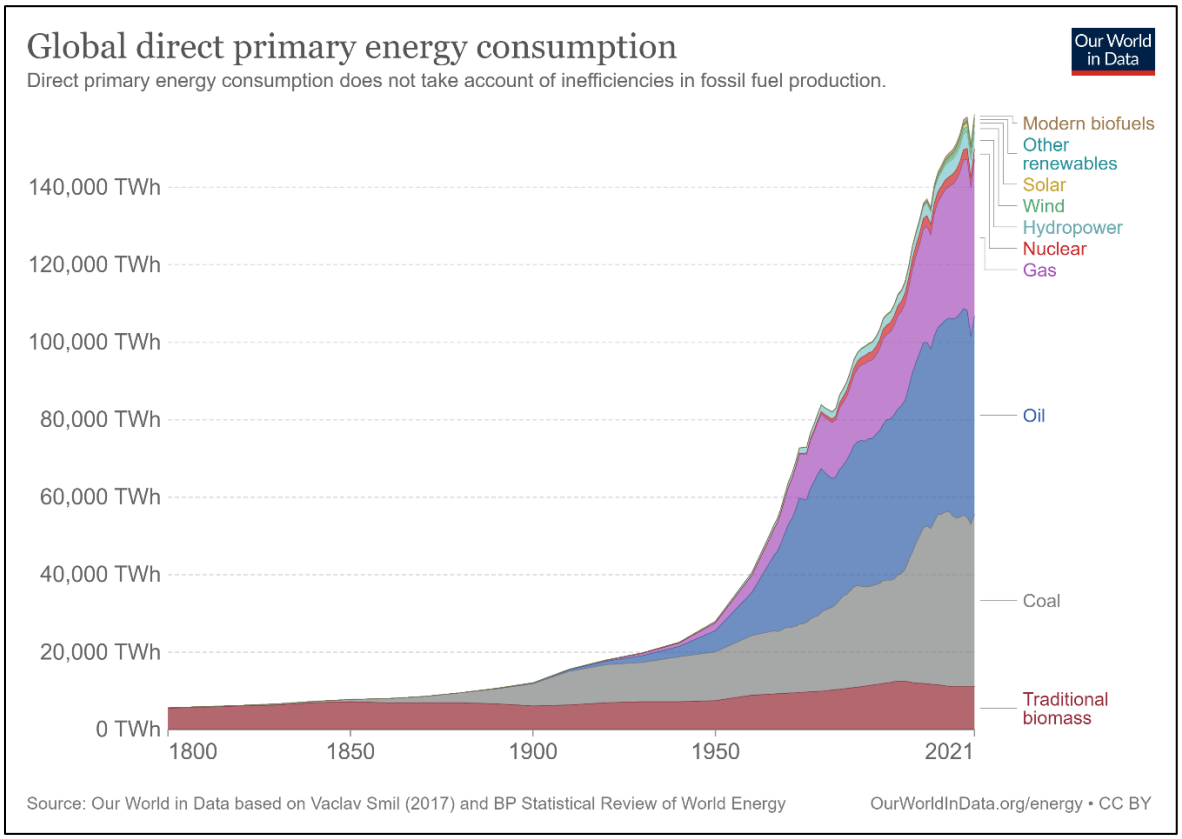
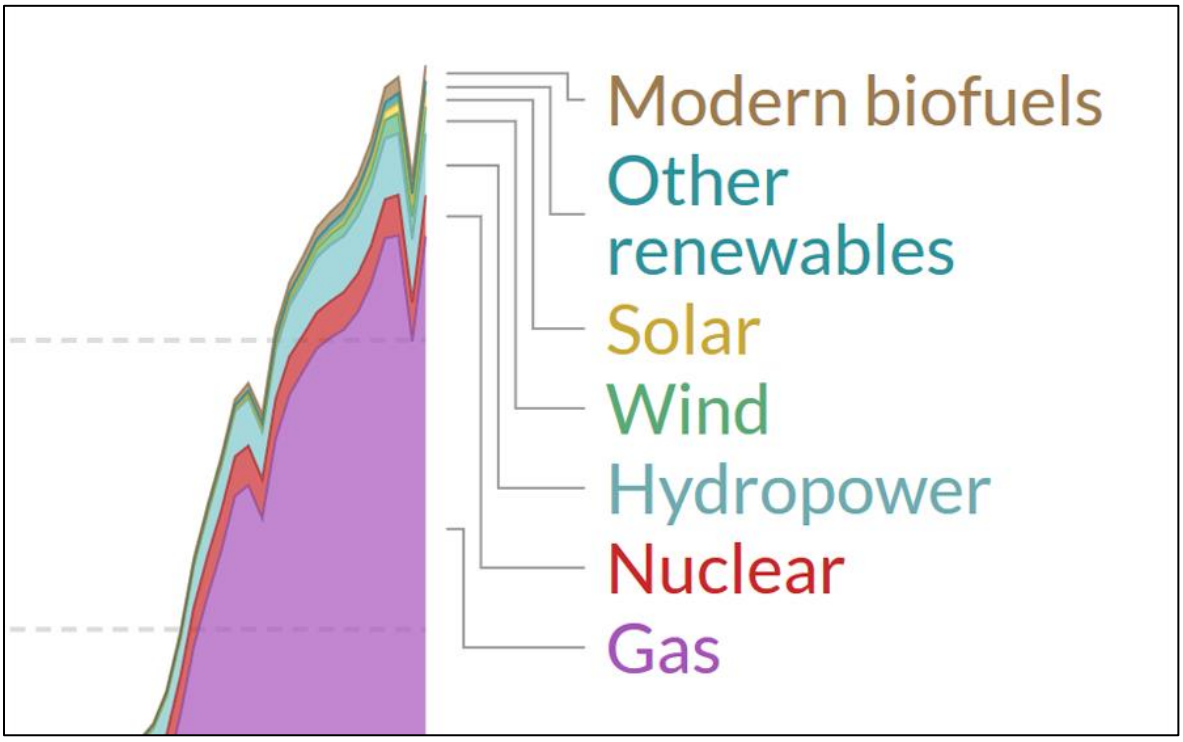
# Solving the 2020s Energy Crisis



# Narration Script

**V1.0 DECEMBER 29, 2022**

**REVISED Episode 1 Notes**

**Listeners, THANK YOU for all your feedback and critique on last week's first episode. I made quite a few changes based on your feedback. Here's the full script for the first two episodes, after editing with your feedback.**

**The big change is the new section on *thermal efficiency* which was moved to Episode 1 from Episode 5 after several of you pointed out that I come across as if I either don't understand this or am intentionally being misleading about the interpretation of the chart. In this week's podcast preview, I'll read that section before reading the full Episode #2.**

**The revised script for Ep. 1 follows below. The script for Ep. 2 begins on pp.19 of this document.**

**Episode 1: The Importance of Energy and Origins of the mid-2020s Energy Crisis**

I'm Erik Townsend. I was a software entrepreneur in the '90s, and later went on to manage a hedge fund. I'm now fully retired, but I remain passionately committed to helping solve the greatest problem humanity faces: the Global Energy Crisis that's certain to occur as we struggle to transition from fossil fuels to cleaner, greener sources of energy to power the global economy, while simultaneously decarbonizing our atmosphere.

This is the first episode of a 5-part documentary series, which will examine the importance of energy to our standard of living and the advancement of human society. Then we'll analyze what it's really going to take to replace fossil fuels with cleaner, greener alternatives. The remaining episodes in this docuseries will explain why a global energy crisis can no longer be avoided in the mid-2020s, and then explore the available solutions for solving the coming energy crisis.

A whole new era of human prosperity is possible if we get the coming energy transition right, and the future couldn't be brighter once we overcome the obstacles ahead of us. But it's going to be a bumpy ride. You see, this is a story of failed government policies, corporate greed, bureaucracy, and corruption causing missed opportunities to solve our fossil fuels addiction decades ago. We'll cover all of that, and lay out a plan to solve the coming crisis, in this 5-part docuseries.

The single most important lesson I've ever learned about understanding the world around us is this: *Societal complexity, and therefore, the pace of advancement of humanity, is a function of the amount of abundant and affordable* ***energy*** *available to the economy.* That's a somewhat nuanced but profoundly important statement, so let's examine its implications.

Please ask yourself why it is that for about 200 years now, society has advanced so much more quickly than it did for centuries before that. Today we live and work in high-rise buildings with heat, air conditioning, electric lighting, and modern plumbing. In developed nations, nobody builds their own home or grows their own food unless they have a personal passion for doing so. Instead, people are free to pursue higher education and then move on to choose from hundreds of careers that never even existed 200 years ago.

If you look back in history, for many centuries before that, the human experience was far more primitive than today, and the pace of advancement was much slower. University education was extremely rare, and few professions even existed, other than the most essential ones such as law and medicine. Most people lived in primitive homes they had no choice but to build themselves by hand. Firewood provided the sole source of heating and cooking energy. Plumbing hadn't been invented yet, and human slaves were the primary source of work needed to operate the farms and plantations.

Please ask yourself what changed that allowed society to progress so much faster in the last two hundred years, so that we now live in high-rise skyscrapers, and have the luxury of spending our leisure time reading social media on our smartphones, or even flying anywhere on earth in just a few hours' travel time? Most people answer that question by saying *technology* is the big thing that changed. The industrial revolution and then the semiconductor and computer technology revolution culminating in the development of the modern Internet are what most people perceive to be the primary drivers of this accelerated pace of human advancement over the last 200 years.

There's some truth in that answer, but *technology* is actually a second-order effect, not the driving force. The true underlying reason that humanity has made so much more progress in the last 200 years than it did in the 500 years before that, *is a marked increase in the availability of cheap and abundant* ***energy***. Again, *societal complexity, and therefore the pace of human advancement, is a function of the amount of abundant and affordable energy available to the economy.*

With Gasoline now costing more than $3.50 per gallon on average in the United States, it might not *feel* like energy is "cheap" right now. But when you consider that one gallon of gasoline produces the same amount of useful work as up to 482 hours of human labor, the right way to think about the cost of energy now vs. 200 years ago is that a single gallon of gasoline costs three and a half dollars, while the equivalent 482 hours of manual labor costs nearly three and a half *thousand* dollars at the current U.S. minimum wage of $7.25/hr. Energy is literally one thousand times cheaper than it would be if we had to pay minimum wage workers to do the work now performed by gasoline-powered machinery. Put another way, even a top athlete can't do as much physical work in one day as the electricity you can buy for less than half a dollar! And that's precisely the reason humanity has advanced so much in the last two hundred years: because of the availability of cheap energy to supplement and replace human labor, allowing more work to be done much more quickly and efficiently than was ever possible before.

The industrial revolution could not have happened until it was enabled by the invention of the steam engine. The newfound ability to convert the potential energy contained in coal into physical motion that could be harnessed to accomplish work and automate previously manual processes was the *turning point in history* which everything else followed. To this day, the unit of measure for work performed by any kind of power generation technology is named after James Watt, the inventor who perfected the Steam Engine from earlier inventors' prototypes into a commercially viable product, between 1763 and 1775. That's when the rapid-pace advancement of human society over the last two centuries all started.

The age of oil began in 1859, when Edwin Drake drilled the first oil well in Titusville, Pennsylvania. The discovery of "rock oil" was an even bigger deal than the steam engine. Petroleum and the abundant and relatively cheap products refined from it such as gasoline, diesel fuel, and now jet airplane fuel, quite literally changed everything. The sudden availability of abundant energy enabled the inventions of everything from the automobile to the airplane to mechanized farming equipment. Advancements such as modern cities, public infrastructure, and high-rise buildings would never have been possible without modern heavy construction equipment, which is powered by diesel fuel refined from petroleum. *Societal complexity is, quite literally, a function of the amount of abundant, affordable energy available to grow the economy.*

Most Americans feel a strong attachment to the words *We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness.* In modern times, it's hard to conceive how it's even possible that those inspiring words were actually written by slave owners! But they were. Please ask yourself how it's even possible that people with such dedication to the inalienable human rights of freedom and liberty could rationalize owning slaves, even as they were drafting the Declaration of Independence.

The answer is that in those days, human slavery was deemed as "necessary" because there was no alternative to human labor to operate the farms and plantations of the day. As shocking as it seems to us in modern times, back when there was no mechanized farming equipment, almost everyone rationalized human slavery as a necessary fact of life.

It's no coincidence that the abolition of slavery coincides with the dawn of the age of fossil fuels. That's how important cheap and abundant energy is to the advancement of humanity: We literally eliminated human slavery thanks to the availability of energy derived first from coal, and then later from oil.

I have a question for you. Do you personally live and work on a farm? Do the vast majority of your friends and family live and work on farms? 200 years ago, almost everyone in society lived and worked on farms, *because there was no alternative.* The only way to sustain ourselves was to keep the vast majority of people directly engaged in growing and harvesting the food we needed to survive. The only reason that we don't *all* have to work on farms today

is that *energy* derived from oil powers modern farming equipment, allowing just a handful of farmers to produce as much food as hundreds of farm workers two centuries ago.

The reason there are hundreds of different professions today, and the reason it's possible for a much larger percentage of society attend university, is that *energy* derived from oil makes possible a world in which we don't all have to work on farms just to feed ourselves. That's how much difference it makes to have cheap and abundant energy available to grow the economy. It's what advances the sophistication of society and the overall quality of the human experience.

When the age of oil began in 1859, there were just over one billion human beings on planet Earth. Today that figure is over 8 billion. That population growth was directly enabled by modern farming technology, which is only possible with abundant energy to run all the equipment. We literally cannot feed the current population of our planet without modern farming equipment, which requires *energy* that's presently supplied by oil.

165 years after it began in 1859, the age of oil is now slowly coming to an end. Fossil fuels won't go away as quickly as our politicians would like to pretend, but they absolutely do need to be phased out. Regardless of whether you personally believe that climate change poses an existential threat to humanity, an immutable fact is that public sentiment and government policy are now firmly aligned toward achieving carbon neutrality. Another immutable fact is that fossil fuels are a finite resource that won't last forever. Even if we try and extend the age of oil, the cost of oil production will continue to increase as a percentage of global GDP, and that will *retard the pace* of societal advancement.

The pace of advancement of human society has measurably slowed just during my own lifetime, and a big part of the reason for that is that gasoline no longer costs thirty cents a gallon like it did when I was a kid. Don't write that off as inflation. Gasoline in the United States cost about 31 cents per gallon in 1972. Adjusted for inflation that's $2 per gallon in today's dollars, or just more than half what gasoline actually costs today. When gasoline prices move back over $4 per gallon, which I'm convinced they will, we'll literally be paying twice as much for energy versus when I was a kid, even after adjusting for actual inflation.

Remember, societal complexity and the pace of human advancement is a function of the amount of *cheap and abundant* energy available to the economy. If $2 per gallon in today's dollars was still the going price of gasoline, a whole lot more progress would be made because the cost of energy, which ultimately determines the pace of societal advancement, would be about half what it is today. When gasoline prices eventually rise over $6 per gallon, as I'm convinced they will by 2025, we'll be paying three times as much for energy as it cost when I was a kid. And that directly translates to societal advancement slowing to one third of the pace it advanced during my childhood.

How many years are left before energy derived from petroleum becomes *prohibitively* expensive is a matter of debate. But at this point, it's an academic debate. Replacing fossil fuels with new, cleaner and greener energy sources is the most important challenge humanity faces. Decarbonization for the sake of arresting climate change is reason enough for most people. But even if you disagree with that sentiment, the fact remains that fossil fuels are a finite resource. We're not running out of oil yet, but the incremental cost of production will continue to increase as more and more technological innovation is required to extract oil from the earth's crust.

The high cost of energy is already retarding the pace of human advancement, and that problem will only get worse. Transitioning the global economy away from oil and gas in favor of new energy sources is going to take longer than we'll be able to continue producing *affordable* petroleum products. That's why a global energy crisis is unavoidable in coming years.

The climate lobby and politicians vying for their votes are fond of *pretending* that wind and solar are going to solve everything. But they never present any data to substantiate their foregone conclusions. Now, to be sure, wind and solar renewables are a vital and important *part* of the solution, and we need to continue to develop more wind and solar energy around the globe. So don't get me wrong: Wind and Soar are **good** things, and we need **more** wind and solar, not less. The cost of photovoltaic solar cells is decreasing exponentially and solar powerplant construction, which consumes much less land area than wind per unit of electricity generated, is increasing exponentially. That's great news!

But it's long past time for politicians and climate activists to stop making unsubstantiated claims that wind and solar will *solve everything*, just because that's what people like to hear. For more than two solid decades now, we've been allowing emotion and hope to cloud the need to look at the cold hard facts and reach conclusions based on *data* rather than *emotion*. Wind and solar are terrific ways to generate energy when the wind is blowing and the sun is shining, but we still need a way to supply the baseload power needed to run the economy the rest of the time. Even with new technology that *stores* the energy produced by wind and solar allowing it to be consumed later, it's still not practical to build enough wind and solar capacity to replace all the energy derived from fossil fuels.

This chart shows global energy consumption broken down by source. The energy we get from wind and solar *combined* is less than 5% of total energy consumption. That's such a tiny percentage that it's hard to even make out wind and solar at the top of the chart. Wind is shown in green and solar is shown above it in orange, but these are such tiny slivers on the chart that they're barely visible. And that's after public policy has aggressively subsidized building out wind and solar energy capacity for more than two solid decades. Compare the size of those tiny green and orange wind and solar slivers on the chart with coal in grey, oil in blue, and natural gas in purple. Collectively, we get more than 85% of our total energy consumption from coal, oil and natural gas, and less than 5% from wind and solar combined.

The next time a politician or climate activist tells you that we're going to replace fossil fuels with wind and solar, I want you to understand their statement in the context of this chart. What they're saying is that they propose we just get rid of the grey, blue and purple energy sources because they don't think we need them anymore. They think the tiny little green and orange wind and solar slivers you can barely even make out on the very top of the chart are somehow magically going to replace all the energy we get from the grey, purple, and blue slices representing fossil fuels. And they believe these things despite that, after two full decades of aggressively subsidized wind and solar energy development, wind and solar *still* don't supply enough energy to meet even 5% of total demand.

If it took more than two decades of subsidized aggressive investment to build the wind energy shown in green and the solar energy shown in orange, how many decades will it take to grow those slivers until they are bigger than the grey coal segment, the blue oil segment, and the purple natural gas segment *combined?* Even if we really doubled down, got super aggressive and committed to building out more new wind and solar energy capacity every 10 years than *all* the wind and solar energy that's *ever* been put in service until now, it would still take at least 170 years to build enough wind and solar capacity to replace fossil fuels. And that's just based on current consumption. Because economic growth will continue and more energy will be required in future years, the problem is even more daunting. Politicians and activists who pretend otherwise are doing a great disservice to society.

Please ask yourself why politicians waxing poetic about how wind and solar can solve all our problems never show you the actual data, or explain in concise detail how much new wind and solar energy capacity would have to be built in order to actually achieve the solutions they propose.

The answer is that our politicians aren't seriously engaged in really trying to solve this problem. They're vying for votes by telling people what they want to hear, even though it's not even remotely possible. We've already wasted two full decades of inaction on finding *realistic* clean energy sources to replace fossil fuels, because of the fairy tale we've been telling ourselves that those tiny little green and orange wind and solar slivers, which supply less than 5% of our energy today, are going to somehow magically replace the grey, blue, and purple fossil fuels sources which supply more than 85% of our energy. That's just plain crazy.

We cannot allow this fantasy to continue to stand in the way of real progress. Wind and solar are a great start, and we do need to keep building more wind and solar energy capacity. But to truly phase out fossil fuels, we need far more energy than wind and solar can ever deliver. When you actually look at the data rather than just the emotions politicians try and cater to, the cold hard truth is that wind and solar will never solve even half of the problem. They're important to the overall solution, but insufficient by themselves.

For humanity to advance, we need a solid plan for replacing ***all*** the energy now supplied by coal, oil, and gas with clean, environment-friendly substitutes. Replacing fossil fuels is a much bigger

undertaking than most people appreciate, and it will take decades. The purpose of this docuseries is to do what politicians have been afraid to do. We're going to work from hard data rather than emotion, be *honest* about how big the problem really is, and explore the *realistic* options we have for replacing all the energy presently derived from fossil fuels. Wind and solar are a very important part of the solution, but they're only a *small* part of any realistic solution.

I want you to open your mind and imagine what the world would be like if we made the best of the coming 2020s energy crisis, by seizing the opportunity not just to *replace* fossil fuels with an *equal* amount of clean energy, but to instead figure out a way to bring online a much *larger* amount of clean, environmentally friendly energy, while at the same time making it cheaper than fossil fuel-derived energy is now. And even cheaper than it was when I was a kid, when gasoline cost just over 30 cents per gallon. What if we could figure out a way to replace fossil fuels with new sources of clean, environmentally responsible energy which cost the equivalent of gasoline prices well below one dollar per gallon in today's inflation-adjusted dollars, but without any of the pollution or exhaustion of finite resources associated with burning fossil fuels?

If energy from coal and later from oil made it possible to *abolish slavery*, made higher education available to the masses, and created a society with hundreds of occupations to choose from, can you imagine what would be possible if we went through *another* similar magnitude increase in the amount of cheap and abundant energy available to the economy? If you favor universal basic income and free university education for everyone who wants it, cheap abundant energy is what would make those policy goals attainable. And that means the standard of living now enjoyed only in "first world" countries could be shared with the entire human species.

***I'm convinced that dream is attainable, and the purpose of this documentary series is to tell you exactly how we could achieve the things I've just described.*** Now to be clear, it's not just a matter of pushing a button or changing a policy. This transition will require a lot of hard work and take more than a decade. And there are still a few technological hurdles we must overcome to make it happen. But it's all within our reach.

Such a profound advance for humanity would threaten the interests of several well-entrenched industries which benefit from keeping energy expensive, even if that means throttling the pace of advancement of the entire human race. For decades now, we've allowed the necessary transition away from fossil fuels to be delayed by politics, corruption, and the conflict of interest posed by lobbyists representing entrenched industries which profit from keeping things the way they are. That has to stop. It's long past time for *We The People* to demand government policy that serves **our** interests. Then a whole new era of human prosperity on the scale of the abolition of slavery and the advancement of society from colonial times to today's modern lifestyle in first-world developed economies will be possible.

My contention is that just *replacing* the energy now derived from fossil fuels with clean alternatives isn't enough. We need to markedly *increase* the amount of energy available to the

economy while simultaneously lowering its cost, so that the *prosperity* known only to the wealthy today can be shared with all of humanity.

But unfortunately, we've already waited far too long to get *serious* about solving these problems. Climate-inspired public policy has become all the rage in recent years, but unfortunately, despite good intentions, much of that policy has been ill-conceived and I'm convinced it's about to backfire in the form of a global energy crisis that could have been avoided.

**The crux of the problem is that we're trying to phase out fossil fuels *before* phasing in viable replacements.**

I want you to imagine living in a place where dangerous air pollution is poisoning you and your family. Would you respond by first denouncing the polluters and then ***stop breathing completely*** in protest, just to make your point? Or would it make more sense to ***continue breathing*** while simultaneously demanding that the pollution be stopped and taking aggressive action to bring about that outcome? And how could a person who ***isn't breathing*** succeed at bringing about the needed change?

A lot of people are just plain fed up with fossil fuels continuing to pollute our atmosphere and endanger our future. Their attitude is to just say no to fossil fuels. They feel we should *do no further harm* than we've already done to our planet, and they feel it's long past time to *Just Stop Oil* in its tracks!

If you feel that way, first and foremost I want to applaud you for your passion and conviction for wanting to protect our environment. I agree it's long past time to solve our addiction to fossil fuels, and I agree that we've already wasted decades making next to no progress on a problem that's been well understood for a very long time. But now I'm going to ask you to hear me out, because I want to make sure you fully understand the implications of *Just Stopping Oil*.

Like it or not, the immutable truth is that the whole world still runs on oil. We already agree that must change, and that time is of the essence to cure our addiction to fossil fuels. But now let's consider what the implications would be if we try and phase out fossil fuels ***before*** phasing in viable replacements.

Planet Earth simply cannot support 8 billion human inhabitants *without* the energy we now derive from fossil fuels. Many of those people now live in poverty. *More* affordable and abundant energy is precisely what's needed to lift them out of poverty and give them better lives.

***Just stopping oil completely, before phasing in viable alternatives, would literally mean committing genocide and culling the lives of at least three billion human beings.*** We simply don't have the ability to feed all those people without modern farming equipment that unfortunately still relies on diesel fuel. If we just stop using oil before replacing it with a clean

alternative, the result would be the deaths of billions of people. That's not exaggeration or hyperbole. That's what would happen if we just completely stopped using oil before replacing it with a clean alternative. Is that really what you meant to propose, or could it be you hadn't fully considered the implications of the policies radical activists have told you that you should favor?

To be sure, we should stop *wasting* energy, and prioritize using it more efficiently. But if you're tempted to suggest that we should just change our ways do without abundant energy, please remember that the advent of cheap and abundant energy is precisely what enabled the abolition of human slavery and made it possible for most of us not to have to work on farms. It's also the reason so many people are now able to pursue higher education, and the reason we can choose from hundreds of occupations other than just farming, which was the only choice for most people 200 years ago.

And it's important to remember that periods of reduced energy consumption equate to economic hardship. This tiny little blip is the 1973 Arab Oil Embargo. This is the 1979-82 double-dip recession when Federal Reserve Chairman Paul Volcker sacrificed the economy to squash inflation, this is the 2008 Great Financial Crisis, and this is the COVID pandemic. Look how small these periods of massive economic and human suffering appear on the energy consumption chart. If we just decided in the name of conservation to cut our energy consumption by 25%, a global depression much worse than the 1930s would result.

To *just stop oil* before bringing clean alternatives online would be equivalent to ***stopping breathing*** just to make a point. It would be suicide by suffocation. Now don't get me wrong. We definitely need to stop wasting time and get serious about making some real progress. But phasing out fossil fuels ***before*** phasing in viable replacements isn't the solution. It's suicide by suffocation!

Politicians eager to win votes from constituents concerned about climate change have engaged in two strategies in recent years. The first is to adopt policies which promote development of renewable energy sources such as wind and solar. That's a good thing, and their actions on that front are commendable. But the politicians don't stop there. Next, they mislead the public with the false insinuation that these renewable energy sources alone could someday replace all the energy we now derive from fossil fuels, which is utter nonsense.

The other major undertaking of politicians striving to signal virtue to their climate-minded constituents has been to scapegoat oil and gas production as public enemy number one. In theatre, everyone loves to hate the villain, and political theatre is no different. Politicians need a bad guy to blame for all our woes, and Big Oil has become the favorite scapegoat.

From cancellation of the Keystone XL pipeline extension to withholding new drilling permits, government policy has shifted from *solving* the energy problem by creating more clean energy sources, to *exacerbating* the problem by vilifying Big Oil and discouraging new oil & gas exploration and production which, unfortunately, is still desperately needed for society to ***continue breathing***.

I predict that the direct result of discouraging and even penalizing new oil and gas exploration in recent years will be a global energy crisis starting in the mid-2020s, which could easily have been avoided. That crisis will cause massive human suffering and starvation, not to mention another global financial crisis that may be worse than 2008. Gasoline, diesel, and electricity prices will all skyrocket, crippling the global economy and limiting economic growth and human prosperity until the crisis is eventually solved.

In order to ***continue breathing***, we cannot afford to scapegoat and punish the fossil fuels industry for the sake of political theatre. As much as it hurts to admit, we still desperately *need* fossil fuels in order not to ***suffocate*** while we're building out viable replacements, something that can only occur over a period of decades, not months or years.

Politicians don't want to face reality when it comes to how long it will take to solve this problem, because doing that would underscore how reckless and irresponsible they've already been by waiting so long before taking the problem seriously. Their most grievous sin has been perpetuating the common public perception that renewable energy initiatives already underway are adequate to solve the problem. They aren't, and it's long past time for the public to be made aware of how monumental the challenge that lies ahead of us truly is. We've barely even *started* solving this problem, and current renewable energy initiatives will only make a small dent in solving a huge problem.

Now don't get me wrong—after spending the last 15 years of my life trading and studying the global crude oil market, I'll be the first to acknowledge that the oil & gas industry has no shortage of shady characters among its leadership. And history includes plenty of examples of Big Oil lobbying lawmakers to adopt legislation that served the interests of Big Oil over those of We the People.

So it's easy to understand why so many young people have become outraged that fossil fuels still dominate our energy supply, decades after it became known that they cause climate-threatening pollution and deplete finite resources that cannot possibly last forever. I really do appreciate that people outraged by the dominance of fossil fuels in our economy have their hearts in exactly the right place. The situation we're in is outrageous and needs to be changed!

But super-gluing yourself to an airport runway, vandalizing centuries-old masterpiece artworks by throwing tomato soup on them in museums, or stopping traffic on major roadways by climbing gantries and threatening to jump off, does absolutely nothing to reform the injustices these well-intended but badly misguided activists want to see reformed.

I submit that the *Just Stop Oil* movement and most other environmental activists are focused on the wrong goal, to the point that their efforts undermine rather than advance their own agendas. Specifically, trying to get rid of fossil fuels ***before*** *installing suitable replacements for them* is counter productive. Doing so would literally cause mass starvation and human suffering. So, my message to *Just Stop Oil* and other activists is that you have exactly the right idea that *we*

*the people* should demand change, but you're seeking the wrong change, because you don't yet have an accurate understanding of the real problem.

The change we should all be demanding is the public adoption of a realistic, aggressive plan to *replace the energy now derived from fossil fuels with clean, scalable replacements.* There's no need to even worry about getting rid of oil, gas, and coal. Just as soon as viable replacements have been put in place, fossil fuels will go away very quickly, because public sentiment already strongly favors replacing them. What we need to focus on, and what all of us should *demand* from our elected leaders, is an aggressive but realistic plan to build out clean, environmentally friendly energy sources that can really and truly replace the energy capacity of fossil fuels. That's not happening today.

In the wake of the pandemic, I started noticing some very concerning signals in the crude oil market, which I traded professionally for well over a decade. The signals I've been monitoring since late 2020 are telling me that it's already impossible for the global economy to return to its full pre-pandemic growth trajectory, because there simply isn't sufficient energy supply to meet demand in that scenario.

Depletion of existing producing resources, a lack of investment to replace them thanks in part to the ESG movement, damage done to the energy industry by the whipsaw in demand during the COVID pandemic, and exhaustion of spare production capacity, are all coming together to form a perfect storm on the near horizon for the global oil market, and I'm convinced that a global energy crisis will be the unavoidable result.

The energy crisis I predict will be driven by supply shortages of oil and natural gas, and it's going to be a really big deal. Therefore, understanding its origins is vitally important. So important that the entire 2$^{nd}$ episode of this docuseries will be dedicated to that subject. For now, please just trust me that a really big storm is brewing. The next episode in this docuseries will fully explain what's coming and why it can no longer be avoided.

Many people have been misled to believe that electricity or hydrogen are viable replacements for fossil fuels, and that the Electric Vehicle revolution already underway is going to solve our addiction to gasoline and diesel fuel. That simply isn't true, so let's focus on that subject next.

To be sure, electrifying the global economy is a very important *step* in a larger strategy to replace fossil fuels with cleaner alternatives. Electric Vehicles have already replaced almost 5% of vehicles powered by internal combustion engines, and we need to accelerate that trend. It's a really important step toward solving our problems, but it's not a solution unto itself.

Electricity and hydrogen are not and will never be a *source* of energy. To say we're going to replace fossil fuels with electricity or hydrogen simply doesn't make sense. Electricity is a wonderfully versatile way of *transmitting* energy from where it's produced to where it's needed, and electricity achieves that with almost no pollution. So electricity is definitely part of the

solution and hydrogen almost certainly will be as well. But neither electricity nor hydrogen are energy *sources.*

It's true we can power vehicles with either electricity or hydrogen, but that electricity or hydrogen doesn't grow on trees. There are no electricity mines or hydrogen wells. Both electricity and hydrogen have to be produced from energy derived from another source. In the case of hydrogen, it's an element that occurs in nature, but there is no natural source of *pure* hydrogen. To get pure hydrogen suitable for use in a hydrogen fuel cell, you have to consume energy produced from another energy source in order to separate and compress the hydrogen into a usable form. To generate electricity, we still need another *energy source* from which that electricity can be generated.

There aren't many viable options for replacing "baseload" electric power generation which is primarily enabled by burning coal today. We'll explore those options in detail in later episodes in this docuseries. But more to the point, the challenge is not *just* to replace the electricity that comes from coal today with something cleaner. We're going to need *much* more electricity than we ever needed before.

Society has already become comfortable with a future in which most vehicles are electric, and that's a really good thing. The electric vehicle revolution is a desperately needed step toward solving the overall problem. Internal combustion engines should be replaced wherever possible with electric motors that don't directly pollute the atmosphere. Not just in passenger cars, but in construction and farming equipment and everywhere else internal combustion engines are used.

But hold on! For some reason, very few people realize that replacing internal combustion engines with electric motors in vehicles, construction equipment and farming machinery represents only one quarter of the challenge of electrifying the global economy. To electrify our world, four separate challenges exist, and very little attention has been paid to the last three.

The **first** challenge is to replace the vehicles and other machines that use internal combustion engines with new versions that use electric motors instead. The electric vehicle revolution already underway addresses this need, and everyone already understands it. We have a lot more gasoline and diesel vehicles left to replace than we've built electric vehicles so far, but at least we're on the right track and off to a decent start.

The **second** challenge is one that nobody ever seems to talk about: where is all the electricity going to come from to power all these new electric vehicles, electric construction equipment, and electric farming machinery? We're used to living in modern society where it *seems* like all you need to do to get electricity is to plug an appliance into a wall socket and it works. But there's a lot more going on behind the scenes to deliver electricity to that wall socket, and that's what we need to talk about next.

A lot of early buyers of Electric Vehicles never realized that if they live in areas where electricity is generated by burning coal, then driving their EV may have resulted in even *more* carbon emissions than driving a high-efficiency diesel vehicle, not less! Of course, there are no carbon emissions directly from the electric vehicle itself, but the electricity needed to recharge that electric vehicle was generated by burning coal and that means carbon emissions. Maybe even more carbon emissions than the old-school vehicle the EV replaced!

Every bit of energy now supplied by gasoline and diesel fuel will need to be replaced with new electric generation capacity *we simply don't have yet*. Returning to this chart, most of the coal shown in grey and about 40% of the natural gas shown in purple is used to produce electricity today. Most of the oil shown in blue is used to produce liquid fuels for vehicles and other machinery.

To electrify the economy, we don't *just* need to find enough new clean electricity to replace the energy we now produce by burning most of the grey coal and 40% of the purple natural gas. We also need to replace almost all the blue oil with new clean electricity to recharge all the vehicles that will no longer be burning liquid fuels. *That's whole a **lot** of electric power generation capacity we simply don't have yet.* And it's not possible for the EV revolution to replace 100% of internal combustion vehicles until we build all that new electric generation capacity we don't even have a plan for yet.

And that's the real point: We don't even have a credible plan yet for where the electric power generation capacity will come from to replace every single watt of energy now derived from burning fossil fuels. Wind and solar only help a *little bit.* They are intermittent sources that play an important role in the overall solution, but they will never provide the 24/7 baseload power supply needed to electrify the global economy. We still need to replace all the grey, 40% of the purple, and most of the blue energy on the chart with continuous energy sources capable of meeting our baseload power demand.

The **third** challenge is one that even fewer people understand: How are we going to get all that electricity from where it's produced to where it's needed? The current electric grid in almost every country on earth is already running at or near capacity. That's why, for decades now, California has been experiencing rolling blackouts during summertime when air conditioning demands the highest electric loads. The electric grid we have now can just barely meet *existing* demand for electricity. It was never designed to recharge electric vehicles.

We're still very early in the electric vehicle revolution. Less than 5% of vehicles on the road today are electric, and many of those are hybrids which recharge themselves by burning fossil fuels. Yet already, electric vehicle recharging needs are straining the capacity of our electric grids.

It's long-past time to *get serious* about solving the fossil fuel problem, and one of the prerequisites to a real and meaningful solution will be to dramatically increase electric grid

capacity worldwide. This is easily within our reach, but it doesn't come free, and it won't happen overnight.

Our elected leaders should have recognized two decades ago that we need a massive public infrastructure investment to build out a new electric grid with far greater capacity than the current one. That will cost a lot of money and take a long time. Those two immutable facts are the real *inconvenient truths* that we should be talking about in public debate, but so far, our elected leaders find it more rewarding to pretend that EVs and windmills alone are going to solve the problem. That's just plain nonsense. We might as well adopt rainbows and unicorns as cornerstones of energy policy.

The **fourth** challenge is the scalability of electric vehicles with specific regard to the battery technology they rely on. The current state of the art in electric vehicles depends heavily on Lithium-Ion and Lithium polymer batteries. Lithium is an environmentally challenging metal to mine, and the global supply of lithium is limited. It's not yet clear where all the lithium would come from to make enough batteries to electrify the 95% of vehicles that still run on fossil fuels, or if that's even possible from known lithium deposits in the Earth's crust. But Lithium is just one of the raw materials needed to make electric vehicle batteries. We're also going to need lots and lots of Manganese, Cobalt, Graphite, and Nickel. That's a whole lot of mining that will have to occur to make all those batteries, and mining is an extractive industry with its own environmental challenges.

Disposal of worn-out lithium-ion batteries presents yet another serious environmental challenge. All these challenges can probably be overcome in due time. We can take steps to improve the environmental impact of mining lithium, we can continue to search for new battery technologies that rely less on scarce and environmentally challenging materials, and we can institutionalize lithium-ion battery recycling globally, so that we don't replace an old form of environmental pollution with a new one.

It's important to appreciate that while these problems are almost certainly *solvable*, they haven't been solved *yet,* and they won't be solved overnight. We don't presently have anywhere close to enough lithium, cobalt, nickel, and other raw materials needed to replace all our internal combustion vehicles with EVs powered by lithium-ion batteries. We don't know where to find the needed materials, and so far, we've yet to invent new kinds of batteries to avoid needing all those exotic materials.

These are just examples of the large number of very real and daunting hurdles which must be overcome to electrify the global economy. Building EVs and windmills is only a very small part of solving the overall problem, and we need to stop pretending this transition will be easier than it really will be. *We're only just getting started.* We should have started decades earlier, but we didn't. What we need to do now is start being realistic and looking at the problem in terms of logic, reason, and hard data in place of emotion, hyperbole, and political scapegoating.

Scarcity of the rare earth elements needed to make the high-powered magnets in wind turbines, and environmental concerns associated with mining them, are yet another example of why the approaches the public is being told will solve this challenge are not really scalable or realistic.

The next topic we need to cover is thermal efficiency of energy conversion, which is really important. We get more than 85% of our energy from coal, oil and natural gas. In all three cases, the way energy is extracted from these fuels is by burning them to release heat energy. The 136k TWh figure I discussed earlier refers to the amount of **heat energy** released from those fuels. But with current technology, we're not very good at using that heat energy efficiently, especially when that heat is being used to generate electricity.

We use the heat energy we get from burning fossil fuels most efficiently when that heat is used directly to heat something else. For example, when natural gas is used to heat a building with a modern high-efficiency natural gas furnace, up to 92% of the total heat energy released by burning the natural gas is put to good use, and very little goes to waste.

But when we burn natural gas to produce electricity, it's much less efficient. Only 45 to 50% of the heat energy in the natural gas gets converted to electricity. About half of the energy goes to waste, in the form of heat released into the atmosphere at the electric power station, contributing to climate change.

Electricity generated from burning coal is even less efficient. The typical coal fired power plant operates between 35% and 38% thermal efficiency, and even the very most efficient state-of-the-art coal burning powerplants only operate at 46% thermal efficiency. More than half the energy released from burning coal goes right up the smokestack, along with all the greenhouse gases given off from burning all that coal. Nuclear is much better than coal, but even the most efficient nuclear power plants still waste half the heat energy produced by the reactor.

Internal combustion engines are even less efficient than burning coal to make electricity! Most gasoline engines operate at around 20% thermal efficiency. That means that when you spend $100 filling your car's tank with gasoline, $80 of your hard-earned money will go to producing heat and greenhouse gases that all come out the tailpipe and do nothing to propel your vehicle. Only 20% of the energy released from your $100 fuel purchase was used to propel your vehicle.

The latest state-of-the-art, high-efficiency diesel engines can operate at up to 40% thermal efficiency, but even then, more than half your money is being spent polluting the atmosphere and nothing else. Less than half the energy released by burning fossil fuels in any internal combustion engine is used to propel the vehicle. Thankfully, electric motors are much more efficient.

But the point I really want to impress upon you is this: The only reason we *need* the full 136k TWh of thermal energy we presently derive from fossil fuels is because we're so inefficient at using that energy. We could make do with half that amount if we could magically convert heat energy into electricity with 100% thermal efficiency and zero waste.

Climate activists sometimes try and argue that this negates the arguments I made earlier that wind and solar can never solve more than half the problem. They argue that wind and solar generate electricity directly, without having to convert heat into electricity, which is true. But then they try and argue that this means electricity from wind and solar really could solve the entire problem, which is nonsense.

First of all, wind and solar both involve significant inefficiencies because windmills never convert anywhere close to 100% of the wind energy into electricity, and solar panels never convert anywhere close to 100% of the energy in sunlight into electricity. But more to the point, wind and solar are *intermittent* power sources that only produce electricity when the wind is blowing, or the sun is shining. To be sure, they're extremely valuable sources of electricity at those times, and that's why they're such an important part of the overall solution.

But even the latest technology that stores energy produced by wind and solar for later consumption when it's needed introduces very significant inefficiencies, just as burning fossil fuels does. Thankfully wind and solar do it without greenhouse gases, and that's why they're such a valuable part of the long-term solution. But they don't provide the baseload power needed to run the economy when the sun is down and the wind is calm, and that's why they'll never solve more than half the overall problem.

Turning heat into electricity with zero waste and 100% thermal efficiency is impossible. But to my thinking, if we sent humans to the moon more than half a century ago, we ought to be able to figure out how to do a whole lot better than wasting *more than half* of the energy we derive from fossil fuels when they're used to make electricity. And there's no need to even try and achieve 100% efficiency. If someone could just figure out how to turn heat into electricity while only wasting 25% of the heat energy instead of just over half of it for electric power generation from natural gas or even as much as 80% of it in the case of gasoline internal combustion engines, that alone would be a game-changer.

This is not my field, and I don't pretend to be an expert. But my instinct is that we've spent way too many years staying stuck on the idea that boiling water into steam and using it to turn a turbine is the only way to make electricity from heat. The steam turbine was invented in 1884, and, so far as I know, almost all the research on converting heat energy into electricity has relied in one way or another on that 140-yr old invention. Smart people have tried to make steam turbine electric generation more thermally efficient for many decades, with little success. Seems to me it's past time for someone to think outside the box, ditch the steam turbines completely, and invent a better way to make electricity from heat! And considering that we're wasting considerably more than half the energy we derive from burning fossil fuels, there's a lot of opportunity to make the world a better place if someone would just invent a better mousetrap.

Let's return now to the main topic of phasing out fossil fuels. To achieve that goal without throwing the world into economic depression and causing mass starvation, we need to first replace every bit of energy we now derive from burning coal, oil, and natural gas with clean

alternatives. We know that *electricity* provides an excellent way to get the energy from where it's produced to where it's needed, so it makes sense to focus on energy sources that are well suited to generating lots and lots of electricity. We know that wind and solar can never solve even half of the problem, and even that's ambitious considering how long it's taken to build the current fleet of wind and solar power generation stations, which supply less than 6% of the energy currently sourced from fossil fuels. Hydroelectric renewables are another great source of clean electricity, but hydro only works in places with waterways conducive to building hydroelectric power stations, so the degree to which hydro can help is location-dependent.

The big question is, where is the rest of the energy going to come from to replace all the energy we now derive from fossil fuels? The purpose of this docuseries is to answer that question. There aren't many alternatives, and we'll discuss them in detail in coming episodes.

But unfortunately, there will be consequences to the mistakes we've already made by trying to phase out fossil fuels *before* phasing in viable replacements. I'm convinced that a global energy crisis is imminent, and that gasoline, diesel and electricity prices will skyrocket. The reason is that ill-conceived policy and insufficient investment have left the global oil and gas industry with inadequate supply and spare production capacity to allow the global economy to return to pre-pandemic growth trajectory. And unfortunately, it's already too late to avoid a major energy crisis.

So the 2nd episode in this series will discuss the impending global energy crisis and its origins and remedies in detail. Then in the final three episodes we'll return to the question of where all the energy is going to come from to replace the fossil fuels we so badly need to phase out.

**Episode 2: Origins of the mid-2020s Oil & Gas Supply Crisis**

I'm Erik Townsend. In episode 2 of this 5-part docuseries, I'll begin with an abbreviated history of the crude oil market. Then I'll explain how and why the escalating cost of oil production has already undermined our quality of life and retarded the pace of societal advancement, even before the COVID pandemic. Then I'll explain several signals I've seen in crude oil markets since the pandemic, which are all flashing red, telling me that a global energy crisis punctuated by much higher gasoline, diesel, and electricity prices is *imminent*.

Let's start with an abbreviated tutorial on the history of oil production, focusing primarily on what you need to know to understand why the pace of societal advancement has already slowed considerably in the last 50 years.

I want you to imagine that your family just inherited a beautiful farmhouse with a big, beautiful apple tree in the backyard, which you plan to harvest to help feed your family. In the beginning, it would be silly to spend money on ladders or take the personal safety risk of climbing the tree trying to pick the apples at the top. There's plenty of *low hanging fruit* ripe for the taking, so at first, it's a simple matter of walking out in the backyard and just reaching out and grabbing all the apples you need to make apple pie every night.

But with the passage of time, you'll use up all the low hanging fruit. You're still a long way from running out of apples; there are still plenty left on the higher branches. But now you need a stepladder to reach more apples. Once you have that stepladder, you won't need a full-height ladder for quite a while, because the next tier of apples was just a couple of feet beyond your reach without the stepladder. But in due time, you'll eventually have to work much harder to get the apples near the top of the tree. If you're farming these apples as a business, that will mean the *cost of production* of each apple will keep getting higher as you have to work harder and harder to get the apples farthest out of reach from the ground.

The oil industry works the same way, but over a much longer time period. In the beginning, there was so much crude oil in the Earth's crust that there were a few places known as tar pits where crude oil would just seep up to the surface all by itself. Think of this like the very lowest hanging fruit on the apple tree. It wasn't even necessary to drill an oil well to get a low-quality grade of crude oil. It seeped up from reservoirs far below the surface all by itself. But that kind of crude oil wasn't suitable for refining into much other than asphalt for making roads with, because sunlight caused a lot of the lighter hydrocarbons that would have been useful for making fuels to evaporate off.

Early oil wells known as *gushers* were akin to the small stepladder in the apple tree analogy. One of the very first and most famous gushers was named Spindletop. It was drilled 3 miles south of Beaumont, Texas in January 1901. In a gusher, the natural underground reservoir pressure is high enough that all you had to do is drill a hole in the ground, and once you did, crude oil came gushing out at high pressure all by itself. In the case of Spindletop, oil gushed out at the rate of over 100,000 bbl/day for nine days straight before the well could be capped.

Spindletop marked the beginning of the Texas oil boom and a turning point in energy history. Before Spindletop, rock oil had been used primarily to provide lighting from oil-burning lamps, and as a lubricant for machinery, which was still relatively new at the time. It was only after the *abundance* of Spindletop's gusher was fully appreciated that *fuels* derived from oil began to replace coal as the primary fuel for engines, starting with oil-fired steam engines and then later, internal combustion engines similar to those that still power most non-electric vehicles today.

The analogy to the low hanging fruit of the apple tree is that in the beginning, the oil industry focused its efforts primarily on finding more *gushers*—oil fields with so much natural reservoir pressure that no more work was required than drilling a hole deep into rock below the surface, to release oil that would pump itself to the surface under its own pressure.

In the early days, when oil was discovered in reservoirs that lacked sufficient pressure to drive the oil to the surface, oil producers generally just moved on looking for the next gusher. After all, why put all the effort into figuring out how to *pump* oil from below ground up to the surface if you could just move on to *lower hanging fruit,* in the form of another gusher where the oil flowed to the surface all by itself. The apple tree was still full of fruit in those early days.

But before long, it was realized that oilfields with sufficient natural pressure to form gushers were becoming fewer and farther between. What's more, some oilfields that started out as gushers experienced a loss of reservoir pressure after a few years of oil production. In the beginning, they were just abandoned when they no longer had sufficient pressure for oil to pump itself to the surface without the need for mechanical pumps. But even in those early days, geologists knew they were wasting plenty of perfectly good oil below ground, for the simple reason they hadn't yet figured out how to get it up to the surface.

Soon the lift pump was invented. Those gizmos you see in oilfields that look like birds bobbing up and down are called *pumpjacks*, and they form the above-ground portion of a crude oil lift pump. This technology made it possible to produce much more oil from any given oilfield after the gushers stopped gushing on their own, and it also made it possible to develop oilfields that didn't have enough natural reservoir pressure to form gushers when the well was first drilled.

I want you to notice a pattern that's already forming in this story, because that pattern is going to continue right up to this day. Each step along the way, the oil industry has always figured out how to overcome challenges that arose, and get more oil out of the ground. We weren't running out of oil then and we aren't running out of oil now. But there's a clear pattern here: For the sake of economics, the industry always starts with the lowest hanging fruit before they spend any money on ladders. In this example, they developed the natural gushers before they invested in inventing and then deploying lift pumps.

What that means is that even though we're nowhere close to running out of oil in the ground, the higher you reach up the proverbial apple tree, the more expensive it gets to produce each incremental barrel. In the beginning, the oil just came gushing out all by itself. Later on, you had

to invest in building and installing lift pumps in order to get the oil you needed. And for decades after that, it kept getting more complicated, and more expensive.

The oil industry has had a long and interesting history with lots of fascinating developments along the way. But in the interest of staying focused on events that relate directly to the subject of this docuseries, I'm going to fast forward just over half a century to the next event relevant to the topic at hand.

In the mid-1950s, a Shell Oil geologist named Marion King Hubbert observed that the production profile of any given oilfield has a predictable shape and looks approximately like a bell curve. In the beginning of any oil field's development, production climbs quickly as more and more oil wells are drilled into the same underground reservoir. But eventually, all those oil wells sucking oil out of the ground cause the reservoir pressure to drop, and that makes it much more work to pump each incremental barrel out of the ground. At the peak, you're nowhere close to running out of oil in the reservoir. There's plenty of oil left down there. But it takes more and more work, and therefore expense, to produce each additional barrel. The result is that production begins to decline predictably.

Hubbert extended this theory to observe that the same phenomenon that applies to a single oil field applies to any collection or group of oilfields. In the late 1950s, Hubbert predicted that lower-48 United States oil production would peak around 1970, and that global oil production would peak around 2000. And his predictions were far more accurate than he's generally given credit for.

In Hubbert's day, the only known way to produce oil was what we call *conventional production* today. That means drilling good old fashioned oil wells on dry land or in shallow water, and then pumping oil out with lift pumps. Newfangled oil production technologies like horizonal drilling and hydraulic fracturing had yet to be commercialized when Hubbert made those predictions, so he didn't consider their effects on production in his calculations.

If you frame Hubbert's predictions in terms of the kind of oil production that was known in his day, he got both calls exactly right. Lower 48 U.S. *conventional* oil production peaked right around 1970 when Hubbert predicted it would. We'll explore non-conventional production in just a minute, but first I want you to take this important point to heart: *conventional production* also peaked globally in 2005, just a few years after Hubbert's 2000 prediction, and has never been exceeded. We've set new production records since then, both in the U.S. and globally. But those higher production levels were only possible thanks to the latest and greatest non-conventional production technology which didn't exist when Hubbert made those shockingly accurate predictions.

Now here's why this is so important to understand. Think of *conventional oil production* as referring to the oil that's easy to find and cheap to get out of the ground. In other words, the apples on the bottom half of the apple tree. When all you need to do to produce crude oil is drill a hole on dry land or in shallow water, install a lift pump, and pump the oil out, it usually costs

less than $20/bbl to produce oil that way, even in today's inflated dollars. But unfortunately, we've already found and developed most of the conventional oil plays on Planet Earth. It's very unlikely there will be any major new oilfield discoveries which can be produced using the simple and cheap technology of conventional production. In other words, by 2005, the bottom half of the apple tree had already been harvested.

Returning to our story, the 1950s and 1960s were a period of great prosperity, and that prosperity was directly enabled by cheap and abundant energy thanks to oil. We didn't yet realize how much damage we were doing to our environment with all the pollution and carbon emissions, but the economic benefits were profound, and quality of life advanced considerably in those decades.

Lower-48 U.S. production peaked around 1970 just like Hubbert predicted, and energy prices started to rise. The 1973 Arab Oil Embargo greatly intensified the problem, and the 1970s energy crisis ensued. It's no coincidence that the 1970s were a decade remembered for crippling stagflation, poor performance for the stock market, and generally difficult economic times for all of society. Remember, societal complexity and the pace of advancement of the human species is a function of the amount of cheap and abundant energy available to the economy. We starved the economy of energy in the early 1970s, and we paid a high price for the rest of the decade.

Another important trend of the 1970s was the Women's Movement, which liberated women allowing them to pursue careers on equal footing with men. Obviously, the women's movement was a good thing, but a consequence that's seldom appreciated is that the positive effect of women gaining the freedom of choice muted our awareness of just how badly the 1970s energy crisis damaged our standard of living. Prior to the 1970s, before U.S. lower 48 conventional production peaked and before the Arab Oil Embargo, one man's salary was entirely sufficient to provide for a family of four in a respectable middle-class lifestyle.

Of course, it was an injustice when women were not allowed to pursue careers, but my point is that before the 1970s energy crisis and ensuing economic stagflation, one salary was all that was *needed* to provide for an entire family. All other factors being the same, when women began careers, creating dual-income households, our standard of living should have improved dramatically thanks to all that additional income. But it didn't. By 1980, working was no longer a *choice* for women—it was a necessity, because by then, two incomes were *needed* to experience the same standard of living that was possible in the 1960s with just one person earning enough money to provide for an entire family.

By the mid-1980s, oil prices had come back down in inflation-adjusted terms. Some people believe that President Reagan brilliantly architected a master plan to bankrupt the Soviet Union by suppressing global oil prices, starving the Soviets of their primary export revenue source, while simultaneously forcing them to spend beyond their means in the arms race. Other people give Reagan far less credit and suggest it just happened to work out that way without any master plan conceived by the President. But one way or another, by 1986, oil prices were the

lowest they'd been in well over a decade, in inflation-adjusted terms. And it was no coincidence that the economy was booming! The 80's were a boom time for the economy and marked the beginning of an epic bull market in stocks. The good times continued through the 1990s and it wasn't until the dot com bust in 2000 that the music finally stopped for the economy. The 80s and 90s were a wonderful time for humanity, and affordable energy prices during that period were a big part of the reason.

But by 2003, the U.S. invasion of Iraq had dire consequences for the global supply of petroleum. Energy prices rose dramatically, and by 2005, gasoline prices reached unprecedented levels. The gulf wars were part of the reason, but another reason this happened is that just as Hubbert had predicted almost 50 years earlier, *conventional* oil production, referring to oil wells drilled on dry land or in shallow water with no fancy technology, had peaked globally.

Speculators in crude oil markets would soon become obsessed with a hypothesis known as *Peak Oil*, which was based on the idea that Hubbert's predictions of global conventional oil production peaking in the early 2000s would result in a massive global energy crisis. The popularity of that hypothesis was one of the factors that led to the meteroric rise in crude oil prices in the first half of 2008. It seemed like nothing could stop oil prices from rocketing higher, and it wasn't until the Great Financial Crisis took hold and demand collapsed, that oil prices finally collapsed as well. The jury is still out on whether high energy prices which lasted through July 2008 played just as big a role as the mortgage fraud crisis in crashing the economy by the 2nd half of 2008.

In my opinion, the Peak Oil crowd had exactly the right idea. They just failed to anticipate that the energy crisis they feared back in 2007 because of **conventional** oil production peaking in 2005, could easily be delayed by at least a decade and maybe even longer, if non-conventional oil production technology could be ramped up to produce more oil than was possible using conventional production techniques alone. And thanks in large part to a mountain of easy money financing in the wake of the great financial crisis, that's exactly what happened.

The oil industry commercialized horizontal drilling and hydraulic fracturing, which helped us recover from the Great Financial Crisis and made the U.S. Shale Oil boom of the 20-teens possible. We've also developed sophisticated new technologies for drilling oil wells in extremely deep ocean water, and even producing oil deep below the ice in arctic regions.

But my whole point is, all this fancy technology comes at a cost. We haven't run out of oil yet, but gushers like Spindletop that made it possible to produce oil for $5/bbl or less are a distant memory. *The low-hanging fruit at the bottom of the proverbial apple tree is long gone.* All the cheap and easy to produce oil accessible with conventional production had already been found, and that kind of oil production peaked in 2005. Since then, so called "tight oil" plays, deepwater offshore drilling, and other exotic and costly technologies are needed to meet global demand for crude oil.

*And that means the cost of production will keep going up.* It's completely impossible for global oil prices to drop below $40/bbl in anything short of a global pandemic collapsing demand, because it costs more than that to produce each marginal barrel using the technologies which are now required to produce all the oil needed to meet global demand.

The U.S. shale oil boom of the 20-teens was enabled primarily by a mountain of easy-money financing, thanks to unprecedented loose monetary policy from central banks in reaction to the 2008 great financial crisis. The shale boom brought energy prices down dramatically, and it's no coincidence that the economy and stock market bounced back with vigor as soon as energy became affordable again.

But very few investments in the shale boom were profitable. It wasn't so much the case that lots of money was to be *made* from producing all that shale oil. Rather, a mountain of easy money was *available to borrow* from the junk bond market at near-zero interest rates, thanks to loose federal reserve monetary policy intended to stimulate the economy after the great financial crisis. That mountain of easy money enabled the shale boom of the twenty-teens, but that series of events is very unlikely to be repeated.

And shale oil works like an apple tree, too. The shale oil producers carefully prioritized their production activities to focus on the low-hanging fruit first. They drilled and fracked their first shale wells in the very most productive deposits known in the industry as *sweet spots*, leaving the less financially attractive drilling sites for later development. The point is that while the shale boom may not be over, the cheapest "low hanging fruit" shale oil has already been produced, and production costs are unlikely to come down from here.

Energy now costs more than double what it did when I was a kid, even after adjusting for inflation. And that directly translates to two incomes rather than one being needed to provide for a family of four with a typical middle-class lifestyle. It means much harder economic times now than in the 1950s and 1960s, and the pace of societal advancement slowing to half what it was when I was a kid.

Remember the core lesson of this docuseries: The *pace of advancement* of human society is a function of the amount of cheap and abundant energy available to the economy. As energy becomes more expensive as a percentage of global GDP, the global standard of living goes down and the pace of societal advancement slows. And that's been happening for more than 50 years now, thanks to the ever-increasing cost of energy as we slowly move higher up the apple tree.

If we can find a way to replace fossil fuels with new sources of energy which are even cheaper and more abundant than energy was when I was a kid—and I'm convinced we can—then it will be possible to offer the entire planet the kind of prosperity which is only known to the rich today. I'll return to that subject in the next episode. But unfortunately, there's still more bad news to come about what I see on the near horizon for oil and gas markets, so let's return to that subject now.

Climate change became the favorite buzzword of politicians by the 20-teens, and it's about time we finally started to get serious about solving our addiction to fossil fuels! We should have started decades earlier, but there's nothing we can do now to change history.

Around the same time, a new trend known as "ESG" began in the investment management business. ESG stands for Environmental, Social, and corporate Governance responsibility. The idea was *meant to be* that instead of focusing only on how to make the highest possible profits from their investments, morally responsible investors would begin prioritizing making investments in things that did good in the world. They would favor investments that were environmentally responsible, socially responsible, and in companies whose senior management, or *governance*, conducted themselves ethically and with strong moral commitment to serving society responsibly.

To be clear, nothing could possibly be more noble, more honorable, more laudable, or just plain more awesome than the owners of wealth finally starting to take responsibility to invest their wealth in ways that focused on making the world a better place for *all* of society, as opposed to *only* paying attention to how the rich could make themselves even richer. So my hat is off to every single investor who embraced ESG in the beginning, believing it was a way to use their wealth to make the world a better place for all of us.

But unfortunately, the folks on Wall Street who were entrusted to invest those ESG investors' money in environmentally and socially responsible ways didn't all share the same moral compass as the investors who entrusted them to do the right thing. Self-serving opportunists on Wall Street quickly realized that since investors were no longer going to measure their investment managers' performance on investment returns alone, the opportunity existed to baffle them with bullshit, and disguise poor investing skill as socially responsible investing.

Soon the running joke on Wall Street was that ESG really stood for "Extremely Stupid and Gullible", which is what some of the ESG money managers really thought of their clients. A trend that became known as *greenwashing* had Wall Street salesmen disguising investments that had nothing to do with the environment or social responsibility as supposedly being "green" when they really weren't. The noble intentions of ESG investors were compromised by the strongest force known in the universe: the self-serving greed of Wall Street bankers!

Investors tried to fight back by establishing objective systems to grade investments based on their degree of social and environmental responsibility. These grades became known as "ESG Scores" and remain an important part of the institutional investment landscape today.

While ESG scores were conceived with the best of intentions, the law of unintended consequences has had a devastating effect. There's some good news in this story: renewable energy projects based on wind and solar get the highest ESG scores, and this has helped attract needed capital to those industries. And that's a good thing, because we very desperately need to phase in clean energy sources so that we'll eventually be able to phase out fossil fuels.

Returning to the devastating effect of unintended consequences, virtually all investments in extractive industries such as mining and oil & gas exploration and production have the worst ESG scores, and that's made these sectors off limits for many institutional investors. Having oil and gas stocks in your portfolio has literally been a career threatening offense for many institutional money managers in recent years.

The result was a lack of investment that was desperately needed just to maintain current levels of oil and gas production. Returning to Hubbert's Peak discussed earlier, all conventional oilfields experience a production profile that looks like this. As producing wells peak and move into steady decline, new wells need to be drilled just to maintain current production levels.

In the case of shale oil wells, which is where most of the growth has been in the last decade, the production decline curves are much steeper. The reason shale wells can produce so much oil is that the procedure of hydraulic fracturing literally cracks the rock containing the oil, allowing it to flow into the well and be pumped to the surface. But once the oil seeps out of the cracks, production falls off very quickly. Therefore, with shale oil in particular, lots of new drilling and fracking is needed just to maintain current production levels, because existing producing wells are constantly declining in their rate of oil production.

Lack of investment means we're not bringing new producing assets online fast enough to keep up with declining production of the older assets. The result is that global oil supply hasn't recovered to its pre-pandemic levels. More to the point, I don't expect oil production to grow sufficiently to allow a full economic recovery from the recession, because the investment needed to bring about that outcome just plain hasn't occurred.

After going negative during the pandemic, oil prices had risen to their highest level in five years by summer of 2021, long before the February 2022 invasion of Ukraine. That was a strong sign that we simply don't have enough oil supply to meet demand. And then in January 2022, prices rose even higher, even before the Ukraine invasion. And that happened when China, the world's biggest consumer of crude oil, was still locked down hard with its Zero COVID policies in full effect, muting demand.

Goldman Sachs and several other analysts predicted that China's economy reopening would cause oil prices to skyrocket even higher. But by the time China began relaxing Zero COVID policies in December 2022, many economists were predicting a global recession, and expectations of collapsing demand. The United States drew down more than one third of its Strategic Petroleum Reserve, causing oil prices to drop considerably from their peak just after the Russian invasion of Ukraine.

Whether demand destruction from the recession will be enough to keep oil prices down for the full duration of the recession was unknown at the time of this recording. But what I feel certain of is that because of insufficient investment to replace declining supply, the global oil market simply does not have the supply needed to allow the global economy to recover from recession and return to its pre-pandemic growth trajectory. There just isn't enough oil supply for that to

happen. And all of this is before considering any war-related effects. Oil demand in 2022 slightly exceeded 2019 demand, despite that China was still locked down and international air travel hadn't fully recovered. To resume pre-pandemic economic growth trajectory, we need *more* oil than we consumed before the pandemic, and we just plain don't have it.

If Russia were to weaponize oil prices and withhold some of its exports for the intentional purpose of crippling the global economy with much higher oil prices, they could do so very easily. And there's almost no limit to how big the resulting price spike would be or how crippling it would be to the global economy.

There's another dimension to the global oil market that's essential to understand. OPEC, the Organization of Petroleum Exporting Countries, has played a key role in determining the cost of energy since its inception in 1960. The 1973 Arab Oil Embargo discussed earlier was orchestrated by OPEC members led by Saudi Arabia, as a sanction against countries including the United States that had supported Israel during the Yom Kippur war.

For decades, the way the system worked was that OPEC members agreed to produce *less* oil than they theoretically could, to avoid flooding the global market with too much oil and collapsing prices. For virtually all of OPEC'ss 63-year history, the name of the game has been to always produce and export *less* oil than the maximum amount possible.

The difference between the amount of oil *actually* produced, and the maximum amount of oil which could *theoretically* be produced if OPEC members pulled out all the stops and produced as much as they possibly could, is known as *spare capacity.* Exactly how much spare capacity each OPEC member country had at any given moment in time has been a closely guarded secret for decades.

OPEC derives its pricing power from agreeing to produce less than its full spare capacity would allow. And that means the more spare capacity OPEC has overall, the more power it has to control the global price of crude oil. From a negotiating advantage standpoint, it never made sense until recently for OPEC members to reveal the full details of their spare capacity limits to the oil importing countries.

In the last few years, OPEC has almost completely run out of spare capacity. In the old days, the OPEC member countries would agree to production *quotas* limiting the amount of oil each member country was allowed to produce and sell on the international market. But cheating was rampant, and the quotas were seldom fully complied with. It was normal for most member countries to try and get away with producing *above* their quotas so they could make more money.

But for the last few years, most OPEC members have consistently failed to *meet* their production quotas. In other words, they've been producing *less* oil than they're allowed to produce under the OPEC quota system! That's incredibly significant, because it means they've run out of spare capacity completely, and are already producing as much oil as they possibly can. Put another

way, there is no decision that can be made in any OPEC meeting to cause those countries to start producing more oil than they already do today. *They're already pedaling as fast as they can!*

Meanwhile, the language used in OPEC press briefings curiously changed in 2022. They used to talk about *quotas*. Now they've begun using the phase *targets*. As if they're struggling to produce as much as the *target*, as opposed to restraining themselves not to produce beyond the *quota*.

Saudi Arabia and United Arab Emirates are the notable exceptions to this. Saudi Arabia currently produces about 11m bbl/day. In 2022 they announced that their maximum production capacity is 12mm bbl/day and that it would **never** be possible to increase their production beyond 13mm bbl/day, even with additional investment. Keep in mind that they derive negotiating power by overstating their spare capacity, so it's very unlikely these figures are low, and entirely possible they could be high. Saudi Arabia has at most 1mm bbl/day of spare capacity beyond current production levels, and even that might be a stretch. United Arab Emirates also has some spare capacity, but it's less certain how much.

The point is, OPEC no longer has anywhere close to the ability it used to have to limit oil prices by increasing production. Most member countries have been producing every barrel they possibly can for several years now. And the very few that have any spare capacity at all, don't have much.

The implications of this are staggering. For example, I've argued that if Russia wanted to weaponize oil prices as a tool of economic warfare, they might simply withhold half of the 8mm bbl/day they normally export, taking 4mm bbl/day off the global market. OPEC clearly doesn't have sufficient spare capacity to increase production by 4mm/day. At first, it's tempting to think Russia could never afford to withhold half its oil exports because of the revenue loss that would cause. But if doing so resulted in a doubling of the global price of crude, they wouldn't lose anything!

But even setting aside war-related risks, the global crude oil market is already showing very strong signs of being completely tapped out. Most OPEC member countries are producing as fast as they can, and have no spare capacity. U.S. Shale production has recovered nicely since the pandemic, but has begun to plateau at just over 12 mm bbl/day.

In order to arrest skyrocketing gasoline prices, President Biden ordered the release of more than 200mm bbl of oil from the U.S. strategic petroleum reserve, which was meant to be an emergency supply to be used in time of war or when foreign imports were otherwise cut off, not as a tool to suppress oil prices in a mid-term election year. The SPR releases created up to 1mm bbl/day of artificial supply, which is not sustainable. The U.S. SPR hasn't been run dry yet, but as of this recording it was at its lowest level since 1983, and was still being drawn down.

Putting this in context, the amount of oil that was drawn down from the U.S. SPR during the autumn of 2022 exceeded the entire 1mm bbl/day spare capacity of Saudi Arabia, implying that if the U.S. hadn't drawn down the SPR and Saudi Arabia had to make up the difference, doing so would completely consume all of Saudi's remaining spare capacity.

It's important to understand that crude oil prices are prone to dramatic price moves in reaction to even small imbalances between supply and demand. For decades now, the oil market has played a juggling game where there was always some spare capacity in the system and plentiful inventory in the storage tanks. Demand would rise as economic conditions improved, so the industry would respond by increasing production to meet that demand. When the economy turned down, the industry would reduce production to match demand.

This process involves time lags because production can't be changed instantaneously, and that's where commercial oil storage comes into play. All major countries have tank farms where crude oil is stored. If there's a short-term imbalance where supply exceeds demand, extra oil can accumulate in the tanks. Conversely, oil needed to meet a supply shortfall when demand picks up can be drawn down from those same tanks.

Both commercial and strategic petroleum inventory levels are now at generational lows around the globe, meaning that most of those big round crude oil storage tanks are nearly empty. That means that as economic conditions improve and demand picks up, there's not enough oil in the tanks to draw upon to meet that increased demand until more supply can be brought online.

Oil prices are famously inelastic to changes in demand, which is just a fancy economic way of saying that oil prices will go through the roof if demand picks up from here and insufficient new supply is brought online to meet that demand. And for several years now, we haven't invested in bringing sufficient new supply online. We were so busy pretending that wind and solar could solve all our problems that we lost sight of the fact that insufficient investment in oil and gas exploration due to ESG policies was setting us up for a global energy crisis.

The reason it's too late to avoid that crisis is that it takes years to bring new supply online once a new oilfield is discovered. So when prices skyrocket in the mid-2020s, it's not just a matter of pushing a button to make more supply. It takes a long period of extremely high energy prices to incentivize new investment, and the economy will feel that pain for a period of years until more supply can be brought online to fully meet demand. The longer we demonize Big Oil and punish investment managers for providing that desperately needed investment capital, the worse the problem will be and the longer it will last.

Taken together, these factors set the stage for a massive energy crisis, in which fuel prices could easily double if supply is lost due to geopolitical events or if demand picks up faster than supply can be created. The U.S. Strategic Petroleum reserve and commercial inventory are at their lowest levels in 40 years, meaning there's no safety buffer to hold us over if supply and demand fall out of balance.

The consequence of this is that the global economy could get locked in a prolonged recession or even a global depression thanks to unaffordable energy prices. The way this would happen is that as the economy begins to recover from recession, demand picks up for petroleum products. But that small increase in demand causes a gigantic increase in fuel prices, because we don't have any spare capacity or commercial inventory to buffer the bumps in the road.

Those skyrocketing energy prices could be exactly what crashes the economy right back down into recession again, effectively putting a cap on economic recovery due to lack of sufficient energy supply to allow the economy to recover. *In other words, we'll be suffocating ourselves and **not breathing**, because our obsession with pretending that wind and solar could solve everything for the last several years led to under-investment in desperately needed oil and gas production capacity.*

And oh, by the way, all of this is happening at a time when geopolitical conflict between the global superpowers of The United States, Russia, and China are escalating. In my opinion, Russia could easily cause a global economic depression simply by withholding half of its energy exports from the global market as a tool of economic warfare.

In recent years, central banks have responded to economic recessions by providing economic stimulus to help the economy recover. But while central bankers could certainly print up more money to stimulate the economy out of recession, they can't print crude oil. My prediction is that if central banks try and reverse a deep global recession or depression using economic stimulus, the money they print will go straight into inflating energy prices to unthinkable levels. Suddenly all those investment managers who signaled virtue to their ESG-minded investors by refusing to invest in oil and gas won't look so virtuous.

If there's any silver lining to be found in this gloomy story, it's that I predict the coming energy crisis will bring so much public attention to energy policy that we'll finally be *forced* to start taking seriously the work we should have begun decades ago: phasing in viable clean replacements for the energy now derived from fossil fuels, so that it will eventually be possible to phase out fossil fuels entirely.

But make no mistake: Phasing out fossil fuels *now,* as the Just Stop Oil activists are proposing, would equate to suicide by suffocation. We can't possibly solve the real problem of phasing in clean energy replacements for fossil fuels if we ***stop breathing*** entirely. And that's exactly what trying to phase out fossil fuels now would equate to.

Politicians don't want to admit any of this because their climate-minded constituents' *emotional* needs are best met by pretending that wind and solar can somehow provide enough energy supply to replace fossil fuels. Retaining that narrative for as long as we have has been reckless and irresponsible, and it has resulted in the predicament that we now find ourselves in.

So I propose a simple two-part plan for coping with the coming crisis. Notice my choice of the word *coping*, not *preventing.* Unfortunately, it's already too late to prevent what's coming.

Under-investment in oil and gas production, and policy initiatives that pretend it's possible to phase out fossil fuels before phasing in viable replacements, have put us in a predicament from which there is, unfortunately, no escape. I'm convinced a global energy crisis is coming, and coming soon. It will have devastating effects on humanity. The best we can do is try and solve it as quickly as possible, and that can be achieved with the following two-part plan.

Step #1: ***Continue Breathing***. As much as it hurts to hear, that means we need to urgently ***increase*** investment in oil and gas exploration and production so that we can continue to operate the global economy, which simply isn't ready to completely decarbonize yet, because we've wasted too many years pretending that wind and solar can fully replace fossil fuels.

Step #2: *Demand Clean Air to Breathe Just as Soon as we can* ***Realistically*** *get it.* That means it's long past time to abandon the misinformed fantasies of politicians and climate activists, and look beyond wind and solar for *viable* alternatives to fossil fuels. If there's any good to come out of the coming global energy crisis, it will be that we were finally forced to get serious and stop believing in wind and solar fairy tales.

I'm only aware of two plausible alternatives for producing the clean energy we need to eventually phase out fossil fuels, and we urgently need to pursue both of them aggressively, making them top priority in public policy. The remaining three episodes in this docuseries will explore those two alternatives in detail.