GTTSi

Global Technical Training Services, Inc. Newsletter

JANUARY 2025

The State of the Industry

Sid Crouch, GTTSi Chief Technical Consultant

In 2025 the energy industry is expecting a rollback of environmental regulations, especially related to fossil fuels. It appears that President-elect Donald Trump's transition team will make the energy industry a focus of their plans during his initial 100 days in office, with emphasis on additional drilling for oil and natural gas and lifting the pause on new export permits for LNG. Another impact expected will be the operation of our coal-fired and natural gas-fired power plants. Many utilities will now rethink their strategies concerning scheduled closures of these plants. Since 2010, >300 plants have been closed resulting in a loss of >40% of our coal-fired generation capacity. Today, coal-fired plants contribute only ~16% of the country's electricity while natural gas accounts for ~43%. For electric vehicle purchases, federal tax credits will most likely come to an end, as the new administration is expected to support gasoline-powered transportation, allowing consumers to decide which type of vehicle will best fit their needs. The growing demand for data center operations will significantly increase electricity consumption and is expected to drive up electricity prices-just how much will depend on regional factors and how much investment is required to upgrade the grid to ensure reliable distribution. However, the increase is expected to be less than what we experienced during the Biden administration. According to the Bureau of Labor Statistics the average cost of electricity in January 2021 was $0.14 per kilo-watt hour. Fast forward to 2024 and the average price is $0.17 per kilo-watt hour, an increase greater than 20%.

I welcome your comments or questions - sid.crouch@gttsi.com

HIGHLIGHTS

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WHAT DOES AI SAY ABOUT NUCLEAR ENERGY?

ChatGPT, Copilot, and other Artificial Intelligence programs are consulted for everything from recipes to resumes. Given that AI gets its information from a variety of sources, including websites, databases, and other publicly available data, the information it generates is always changing. With that in mind, the question arises: What does it say about Nuclear Energy? We sought to explore this question by asking one of the most commonly used AI chatbots to generate the answer to a controversial question:

How dangerous is Nuclear Energy?

The answer below was AI-generated. GTTSi made no additions, modifications, or deletions. The answer AI generated may surprise you:

Nuclear energy is often perceived as highly dangerous, but in reality, its risks are well-managed, and its safety record is better than many other energy sources. Here's a breakdown of its dangers and how they're mitigated:

1. Accidents and Failures
While catastrophic accidents like Chernobyl (1986) and Fukushima (2011) receive significant attention, they are extremely rare. Modern reactor designs incorporate multiple layers of safety systems, including passive cooling and containment structures, to prevent meltdowns even in extreme scenarios.

2. Radiation Exposure
Radiation from nuclear plants is tightly controlled and monitored. Workers and the public receive far less radiation exposure from nuclear plants than from natural sources like radon gas or medical procedures such as X-rays.

3. Nuclear Waste
Spent nuclear fuel is highly radioactive and remains so for thousands of years. However, it is carefully stored in secure facilities, often in steel and concrete containers. Long-term solutions like deep geological repositories are being developed to isolate waste safely for millennia.

4. Weapons Proliferation
A concern with nuclear technology is its potential misuse for weapons. Strict international regulations and safeguards, overseen by organizations like the International Atomic Energy Agency (IAEA), aim to prevent diversion of nuclear materials for weaponization.

5. Comparison with Other Energy Sources
Per unit of energy produced, nuclear power causes fewer deaths than coal, oil, or natural gas, which contribute to air pollution and climate change. Even renewable energy sources, such as hydroelectric dams, have had more catastrophic failures (e.g., dam collapses) than the nuclear industry.

In summary, nuclear energy has inherent risks, but advancements in technology and rigorous safety protocols have made it one of the safest large-scale energy sources available today. Its benefits in reducing greenhouse gas emissions often outweigh its potential dangers.

2 HOURS TO CATASTROPHE: INSIDE THE CHERNOBYL CONTROL ROOM ON APRIL 26, 1986

The Chernobyl nuclear accident occurred on April 26, 1986, at Reactor 4 of the Chernobyl Nuclear Power Plant in Ukraine, then part of the Soviet Union. A flawed reactor design and a series of operator errors during a safety test led to a catastrophic explosion and fire, releasing massive amounts of radioactive material into the atmosphere. The disaster resulted in widespread environmental contamination, forced the evacuation of thousands of people, and remains one of the worst nuclear accidents in history.

The town of Pripyat with the Chernobyl Nuclear Power Plant in the Background
Image Credit: Britannica.com

GTTSi Chief Consultant, Sid Crouch, offers a synopsis of the activities within the control room from 11:30 pm on April 25 until 1:24 am on April 26:

On Friday, April 25, 1986, at 11:30 pm the Midnight Shift had just arrived at Chernobyl Unit 4 for turnover. A turbine generator test, called the ***"unit rundown"*** test had been scheduled for 2 o'clock, that afternoon, but the central dispatcher in Kyiv had ordered Unit 4 to stay online until peak load had passed, typically after 9 pm at the earliest. The mood was tense since the test was 2 years overdue and should have been performed before Unit 4 was even approved for operation.

The ***"unit rundown"*** test would check a key safety system design that was intended to protect Unit 4 during an electrical blackout (***total loss of power to the plant***). Should a blackout occur, momentum of the turbine generator was expected to continue driving the reactor coolant main circulating water pumps, thereby keeping water circulating through the reactor core until the station's emergency diesel generator could start-up (***40 seconds to 3 minutes***) and provide power for the pumps. This was critical because the RBMK reactor is a much different design from U.S. reactors. If an RBMK reactor loses water circulating through the core, it could reach core meltdown temperatures in just a few minutes.

Nicolai Fomin, the Chief Engineer, considered simulating a total power blackout on a single unit as an uncomplicated process. Most of the other staff, there for the ***"unit rundown"*** test, considered the test a matter for the electricians…the reactor's role was considered incidental. After all, this test had been performed on Unit 3 in 1984, and although it failed because it did not generate enough power to keep the reactor coolant main circulating water pumps running, it was concluded without an incident. In fact, Fomin was so confident and emboldened that he ordered the test himself without clearance from above . He never told Director Brukhanov that the ***"unit rundown"*** test was going to occur, nor did he notify the State Committee for Nuclear Safety, NIKIET, or the specialist at the Kurchatov Institute in Moscow. At midnight, the team of engineers waiting to monitor the test were threatening to leave and head back to Donetsk. In addition, the control room staff briefed for the test were leaving, and the physicist from the plants' Nuclear Safety Department was told the test was completed.

25-year-old newly promoted Senior Reactor Control Engineer, Leonid Topturnov was preparing for his first reactor shutdown and the ***"unit rundown"*** test. In front of his desk were two giant backlit displays – one illustrated the operating conditions and status of the 1,659 fuel channels, while the other displayed 211 Selysyn control rod monitor dials, arranged in a circle, three meters across, indicating the position of the boron-carbide-graphite tipped control rods.

In accordance with procedure, the test team decreased turbine generator load along with reactor power to achieve 720 MW (***megawatts***) – a value just above the minimum level needed to perform the test. Everyone was stationed, ready to begin the test, waiting for permission from Kyiv Dispatcher.

While waiting, Deputy Chief Engineer of Operations, Anatoly Dyatlov insisted on decreasing generator load to 200 MW. Shift Foreman, Alexander Akimov, with the ***"unit rundown"*** test procedure in-hand, disagreed and argued that at 200 MW, the reactor was dangerously unstable. Dyatlov overruled and the order was given to decrease load to 200 MW.

At 12:28 am, in response to the new load requirement, Topturnov made a mistake while switching from local automatic control to global automatic control. He forgot to program the reactor power level, and the system defaulted to its last setpoint, which was near zero. By 12:30 am the reactimeter was almost reading zero. At this point, with reactor power stalled at a minimum and xenon building in - adding negative reactivity to the core - the operators should have aborted the ***"unit rundown"*** test and shut down the reactor immediately, but they did not.

Instead, Deputy Chief Engineer of Operations, Anatoly Dyatlov, ordered Topturnov to withdraw control rods to increase power. Around 1:00 am, 203 of the 211 control rods were at their upper limit stop, which was against procedural protocol unless authorized from the Chief Engineer, Nikolai Fomin. Dyatlov's orders were carried out and power was increased by withdrawing control rods, but it could go no further than 200 MW.

At the same time, two more reactor coolant main circulating water pumps were placed in service. Although this was part of the original test program, the addition of these pumps would never have been intended at such a low power level (***200 MW***). This action further upset the balance of reactivity, water pressure, and steam content within the reactor.

It was 1:22 am and Dyatlov was determined to move forward despite a procedure protocol violation and the concerns of his subordinates. After all, he had ten men stationed for the ***"unit rundown"*** test, with their eyes glued to various instruments and indications.

The first step would be to cut off the steam supply from the reactor to the turbine generator. At the same time, they would push a button to simulate the unit blackout. This action would connect Turbine Generator #8 to the reactor coolant main circulating water pumps and initiate startup of the emergency diesel generator (***expected to take 40 sec to 3 min***). If all went well, Turbine Generator #8 would keep water flowing through the reactor by driving the reactor coolant main circulating water pumps until the emergency diesel generator could supply power to them, and the test would end when the reactor was shut down by tripping the AZ-5 system for a full emergency stop.

At 1:23 am the reactor was stabilized at 200 MW with 203 of the 211 control rods at their upper limit stops. Everything was set up and they were ready to begin the test. Dyatlov asked, ***"What are you waiting for"?*** Just a few seconds later, Metlenko (***head of the team of electrical engineers from Donetsk that drafted the test procedure that was approved by Fomin and Dyatlov***) gave the command to start the test.

Senior Turbine Control Operator, Igor Kershenbaum, closed the turbine steam relief valves and seconds later the button was pushed to simulate the blackout condition. As the speed of Turbine Generator #8 decreased, its reactor coolant main circulation water pumps coasted down. This resulted in the cooling water, passing through the reactor core's fuel channels, to slow down. The water flowing through the lower reactor core channels was getting hotter and turning to steam. As this steam area grew, fewer and fewer neutrons were being absorbed, adding positive reactivity back to the core. This resulted in additional heat, allowing the positive void coefficient of reactivity to take hold, creating a feedback loop that would produce an uncompromising result.

When Turbine Generator #8's speed decreased to 2,300 rpm, it was time to end the test and Akimov ordered – ***"shut down the reactor"***. Akimov lifted the transparent cover over the reactor trip button and Topturnov pushed the button. Just 36 seconds after the ***"unit rundown"*** test had begun, it was over.

Topturnov announced that the reactor had been shut down, but this was far from the truth. The Selsyn control rod monitors displayed a slow descent of the control rods into the core. But reactivity within the core was increasing faster than reactor instrumentation had the capacity to record. Although the boron carbide control rod portion of the rods entering the upper portion of the core were functioning properly – decreasing reactivity - the graphite tip portions entering the lower portion of the core were displacing water out of the fuel channels adding positive reactivity, which in turn, generated more steam adding more positive reactivity, creating a local critical mass in the bottom of the core.

Within 2 seconds, the ***"power excursion rate emergency increase"*** and the ***"emergency power protection system"*** alarms flashed and sounded in the control room. Topturnov shouted out, ***"POWER SURGE"*** and Akimov yelled, ***"SHUT DOWN THE REACTOR."***

Within 3 seconds, the reactor's thermal power was one hundred times maximum. In the lower southeast quadrant of the reactor core the temperature approached 3,000 °C resulting in the zirconium cladding of the fuel assemblies to soften, rupture, and ultimately explode, dispersing small fragments of metal and uranium oxide into the surrounding channels. This resulted in a cascade effect, as other channels reached these high temperatures and exploded, as well. The result left the control rods only halfway inserted into the core and pressure within the reactor coolant system was increasing rapidly – all eight emergency steam release valves of the reactor protection system opened but were overcome and eventually blown apart.

As the fuel channels failed, water circulation through the core diminished and eventually ceased. The check valves on the reactor coolant circulating water pumps closed and the remaining fluid trapped within the reactor core flashed to steam. The reactor surged and its thermal power eventually reached twelve billion watts. Steam pressure increased by eight atmospheres in a second and the massive two-thousand-ton concrete and steel upper biological shield (***called Elena***) was heaved upward shearing the remaining tubes and temperature of the reactor core rose to 4,650 °C.

The Selysn control rod indicators were frozen at a reading of three meters. In desperation Akimov tried to release the control rods from their mechanisms, hoping that some or most of them would fall into the core but it was too late. Reactor Number 4 was lost. There was nothing more he could do.

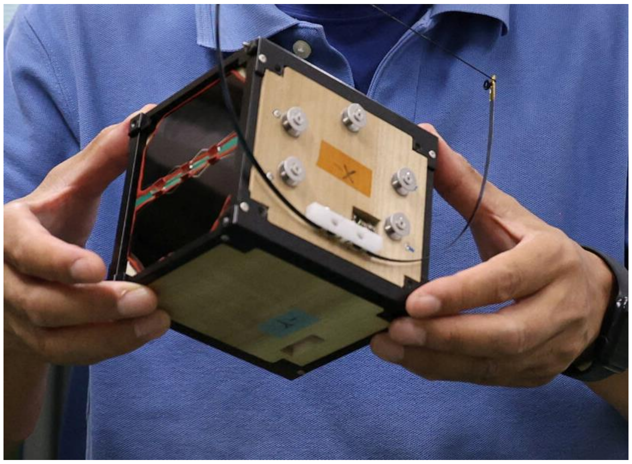
At 1:24 am, just two minutes after the start of the "unit rundown" test, a tremendous noise occurred, believed to have been an explosion due to the mixture of hydrogen and oxygen within the reactor space. This explosion caused the entire building to shudder. Reactor Number 4 was torn apart…the explosion was estimated to have been equivalent to sixty tons of TNT exploding.

This explosion tossed Elena like you would flip a coin. It moved the 350-ton refueling machine and the high-bay bridge crane off their rails, demolished the upper walls of the reactor hall, and smashed open the concrete roof. With the reactor core destroyed, almost seven tons of nuclear fuel together with pieces of control rods, zirconium channels, and graphite blocks were pulverized and escaping with gases and aerosols containing radioisotopes such as, Iodine-131, Cesium -137, Neptunium 239, Strontium-90, and Plutonium-239.

Ukraine Monument to Emergency Workers, Known as Liquidators, Who Responded to the Chernobyl Accident
Image Credit: Britannica.com

If you would like to learn more, including the whole story of what happened that night and, in the days, weeks, months, and years that followed I would recommend you get a copy of the New York Times Best Seller "Midnight in Chernobyl" by Adam Higginbotham.

DID YOU KNOW?



"CubeSat" is an “artisanal” satellite carried by a SpaceX rocket to the International Space Station for launch into orbit. Japanese scientists blended traditional woodworking techniques with state-of-the-art electronics to fashion this unique wooden satellite that measures just 4 inches by 4 inches by 4 inches. The wood was processed using a centuries-old Japanese woodworking technique called "sashimono," which uses intricate joints instead of screws, nails, or glue. Magnolia wood was selected for its lightweight properties and resistance to cracking. The project could help address a problem in space exploration: environmental impact when satellites burn up. Burning wood simply produces water vapor and carbon dioxide, a cleaner byproduct, than produced by burning metal.

RBMK (**Reaktor Bolshoy Moshchnosti Kanalny**), or "High-Power Channel Reactor," is a type of nuclear reactor designed and built in the Soviet Union. These reactors use graphite as a neutron moderator and light water as a coolant, with uranium dioxide fuel housed in pressure tubes. RBMK reactors are known for their large size and ability to be refueled while in operation, offering operational flexibility. However, the design has significant safety flaws, including a positive void coefficient, which means that an increase in steam production can accelerate the nuclear reaction. This instability contributed to the Chernobyl disaster in 1986, leading to major design modifications in remaining RBMK reactors to enhance safety. As of December 2024, seven RBMK reactors remain operational in Russia: **Leningrad Units 3 and 4, Smolensk Units 1, 2, and 3, and Kursk Units 3 and 4.**

Smolensk Nuclear Power Plant.
Image Credit: Rosenergoatom.ru

Image Credit: MEXEM.com

Google’s top executive, Sundar Pichai, said that Google’s goal of being carbon neutral by 2030 will be challenged by the need to develop data centers amid the boom in artificial intelligence. He confirmed that they are working on large scale data centers that would use more than 1GW (***gigawatt***) of power. Pichai recently said, “I think in the short term it is challenging …in the medium to long term I’m optimistic, because I think it also brings a lot of capital investment to developing new sources of energy. We invested very early in wind and solar because we saw the opportunity there. And today, many of our data centers operate at around 90% carbon-free basis.”

JANUARY 2025

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GTTSi has been providing professional services to the energy and nuclear industry since 1980. We are an MWBE (***minority woman-owned business enterprise***) and have served over 80% of the US commercial nuclear facilities, 8 Federal agencies and prime contractors, and one foreign government. If you are qualified and interested in any of the job opportunities listed below, please contact us at ginfo@gttsi.com or call **864.882.3111.**

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