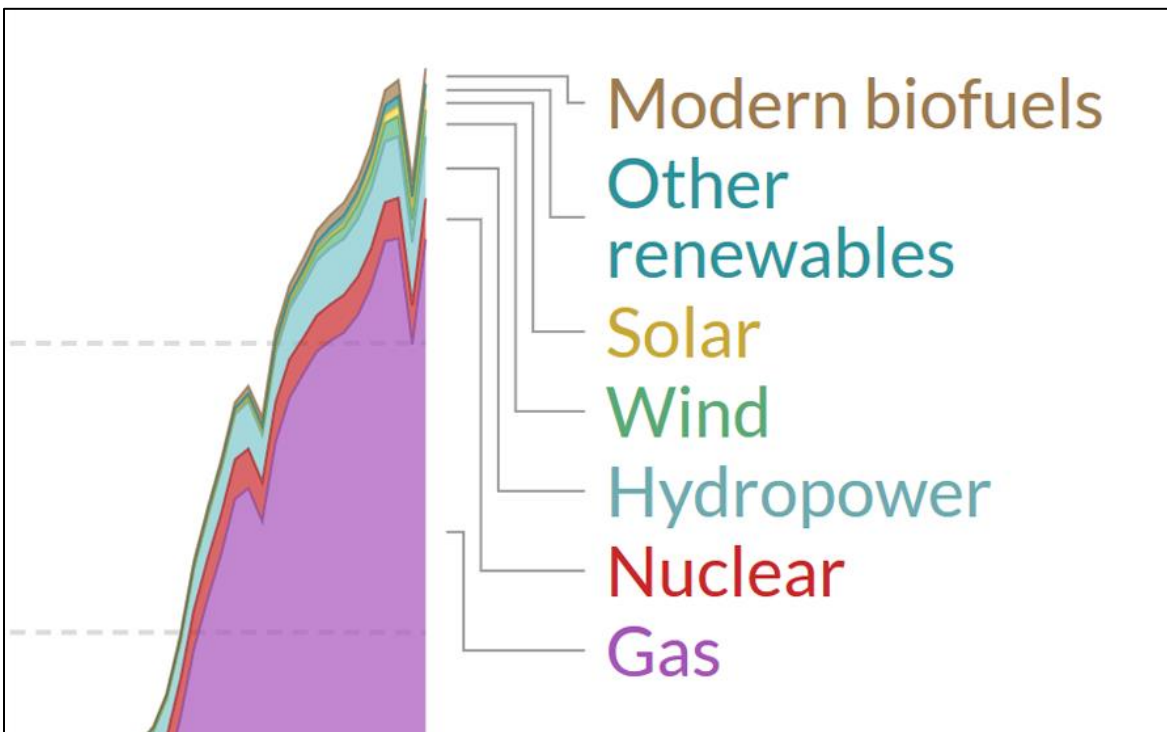
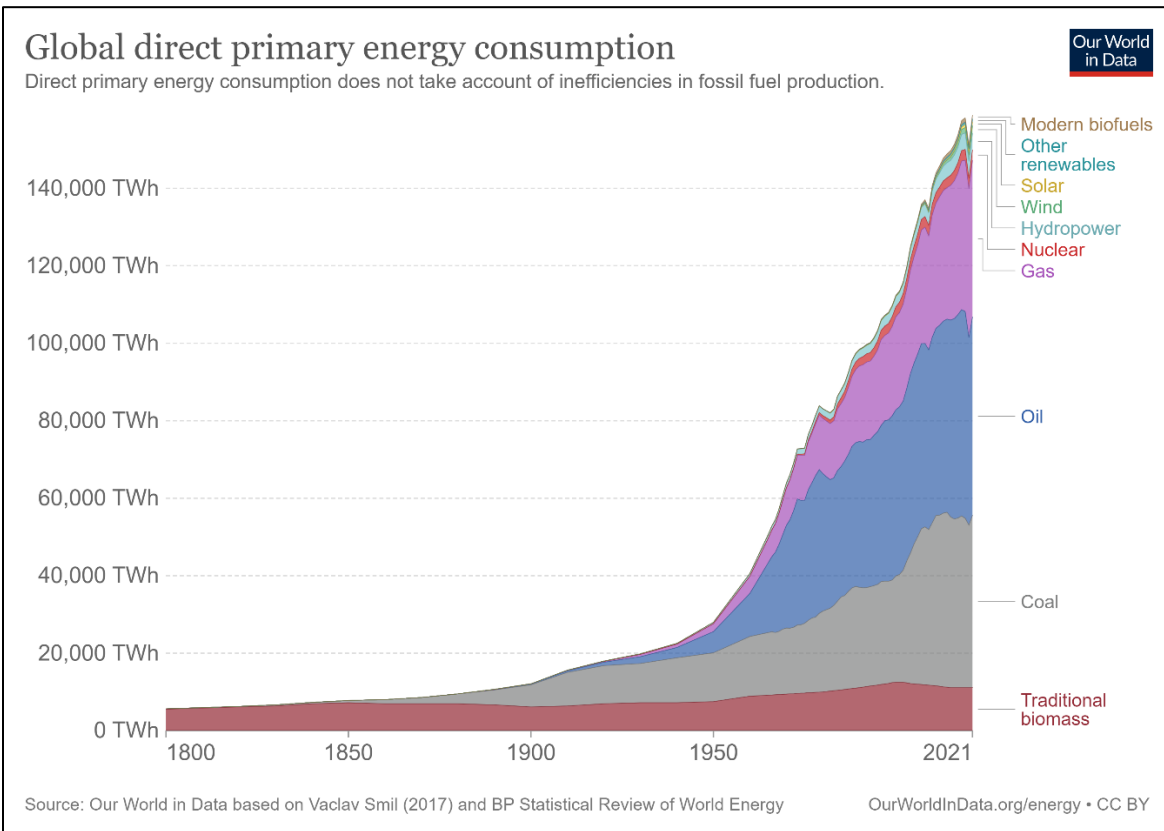


Solving the 2020s Energy Crisis



Narration Script

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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 1990s, 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. As you're about to learn, renewable energy sources like wind and solar will play an important role in the solution, but they won't be enough by themselves. The remaining episodes in this 5-part docuseries will go on to explain why a global energy crisis cannot be avoided in the mid-2020s, and then explore the available solutions for solving the coming energy crisis, by supplying the cheap and abundant clean energy needed to arrest climate change and replace fossil fuels with even more affordable and abundant sources of energy.

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. 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 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 a much 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 oil. 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 family and friends 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, which allows 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 anthropogenic global warming 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 advances we've seen in the human experience have 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 it 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 today 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 before 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 literally 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 in the near future. 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 virtue-signaling politicians are fond of *pretending* that "renewable" energy sources such as wind and solar are going to solve everything. Simply put, that view is just plain wrong. To be sure, 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.

But it's long past time to stop allowing emotion and hope to cloud the immutable scientifically provable fact that renewables cannot ever and will not ever replace even *half* of the energy now derived from fossil fuels. 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're now producing from wind and solar is such a tiny percentage of overall energy consumption that it's hard to make out 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 of the chart that we can barely make them out. And that's after public policy has aggressively subsidized these industries for more than two decades. Compare the size of those renewable sources with coal in grey, oil in blue, and natural gas in purple.

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 we can just get rid of the grey, blue and purple energy sources because we don't 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 grow big enough to replace the grey, purple, and blue slices, despite that after two decades of government subsidies, they currently make up such a small percentage of overall energy consumption that it's hard to even see them on the chart!

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*? The answer is, a whole lot longer than we can afford to wait before phasing out fossil fuels. We've already wasted two decades of inaction on finding more realistic clean energy sources to replace fossil fuels because of the fairly tale we've been telling ourselves that those tiny little green and orange wind and solar slivers are going to obviate the need for the grey, blue, and purple fossil fuels sources.

We cannot allow this fantasy to continue to stand in the way of real progress. Even with the subsidies wind and solar already enjoy, it would take many more decades than we can afford to

wait before wind and solar could even begin to replace fossil fuels. Renewables are a great start, but we need far more energy than they can ever deliver to truly solve this problem.

For humanity to advance, we need a solid plan for replacing *all* the energy now supplied by oil, gas and coal with clean, environment-friendly substitutes. Replacing fossil fuels is a much bigger undertaking than most people appreciate, and it will take decades. Wind and solar are an important part of the solution, but they'll never solve even half of the problem. They're important, but insufficient by themselves. The purpose of this docuseries is to explore *realistic* options for replacing all the energy presently derived from fossil fuels that wind and solar will never be sufficient to replace.

Some people think we should just focus on consuming less energy. 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 to cut our energy consumption by 25% in the name of conservation, a global depression worse than the 1930s would result.

Planet Earth simply cannot support 8 billion human inhabitants *without* the amount of 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. So reducing the total amount of energy we consume is not the solution, but using it more efficiently will help.

I want you to open your mind and imagine what the world would be like if we made the best of the 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 to achieve. And there are still a few technology hurdles to be overcome to make it happen. But it’s all well 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 would 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 is ***not breathing*** succeed at bringing about the needed change?

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 public is being misled by the false insinuation that these renewable energy sources could someday replace all the energy we now derive from fossil fuels.

Returning to this chart showing global energy production broken down by source, if we take all of the wind and solar energy that's ever been brought online through the end of 2021... Every single windmill and every single solar array now in service, it would literally take 18 *times* the energy they produce to equal the energy we now derive from fossil fuels.

It took more than 25 years to build the current fleet of wind and solar energy sources. Even if we *double* the pace of renewables development and build just as much new renewable capacity every 10 years as *all* the renewable capacity *ever* built until now, it will still take 170 years to build out sufficient renewables capacity to replace all the energy we get from 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. More to the point, we can't afford to wait 170 years to solve this problem.

So renewables are a good start, but wind and solar alone will never solve the fossil fuels problem. To replace fossil fuels completely, we need *much* more energy than renewables can ever provide. Politicians and activists who pretend otherwise are doing a great disservice to society. In reality, all of the wind and solar built to date, after two decades of government subsidies, barely solves 6% of the fossil fuels problem.

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 desperately needed 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*.

There can be no question that fossil fuels must be phased out in favor of cleaner, environmentally responsible energy sources. The key point to understand is that they cannot be phased out *before* phasing in viable replacements! We don't yet have those replacements, nor do we have a viable plan to get them in a reasonable timeframe.

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 wind and solar energy initiatives already underway are going to solve the problem. They won'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 haven't even *started* solving this problem yet, if you define "solving" the problem to mean pursuing *realistic* solutions with public policy.

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. So, I really do appreciate that young 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 youngsters 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 dangerous and counter-productive. 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 have an accurate understanding of the real problem.

The change we should all be demanding is the public adoption of a realistic 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 really and truly replace the energy capacity of fossil fuels. That's not happening today.

The reason this is so poorly understood is that virtue-signaling politicians and misguided activists have been perpetuating the myth that renewable energy initiatives centered on wind and solar are going to replace the energy now derived from fossil fuels. That's nonsense, as this chart we discussed earlier clearly illustrates.

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 potential, 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 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 coming energy crisis will be driven by shortages of oil and natural gas supply, and it's going to be a really big deal. Therefore, understanding its origins is vitally important. So important that the entire 2nd episode of this series will be dedicated to that subject. For now, please just trust me that a really big storm is brewing. Episode #2 in this series 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 are already beginning to replace vehicles powered by internal combustion engines, and we need to continue 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 probably 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. 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. The same is true for electricity: to generate electricity, we still need another *energy source* from which that electricity can be generated.

Electricity and hydrogen are not energy *sources* unto themselves. Rather, they provide excellent ways to *move* energy from where it's produced to where it's needed, and they do so without producing the pollution associated with burning fossil fuels at the point of use, which was the old way of doing things.

There aren't many viable options for replacing the "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 entranced with visions of 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, and we should continue doing everything possible to electrify the global economy, so that pollution-producing internal combustion engines are replaced wherever possible with electric motors that don't directly pollute the atmosphere.

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 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 coming from most of the grey coal and 40% of the purple natural gas. We also need to replace most of the blue oil shown on the chart 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*.

So truly phasing out fossil fuels will take much longer, and cost much more, than almost anyone realizes. Hoping that wind in green and solar in orange will generate enough electricity to replace all the energy now supplied by coal, oil and natural gas is just plain crazy.

Electrifying the global economy and getting rid of internal combustion engines is a *prerequisite* to fully solving the fossil fuels problem, but it's not a solution unto itself. We still need to figure out how we're going to add enough new electric power generation capacity to replace every single watt of energy now derived from burning fossil fuels. And that's a *lot* of electricity. Renewables only help a *little bit*. The sooner our politicians and activists stop pretending wind and solar can fully meet this need, the sooner we can get to work on realistic solutions to this problem.

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 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 batteries. Lithium is an environmentally challenging metal to mine, and the global supply of lithium is not unlimited. Furthermore, disposal of worn-out lithium-ion batteries presents a serious environmental challenge. All these problems can be overcome. 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*. We don't have anywhere close to enough lithium to replace all our internal combustion vehicles with EVs powered by lithium-ion batteries. We don't know where to find the needed lithium, and so far, we've yet to invent new kinds of batteries to avoid needing all that lithium. 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.

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.

Tying this all together, there's a really big missing piece to this puzzle. We need to replace every bit of energy we now derive from burning coal, oil, and natural gas. 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.

So 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 gasoline, diesel and electricity prices will skyrocket. The reason is that ill-conceived policy and insufficient investment has 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.