initially, the lab was named the Solar Energy Research Institute and was designed to research and develop photovoltaic materials, such as solar panels. Under the Jimmy Carter administration, it received an extremely generous budget that exceeded its research needs. The excess was used to "popularize knowledge about already existing technologies, like passive solar, amongst the population."[64]

"In the early 70s, the Public Service Company of Colorado (PSCo) applied for and received an operating license under the Atomic Energy Act, which permitted the construction of what would be known as the Fort St. Vrain Generating Station."

Emerging technologies, such as new reactor designs, did not get the same publicity. While the water-cooled Naval reactor designs had been tried and true, several slightly more experimental designs were also being tested. In the early 70s, the Public Service Company of Colorado (PSCo) applied for and received an operating license under the Atomic Energy Act, which permitted the construction of what would be known as the Fort St. Vrain Generating Station. The specific permit "allowed a great deal more operational flexibility to the operators and additionally required far less discussion with and approval by the AEC itself on various matters concerning plant design, operation, administration and developmental testing."[65] Although the plant initially started up in 1974, it wasn't declared "in commercial operation" until 1979 due to technical and operational issues occurring from the beginning.[66]

Fort St. Vrain's reactor design was incredibly efficient on paper, but its incredible complexity made it difficult to construct and operate – especially without the assistance of modern computers. Instead of using water to cool the reactor, Fort St. Vrain used helium gas, which required uniquely engineered seals and was vulnerable to pressure/temperature swings, resulting in chronic moisture issues within the helium circulation bearing system.[67] These issues plagued the plant from its inception, severely limiting its power generation capacity.

Ten years later, Fort St. Vrain had a control rod pair stuck in their channel. During the shutdown, operations teams performed routine inspections, revealing a significant issue: cracking in the main header pipe directing steam from the 12 steam generator modules to the secondary plant. Assessments determined that repairing or replacing the header would be prohibitively expensive, so the PSCo Board decided to permanently retire the plant on August 29, 1989.[68] Unfortunately, Colorado's first and only nuclear-powered generating station was a failed experiment.

FACT AND FICTION: THE CHINA SYNDROME AND THREE MILE ISLAND

Two other reactors made national news the same year that Fort St. Vrain was declared in commercial production. The first was a fictional reactor plant, shown in a blockbuster hit "The China Syndrome" featuring Jane Fonda and Michael Douglas. In the film, a fictional reactor undergoes a SCRAM (an automated shutdown that places the reactor in the safest condition possible). This "near catastrophe" is serendipitously captured on camera by Jane Fonda, and when an engineer is murdered after threatening to "expose the SCRAM," she must decide whether to be a whistleblower.[69]

Seeing how easily this film could misinform the general public, groups such as General Electric, The Atomic Industrial Forum, and Reddy News spoke out against its inaccuracies.[70] The film derives its name from the idea that if a reactor were to experience a meltdown, "it would burn through the Earth to China." Regardless of how ridiculous that sounds now, some percentage of the public believed it was a real concern, including high-profile cast member Michael Douglas, who said the film sparked his crusade for nuclear disarmament.[71]

The other plant that made national news would prove that a meltdown does not tunnel to China: Three Mile Island. A combination of equipment malfunctions, design issues, and operator error led to a partial meltdown of one of the site's reactors, TMI-2, and prompted the Nuclear Regulatory Committee to enact sweeping changes across the industry. At around 4:00 am on March 28, 1979, an issue with a pump caused a reactor shutdown. After the shutdown, pressure continued to rise due to decay heat, and a primary relief valve lifted. Pressure returned to the normal operating band, and although the indicators showed the relief valve had closed, it was actually stuck open. Water that should have been circulating to cool the reactor was instead evaporating out of the stuck relief valve. The operations team failed to realize that the plant was experiencing a loss of coolant casualty and took corrective actions that exacerbated the problem.[72]

"The other plant that made national news would prove that a meltdown does not tunnel to China: Three Mile Island. A combination of equipment malfunctions, design issues, and operator error led to a partial meltdown of one of the site's reactors, TMI-2, and prompted the Nuclear Regulatory Committee to enact sweeping changes across the industry."

As the coolant evaporated, the core became "uncovered," meaning the fuel was exposed to air instead of being submerged in circulating water. The fuel then melted through the bottom of the pressure vessel, but nearly all contamination was limited to the

inside of the containment structure. In the months following the incident, thousands of samples were taken by the EPA, the Department of Health, Education and Welfare (now Health and Human Services), the Department of Energy, and the Commonwealth of Pennsylvania to determine the impact on the environment and on the two million people living around TMI-2.[73] Air, water, milk, vegetation, soil, and foodstuffs were all tested, and despite the incredible negative publicity and public outcry, "well respected organizations, such as Columbia University and the University of Pittsburgh, have concluded that in spite of serious damage to the reactor, the actual release had negligible effects on the physical health of individuals or the environment."[74]

"The most serious nuclear accident in U.S. history left no injuries and no impacts on the environment, but it did result in lasting industry changes."

The most serious nuclear accident in U.S. history left no injuries and no impacts on the environment, but it did result in lasting industry changes. Most notable are operator training and staffing requirements, more stringent design and equipment standards, improvements to instrumentation and control equipment, emergency response drills and 24-hour command centers, periodic risk assessments and performance analyses, and the implementation of the resident inspector program.[75]

Due to misrepresentation in the media, nuclear power suffered a public relations problem; new reactors were being built at the same rate that old ones were being decommissioned, and public support was at a low. Colorado's once-thriving mining industry was also in decline. Uravan, which began as a radium mill during World War I, ceased operations in 1984 after 70 years of production.[76] Along with two other sites in Colorado that supported the early nuclear and weapons programs – a period without regulations for cleanup or long-term maintenance – Uravan was entrusted to the NRC for decontamination. Soil cleanup at the 863-acre site is largely complete today, but still ongoing.[77]

FROM BEGAY TO CHERNOBYL AND BACK TO ROCKY FLATS: 1979-1989

Filed in 1979 and coming to trial in 1983, *Begay v. United States* also played an important role in the public's perception of anything "nuclear," especially in Western states. The landmark case involved a group of miners who argued that the U.S. government, as the sole purchaser of uranium, had an obligation to the health and safety of miners, which they failed to meet. According to the court, PHS had identified radiation levels in certain mines that exceeded its recommended limits and, in some cases, were "even higher than the doses received from the atomic bomb explosion in Japan."[78] However, on July 10, 1984, the court ruled that the United States was immune from legal action because of matters relating to national security.[79]

The Begay decision acknowledged that the uranium miners' suffering needed to be addressed; however, due to the doctrine of sovereign immunity, the court stated it was unable to offer compensation. By 1990, among the 4,100 miners in the Colorado Plateau study group, 410 lung cancer deaths had occurred—far exceeding the approximately 75 cases expected in a similar group.[80] That same year, Congress enacted the Radiation Exposure Compensation Act (RECA) as a corrective measure not requiring

litigation, granting $100,000 in compensation to miners diagnosed with lung cancer or nonmalignant respiratory diseases, provided they met specific criteria.[81]

Then, the accident at the Soviet nuclear plant in Chernobyl occurred. It's a complicated event worthy of an exhaustive report, but in summary, a power surge during a reactor systems test destroyed Unit 4 on April 26, 1986. The reason it became an international issue isn't the accident itself, but the fire that followed. The Soviet RMBK reactor design didn't include a containment structure, so volatile radioactive contamination went airborne into the environment with the smoke.[82] The plume wafted over wide areas of Belarus, the Russian Federation, and Ukraine—all areas inhabited by millions—yet the majority of the people in these regions received radiation doses comparable to background levels.[83] In the history of nuclear power, the 28 site workers who lost their lives in the initial Chernobyl accident response due to the effects of radiation are the only deaths directly related to nuclear power.[84]

"In the history of nuclear power, the 28 site workers who lost their lives in the initial Chernobyl accident response due to the effects of radiation are the only deaths directly related to nuclear power."

Chernobyl was both a tragedy and a global learning experience. In the U.S., the NRC launched an assessment into the Soviet accident and determined that a multitude of factors protect domestic plants against the combination of failures that ultimately led to the incident abroad. Differences in plant design, improved safe-shutdown capabilities, and multi-layered containment structures are just a few ways that U.S. reactors keep public safety in the forefront.[85] In a fact-finding document titled "Implications of the Accident at Chernobyl for Safety Regulation of Commercial Nuclear Power Plants in the United States", the NRC found that Chernobyl highlighted the importance of proper procedures and controls for operations and emergencies, competent and trained personnel, and the availability of backup systems. Notably, the agency concluded the lessons learned at Chernobyl didn't warrant any changes to U.S. nuclear regulation.[86]

Colorado was having controversy of its own. Based on years of investigations into "patently illegal" practices, over 70 FBI agents raided the Rocky Flats facility on June 6, 1989.[87] Allegations of improper permitting, illegal waste storage, and even missing plutonium prompted the raid and the formation of Colorado's first special grand jury to focus on the case.[88] The two dozen citizens who made up the grand jury met monthly for over two years, reviewing evidence and witness testimonies. They ultimately recommended indictments for eight individuals, five from Rockwell (the operator of Rocky Flats) and three from the DOE for environmental crimes. However, U.S. Attorney Mike Norton refused to approve indictments against any DOE or Rockwell employees. Shortly after, prosecutors informed the grand jury that their work was complete—nobody would be going to jail.[89]

Instead, Rockwell pleaded guilty to multiple environmental crimes and paid $18.5 million in fines—the largest amount ever collected by the government for waste disposal law violations.[90] After the dust settled, Rocky Flats never machined another plutonium weapon component. In 1995, the Rocky Flats Summit was held with 150 community members, regulators, state officials, and others to talk about the difficult and expensive

task of cleanup. The Rocky Flats Vision and Rocky Flats Cleanup Agreement were soon signed into action by Governor Roy Romer, putting the community's plans into action.[91]

After nearly a decade and $7.7 billion, the remediation effort was completed in 2005. Over 800 structures were decontaminated and demolished, including five major plutonium facilities and two significant uranium facilities. While most low-level radioactive waste was transported to external disposal sites, the most contaminated debris was buried deep underground in the 1,308-acre Central Operable Unit (COU), the facility's core manufacturing area, which was permanently declared off-limits. In 2007, the 5,000+ surrounding acres, designated as the Peripheral Operable Unit, were transferred to the U.S. Fish and Wildlife Service to be converted into a wildlife refuge.[92] With the retirement of Fort St Vrain and the completion of Rocky Flats clean-up, Colorado ended its long relationship with nuclear energy.

A LEGISLATIVE TURNING POINT

Despite multiple recent attempts, Colorado lawmakers long resisted recognizing nuclear energy as a clean resource, reflecting the political weight of the state's complicated nuclear legacy. Multiple bills in 2023 and 2024 all failed despite growing national momentum for nuclear as a zero-emissions energy source. Opponents, often aligned with entrenched environmental groups, recycled outdated talking points about safety, waste, and cost—ignoring decades of innovation and international advancements in nuclear reactor technology.

The irony was not lost on many energy advocates: Colorado had no history of public harm from nuclear electricity generation, yet policymakers continued to treat nuclear energy as if it were responsible for the state's past missteps in weapons manufacturing and poorly regulated mining. Agencies like the Colorado Energy Office (CEO), despite a 2018 law[93] to promote nuclear as a cleaner energy option, remained silent. Notably, nuclear energy was all but absent from the CEO's public communications and long-term modeling scenarios.

Finally, Colorado goes nuclear in 2025 with the passage of **House Bill 25-1040**, marking a long-overdue legislative shift. For the first time, nuclear energy was officially designated as a clean energy resource under Colorado statute. The bill passed quietly, with no press conference or celebratory bill signing ceremony, but the significance was undeniable. After years of scientific advancement, policy debate, and shifting public opinion, the state finally took a modest yet meaningful step toward recognizing nuclear's potential role in meeting energy demand without emissions.

This reversal did not come from nowhere. A growing understanding of Colorado's electricity needs—driven by data centers, artificial intelligence, electrified transportation, and grid reliability concerns—compelled lawmakers to reassess. From an energy security perspective, nuclear now offers something that intermittent renewables cannot: firm, dispatchable, zero-carbon power that can anchor an increasingly volatile grid.

CONCLUSION

Colorado's nuclear past is complex, marred by environmental mismanagement, weapons-related secrecy, and the painful legacy of uranium mining. But that legacy should not—and cannot—be used to disqualify an entire technology that was never the root cause of those harms. The Fort St. Vrain nuclear power plant, though underwhelming in performance, was safe. Its shortcomings were due to flawed design choices, not the intrinsic dangers of nuclear fission.

Today's nuclear energy bears little resemblance to the Cold War-era facilities that shaped public perception. Modern reactor designs—especially small modular reactors—are safer, more efficient, and offer a path toward decarbonization without sacrificing grid stability or affordability. Meanwhile, Colorado's explosive demand for power, driven by digital technologies and electrification, makes an all-renewables path increasingly implausible without firm resources like nuclear.

"For decades, Colorado's only problem with nuclear power was that it didn't have enough of it. With HB25-1040, the state has finally acknowledged that reality."

For decades, Colorado's only problem with nuclear power was that it didn't have enough of it. With HB25-1040, the state has finally acknowledged that reality. Whether it embraces the full potential of nuclear in the coming years remains to be seen. But one thing is clear: overcoming fear and political inertia is the first step toward an energy future that is clean, reliable, and resilient.

APPENDIX

IONIZING RADIATION

There are many reasons why nuclear materials are regulated, but a notable one is their emission of ionizing radiation. While radiation, including ionizing radiation, always exists everywhere on Earth, it can be hazardous to biological material in large doses or through prolonged exposure. When radiation interacts with matter, several different atomic processes can occur. The type and chance of interaction is determined largely by the type of radiation, its energy, and the properties of the material it passes through.[94] The chance of radiation causing bodily harm is directly proportional to the type of radiation, the bodily area affected, and the duration of exposure.

Because of that, modern facilities are held to strict regulatory standards to limit radiation exposure to workers and nearby populations. Reactors are designed with shielding, containment structures, and monitoring systems to minimize radiation levels in occupied spaces. Radiological work controls are also strictly regulated. When performing maintenance in areas with radiation levels higher than background radiation, nuclear-trained personnel minimize the time they're exposed, maximize their distance from high radiation sources, and utilize shielding to absorb what they cannot avoid.[95] Aside from operational reactor plants, the decay of radioactive isotopes, such as those found in uranium mill tailings, is also a source of ionizing radiation.[96]

Colorado has a long history with radium, which emits ionizing radiation when it decays into radon over thousands of years. Radon, like its parent nuclide radium, is an "alpha emitter," meaning that it emits ionizing radiation mostly in the form of alpha particles. However, unlike radium, radon is a gas. This is a particular concern because of the nature of alpha emitters. The extremely low penetrating power of alpha particles prevents them from passing through even a sheet of paper; however, their relatively high positive charge makes them extremely dangerous to sensitive tissue. Should radon be inhaled, ingested, or absorbed through a wound, the alpha particles which are emitted would strip the electrons from the atoms in the body, causing significant cell damage.[97] Large quantities of radon in poorly ventilated mines is a major reason why early uranium miners were more likely to develop lung cancer.

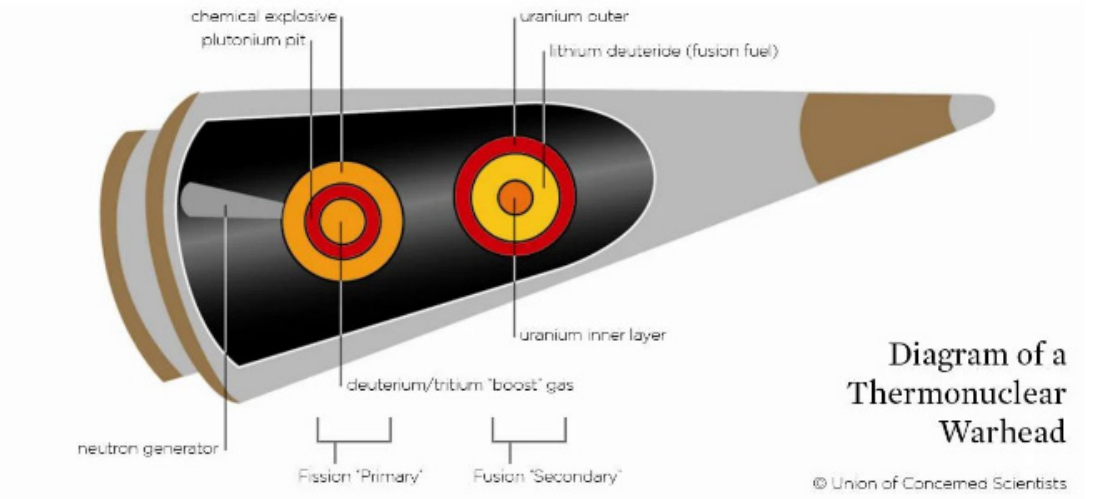
LAND USE POST-DECOMMISSIONING

Unlike early 20th-century mining sites or nuclear weapons testing grounds, decommissioned nuclear power plants don't leave lasting scars. For example, consider the Fort St. Vrain Generating Station, which was successfully converted to a gas plant after housing an operating reactor for years. Across the country, the Knolls Atomic Power Laboratory (KAPL) S1C Site in Windsor, Connecticut, stands as another success story. For over 30 years, S1C was used to "research, develop, and manufacture nuclear fuel; to develop, design, and fabricate fuel-element subassemblies for submarines; and to construct and operate the S1C test reactor facility for the U.S. Navy." Yet today, according to the U.S. DOE Office of Legacy Management in Grand Junction, CO, "the Windsor site is privately owned, and a mixed-use development is under construction. The cleanup activities performed at the Windsor site allow for unlimited use and unrestricted

exposure of the property."[98] The Windsor Site is proof that when reactors are operated under sensible regulation by properly trained personnel, the land that they occupy can be returned to "green field" conditions much faster and cheaper than legacy mining sites, or Cold War-era nuclear manufacturing facilities such as Colorado's Rocky Flats.

WEAPON AND REACTOR CONSTRUCTION DIFFERENCES

Nuclear devices, such as the 40-kiloton bomb which was detonated underground outside of Parachute, Colorado as part of an oil and gas fracking experiment in 1969[99], are designed to release as much energy in as short a time as possible. Most fuel for modern nuclear devices is >90% of either uranium-235 or plutonium-239, because those isotopes are readily fissile. Nuclear weapons are designed to maximize the rate of fission of the fuel; upon detonation, the entire fuel assembly will fission within fractions of a second, causing an explosion.[100]



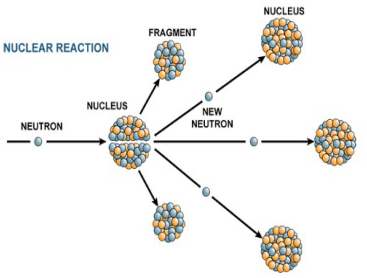
Commercial nuclear reactors, however, are designed with the complete opposite intention. Every aspect of a reactor is designed with the intent of having a safe and controlled rate of fission. Control rods in the core act as neutron sponges, allowing operators to change the operating temperature of the reactor. The "moderator" which surrounds the fuel is designed to slow the speed at which the neutrons travel to increase their chance of absorption in the fuel. The fuel itself is a different isotope than what is used in weapons. Nearly all commercial reactors use uranium-238, which is the isotope that makes up 99% of all uranium found in nature but is far less efficient than U-235.[101] Reactor cores (and their steam systems) are also covered in clusters of instrumentation which monitor plant parameters, providing operationing data for use in casualty response and long-term core health assessments. In the unlikely event that a fuel element failure occurs, the containment structure surrounding the core is designed to prevent radiological contamination from being released to the environment.

GLOSSARY[102]

Element: One of the 103 known chemical substances that cannot be broken down further without changing its chemical properties. Some examples include hydrogen, nitrogen, gold, lead, and uranium.

Isotope: Two or more forms of a given element that have identical atomic numbers (the same number of protons in their nuclei) and the same or very similar chemical properties but different atomic masses (different numbers of neutrons in their nuclei) and distinct physical properties. Among their distinct physical properties, some isotopes (known as radioisotopes) are radioactive because their nuclei emit radiation as they strive toward a more stable nuclear configuration. For example, carbon-12 and carbon-13 are stable, but carbon-14 is unstable and radioactive.

Contamination: Undesirable radiological or chemical material (with a potentially harmful effect) that is either airborne or deposited in (or on the surface of) structures, objects, soil, water, or living organisms.



Fission: The splitting of an atom, which releases a considerable amount of energy (usually in the form of heat) that can be used to produce electricity. Fission may be spontaneous but is usually caused by the nucleus of an atom becoming unstable (or «heavy») after capturing or absorbing a neutron. During fission, the heavy nucleus splits into roughly equal parts, producing the nuclei of at least two lighter elements. In addition to energy, this reaction usually releases gamma radiation and two or more daughter neutrons.

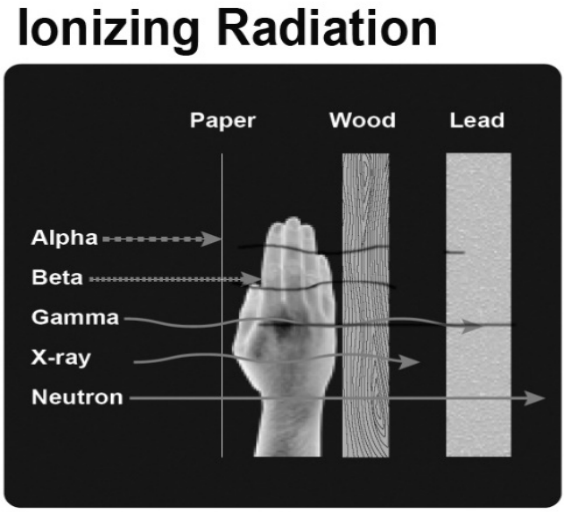
Decay: The spontaneous transformation of one radioisotope into one or more different isotopes (known as "decay products" or "daughter products"), accompanied by a decrease in radioactivity (compared to the parent material). This transformation takes place over a defined period of time (known as a "half-life"), as a result of electron capture; fission; or the emission of alpha particles, beta particles, or photons (gamma radiation or x-rays) from the nucleus of an unstable atom. Each isotope in the sequence (known as a "decay chain") decays to the next until it forms a stable, less energetic end product.

Radioactivity: The property possessed by some elements (such as uranium) of spontaneously emitting energy in the form of radiation as a result of the decay (or disintegration) of an unstable atom. Radioactivity is also the term used to describe the rate at which radioactive material emits radiation. Radioactivity is measured in curies (Ci), becquerels (Bq), or disintegrations per second.

Radiation: The emission and propagation of energy by means of electromagnetic waves or particles.

Background radiation: The natural radiation that is always present in the environment. It includes cosmic radiation, which comes from the sun and stars; terrestrial radiation, which comes from the Earth; and internal radiation, which exists in all living things. The typical average individual exposure in the United States from natural background sources is about 300 millirems per year.

Ionizing radiation: A form of radiation that includes alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, and high-speed protons. Compared to non-ionizing radiation, such as found in ultraviolet light or microwaves, ionizing radiation is considerably more energetic. When ionizing radiation passes through material such as air, water, or living tissue, it deposits enough energy to break molecular bonds and displace (or remove) electrons. This electron displacement may lead to changes in living cells. Given this ability, ionizing radiation has a number of beneficial uses, including treating cancer or sterilizing medical equipment. However, ionizing radiation is potentially harmful if not used correctly, and high doses may result in severe skin or tissue damage. It is for this reason that the NRC strictly regulates commercial and institutional uses of the various types of ionizing radiation.



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