The Case for Nuclear Electricity

Episode 78 | Everything is Everything

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Transcript

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Abstract

Nuclear energy faces a perception problem. While people fear spectacular accidents like Chernobyl and Fukushima, the data tells a different story. Nuclear power has killed fewer people in 60 years than coal kills in a single month, making it the safest form of energy known to humanity. Yet ideological opposition and regulatory barriers have prevented its widespread adoption.

Ajay and Amit examine why nuclear energy has disappointed globally, from capital intensity to safety fears, before exploring emerging solutions like small modular reactors (SMRs) that promise to revolutionize the industry through mass production. They argue that the path forward lies not in government mandates but in removing barriers that prevent private companies from choosing nuclear power based on business fundamentals. For India specifically, this means reforming five key areas: import restrictions, grid access, security protocols, international treaties, and liability laws.

The conversation builds toward a vision where private players can freely choose between solar-wind-storage combinations and nuclear baseload power, letting market forces rather than central planning determine the optimal energy mix.

Supplementary Resources

- **The Future of Nuclear Energy in a Carbon-Constrained World** by Buongiorno et al. (Report) [1]
- **Small Modular Reactors: A Comprehensive Overview of Their Economics and Strategic Aspects** by Locatelli, Bingham, and Mancini (Journal Article) [5]
- **Small Modular Reactors (SMR) Feasibility Study** by National Nuclear Laboratory (Report) [6]
- **Small Modular Reactors: Challenges and Opportunities** by OECD Nuclear Energy Agency (Report) [7]

- **How Much Did the Liberty Shipbuilders Learn?** by Thompson (Journal Article) [11]
- **The Power of Moore's Laws** by Shah and Varma (Podcast Episode) [10]
- **The Brave New Future of Electricity** by Shah and Varma (Podcast Episode) [9]
- **Ships for Victory** by Lane (Book) [4]
- **Armored Thunderbolt: The U.S. Army Sherman in World War II** by Zaloga (Book) [12]
- **Arsenal of World War II** by Koistinen (Book) [3]
- **A New Dawn for Nuclear Energy?** by Shah (Op-ed) [8]
- **Making the Way for Nuclear Energy in India** by Jaitly and Shah (Op-ed) [2]

Contents

Introduction: What's in a Name?

[00:00:15] Amit Varma: Welcome to Everything is Everything. I'm Amit, and this is my good friend Ajay.

[00:00:19] Amit Varma: And my good friend Ajay has been facing a little bit of a difficulty in recent times.

[00:00:24] Amit Varma: My good friend Ajay went to a conference recently, and three different people came to him and called him Amit.

[00:00:29] Amit Varma: And then Ajay was pretty perturbed by that, and he messaged me and said, "Do people call you Ajay¿'

[00:00:34] Amit Varma: And no one's ever called me Ajay. So I said, "No, bro, never happened to me. Must be something with you."

[00:00:39] Amit Varma: Though I must confess that if you really think about it, I do kind of look like an Amit, and you do kind of look much more like an Ajay, though what you look most like is a Narendra.

[00:00:48] Ajay Shah: (Laughs)

Chapter 1: The Broad Case for Nuclear Energy

[00:00:58] Amit Varma: So in today's episode, we're going to talk about nuclear power and how to think about it.

[00:01:02] Amit Varma: Now, we have done a fantastic episode on power, and I say fantastic, even though, you know, it's not actually an act of vanity.

[00:01:08] Amit Varma: It was a masterclass delivered by you on how we should think about the power sector and the future of electricity, and I absolutely loved that episode.

[00:01:16] Amit Varma: And at the end of that episode, you allowed me to go on a little rant about nuclear energy, which I absolutely support and wholeheartedly want more of.

[00:01:25] Amit Varma: And both of us are agreed on that. So I'll kind of repeat what my rant there was about.

[00:01:30] Amit Varma: I'll also link to a great piece co-written by Steven Pinker in the New York Times, which lays out some of the data I'm about to give you here.

[00:01:36] Amit Varma: But net-net, here's the thing. Nuclear energy is the safest form of energy known to man, right?

[00:01:43] Amit Varma: People will often point to the three accidents that have happened, Three Mile Island in 1979, Fukushima in 2011, Chernobyl in '86, right?

[00:01:51] Amit Varma: And the thing with all of those is the Three Mile Island nuclear accident killed no one.

[00:01:55] Amit Varma: Fukushima killed no one because of the nuclear mishap. People died because of the tsunami and a hurried evacuation of that place.

[00:02:03] Amit Varma: And Chernobyl, yes, it did kill people. The actual numbers are disputed, direct deaths are small, but many people got cancer.

[00:02:10] Amit Varma: Even if you take the most negative estimate of how many people died in Chernobyl, it still remains a fact that in 60 years of nuclear energy, less people have died than in a month of coal accidents or accidents related to coal.

[00:02:24] Amit Varma: Right? If you look at the rest of the energy landscape, you know, hydrocarbon, coal, etc, etc, there's a lot of, you know, danger there, a lot of deaths being caused by them, which we don't even take into account.

[00:02:39] Amit Varma: Now, people often make the mistake of thinking that, oh, nuclear energy, nuclear bombs, they have the word nuclear, there must be some issue there.

[00:02:46] Amit Varma: We know that not to be the case. There are 24 countries in the world which have nuclear power, but they haven't built nuclear bombs.

[00:02:51] Amit Varma: These are completely separate things. For some reason, in the '70s, in the peace movement, environmental movement, they got conflated.

[00:02:58] Amit Varma: And how ideological tribes form is that they will take a package of dogmatic assertions and then they will stick to the entire package.

[00:03:06] Amit Varma: You're not allowed to dissent even if the facts change and even if you, you know, get to know the other side of the story.

[00:03:14] Amit Varma: So the thing with nuclear energy is if you look at the history of the world with nuclear energy, Germany adopted it, but surprisingly and really sadly took a U-turn and suffered for it.

[00:03:23] Amit Varma: France has been a wholesale adopter of nuclear energy. 71% of France is powered by nuclear energy.

[00:03:31] Amit Varma: And their per capita emission of carbon dioxide, that is the amount of carbon dioxide plus a per 10 megawatts or whatever, is 1/10th the rest of the world.

[00:03:42] Amit Varma: There have been no safety issues, they've brought cost down dramatically, and as far as climate change is concerned, the impact is so miraculous that I simply wonder why people don't take nuclear much more seriously.

[00:03:53] Amit Varma: Yet, there are these hidebound attitudes that, oh, nuclear is dangerous, it's not safe. What will happen to nuclear waste?

[00:04:00] Amit Varma: 60 years of nuclear waste could fit in an underground bunker the size of Walmart.

[00:04:05] Amit Varma: These are really not issues anymore, but we grow up, you know, with this dark sort of cloud hanging over nuclear.

[00:04:12] Amit Varma: And the facts are, you know, completely different.

Chapter 2: A Historical Perspective: Why Nuclear Stumbled

[00:04:24] Ajay Shah: So Amit, today I want us to walk the full story of the case for nuclear electricity.

[00:04:30] Ajay Shah: What has gone wrong worldwide? What are the reasons for optimism that we see today?

[00:04:35] Ajay Shah: And then turn to an Indian environment that what are the five things that need to get done.

[00:04:39] Ajay Shah: And gentle reader, all this work that I'm reporting is joint with my co-author Akshay Jaitly.

[00:04:46] Ajay Shah: You see his photograph here. Do you see his photograph here?

[00:04:48] Amit Varma: And he's done a great episode of The Seen and the Unseen with me.

[00:04:51] Ajay Shah: And he and I did a Seen and the Unseen episode with Amit when we got our first paper out.

[00:04:57] Ajay Shah: Okay, so Akshay is co-author of everything that happens today.

[00:05:01] Ajay Shah: Okay, so let's get started at nuclear energy. Uh, worldwide, nuclear energy has been a disappointment.

[00:05:06] Ajay Shah: If you stood in 1945, the mood was of a boundless optimism that we're going to crack this, that we figured out the whole thing.

[00:05:15] Ajay Shah: And there's going to be endless free energy. In practice, what has happened is that nuclear energy has proved to be extremely capital intensive.

[00:05:24] Ajay Shah: Partly because the equipment is expensive, partly because the delays in construction. It takes 20 years to build a modern large scale nuclear plant of maybe 2,000 or 4,000 megawatts.

[00:05:36] Ajay Shah: And when you just add up all the economics, it looks terrible.

[00:05:40] Ajay Shah: So, it's not been a compelling case for investments in nuclear.

[00:05:44] Ajay Shah: And then, of course, you correctly said, the whole fear around Three Mile Island, and then Chernobyl, and then Fukushima.

[00:05:54] Ajay Shah: When Chernobyl happened, for a lot of people, you could rationalize it in a reasonable extent, saying, oh, that's the Soviet Union.

[00:06:02] Ajay Shah: Okay, that's just the monumental stupidity and systemic failure of the Soviet Union.

[00:06:08] Ajay Shah: That authoritarian systems make people stupid and they make mistakes. And I think there's an HBO series called Chernobyl.

[00:06:16] Amit Varma: There's a series is also a great book by Adam Higginbotham on Chernobyl, which kind of lays it out, it's a textbook sort of delineation of how a big oppressive state inevitably fails, nothing to do with nuclear power.

[00:06:29] Ajay Shah: So, after '86 for some time, there was hope that, look, yes, Chernobyl was a terrible disaster, but it's a fault of the Soviet Union.

[00:06:37] Ajay Shah: That, you know, if you can run a normal civilized society, you can be a liberal democracy, then human beings will not be so distorted.

[00:06:44] Ajay Shah: And there will be better check and balance, people will start noticing things are wrong, and better decisions will be made.

[00:06:49] Ajay Shah: So the entire decision failure in Chernobyl in an oppressive context where people were afraid of being sent to Siberia.

[00:06:56] Ajay Shah: So they just kept on making the wrong decisions. It was felt that okay, Chernobyl happened to the Soviet Union, but if you can be a decent liberal democracy where human beings can make better decisions under conditions of freedom, then it's not so bad.

[00:07:09] Ajay Shah: And then came Fukushima in 2011. Uh, the Fukushima accident was just a real disaster.

[00:07:15] Ajay Shah: And I remember a priceless moment which really shook me also.

[00:07:20] Ajay Shah: Which was that Angela Merkel, who was the head of state of Germany, called a meeting after the Fukushima disaster around the following sentence.

[00:07:29] Ajay Shah: She said, the Japanese are as good as us. So if a nuclear accident happened there, can it happen here?

[00:07:36] Ajay Shah: And note, she's no pushover. She is a PhD in chemistry. She's a very smart person. So she's not like one of the less literate politicians and heads of state.

[00:07:46] Ajay Shah: She was a scientific mind with full ability to understand the complexities of nuclear energy and also to engage in probabilistic reasoning.

[00:07:56] Ajay Shah: But the logic in Germany was very simple, that we are not better engineers than the Japanese. We are better engineers than the Soviets.

[00:08:03] Ajay Shah: So, you know, something stupid happens in Russia, in China, fine. Like those are second rate countries with bad political systems.

[00:08:11] Ajay Shah: But Japan is as good as Germany. So if an accident could happen in Japan, could it happen in Germany?

[00:08:16] Ajay Shah: And there was a great deal of torment around this question, and we know in hindsight that a decision was taken in Germany to shut down all nuclear energy at the time.

[00:08:25] Ajay Shah: And I think standing in 2024, that was not such a great decision. And the main body of our episode today is going to talk about why.

[00:08:33] Ajay Shah: But this is the crisis of nuclear energy, that in a way, a boundless source of energy, in a way, an economic failure that when you do hard dollars and cents calculations, the NPV doesn't look great.

[00:08:46] Ajay Shah: And then there is the looming problem of safety. And it is our main contention. Amit and I and Akshay argue that these problems have been largely solved or are within reach of being solved.

[00:08:59] Ajay Shah: So, we are in for a happy world of better safety and better pricing. So all of us should bring this back into our reasoning.

Chapter 3: Let's Talk About Safety

[00:09:15] Amit Varma: So tell me more, tell me about the safety angle. Why did those three disasters happen?

[00:09:20] Ajay Shah: When you go to first principles reasoning around these important nuclear disasters, there are three things going on.

[00:09:26] Ajay Shah: The first is that there are radioactive materials, and it's a different game compared to the normal materials that we deal with in everyday life.

[00:09:36] Ajay Shah: We are not used to the complexities of radioactive materials. A release of radioactive gas into the air will travel for thousands of kilometers, will come down as radioactive rain.

[00:09:46] Ajay Shah: Okay, it will trigger off birth defects in children. So, you know, it's a different kettle of fish that we've got to figure out.

[00:09:53] Ajay Shah: The second problem is the issues around a chain reaction, that there is such a thing as a chain reaction.

[00:10:01] Ajay Shah: And what that's what happens in a nuclear bomb. And if you don't do the correct things, then potentially there can be a chain reaction.

[00:10:07] Ajay Shah: And so you get a runaway reaction where the nuclear material heats up and the reaction goes faster and it becomes super hot and it digs a hole into the ground where it literally melts the ground.

[00:10:23] Ajay Shah: And it goes hundreds of meters into the ground. It can contaminate ground water, it can reach rivers.

[00:10:28] Ajay Shah: So, there is a very genuine thing of the way in which the failure process of a nuclear reactor can lead to a chain reaction.

[00:10:36] Ajay Shah: And the third problem is called complex systems reasoning, that it is a deep insight about the world that non-linear interactions are a new problem.

[00:10:47] Ajay Shah: So you don't have a simple causality. You have a complex system where many pieces are interacting, and then there can be unpredictable events that will come.

[00:10:55] Ajay Shah: Also, the way in which a human error will magnify and turn into something much bigger is far more dangerous in that complex system setting.

[00:11:05] Ajay Shah: So these are sort of the three elements that have come together to create safety issues.

[00:11:11] Ajay Shah: Now in response, I would make the following list of arguments. The first is your argument, saying with all these difficulties, let us sit and count the impact on excess mortality of 60 years of nuclear energy.

[00:11:24] Ajay Shah: And the numbers are actually modest. And there is no question that the killer is coal. The killer is coal and you haven't even started counting climate change yet.

[00:11:34] Ajay Shah: With coal, coal mining is hazardous. The burning of coal releases horrible gases into the air over and beyond carbon dioxide.

[00:11:44] Ajay Shah: And the industrial safety record of coal and coal related industries is pretty bad.

[00:11:48] Ajay Shah: So, with all these three problems on the table, nuclear is safer than coal.

[00:11:53] Ajay Shah: So if you think that it's not an abstract decision, we will add nuclear risk to the world. We will add nuclear risk to the world, and we will reduce coal risk in the world.

[00:12:02] Ajay Shah: So, coal is the dirtiest of all energy sources, both in terms of pollution, in terms of carbon dioxide, in terms of safety, in terms of deaths.

[00:12:12] Ajay Shah: Coal is the nightmare, and you got to fight coal. And then you have to think in terms of excess deaths per megawatt hour.

[00:12:20] Ajay Shah: And then nuclear wins. Okay, so you have to re-normalize that there is a very large coal industry, there are a very large number of deaths.

[00:12:26] Ajay Shah: This is intuitively similar to the probabilistic reasoning that would happen around driving a car from Bombay to Delhi versus taking a plane from Bombay to Delhi.

[00:12:36] Ajay Shah: Yes, plane crashes are big spectacular events, they make headlines, but honestly if you count the death rate of getting from Bombay to Delhi, it is like 1/10th or 1/50th of the death rate of driving from Bombay to Delhi.

[00:12:48] Ajay Shah: So it's the same kind of problem that a car accident doesn't make headlines. A plane accident makes headlines, and that is messing with our ability to do probabilistic reasoning.

[00:12:58] Ajay Shah: This is the first reason why we should not be as scared about nuclear energy, even though there are those three peculiar problems.

[00:13:06] Ajay Shah: The second is that this doesn't, the fact that these three problems are there doesn't mean that they are inexorably there.

[00:13:14] Ajay Shah: There is human ingenuity. So I want to take you back. 1965, Ralph Nader wrote a famous book, Unsafe at any Speed, where he documented the safety difficulties of cars in the United States at the time.

[00:13:27] Ajay Shah: Now that doesn't mean we stand still. In fact, revolutionary gains were obtained in the safety of cars after that period.

[00:13:36] Ajay Shah: And it is not beyond the dint of man to think about these problems and solve them. Most notably, on the question of a runaway nuclear reaction.

[00:13:44] Ajay Shah: There are many improved reactor designs where when the, when a safety incident happens, the reactor just spontaneously shuts itself down.

[00:13:54] Ajay Shah: That forces like gravity come into play and they pull the fissile material apart. So there can be no question of a runaway chain reaction.

[00:14:02] Ajay Shah: This is the heart of the idea that it's about clever engineering. It's, yeah, you face a problem that doesn't mean you stop.

[00:14:08] Ajay Shah: It means you try harder. And already over the last 50 years, so many good innovations have come.

[00:14:14] Ajay Shah: The 1979 Three Mile Island reactor, the 1986 Chernobyl reactor, and the Fukushima 2011 reactor.

[00:14:21] Ajay Shah: These were all first generation designs. These were very old designs at a time when humankind was just about starting to figure out this.

[00:14:28] Ajay Shah: By today, the brain power that is available is way beyond that. We are understanding these things deeply.

[00:14:35] Ajay Shah: And I think we have to respect human ingenuity that the safety problem is not a given. It is a matter of fighting with it and thinking about it and getting better.

[00:14:45] Ajay Shah: Now, in fact, we have already got evidence about a large number of nuclear reactors who have worked at ridiculously perfect levels of safety characteristics.

[00:14:56] Ajay Shah: These are the nuclear reactors that are used on aircraft carriers and nuclear submarines.

[00:15:01] Ajay Shah: Okay, so aircraft carriers are ridiculously power hungry things and there's no way to make a modern aircraft carrier without putting a nuclear reactor there.

[00:15:11] Ajay Shah: All modern aircraft carriers have nuclear reactors on board. And these have been running for decades.

[00:15:18] Ajay Shah: They've never had a safety incident. So this is really testimony that this thing is real. It's not just a hypothetical possibility.

[00:15:25] Ajay Shah: And then of course nuclear submarines. There is no way to run a modern submarine without a nuclear reactor on board.

[00:15:31] Ajay Shah: All modern submarines have a nuclear reactor on board, and they work very well. The safety characteristics have been excellent.

[00:15:37] Ajay Shah: Again, you got to keep the Soviet Union out. So the Soviet Union never really figured out how to make an aircraft carrier, how to make a submarine. That's just, you know, Soviet Union.

[00:15:46] Ajay Shah: But once you come to advanced economies and the engineering capabilities of an advanced economy and the freedom of speech, the ability to dissent and debate and criticize, then you actually get great gains.

[00:15:58] Ajay Shah: So, I'm not just making a hypothetical statement that nuclear energy can be safe with aircraft carriers and with nuclear submarines.

[00:16:06] Ajay Shah: We have thousands and thousands of man hours of flawless operation happening every year on a large scale across many countries all over the world. So this thing can be done.

[00:16:16] Ajay Shah: So I just like to say to all of us that let's not start with a very hostile approach to nuclear energy.

[00:16:24] Ajay Shah: Let's look at the evidence and let's debate that, you know, yes, there are problems and we should argue about them. Everything has problems. Coal has problems, cars have problems, okay?

[00:16:33] Ajay Shah: The internet has created lots of unintended effects. That doesn't mean you run away from the technology. It means you figure out how to make it better.

[00:16:41] Amit Varma: And I want to add to your point that not only do we know that using nuclear energy doesn't kill as many people as you think it would, like, you know, 60 years of it is equal to one month of coal.

[00:16:49] Amit Varma: I also want to say that not using nuclear energy can cost you lives.

[00:16:55] Amit Varma: You pointed out just before we started recording that what happened in Fukushima was that deaths happened because they shut down the reactor and they shifted to coal.

[00:17:04] Amit Varma: And there were deaths because of that. So actually, it wasn't the nuclear energy per se or that accident that caused deaths.

[00:17:11] Amit Varma: It was then stopping to use it, getting carried away that caused further deaths. Similarly, you spoke about, you know, flying versus driving.

[00:17:18] Amit Varma: And I remember this vague fact that I heard that after 9/11, when security measures went up and people were also scared, they started driving more and flying less.

[00:17:28] Amit Varma: And because of that, mortality went up because obviously more people die in car accidents than they do in plane crashes by an order of magnitude, right?

[00:17:37] Amit Varma: So you also have to think of the opportunity costs that it is not just about, oh, if we use nuclear power, it won't be dangerous.

[00:17:45] Amit Varma: I will argue that not using nuclear power is dangerous and is costing you lives.

[00:17:49] Ajay Shah: And, you know, if you care about the warming world and carbon dioxide emissions, this is really one of the great options, alongside solar and wind.

[00:17:57] Ajay Shah: So solar is great, wind is great, and nuclear is great.

[00:18:01] Ajay Shah: I don't like a simple environmentalist view that solar is good and wind is good, but nuclear is to be proscribed.

[00:18:08] Amit Varma: In fact, there's tremendous cognitive dissonance there. There is tons that is wrong with the modern environmental movement, but one of them is the cognitive dissonance.

[00:18:15] Amit Varma: That you want to solve climate change. You think it's one of the great problems of our times, which it is. You know, nuclear energy is something that then you should wholeheartedly support.

[00:18:23] Amit Varma: The data is all in favor of that, and it's just irrational to not do so.

Chapter 4: Small Modular Reactors

[00:18:37] Ajay Shah: And now the next problem that we should think about is cost. It is true that when you think of the delays and the capital costs of building conventional large nuclear energy plants worldwide, it is just nuts.

[00:18:49] Ajay Shah: And modern solar, modern wind, modern lithium ion batteries and other clever batteries just blow it out of the water.

[00:18:58] Ajay Shah: I get that criticism and we should not be dogmatic. We should look at it, we should recognize.

[00:19:03] Ajay Shah: But the solution lies in some very different things. And all the great stories of the world begin at the Second World War. So I'm going to fly back to 1941 and tell you a story.

[00:19:13] Ajay Shah: In 1941, the Battle of the Atlantic was taking place. And the essence was that German submarines, the so called U-boats, were shooting down the ships that were coming into Britain from America carrying food and military supplies and everything.

[00:19:31] Ajay Shah: Britain was an island. And if you could cut off the connectivity of Britain to America, then you would basically strangle the ability of the British to resist.

[00:19:40] Ajay Shah: So the Germans knew this strategy. They had kind of begun this in the first World War as well. And this was being done at a completely different scale in the Second World War.

[00:19:50] Ajay Shah: It's one of the great stories. Gentle reader, I encourage you, just go study the Battle of the Atlantic. It's not adequately noticed by many people. It's a fabulous story.

[00:20:00] Ajay Shah: It's one of the most interesting stories of the Second World War about how ingenuity, effort, imagination, creativity came together and the allies won the battle of the Atlantic.

[00:20:11] Ajay Shah: They basically blasted their way through the Atlantic and got uninterrupted passage. There were many, many elements in that story. Maybe we should make an EIEI episode on that story.

[00:20:22] Ajay Shah: But one element of that was the idea that the Germans were shooting transports out of the water.

[00:20:28] Ajay Shah: Okay, so imagine there's a transport ship carrying food, carrying weapons, and the German submarines were destroying those ships.

[00:20:35] Ajay Shah: And it started becoming a problem that how many ships do you have? Because hundreds of ships were getting killed.

[00:20:42] Ajay Shah: Okay, so just pause to think of a world where hundreds of ships were getting killed.

[00:20:46] Amit Varma: There's a Bob Dylan song about this. How many ships must a sub shoot down?

[00:20:49] Ajay Shah: How many ships must a sub shoot down before the British have no food?

[00:20:54] Ajay Shah: Okay, and this was a crisis and it had to be solved. And the glory of that period was that they decided to go for broke in solving it.

[00:21:05] Ajay Shah: So there was a British design of a transport ship which is affectionately called the ugly duckling. It's basically a mediocre stupid ship with about 10,000 tons of displacement.

[00:21:20] Ajay Shah: And they came up with the idea, the Americans came up with the idea that we will mass produce this on an assembly line. This had never before been done.

[00:21:29] Ajay Shah: Ships were artisanal projects. You would build a ship. Okay, so a bunch of people would come together and bit by bit, they would put all the pieces together.

[00:21:36] Ajay Shah: It becomes a ship and you would launch it and each ship would be different because it's being done at an artisanal scale.

[00:21:43] Ajay Shah: They said, no, we're going to do Henry Ford style assembly line manufacturing for these ships.

[00:21:50] Ajay Shah: And this was done at 18 shipyards. Assembly lines were built to roll out ships.

[00:21:57] Ajay Shah: And what you get out of this is the gains from industrialization. Also very importantly, the gains from learning.

[00:22:04] Ajay Shah: As you do this over and over, the processes get better. So at the beginning of this journey, it took 270 days to commission a ship.

[00:22:12] Ajay Shah: And at the end of this journey, it took 35 days. At the end of this journey, in 35 days, from start to finish, you were rolling a ship into the sea.

[00:22:21] Ajay Shah: And a total of 2,700 ships were built. And it gave a crash in the price, in ways that is difficult to estimate and make comparable.

[00:22:31] Ajay Shah: But it gave a huge reduction in the price as well. So their approach to the Germans was, yeah, you keep shooting down our ships, we'll make even more of the ships.

[00:22:39] Ajay Shah: Okay, that mighty American manufacturing was bigger than any submarines that Germany could put into the sea.

[00:22:47] Ajay Shah: Similarly, there is a story around tanks. The German Tiger tank was a great tank, but it was an artisanal product.

[00:22:55] Ajay Shah: Here's a fundamental fact around the Tiger tank. Every 11 Tiger tanks that were produced, there would be a change in the design because the people making those tanks were master craftsmen.

[00:23:06] Ajay Shah: And that's dumb. It drives up the cost. What you want is an assembly line. You make a factory, you just mass produce this.

[00:23:12] Ajay Shah: And this was done by the Americans with the Sherman tanks, and they taught the Soviets how to do this with the T-34s, and they just like blew away German manufacturing by 10x.

[00:23:22] Ajay Shah: So let's apply these thoughts and these principles to nuclear reactors. How do you get the price of a nuclear reactor down?

[00:23:29] Ajay Shah: The answer is industrialization. How do you do mass production?

[00:23:34] Ajay Shah: And can you produce a large unit quantity? And this straight away encourages us to think smaller.

[00:23:40] Ajay Shah: That if you're going to make a 4,000 megawatt reactor, you'll probably only make a handful of them. So it's very cute that, wow, we have a single reactor that makes 4,000 megawatts.

[00:23:52] Ajay Shah: But you won't be able to industrialize it. Whereas if you come down to 50 megawatts, 100 megawatts, now you can think of making a thousand of them, or making 10,000 of them.

[00:24:01] Ajay Shah: And then we'll get scale economies because every component in that will be mass produced. It won't be weird artisanal components going into the reactor.

[00:24:10] Ajay Shah: And everybody's dream is, we will bloody have an assembly line which will mass produce these reactors.

[00:24:18] Ajay Shah: Okay, and then the kind of cost savings that we're going to get will really surprise all of us.

[00:24:23] Ajay Shah: So I think this is the end run around the problem of nuclear and cost. Now, related to this, this is what is called the small modular reactor, SMR.

[00:24:32] Ajay Shah: Related to this is the problem of the construction projects and, you know, it takes many decades to build a large nuclear plant.

[00:24:38] Ajay Shah: Well, the dream with the SMR, it's the size of a big truck and it's fully self-contained. So you just go buy an SMR off the shelf from a D-Mart and you'll plop it in your backyard and you've got a nuclear reactor up and running.

[00:24:56] Ajay Shah: Okay, that's the dream. So you just have no concept of construction costs because you just buy a prefab ready SMR, which is about the size of a big truck.

[00:25:06] Ajay Shah: So think 30% bigger than the biggest truck is a 50 megawatt or 100 megawatt plant. And it just comes in a crate and it gets placed on site and you throw a switch and it starts generating.

[00:25:19] Ajay Shah: There's no multi-year process for constructing a nuclear plant. Okay, this becomes like a captive gen set.

[00:25:26] Ajay Shah: So imagine, lots of companies in India have a diesel gen set. Okay? So imagine how we do that. We buy the diesel generator, we put it in a corner of a factory, we place it there, we throw a switch.

[00:25:39] Ajay Shah: That's how we should have SMRs working, that really there is no complexity in terms of the construction of a large complex nuclear plant.

[00:25:49] Ajay Shah: You just buy these modules and you scale up the manufacturing, you get economies of scale.

[00:25:55] Ajay Shah: While I'm on this subject, a very important secret of the cost collapse of solar. Solar energy has had one of the greatest cost collapses of world history, in some ways even better than CPUs.

[00:26:06] Ajay Shah: Why did that happen? Because there are exactly two steps in solar manufacturing.

[00:26:12] Ajay Shah: Uh, you have to make polycrystalline silicon, polysilicon, which is a scale business. There are only 10 factories in the world who do this at scale.

[00:26:20] Ajay Shah: So you just ramp up the scale and the perfection of the manufacturing process. It's not fiddly, it's not artisanal.

[00:26:26] Ajay Shah: So you get a cost crash there. And then you cut the polysilicon and put it into a simple semiconductor manufacturing process to get the solar panels.

[00:26:36] Ajay Shah: Once again, a simple, dumb process. Do it on an industrial scale. That's how you get the costs down.

[00:26:42] Ajay Shah: So it is manufacturing that drove the cost reduction of solar. And if there is to be any future in nuclear, it will come because of manufacturing, that we'll crash prices of SMRs.

[00:26:55] Ajay Shah: That is my opinion of where this goes.

[00:26:57] Amit Varma: You know, Ajay, I think of you as in a sense an artisan, right?

[00:27:00] Amit Varma: And therefore, it is like, this is an artisanal show. We are both artisans, if not artists. We can have, you know, delusions about that.

[00:27:07] Amit Varma: And so it's almost kind of ironic that you're saying that when it comes to all of these important things, don't do things the artisanal way. Let's industrialize and all that.

[00:27:15] Amit Varma: Couple of really newbie questions about these modular nuclear reactors.

[00:27:21] Amit Varma: Number one, explain to me what is 50 megawatts? Bring it to life for me. How much can 50 megawatts power?

[00:27:26] Amit Varma: Like, can I for example get a small modular nuclear reactor and that 50 megawatts, will it power a neighborhood, for example, or a suburb? Or what is the scale?

[00:27:35] Ajay Shah: So roughly speaking, the energy consumption of one household is about 2,000-3,000 watts. Okay, just between friends, I'm going to call it 1,000.

[00:27:43] Amit Varma: Daily or yearly or?

[00:27:44] Ajay Shah: At an instant in time.

[00:27:46] Amit Varma: Okay.

[00:27:46] Ajay Shah: Okay? So at every instant in time to fire up one air conditioner and 15 appliances is about 2,000 watts. Okay? And I'm going to round that to 1,000 because, you know, to do good oral calculations, we don't want pesky little details.

[00:28:01] Ajay Shah: So, 1 megawatt, 1 million watts, is 1,000 households. 50 megawatts is 50,000 households. But now knock out that two, because I was doing the approximation.

[00:28:12] Ajay Shah: So it's about 25,000 households. So a village with 25,000 households would be served by one 50 megawatt plant. Or 50 megawatts is a good factory.

[00:28:22] Ajay Shah: So a large number of factories in the world, one 50 megawatt plant would run the entire factory with some energy left over to sell back to the grid.

[00:28:31] Amit Varma: So basically not Andheri size, maybe Versova size, definitely Yari Road size. So you're getting that done.

[00:28:38] Amit Varma: And the other aspect of it is that once you get this modular thing and I'm assuming these are totally safe, new gen reactors, all of that isn't an issue.

[00:28:45] Amit Varma: But how do you get to connect it up to the rest of the neighborhood?

[00:28:48] Amit Varma: Let us say that I buy it for the area where I live, which is four bungalows in Andheri, and you know, there's been a catastrophe, the state has failed us, no other power is working.

[00:28:57] Amit Varma: That invisible infrastructure, as it were, of getting connectivity to all the households, how complex is that and, and I'm guessing it is super easy for a big company to do it.

[00:29:06] Ajay Shah: This is indeed a huge issue. The Seen and the Unseen episode that Akshay and I did with you is centered around that.

[00:29:13] Ajay Shah: There is a magic that is called the grid. Okay, a whole bunch of different, different producers of electricity come into the grid and all the grid connects up to a large number of users of electricity, both commercial and residential.

[00:29:28] Ajay Shah: And the grid is supposed to do all the transportation. So think of the transmission system and the distribution system like big highways and then small patli gallis in Versova.

[00:29:39] Ajay Shah: Okay, that all that is the grid. It's a system for moving energy around.

[00:29:43] Ajay Shah: In India, that is significantly broken in many states because of the way the public sector grid has operated. That will indeed be a choke point.

[00:29:52] Ajay Shah: For this reason, a lot of the solar and wind and potentially nuclear innovation is happening and will happen at a B2B scale. It's a big business that sets up a solar or a wind or a nuclear facility, either for captive consumption or to sell to another big business.

[00:30:03] Ajay Shah: But getting it out into the grid has proved to be problematic because the foundations of Indian electricity policy are broken and the grid doesn't work too well.

[00:30:11] Ajay Shah: That's a separate debate which we should do and I think we began that in the Seen and the Unseen with Akshay.

[00:30:18] Ajay Shah: So the future of the grid is another lovely story, but right now I'm just going to pretend we are focusing on generation technologies.

Chapter 5: The Indian Story

[00:30:33] Amit Varma: So Ajay, what's the Indian story? What is India's relationship with, you know, thinking about nuclear power in general?

[00:30:40] Ajay Shah: So just like in space research, the assumption in India was that if this stuff is going to be done, it can only be done, it will only be done by the government.

[00:30:52] Ajay Shah: Okay and if you look back at 1945 and 1955.

[00:30:58] Ajay Shah: It's debatable even at that point, but by today, these are very wrong propositions.

[00:31:04] Ajay Shah: Now, there is a mix here between nuclear weapons and nuclear energy.

[00:31:09] Ajay Shah: And we should decouple the two. Okay. So you use steel to make guns, you use steel to make artillery shells.

[00:31:16] Ajay Shah: That's a defense business. And there you need a defense mindset where you will worry about strategic autonomy and having your own supply chain where you are not vulnerable to others and so on.

[00:31:29] Ajay Shah: But when you come to energy, then you'll be a normal part of globalization that, you know, you're buying good equipment from everywhere in the world.

[00:31:36] Ajay Shah: So Bharat Heavy Electricals makes generation equipment, but it's not a monopoly, and imported equipment competes with that.

[00:31:45] Ajay Shah: And there is very good coal and gas fired generation equipment that is being imported from other places in the world.

[00:31:54] Ajay Shah: And it's fine that you don't need a public sector monopoly anymore.

[00:31:58] Ajay Shah: So a problem in the nuclear business is we tend to assume that everything shall be Department of Atomic Energy.

[00:32:05] Ajay Shah: And in the time of Homi Bhabha, there was a different kind of ethos and excitement around it.

[00:32:13] Ajay Shah: And all credit to the Indian nuclear science establishment that they got to the testing of a nuclear bomb in 1974.

[00:32:23] Ajay Shah: That was quite an achievement. And this was done without any proliferation.

[00:32:27] Ajay Shah: India is one of the few countries which figured this out entirely alone.

[00:32:31] Ajay Shah: Whereas in most of the other nuclear powers, somebody or the other leaked information to them.

[00:32:36] Ajay Shah: So the Soviets stole nuclear secrets from the Manhattan projects, the Soviets proliferated to the Chinese, the Chinese proliferated to the North Koreans and the Pakistanis and so on.

[00:32:48] Ajay Shah: But in India, this was figured out from scratch to a nuclear test in 1974.

[00:32:53] Ajay Shah: This is the glory days of Homi Bhabha and Raja Ramanna and Sethna and all those people.

[00:33:00] Ajay Shah: More power to them. But building efficient, cheap nuclear energy is a different problem.

[00:33:07] Ajay Shah: It's more analogous to Bharat Heavy Electricals. That how do you operate in a normal industrial problem and get to scale and unit economics.

[00:33:18] Ajay Shah: This is not something that fits well in the Indian state.

[00:33:21] Ajay Shah: So I feel a huge change is required in our minds where I am going to describe some role of the state where the government is required in some pieces of the nuclear energy problem based on market failure type reasoning.

[00:33:35] Ajay Shah: But other than that, we don't require the government to be central to this story.

[00:33:41] Ajay Shah: So, you know, L&T as a private company should wonder, should we be making SMR reactors and competing in the world market.

[00:33:48] Ajay Shah: Or Hindalco as an aluminum company should be wondering that should I be buying a French SMR reactor?

[00:33:55] Ajay Shah: Because it's a cost efficient way to make energy. It should leave the subject of government and it should become a subject of private decision making.

[00:34:05] Ajay Shah: And there is some role for the state and we'll describe that in a moment.

[00:34:09] Ajay Shah: So I'm saying this in two, three different ways. It is congenitally not possible for the Indian state to do anything efficiently.

[00:34:16] Ajay Shah: So if you want to get into business, it's a mistake to put the Indian state into any business activity.

[00:34:21] Ajay Shah: Okay. So for example, we talked about digital public goods and UPI and I shake my head that really, you want a public sector company to do a high-tech business?

[00:34:31] Ajay Shah: You know, surely the private sector will do this better. The energy, the competition of multiple private players will do this better.

[00:34:38] Ajay Shah: It's that same spirit here that building nuclear reactors is a business. It's a normal private business with some interplay with the government and we'll come to that in a moment.

[00:34:48] Ajay Shah: Operating a nuclear reactor and generating energy is a business.

[00:34:52] Ajay Shah: It's for a BSES, oh, it's called Reliance Energy.

[00:34:56] Ajay Shah: It's for Reliance Energy or Tata Power to choose that do we want to buy a nuclear generating station.

[00:35:03] Ajay Shah: That's their legitimate private business. Or you have completely captive that I'm an aluminum company.

[00:35:09] Ajay Shah: Do I want to buy a nuclear reactor as a low-cost captive source of energy?

[00:35:14] Ajay Shah: These are all private decisions. So the big thing we've got to get out of in India is this idea that the government is going to do everything.

[00:35:22] Ajay Shah: And frankly, the government thing has not worked. The government approach has not worked.

[00:35:27] Ajay Shah: The share of nuclear energy in Indian energy consumption is minuscule. It has not grown over the years.

[00:35:34] Ajay Shah: And I remember when I was in the Ministry of Finance, I had started on some early calculations that this isn't going anywhere.

[00:35:42] Ajay Shah: There is just no way in which the Indian correctly measured cost of government nuclear energy plants plays a meaningful role in the Indian energy mix because the efficiency is not there.

[00:35:55] Ajay Shah: And at the time, it was so clear that when you go to the French, when you go to the Americans, the top of the line reactors are very, very cost efficient compared with what happens here.

[00:36:05] Amit Varma: And you mentioned that, you know, Tata Power and Reliance Power should have the freedom to, you know, get nuclear reactors if they want, you know, to plug into their systems.

[00:36:15] Amit Varma: And gentle readers, a lot of you would then instinctively immediately think that, oh, the government has to regulate that because what about safety?

[00:36:23] Amit Varma: And I am thinking that if the government actually had to regulate it because of safety concerns, they would immediately mandate that they get nuclear power because it is far safer than any other kind of power in use now.

[00:36:34] Amit Varma: And of course, you and I believe that the government should not mandate that. You know, let the forces play out and we will get there anyway.

[00:36:41] Amit Varma: And since you mentioned Homi Bhabha, I'd also like to recommend this excellent book, mid-episode recommendation, Atomic State by Jahnavi Phalke.

[00:36:47] Amit Varma: Wonderful book that actually has a narrative about these early pioneers of nuclear energy in India.

[00:36:54] Amit Varma: She's also got a great episode with me on The Seen and the Unseen, which is called Jahnavi and the Cyclotron.

[00:37:00] Amit Varma: And a delightful conversation where we, you know, spoke about much other than nuclear power.

[00:37:04] Amit Varma: We spent a fair bit of time speaking about Patti Smith and Robert Mapplethorpe, who have in fact been compared to our crew, Nonsita Harit, Ashay and Vaishnav Vyas.

[00:37:13] Amit Varma: As these photographs will indicate, is there a similarity or not? I leave it to you to decide, gentle readers.

Chapter 6: Our Nuclear Energy Dream

[00:37:28] Amit Varma: So Ajay, what is your dream for how this goes?

[00:37:31] Ajay Shah: So in the dream, we have multiple foreign firms making nuclear reactors.

[00:37:37] Ajay Shah: Maybe after 5, 10, 20 years, Indian engineering firms also making nuclear reactors entirely private.

[00:37:45] Ajay Shah: Private buyers either in the electricity business or in other high energy consuming operations choosing that is this efficient?

[00:37:54] Ajay Shah: Now, when you come to the choosing, it boils down to solar, wind, storage versus nuclear.

[00:38:01] Ajay Shah: Okay. So our previous episode on the future of electricity showed this beautiful tension that in the daytime while the sun is shining in India, solar energy is a fabulous low cost resource.

[00:38:14] Ajay Shah: And you really can't compete with the price of solar while the sun is shining.

[00:38:18] Ajay Shah: But the sun has an unpleasant habit of setting every evening.

[00:38:21] Ajay Shah: And so every evening you have a crisis that there's a collapse in energy supply and that happens to precisely be the time at which human consumption of energy goes up.

[00:38:31] Ajay Shah: People go back home and they flick on their TVs and their air conditioners and their mixers and so on.

[00:38:37] Ajay Shah: They open their refrigerator and the refrigerator warms up and that triggers the compressor to come back on and so on.

[00:38:44] Ajay Shah: So without nuclear in the picture, there would be a price surge in the evening and that price surge would require storage.

[00:38:54] Ajay Shah: And the equilibrium would be one where the cost of storage is counterbalanced against the price premium.

[00:39:01] Ajay Shah: Now suppose you are a speculator and you believe that look, the storage technology is not good enough.

[00:39:07] Ajay Shah: We're going to have an insane price surge in the evening. Okay, because all the coal is on its way out.

[00:39:13] Ajay Shah: Okay, in the dream, we will shut down all the coal fired plants of India.

[00:39:17] Ajay Shah: We will close down all coal mines in India. Okay, that's the dream.

[00:39:21] Ajay Shah: So, in the evening, there would be a real crisis every day because the wind would continue to work, but the solar would shut down.

[00:39:28] Ajay Shah: And our storage technology is strong enough to curtail the evening price surge is the question.

[00:39:35] Ajay Shah: Suppose you're a speculator and you believe that no, this is nuts. That there is no way in which storage technologies are good enough.

[00:39:41] Ajay Shah: Then you will think nuclear technology. This is the business bet that private people have to make that either you believe that wow, there's going to be a crazy peak, but storage is going to work.

[00:39:51] Ajay Shah: Great. By all means, go build storage plants based on your speculative view.

[00:39:58] Ajay Shah: No central planning, no government telling you that I want a storage plant here.

[00:40:01] Ajay Shah: You're making a storage plant because you believe you will make money filling up the storage plant in the daytime with cheap nuclear with cheap solar energy and selling in the evening peak at a very good price.

[00:40:13] Ajay Shah: Or you believe that all the storage technologies will not suffice to solve the evening peak.

[00:40:21] Ajay Shah: Then you will say, you know what, let's make nuclear. Because nuclear will work into the evening and we will get a lot of money by selling nuclear energy in the evening.

[00:40:31] Ajay Shah: And these will be private decisions. So that's the dream.

[00:40:35] Amit Varma: So, you know, Ajay, you spoke about the sun setting. And I want to tell you ki sir, sun set nahi ho raha hai.

[00:40:40] Amit Varma: Hum ghum rahe hain.

Chapter 7: The Five Conditions for Success

[00:40:50] Amit Varma: So Ajay, I must commend you on your timing because you wrote a fantastic article on this with Akshay Jaitly.

[00:40:55] Amit Varma: And that article came out in the same week practically that Meta, aka Facebook, and Google placed big orders for small modular reactors.

[00:41:04] Amit Varma: So we are beyond the world of theory. Shit is happening. Orders have been placed for them.

[00:41:09] Amit Varma: And when big players like these get into the business, you can bet that things are going to happen, that scale is possible, and this is something we should think about seriously.

[00:41:17] Amit Varma: So give me your sense of how should we think about it here in India?

[00:41:21] Amit Varma: How should the state think about it? How should individuals think about it?

[00:41:26] Ajay Shah: The Indian state needs to work on five problems.

[00:41:29] Ajay Shah: Okay. So the first problem is establish the ability of private Indian people to make a decision to import a nuclear plant.

[00:41:38] Ajay Shah: Okay? I don't even know what are all the log jam of import restrictions or government monopoly or you know, who knows what is the legal system and what are the intrusions coming in from the legal system.

[00:41:50] Ajay Shah: But principle one, private people should be free.

[00:41:54] Ajay Shah: And it should be a private decision based on business considerations that does it make sense for me to buy a 50 megawatt plant or not.

[00:42:02] Ajay Shah: I believe a 50 megawatt plant is about 2 to 300 million dollars, which is like 1500 to 2500 crore rupees, which is a feasible decision for the corporate financial power of the top 100 companies of India.

[00:42:18] Ajay Shah: Okay, so they should choose and that's idea number one.

[00:42:22] Ajay Shah: Idea number two, if you try to go to a Indian distribution company, the grid, and say to them that buy my nuclear energy or that the discom should build a nuclear plant.

[00:42:34] Ajay Shah: The discoms are generally not interested. They think this is too expensive. They think this is too capital intensive.

[00:42:40] Ajay Shah: Now we have a direct analogy with the field of offshore wind. Offshore wind generators are also pretty expensive, they're capital intensive.

[00:42:49] Ajay Shah: And the solution is economic freedom.

[00:42:54] Ajay Shah: That if you believe as a speculator that it is a good idea to build offshore wind because you'll be able to sell energy into the evening peak, you have the ability to directly sell electricity to an industrial or a commercial buyer.

[00:43:07] Ajay Shah: You don't have to bring the grid into it. Okay, so just a simple statement of economic freedom that nobody's forcing a high cost source upon the discoms who are often public sector organizations and who are saying, look, I don't want to get committed to a very expensive form of energy.

[00:43:23] Ajay Shah: Fine, you don't get committed. So our policy environment should be that the maker of a nuclear plant, the owner of a nuclear plant should have the ability to directly sell, should have the freedom to directly sell to private buyers and we keep the discom out of it.

[00:43:37] Ajay Shah: Okay. Third is the problem of safety in a sense of physical security.

[00:43:45] Ajay Shah: People will think correctly that, oh, but I've got uranium inside these plants and uranium can be used to make an atomic bomb.

[00:43:53] Ajay Shah: Now, here there is a very good analogy with airports.

[00:43:57] Ajay Shah: Okay, so in aviation, we indeed have a problem with how to block crime because attackers against planes like to pull off spectacular hijackings and blowing up a plane in the air and all that.

[00:44:12] Ajay Shah: And that is a part of the criminal justice system. But the world has fully figured this out that you have planes made by private persons, operated by private airlines, flying in and out of private airports.

[00:44:25] Ajay Shah: And the government runs the aviation safety system inside the private airport.

[00:44:31] Ajay Shah: So that's the kind of bargain that needs to be struck that yeah, how will you protect that uranium?

[00:44:36] Ajay Shah: How will you protect the nuclear waste? You will have government guys, the CISF will be doing that.

[00:44:42] Ajay Shah: And the precise protocols and techniques need to be established.

[00:44:46] Ajay Shah: And that's a positive task for the government that the government needs to write down the manual and the protocol saying, guy, you want to build a nuclear plant, you have to come to me in this fashion.

[00:44:56] Ajay Shah: I will run this kind of security system for you and you will pay me so much because you want it to go back on a cost sharing basis.

[00:45:03] Ajay Shah: You don't want the larger public to be burdened with this. So this is a element three of what needs to be done, which is to think about how CISF will work nuclear.

[00:45:15] Ajay Shah: Okay. So CISF needs to understand nuclear energy, the way CISF understands civil aviation.

[00:45:20] Ajay Shah: Okay. Element four, the International Atomic Energy Agency runs a global set of standards around the safety procedures and protocols and the life cycle handling of fuel and waste and all that.

[00:45:33] Ajay Shah: And India needs to sign all those treaties and become a first-class participant because otherwise the rest of the world is not going to participate and collaborate in selling fuel and selling reactors and so on into India.

[00:45:45] Ajay Shah: That there are international standards and we need to sign and we need to agree to comply with the entire fuel cycle, the procedures and the steps that are used by the IAEA and all the member countries.

[00:45:59] Ajay Shah: Finally comes the last problem, which is civil nuclear liability.

[00:46:04] Ajay Shah: Okay. Here in short, the idea runs like this that if you're driving a car and you have an accident, are you responsible or is the maker of the car responsible?

[00:46:13] Ajay Shah: Okay, and intuitively we would think that after I purchase the car, it becomes my responsibility.

[00:46:18] Ajay Shah: And you know, the maintenance of the brakes is my responsibility. It's not the car maker's problem.

[00:46:24] Ajay Shah: That is not how the Indian legal system works on nuclear liability.

[00:46:29] Ajay Shah: The approach taken by the Indian state is that the vendor who sells the nuclear reactor is forever liable for all safety issues that emanate from the nuclear reactor.

[00:46:39] Ajay Shah: And I think that's not fair. That's not correct. And in any case, it is dysfunctional because if you put up this liability, then all the vendors of the world have said that, okay, fine, in that case, I'm not keen to sell you a reactor.

[00:46:52] Ajay Shah: So I think we need to man up around this that like all other industrial equipment, there is a handover date and then responsibility shifts to the operator.

[00:47:03] Ajay Shah: So there is a very interesting international doctrine around this. So you may say that, okay, I had a car accident, but the problem in the accident was because of a design flaw in the car.

[00:47:18] Ajay Shah: Okay. So the global arrangement is like this that step one, liability rests only with the operator.

[00:47:26] Ajay Shah: So if there is an accident and 100,000 people are affected, they go sue only the operator.

[00:47:30] Ajay Shah: There's one clear local person. So it's Tata Power who is running the plant, who is responsible for compensating the 100,000 people who be adversely affected.

[00:47:40] Ajay Shah: But Tata Power and Tata Power alone has the ability to go to a foreign source of the reactor and say, you had design mistakes which caused this accident.

[00:47:49] Ajay Shah: That is their choice. So there is a legal liability, but it doesn't come from 100,000 people.

[00:47:55] Ajay Shah: It comes only from the operator that the operator can sue saying it is because of your design defect that we had an accident.

[00:48:02] Ajay Shah: Okay. So there are these nice subtleties around the nuclear liability and the present Indian law is not structured correctly.

[00:48:10] Ajay Shah: As long as the Indian law is structured in the way it is today, there will be no transactions.

[00:48:14] Ajay Shah: No global firm is going to sell a nuclear reactor to an Indian buyer.

[00:48:19] Ajay Shah: So that is one more piece that needs to be changed. So these are the five pieces that need to be changed to create conditions for Indian private people to choose.

[00:48:28] Ajay Shah: So note, I'm not dreaming that there will be a great renaissance in India and there will be so much nuclear.

[00:48:33] Ajay Shah: I'm dreaming that private people will have the right to choose. That's the most you can ask for.

[00:48:38] Ajay Shah: Under conditions of freedom, people should have choices. That will you use solar plus wind plus storage, if it makes business sense, by all means do so.

[00:48:46] Ajay Shah: Or will you believe that the evening peak is so bad that there will be good opportunities to make money with nuclear base load, by all means do so.

[00:48:56] Ajay Shah: And it is not our job as thinkers or government policy makers to centrally plan that there will be 50,000 megawatts of nuclear.

[00:49:05] Ajay Shah: What is needed is to create conditions where private people will look at the business choices and make the right decision.

[00:49:19] Amit Varma: So Ajay, we began this episode with this preamble about how we should look at nuclear differently, that it is actually damn safe.

Chapter 8: An Argument for Freedom

[00:49:25] Amit Varma: It is, I think just by orders of magnitude and incredibly better source of energy than everything that is mainstream today.

[00:49:33] Amit Varma: And in this episode, what we have done is we have not made an argument for action.

[00:49:38] Amit Varma: We have made an argument for freedom. So our argument is not that nuclear is great.

[00:49:42] Amit Varma: Oh, private people go invest in nuclear. That's not our argument. Our argument is not nuclear is great.

[00:49:47] Amit Varma: Oh, Indian state solve our power problems and go for it.

[00:49:50] Amit Varma: We are not arguing for action. We are arguing for freedom that this is incredible.

[00:49:56] Amit Varma: Let's not shut it out with state action that gets in the way.

[00:49:59] Amit Varma: You know, let private players decide according to their own estimations, according to their own imperatives.

[00:50:05] Amit Varma: And then if good things are happening, let them happen. Now, my question to you is that a term that you have often used and I've been telling you you should write a book on it and we should do an episode on it, is the term invisible infrastructure.

[00:50:17] Amit Varma: There are certain ways of thinking about organizing the relationship between the state and society that can work in a westernized country because they have that invisible infrastructure.

[00:50:26] Amit Varma: You know, the rule of law is much better and they have processes honed over decades of thinking about such stuff.

[00:50:33] Amit Varma: We don't have that invisible infrastructure. So how does this work out?

[00:50:36] Amit Varma: Because I can see a number of things going wrong with this. Number one, the state could decide randomly that, oh, this is amazing.

[00:50:43] Amit Varma: Let us give it to a crony and only the crony will do it and no one else can enter, you know, which is absolutely not what we want because you want the freedom and the dynamism of a marketplace, right?

[00:50:53] Amit Varma: Second, what could happen is that the state could get in to provide the kind of services you talk about in airports except it is not as experienced with nuclear plants as it is with airports and that could go awry.

[00:51:05] Amit Varma: And third, wherever you give the state even the slightest role, it expands that role and it becomes rent seeking and it creates so much friction that everything gets ossified and nothing happens.

[00:51:16] Amit Varma: So, you know, how do you think about this?

[00:51:17] Ajay Shah: These are all fair concerns and my answer will basically be in the EIE episode, the long road to change.

[00:51:25] Ajay Shah: The answer lies in knowledge and community that we need enough people in India who think, who write, who debate, who criticize.

[00:51:33] Ajay Shah: And that will create the homeostatic process by which governments will always fumble. They'll go too much in this side, they'll go too much in that side.

[00:51:39] Ajay Shah: And what you need is a vibrant intellectual landscape where there are thinkers, there are researchers, there are people writing papers, and there are people criticizing the mainstream.

[00:51:49] Ajay Shah: Out of that, we become a better country. So I have no illusions that there's a smooth path to these five things.

[00:51:57] Ajay Shah: There will be a difficult path to these five things.

[00:52:08] Amit Varma: Ajay bhai, give us recommendations, whether nuclear or non-nuclear.

Chapter 9: Recommendations

[00:52:12] Amit Varma: I already recommended Jahnavi Phalke's excellent book Atomic State. I will also recommend our EIE episode on power, my Seen and the Unseen episode with you and Akshay, and the two articles written by you and Akshay on this subject.

[00:52:23] Amit Varma: They'll be down below in the yeah, they are there. They're down below in the show notes.

[00:52:27] Amit Varma: Uh most excellent reading. What about you? What do you recommend?

[00:52:30] Ajay Shah: I would recommend a song, which is absolutely nothing to do with nuclear.

[00:52:33] Ajay Shah: And what is amazing about this song is that it was made in 2016.

[00:52:36] Ajay Shah: See, I'm an old fogey, right? So normally my music is all ancient.

[00:52:40] Ajay Shah: So I'm amazed that I now have one song that I absolutely love, which is made as recently as 2016.

[00:52:46] Ajay Shah: It's a song called Paul by a band called Big Thief.

[00:52:50] Amit Varma: Magnificent. I will check it out.

[00:52:52] Amit Varma: And since you say Paul, I am reminded of this classic song which was covered by Paul Young.

[00:52:57] Amit Varma: I think it's originally by Marvin Gaye. It's called Wherever I lay my hat, that's my home.

[00:53:01] Amit Varma: It's a masterpiece. Where is your home, Ajay Shah? Your spiritual home, your intellectual home. Where is it?

[00:53:07] Ajay Shah: Bandra East.

[00:53:08] Amit Varma: Bandra East. Bandra East is your home?

[00:53:10] Ajay Shah: My home.

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