## Episode 5 – "The Case For and Against Nuclear Power"

Previously, on Energy Transition Crisis: Prior episodes explained the importance of energy transition, laid out a plan to replace fossil fuels with clean energy, explained why a global energy crisis is unavoidable in the mid-2020s, and explained geothermal renewable energy. Now, to show you the whole story on the arguments for and against nuclear power, here's Erik Townsend.

Barring a major breakthrough in deep geothermal, Nuclear power is the only source of baseload energy that could realistically be built out to supply 80k TWh of clean electricity by 2050. And all the technology needed to do that is already known and proven to work. But public sentiment against nuclear couldn't be much stronger. What most people don't realize is that technological advancements already solved all the common objections to nuclear power years ago, but government bureaucracy has stood in the way of adopting those technological advances. I'll show you the arguments both for and against nuclear energy, in this episode of Energy Transition Crisis.

The three big objections to nuclear power are Operational safety risks, such as core meltdowns, weapons proliferation, and waste disposal. In the first episode I promised not to sugar-coat the challenges we face, so in this episode I'll show you the arguments for and against nuclear energy in full detail, then in the next two episodes I'll show you how advanced nuclear technologies and small modular nuclear reactors fully overcome most of the arguments against nuclear.

Contrary to common perception, nuclear energy is already the safest form of baseload power generation in existence. The number of deaths and diseases—including cancer—is far lower in nuclear powerplants than in coal mines and the oil patch. But similar to aviation, while the accidents are few and far between, on the rare occasions they do happen, it's always front page news, and the public never forgets them, despite that far more deaths and diseases are caused by coal than nuclear.

The argument in favor of nuclear is simple: Barring a major breakthrough in geothermal, which hasn't happened yet, Nuclear the ONLY option that can realistically build out the 80k TWh of 24/7 baseload power generation we need by 2050. There simply is no other option that can realistically provide all the clean energy needed to phase out fossil fuels. So therefore, there can be no successful energy transition without nuclear energy.

Nuclear power offers the lowest operational cost of baseload electricity generation in existence. That's super important, because to usher in a whole new era of human prosperity, our challenge is not just to replace fossil fuels. We need to replace fossil fuels with a clean alternative that makes possible cheaper and more abundant energy that we ever had before, and nuclear power is ideally suited to that task.

I've argued in prior episodes that Wind and Solar combined still supply less than 2% of our energy needs after two decades of aggressive development, and I've cited this as reason to question whether it's realistic to build 50 times more wind and solar in the next 25 years than we've built in the last 25 years. So I feel obliged to acknowledge that just like wind and solar, nuclear supplies less than 2% of our energy today, and it will be necessary to build 50 times that amount by 2050 to phase out fossil fuels completely. So it's reasonable to question whether I'm being hypocritical when I say it makes perfect sense to embrace nuclear as our primary strategy for baseload power generation.

The big difference is that we've been trying as hard as we possibly can to build as much wind and solar as possible. Yet after two full decades of government subsidies, wind and solar combined supply less than 2% of our energy today. We haven't been trying to build ANY new nuclear powerplants. In fact, the big trend in public sentiment and government policy has been to decommission perfectly good nuclear powerplants. Yet despite all this, just a handful of old-technology nuclear powerplants built mostly in the 1960s and 70s already supply as much energy as wind and solar combined.

Building out 80k TWh of electric generation capacity by 2050 using nuclear will require a small fraction of the amount of land and other resources that would be needed to do the same thing with wind and solar. And nuclear doesn't depend on rare earth elements, the scarcity of which are likely to impede large-scale wind turbine manufacturing.

Nuclear offers the 24/7 baseload power we need to complement the intermittent sources of wind and solar, without requiring batteries for energy storage. That means that an energy transition solution based on nuclear as the baseload energy source will leave all the available battery metals to be used where they're needed; for vehicle batteries.

So the case for nuclear is overwhelmingly compelling. But the three big objections of meltdown risk, weapons proliferation, and waste disposal cannot be ignored. So the rest of this episode will be dedicated to the arguments against nuclear power, then the next two episodes will explore technology advancements that overcome these concerns.

There are many different nuclear reactor designs. For sake of brevity, I'm going to focus on the design most commonly used by nuclear powerplants in use today and under construction: The Pressurized Water Reactor.

A nuclear reactor works by harnessing heat energy released by a nuclear fission chain reaction. The reactor core contains fuel rods made of low-enriched uranium. The core is filled with water, which absorbs the heat created by the nuclear fission chain reaction.

That means the water gets really hot, really quickly. So it has to be continuously circulated out of the core into a heat exchanger, where the heat can be removed and used to produce steam to turn a turbine and generate electricity. Nuclear reactors are so good at heating water quickly that most of the problems arise only when that heat can't be removed quickly enough.

To shut down the nuclear fission reaction, control rods are inserted into the core. The purpose of the control rods is to absorb the neutrons flying around inside the core, which are essential to sustaining the nuclear fission reaction. With the control rods fully inserted, the nuclear fission reaction will completely stop. 94% of the heat being generated in the fuel rods will stop instantly when the control rods are inserted and the nuclear fission chain reaction stops. But the remaining 6% of the heat generated by the fuel rods is known as decay heat, and it doesn't just switch off instantly like a light switch. It takes quite a while after the control rods are inserted before the fuel rods stop producing decay heat, so it's critically important to keep removing heat from the coolant water to prevent the core from overheating.

That's why coolant circulation pumps are essential to reactor safety. If the circulation pumps stop working, the water in the core can overheat and boil off. If that happens, even though the nuclear fission chain reaction has already stopped, the fuel rods are still making so much decay heat that they can melt and burn through the bottom of the core chamber. That's the so-called nuclear melt-down scenario you hear so much about in Hollywood movies.

And that's exactly what happened at Fukushima Daiichi. When the earthquake hit, seismic sensors were triggered, and the reactors shut down automatically. All that was necessary to prevent disaster was to keep the circulation pumps running to cool the fuel rods in the core, and everything would have been fine.

Once the reactors shut down, the electricity produced by the nuclear plant was offline, but the pumps could run on electricity from the power grid. And just in case the power grid failed, which it did, there were diesel backup generators installed specifically to cover this exact scenario. The backup generators were supposed to provide electricity to run the circulation pumps even after the electricity from the power grid was cut off. But when the Tsunami hit, everything was flooded including the electrical switching equipment for connecting the backup generators. The circulation pumps shut down, the reactor cores overheated and eventually melted down, and the rest is history.

I want you to remember one very important detail about how this type of nuclear reactor works: The coolant used to remove heat from the core is ordinary water. And as we'll see, that leads to quite a few problems.

The water inside the core circulates through a heat exchanger so that heat produced by the nuclear fission chain reaction can be used to boil a separate source of water into steam that drives a turbine to generate electricity. The amount of energy the reactor can produce, and thus the amount of electricity it can generate, depends primarily on how hot the water in the core can get.

Water boils at 100C. In theory, you could operate a nuclear reactor with water that never gets hotter than 100C. But if your goal is to run an electric power plant, that's not nearly hot enough. To get the most out of the nuclear fission reaction and produce enough electricity to power the grid, you need to get the water up to several hundred degrees Celsius.

At normal atmospheric pressure, water can't get that hot. It boils to steam at 100C. The solution that's used by most reactor designs is to pressurize the water in the reactor core. Just as a pressure cooker makes it possible to heat food in liquid form to more than 100C without boiling, a pressurized core allows the coolant water to be heated to several hundred degrees Celsius, allowing much more energy from the nuclear fission reaction to be harnessed to generate electricity. This requires pressurizing the core to about 150 times atmospheric pressure, or about 2,200psi in a typical pressurized water reactor.

But as any engineer in almost any field will tell you, any time you build any machine that operates under such high pressure, there's always a risk that a failure will occur, and all that pressure will suddenly be released. If that happens to water that's been heated to several hundred degrees Celsius, the water will flash to steam instantly. And that's the whole reason that such large containment buildings are needed for relatively small nuclear reactor cores. If something breaks and the water in the core depressurizes, it will instantly flash to radioactive steam. One of the primary purposes of the containment building is to prevent the radioactive steam from escaping into the atmosphere.

I know, that sounds pretty scary, right? Hold on, it gets worse. The risk of the water in the core flashing to radioactive steam if the core depressurizes is just one of the inherent shortcomings of using water as the coolant. To understand the next one, we need to recall the chemical formula for water, which everyone knows: H2O. In other words, every water molecule consists of two hydrogen atoms and one Oxygen atom.

Hydrogen is the extremely flammable gas that the Hindenburg was filled with, and Oxygen is the stuff that makes everything burn faster and hotter. The combination of pure hydrogen and pure oxygen is an explosive mixture you could literally make a bomb with. Yet water, which is made of hydrogen and oxygen atoms, is what we use to put fires out with! Please ask yourself how this is even possible.

The answer is that the hydrogen and oxygen atoms in every molecule of water are bound together so strongly they can't be separated without consuming a huge amount of energy. It's what scientists call a covalent bond, and it holds those hydrogen and oxygen atoms together in a way that makes them perfectly safe. In almost any normal, everyday situation, there's no risk whatsoever that water could separate into the incredibly dangerous combination of pure hydrogen gas and pure oxygen gas, because it takes so much energy to break the covalent bonds holding the water molecules together that extraordinary amounts of energy and just the right chemical conditions are required to break them apart.

NEWS FLASH! Guess what's going on inside a nuclear reactor core during a meltdown accident? You guessed it: extremely high temperatures, radiation, and the presence of another element called Zirconium which acts as a catalyst to make it even more likely that the covalent bonds in the water molecules will break, causing it to separate into incredibly dangerous pure hydrogen gas, which could explode and blow the roof off!

And to be clear, I'm not using the phrase "blow the roof off" figuratively. That's exactly what happened at Fukushima Daiichi. Here's the video of a hydrogen explosion literally blowing the roof off the reactor building after the circulation pumps failed, and the reactor core melted down, separating some of the coolant water and releasing explosive hydrogen gas.

Hydrogen explosions also played a major role in the Chernobyl nuclear disaster. In the case of Three Mile Island, hydrogen separation during the partial core meltdown caused a hydrogen bubble to form in the core chamber, and a serious risk existed that it could detonate and explode the reactor core, releasing enough radiation to cause mass casualties.

Are you getting the picture now why I'm not the biggest fan of water as a nuclear reactor core coolant when better choices have been available for decades? The alternative coolants don't separate into explosive gases if the core melts down, and they have other benefits too. But all of our nuclear powerplants use water-cooled reactors. More on that in the next episode.

Nuclear weapons falling into the hands of terrorists or rogue nations is such a terrifying thought that even the smallest chance that nuclear power might increase that risk must be taken seriously!

Contrary to common perception, it simply isn't possible to make a nuclear bomb from the low-enriched uranium used to fuel civilian nuclear reactors. To make a nuclear weapon requires weapons-grade enriched uranium or plutonium, neither of which are used by or produced in civilian nuclear power reactors.

Natural Uranium, which can be mined from the Earth's crust, contains less than 1% U-235, the fissile isotope of uranium. The rest is U-238, which isn't useful for building bombs or fueling most nuclear reactors. Natural uranium must be enriched to contain between 3% and 5% U-235 using sophisticated centrifuge equipment, in order for it to be used as nuclear reactor fuel. This is called low-enriched uranium. But to make a nuclear bomb requires enrichment to at least 90% U-235.

Having possession of low-enriched uranium or operating a nuclear reactor fueled by it poses no risk whatsoever of anyone getting their hands on weapons grade uranium. That's simply a myth.

But having the specialized centrifuge equipment needed to enrich natural uranium into low-enriched uranium reactor fuel poses a very real risk, because bad actors could use that equipment to continue enriching uranium all the way to 90% U-235, creating weapons-grade uranium.

The point I want you to take to heart is that the weapons-grade uranium proliferation risk has nothing to do with operating nuclear power reactors or having the fuel needed to operate them. It has to do with who has the equipment needed to manufacture the fuel rods for those reactors. That's who could abuse the resources in their possession to make weapons-grade uranium. Put another way, managing weapons grade uranium proliferation risk has nothing to do with restricting who can operate a nuclear reactor and everything to do with who is allowed to manufacture fuel for nuclear reactors.

Weapons-grade plutonium is a different story. Plutonium is a by-product of a uranium fission chain reaction. That means the fuel rods that go into the reactor containing only low-enriched uranium will transform during use to also contain some plutonium. The reactor-grade plutonium created this way cannot be used to make a nuclear bomb, so there is no direct or immediate risk of anyone getting their hands on weapons-grade plutonium. The only way anyone can get weapons-grade plutonium is to have a special plutonium production reactor designed for the purpose of making weapons-grade plutonium.

But that doesn't mean there's zero risk. In May of 1974, India detonated a nuclear bomb that was made by re-purposing a civilian power reactor designed in Canada, and changing its design to produce weapons grade plutonium as a by-product of the uranium fission chain reaction. This was no easy feat, and required the full technical skills of India's best nuclear scientists. But it proved that with enough effort and know-how, it is in fact possible to re-purpose a civilian power reactor to produce weapons-grade plutonium.

Nearly one-quarter million metric tons of high-level nuclear waste that will remain radio-active for the next 100,000 years are now in storage, and more is being added every year as we continue to operate nuclear powerplants. That statement alone should send a chill down your spine!

But let's be clear: The reason that statement sends a chill down almost any reasonable person's spine is because it was carefully crafted by anti-nuclear activists to distort the actual facts and present them out of context for the intentional purpose of fomenting anti-nuclear public sentiment. I promised not to sugar-coat the challenges we face, and I won't. But I'm also going to call bullshit on propaganda like this and tell you the straight story, doing my best to be unbiased and present both sides of the story objectively.

First of all, the quarter-million metric tons figure is accurate, and so far as I'm concerned, it's unacceptable that we've allowed so much nuclear waste to accumulate and continue to do so. The statement that, if left alone, this waste would remain radio-active for 100,000 years is also true, but it's horribly misleading. The statement was worded to imply that we are stuck with this waste for 100,000 years and nothing can be done to get rid of it, which is utter nonsense. So let's take a closer look at the real story here.

High-level nuclear waste consists primarily of spent fuel rods removed from nuclear reactors at the end of their service life. A true statement, and frankly, an indictment of the nuclear industry, is that with only a few exceptions such as France, almost no attempt whatsoever has been made to recycle this waste. The widely accepted practice is to allow spent fuel rods to cool in a pool of water for several years after being removed from the reactor core, then they are put in storage cannisters called dry casks, which are usually kept in storage indefinitely at the nuclear plant where the fuel was consumed.

Imagine that your waste management strategy for your home was to just stack bags of garbage up in your backyard indefinitely, making no attempt to recycle or dispose of anything. Just let the trash pile up forever, making the pile of trash bags in your backyard bigger every year. If the people in your neighborhood were that stupid, soon your community would have a quarter-million tons of waste piled up, just like the nuclear power industry.

95% of spent fuel waste is perfectly good uranium that can and should be recycled to make new fuel rods. France has been recycling its spent fuel waste for years, but most countries don't bother.

The remaining 5% is some nasty stuff called trans-uranics, and it does in fact stay radio-active for as long as 100,000 years. But that statement is badly misleading. 99% of the radio-active decay that is dangerous to humans occurs in the first 50 years. After that, the material is still radio-active, but the radiation it gives off is just slightly above safe background-level. So the perception that this horribly dangerous nuclear waste stays horribly dangerous for 100,000 years is and always has been a distortion of the facts, intentionally taken out of context by anti-nuclear activists to manipulate the emotions of the public.

Now don't get me wrong: I personally don't approve of there being a quarter million metric tons of nuclear waste in storage, even if it's only a little bit radio-active. But I also know there's no need for this injustice to continue, because the technology to completely solve the problem was invented decades ago but still goes mostly unused today. More on that in the next episode.

It's important to understand that nuclear waste is nowhere close to as dangerous as most people perceive it to be. To make this point, the Dutch government built a single building which serves the unlikely dual purposes of nuclear waste storage facility and children's museum. Look at the big circles on the floor of the children's art museum. Those are the tops of the dry cask cylinders which are full of spent nuclear fuel waste. The children are invited to play right on top of giant canisters of nuclear waste just to prove to their parents and the world that nuclear waste isn't really the stuff of horror movies as it's made out to be by anti-nuclear activists.

But the real problem is the asinine strategy of just letting the waste pile up in the backyard, when much better solutions have been known for decades. More on that in the next episode.

There's another category of nuclear waste nobody ever talks about. A conventional nuclear powerplant is built using a huge amount of concrete and other building materials, which absorb nuclear radiation for decades, leaving them slightly radio-active. This makes decommissioning and tearing down a nuclear powerplant incredibly expensive. The rubble left over when a nuclear plant is torn down isn't nearly as radio-active as spent fuel waste, but it still has to be disposed of as low-level nuclear waste, and because it's so massive, that costs a fortune.

I told you earlier in this episode that nuclear energy offers us the cheapest electricity source in existence. So now it's time to call bullshit on myself! That statement was absolutely true, and it really is every bit as important as I made it out to be earlier. But to do justice to this subject, we need to examine that statement more closely, and put it in context.

The true statement I made earlier is that the operational cost of making electricity with a nuclear powerplant is lower than from any other source of electricity. But to understand this in context, we need to focus on the phrase operational cost. That means the cost of running the nuclear powerplant, not the cost of building the nuclear powerplant in the first place. That's the "fine print" we need to focus on, because that's where the nuclear power industry has failed miserably through its entire history.

The price consumers pay for electricity from any source is determined by adding together three primary components of cost. The first is the operational cost of running the powerplant. That includes the fuel consumed, which could be coal, natural gas, or uranium in the case of a nuclear powerplant. It also includes the payroll cost for the employees of the powerplant and various overhead costs. And this is where nuclear really shines. There is no other source of baseload electricity known to man that compete with nuclear in terms of operational cost of energy production.

But operational cost is not the only factor that determines the price consumers pay for electricity. The cost of building the powerplant, and then the eventual cost of decommissioning the powerplant and tearing it down at the end of its service life must be spread out across the expected operating life of the powerplant, and these costs are passed on to consumers.

This is where the nuclear power industry has consistently failed, and failed miserably at that. When the first nuclear plants were being built in the 1960s and 70s, the promise that was sold to the public was that cheaper electricity than had ever been seen before was coming their way. In reality, electricity from the first nuclear powerplants was more expensive than any other source of electricity. The reason that promise was broken is that every nuclear powerplant project ran massive cost overruns, and the construction projects were notorious for corruption and greed of construction contractors who exploited rules intended to protect the public safety in order to exact huge profits for themselves.

This is a reflection of a larger overall problem: We're just not as good as we used to be at large bespoke public works projects. When the Golden Gate Bridge was completed in 1937, it came in just under budget at $35mm, which is about $700mm in today's dollars after adjusting for inflation. It took just four years to complete, start to finish. A project is underway right now to add a suicide prevention net under the bridge. That project has already taken more than the four years it took to build the entire bridge, and it's over budget with more than $400mm spent to date —that's more than half what it cost to build the entire bridge—even after adjusting for inflation. Just to add a net under the bridge to catch suicide jumpers. And $400m later, it's not even done yet!

In the nuclear power industry, these problems persist to this day. Cost overruns at the Vogtle nuclear powerplant construction project in Georgia literally bankrupt Westinghouse in 2018. Westinghouse is the company that designed and built most of the nuclear powerplants operating today.

Another closely related problem is the amount of time it takes to build a new nuclear powerplant. Even after all the public debate about whether or not to build a nuclear plant has ended, and all the permits have been issued, it still takes at least 7 years to build a conventional nuclear plant and bring it online. We would need a whole lot more nuclear plants between now and 2050 to fully solve the energy transition problem. This time lag has frequently been cited by politicians to argue against building nuclear powerplants which won't come online and offer benefits to the public until long after they've left office and aren't around to take credit for the decision to build them.

Audio from video clip

We have to solve this problem in order for nuclear to become a key part of the energy transition strategy. I'm convinced the solution to the problem is to build nuclear reactors on assembly lines in factories, and this important trend toward small modular nuclear reactors is so important that it gets its own episode later in this docuseries. So stay tuned for much more on how small modular reactors will revolutionize nuclear power.

In the entire history of nuclear energy, there has never been a serious accident other than those caused by human beings doing really stupid things they should have known better than to do. I know, it probably sounds crazy when I suggest there have been no serious accidents, since everyone knows that serious accidents at Chernobyl, Three Mile Island, and Fukushima have shaped the public psyche when it comes to nuclear energy. So let's examine what really happened in each of those accidents.

In the case of Chernobyl, that reactor design would never have been permitted in the West to start with. Operators at the Chernobyl plant were trying to perform a safety test they had botched 3 times previously. They didn't bother to run their test plan past the reactor's designers or the nuclear regulator.

The test was scheduled during the day shift, but it went badly awry, resulting in an unplanned near-total shutdown of the reactor. When they finally got the reactor running on only partial power, well below the threshold level their own written test plan called for, they still weren't sure why the reactor had almost completely shut down. But despite uncertainty as to why the reactor wasn't behaving as expected, they decided to press on rather than abandoning the test. They intentionally disabled the emergency core cooling system in the course of their efforts to get the reactor back up to full power. That's the system designed to protect the core from meltdown in event of a loss of coolant accident, so disabling it was reckless to say the very least.

Because of all the unforeseen complications, the test originally planned during the day shift ran late into the night, but the operators still pressed on rather than abandoning the test. Just after midnight, the reactor was being operated by a 25-yr old night shift technician with 3 months experience in his position. He made several serious mistakes that would ultimately result in catastrophic failure of the reactor. The accident was 100% the result of human error. There was nothing wrong with the reactor, and no significant malfunction occurred. The problem was with the humans operating the reactor, whose reckless test plans and egregious operational mistakes directly caused the disaster.

In the case of Three Mile Island, when a loss of coolant accident occurred, automated safety systems turned on the emergency coolant pumps to protect the reactor core from meltdown. Human operators responded by overriding the automatic safety systems, and turning the emergency coolant pumps back off!

He turned off the coolant pump because his woefully inadequate training left him with no clue what was happening or how to interpret the complex and rapidly unfolding situation. He and the other operators had already convinced themselves there was no loss of coolant. They decided the emergency cooling system, which had activated automatically to prevent a meltdown, wasn't needed. But they were dead wrong. In reality, it was desperately needed to prevent a core meltdown. But they shut it off anyway. The resulting partial core meltdown could have been prevented had the operators not intervened to prevent the automated safety systems from doing the job they were designed to do.

In the case of Fukushima Daiichi, tsunami-related safety recommendations were made but then ignored not just once, but twice, first in 2000, and then again in 2008. Safety inspectors had informed the operator that the seawall wasn't high enough and recommended that it be extended to protect against a Tsunami, but no action was taken.

The diesel backup generators for the coolant system were originally located in the basement of the turbine building. Engineers from GE informed the operator of the plant that this location was vulnerable to flooding and that the generators should be moved to higher ground. The operator responded by moving the generators to higher ground, while leaving all the electrical switching equipment for connecting the generators to the cooling pumps in the basement, where it was flooded by the Tsunami, rendering the generators on higher ground completely useless.

Regulators ultimately ruled that even with the extent of damage from the Tsunami, the entire nuclear disaster could easily have been prevented had safety recommendations been heeded. There was no unforeseeable freak of nature. The exact scenario of a tsunami hitting the plant and resulting flood damage disabling the emergency backup power for the coolant circulation pumps was fully understood and anticipated by safety inspectors who informed the plant operator in writing exactly what needed to be done to mitigate those exact risks, years before the accident occurred. Those written instructions were ignored not just once, but twice.

So history is clear: The problem is not that nuclear energy is inherently unsafe. The problem is that human beings prone to doing stupid things should not be allowed to operate nuclear reactors. The solution is automation, and that solution is well within our current technological capability. The latest Generation III pressurized light water reactors have far more sophisticated automation and passive fail-safe systems than the reactors that melted down in Three Mile Island and Fukushima. The state of the art in nuclear energy safety could still be improved a whole lot more, as I explained in great detail earlier in this episode. But it's already the safest form of power generation in existence.

Going forward, we need to design fully automated reactors which don't rely on human operators at all, and which don't have big control rooms full of confusing instrumentation. The lesson we should learn is to design future reactors so that even Homer Simpson couldn't possibly cause a disaster by trying to interfere with automated systems that are better equipped to handle an emergency than human decision makers who have repeatedly failed to perform under pressure.

I promised to be unbiased and not sugar-coat the very real challenges that we face, including the risks associated with nuclear power. I hope you agree I've done a good job of telling both sides of the story in this episode.

Despite its various problems, the fact remains that nuclear is the safest source of energy in existence. Far more deaths and diseases have occurred in coal mines and oilfields than in nuclear plants, even when you include Chernobyl, Three Mile Island, and Fukushima. But this is the longest episode in this entire docuseries, and the reason is that's how long it took just to spell out all the major problems nuclear energy still faces, such as core meltdowns, hydrogen explosions, core depressurization accidents, weapons proliferation risks, and nuclear waste disposal.

I know that, despite nuclear having the best overall safety record of any energy source, that long list of scary problems will anger many of you. So put your seatbelt on, because now I'm going to make you even angrier! What if I told you that not only do we already have the technology needed to solve every one of these problems, but we've had that technology for decades! We've never put it to use because of government bureaucracy, corruption, and political favoritism standing in the way of public safety!

Well, that's exactly what I'm telling you now. There are good solutions to all these problems, and most of them are anything but new. Yet governments have done such an abysmal job of regulating this industry that most of these solutions have gone unused. This failure of government to serve the public interest is so egregious that it's going to take two more full episodes of this docuseries just to substantiate the statements I've just made.

So stay turned for the next episode of Energy Transition Crisis, which is all about the advanced nuclear technologies we should have adopted decades ago to improve the safety of nuclear energy.