KEYNOTE: STATE OF OIL

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Thank you everybody. And I first of all want to apologize that I am not with you in person. I had really looked forward to being in Bismarck; I have family there, I lived there for a number of years. I'm a native of North Dakota, I love to come back to North Dakota, and will probably do so later this summer. I might teach another volunteer class at the law school for a little bit. I'm sorry, it's mostly class problems that allowed me not to be there. I've been vaccinated so I would have been comfortable traveling, but I'm just not able to do so at this particular time.

So, my assigned task is the state of oil. To talk about the state of oil we really have to talk about more than just oil. So, here's kind of an outline of my remarks. I'm going to first address climate change, and it's real. We're going to have to have a multi-faceted strategy. I think the oil and gas industry can play a very helpful role in resolving climate change. They could stimy it if they don't make some very important and needed reforms. But I think that, on balance, the oil industry has more to contribute, and I think frankly the industry will contribute to the solution. Even though it's fair to say that in the past they've been a source in part of the problem.

So, like it or not, and I don't like it, but I have to accept it, the world has a climate change problem. And frankly this has been proven beyond a reasonable doubt. Mankind is responsible for about 25% of the greenhouse gas emissions, but that's the part of the emissions that's causing the problem. The largest share of it, of course, comes from fossil fuels, which is why the oil and gas industry in particular, and the coal industry, but particularly the oil and gas industry, needs to be responsive. And I think it can be responsive and I'm optimistic that it will be responsive. In 1919 [sic] I worked as a Fulbright recipient at the University of São Paulo at a think tank that was looking at oil and gas and the energy transition. It was all sponsored mostly by Shell Oil Company, so it wasn't some left-wing deal. We worked on natural gas usage and natural gas reform in Brazil which is a very big topic. But we also looked at carbon capture utilization and storage. As a part of my work there I listened to a lot of the climate science, and if you listen to the climate science I think

* A recording of Professor Anderson's presentation can be found online at: https://youtu.be/aRxB9tYL2JM?t=9221.

you come away convinced that this is a serious problem that needs some serious solutions.

And in fact, here's just a little graphic that shows the monthly temperature details since 1851. What's interesting is that in every month in every year since 1976 temperatures have trended warmer than the 1850 to 1900 averages. And only 7 months out of more than 1000 months since 1985 have temperatures been cooler than the 1850 to 1900 averages. Now I could say more about it but I think this slide should say enough.

Now, we have to reduce our greenhouse gas emissions significantly. The big question is how do we do this. Well, I don't have very specific answers but I'm going to tell you about some possibilities. Mark your calendars for May the 18th because the International Energy Administration has promised to publish a comprehensive roadmap for achieving net zero by 2050, which would hopefully limit our global temperature increases to 1.5 degrees centigrade. Now, providing any sort of roadmap has been one thing the Intergovernmental Panel on Climate Change [IPCC] has failed to do during its many years of deliberations. They point out the problem, they tell us in very broad ways how to fix it which is to reduce emissions, but they don't give us much in the way of specifics. The IEA is hopefully going to give us some specifics. This slide by the way is just trying to show you how much we have to address CO2 emissions, which is not the only one, just to have a hope of reaching a 2 degree or preferably yet a 1.5 degree temperature increase.

Here's our CO2 emissions worldwide. You see that electricity and heat represent about 40% of the total emissions, followed by transport, manufacturing, and construction. So, there's lots of areas for improvement.

This shows you the dramatic increase in CO2 emissions as a result of man's activities. I mean, these are all now man-made emissions. We're not talking about the historical natural emissions; they've been cut out of this graph. You see that initially most of these emissions were coming from Europe and the United States until about 1980. Since 1980, mostly from the rest of world but especially from India, China, and the rest of Asia. Reducing CO2 emissions is a daunting task and unfortunately, we probably have less than 10 years to make a major dent, or we reach what scientists are warning could be a catastrophic tipping point.

Now, here you see, on the left, that non-OECD countries, which would include India and China with the developing world, consume far more energy than the OECD countries which includes the United States. Based on this prior slide that tells you that China and India have been responsible for most of the emissions along with the rest of the developing world since 1980 and looking at this slide on the left you'd be tempted to blame China and India for the climate change problem. But when you look at the right-hand side you see that North America has had by far the largest per capita energy consumption, while the Asia-Pacific countries, which includes China and India, are far lower energy consumers per capita. So, if you look at it on a per capita basis China and India don't look quite so bad.

Here's another culprit in greenhouse gas emissions, which is methane. Here we see that agriculture is the biggest emitter. Now methane emissions are far smaller in total emission volume, so if you compare this slide to the prior slide, you notice a big difference in volume. Methane emissions are far smaller, and they mostly dissipate, they don't entirely dissipate, but they mostly dissipate out of the atmosphere in about nine years. So, methane is about 25 times more effective, but I should say, it's a big but, methane is about 25 times more effective at trapping heat than CO2. By comparison CO2 lasts much longer in the atmosphere, gradually dissipating over 1,000 years, although most of it between 20 and 200 years. The science on that is a little less precise.

Well, what's one of the problems with methane? Gas flaring, although not for the reason that you might think. We ought to eliminate gas flaring. It wastes valuable energy. When we flare it though, we actually convert most of the methane to CO2. So, the CO2 is what gets emitted, not quite as potent but much longer lasting. The good news is that the flaring and the venting has been reduced by about three quarters in relative terms since 1970. But the total annual flaring and venting is about equivalent to Africa's total annual natural gas consumption. A lot of that gas could be put to a much better use than flaring it. This results in emissions of roughly 275 megatons of CO2 in 2018 from flaring, as well as some methane emissions because there's uncombusted parts of the flare so the methane rises into the atmosphere. And then of course we have other greenhouse gases such as black carbon and nitrous oxide and chlorocarbons, etcetera. Russia, Iraq, Nigeria, and the United States are responsible for more than half the global flaring. Not shown in this slide is methane leakage. If burned in a modern gas-to-electric generating facility, natural gas is 50% better than coal at reducing greenhouse gas emissions, but that advantage disappears if we have a lot of methane leaks. So, 3.2% methane leakage negates the beneficial differences between coal and natural gas. Chesapeake just announced this morning, Chesapeake Energy in Oklahoma City, its intention to embrace the Project Canary movement. What Project Canary movement is, is a third-party certification program that will measure methane leakage from wells and associated equipment that will trigger a response to contain it. But the certification will help because it will be used by Chesapeake and others who embrace the project to market what they would say would be sustainable natural gas; natural gas that has been produced under the best circumstances possible to eliminate the issue of methane leakage.

Here is a rather busy slide; it deserves careful study. I'll make sure these slides are available to you so you can look at it. You see here that human CO2 comprises about 75% of the total contributed – human contributed – greenhouse gas emissions. Mankind is responsible for about 25% of all greenhouse gas emissions. CO2 comprises about 75% of those human caused emissions. Methane is responsible for about 17% human related methane. And that includes agriculture of course. You can also see the sectors here that are responsible for the emissions. Take a close look here at agriculture. Notice that livestock are responsible for about 1/3 of agriculture's total methane emissions. Much of this is blamed on cattle that burp methane. We used to talk about farting cows but that's really not the problem; it's burping cows. But the question is, is how responsible are cattle for the current climate change problem?

Note here that the beef and dairy cattle numbers have been flat since 1961 which predates any modern concerns about global warming by about 2 decades. Productivity is up which does imply a per head increase in methane emissions but I was not able to find data that really gives me a picture of what that means – a true picture. About 10% of beef and dairy feed contributes to burping methane, in other words it's wasted feed. Research is underway to curb cattle burping using feed additives. Studies might even demonstrate that adding these additives may save money in the long run because it will add more weight to the cattle and more milk production so that utilizing these new feed additives might actually make economic sense. But encouraging less consumption of beef and dairy is likely to do more harm than good and I'm fearful about what the IEA may say on May 18th about this. Why might it do more harm than good? Well, first of all farmers and ranchers who are going to be dramatically affected by climate change should really be natural allies in the fight to combat it. So, let's not alienate a whole segment of society from the climate change goals. Scientists have a hard enough time with climate change deniers so let's not needlessly add to the number of skeptics. Meat grown in laboratories is not the answer because it generates longer term CO2 emissions. And moreover, pastures are natural carbon sinks. Without cattle those pastures would likely be replaced by more intensive agriculture. Ranchers are not going to let their land go idle, resulting in even more CO2 emissions.

Let's get back to fossil fuels. Fossil fuels consumption, unlike beef and dairy cattle the numbers of which remain flat, have gone up a colossal 325% since 1965. Managing these fuels are the key to effectively addressing climate change. But reducing fossil fuel consumption I think is only a partial answer and I think it's one that's likely to fail if that's where our focus is. If we only do that, we will fail because we will not achieve the necessary reductions. There's lots of reasons for that, but two big ones is that some greenhouse gas emissions are very hard to abate. Iron, steel, cement, and chemical plants – we can't abate it, we may be able to capture some of it, but we can't stop it. As of right now, we need all of those things. Just a little factoid here, in a 3-year period from 2011 to 2013, China used more cement than the United States in the entire 20th century. The ultimate solution is to substitute different products for cement, but that's years off. Another problem is long distance transport. Electricity requires a big storage breakthrough, either batteries or hydrogen, and the electricity used to charge the batteries or to make the hydrogen would need to be carbon neutral unless we otherwise capture that carbon. Natural gas, though, could really help long distance transportation if we figure out a way to capture the carbon.

Now, what's the oil industry response been to climate change? I've eliminated the list of oil companies; I don't list any companies except I do mention a couple here. The oil companies, mostly smaller ones that are climate change deniers, are only a small part of the total production so they don't concern me so much. Most of the larger producers are becoming proactive about climate change, some more than others. But we have three different kinds of emissions that we talk about when we talk about the oil industry. Direct emissions are the emissions that the oil industry itself, the oil companies themselves, are responsible for. It's a small amount. Exxon Mobil has announced a plan to greatly reduce its greenhouse gas intensity by 2025. BP on the other hand pledged net zero by 2050 and they're going to invest a lot in renewables. But to accomplish this requires some deception on BP's part. Exxon Mobil gets criticized for not being aggressive, but I think for the most part Exxon Mobil has tried to speak the truth about what it intends to do. BP says they're going to be net zero by 2050 but they're going to accomplish this by selling off, not shutting down, a lot of its greenhouse gas emitting assets. So, whoever buys them is going to go on to continue the emissions. And also, BP conveniently exempts, so doesn't really publicize it very well, that is has an almost 20% stake in Rosneft, that's exploiting a massive oil project in the Arctic, and it exempts that from its pledge of net zero. It's kind of a big deal. The point is you've got to look at these pledges very, very carefully. But I'm very, very happy to see that many, many companies are getting serious about it.

The second scope is emissions by contractors. That would be the drilling contractors and the other service providers that actually do most of the work out in the oil patches. This usage is large but of course it still pales by comparison to scope 3 emissions. But some of the big service providers are also pledging to reduce their emissions.

Then we have the scope three emissions that are the emissions by customers. These are the big emissions. Some of those can be captured at refineries and petro-chemical plants. Some of the CO2 can actually be used for enhanced oil recovery. But for carbon capture to be meaningful, we really have to focus on sequestration of carbon that has nothing to do with benefits like enhanced oil recovery. It's not because we're going to produce yet more oil, it's because the amount of CO2 that we can use just for enhanced oil recovery is nowhere near enough of a reduction in CO2. We really have to capture and sequester it on a massive scale in deep saline aquifers. Who has the best experience analogously to do that? It's the oil and gas industry. Occidental is one company that's taking the lead on that in the United States.

This slide shows how mother nature manages naturally occurring CO2 emissions. If you add up those numbers, it looks like we have the ability to sequester about 17 gigatons of CO2 safely. In other words, manmade CO2, but that's misleading. It is misleading because our CO2 emissions were nearly twice that in 2019, there were 33 gigatons. Also, CO2 is not the only human generated greenhouse gas emission. There's methane, ozone, nitrous oxide, chlorofluorocarbons, and hydro chlorofluorocarbons. And most significantly, greenhouse gases accumulate in the atmosphere and dissipate gradually over time. Think of it as constantly eating more and more food while being only minimally active. You'll gradually gain more weight and more weight without burning it off. We don't have a 17 gigaton safety zone because we have to try to whittle away at the greenhouse gas emissions that are already in the atmosphere which dissipate very slowly.

So, what are our solutions? Certainly more renewables. Certainly more nuclear power. Probably including fusion, I mean, I used to say that nuclear fusion was always 20 years away. It may not be 20 years away anymore. We may have the capability of nuclear fusion within the decade. More efficiency, reduced fossil fuel demand, carbon capture utilization and storage, solar radiation management, all of the above. We have to do all of these things. The oil industry can participate and contribute to many of these. The big one is carbon capture utilization and storage. It's a policy problem, a legal problem, property/contract law/regulation/tax incentives, it's a technology problem, an innovation problem, it's a cost problem. It's a commerciality problem. It's an infrastructure problem. And it is a really big scale problem. But we're making progress. And we need to focus on it more intensely. I first wrote about this in terms of legal aspects over ten years ago, and yet we still have not really addressed many of the legal issues because we've lost about ten years in any meaningful effort towards CCUS. Although the research hasn't stopped and that's been a good thing. A handful of states have enacted sequestration laws, including North Dakota. They're probably going to be inadequate when it all shakes out, there's probably going to have to be some changes made in those laws but they're trying and that's a good thing. Some of this, as I said before, can be used in EOR, but we're still going to have to have much larger scale sequestration.

Direct carbon capture has to be commercialized so we have to have a carbon price. A carbon tax is not necessarily needed. Investors would just be paid to capture the carbon directly from the atmosphere and sequester it in deep saline reservoirs. The technology is there, the scale has yet to come about. A portion of these costs in my view should be directly funded by government tax revenues, federal tax revenues, because ultimately, it's the private demand for the consumption that has benefited society and the economy on whole, so placing all of that burden on let's say the upstream oil and gas industry or the upstream coal industry would not be very fair. In any case, it would have to just be passed down anyway so why not put some direct federal money into it? A portion of the costs could be funded by the private sector to encourage more energy efficiency and the transition to a more carbon neutral energy.

Here is the controversial one: radiation management through geoengineering. It's not a new concept. In fact, the best evidence is really mother nature herself. When there are volcanic eruptions that are strong enough to send particles, particularly sulfur particles, up into the stratosphere it actually cools the planet. But of course, it only does so temporarily because they don't stay there. But I think we're going to have to look at solar radiation management. That might mean putting some pretty scary stuff into the stratosphere. Now the danger of this of course is unforeseen consequences, but I think we're going to have to say yes to some things that may have unforeseen consequences. Perhaps a little bit analogous to the Johnson and Johnson vaccine; it's ran into some temporary issues. Would we rather not have the vaccine? Especially when the data that just came out this morning showed you're ten times more likely to suffer a brain clot if you get COVID than if you take the Johnson & Johnson vaccine. These things are extraordinarily rare, 6 out of several million people. Well, I think again we have to do some careful weighing and we probably are going to end up having to take some risks. Because we probably don't have time to just assume that we can solve the problem with more readily acceptable alternatives.

That brings us to an aside, because I mentioned environmental community. You have to understand, and this is kind of a, none of this is intended as a response to the prior panel that I was allowed to, able to listen to. I couldn't tune in for the initial presentation this morning because of class but none of what I say is intended as a response, it may sound like that. But the environmental community targeted coal prior to 2008 because they thought that nuclear wasn't going to go anywhere; everybody opposed that. And they weren't concerned about oil and gas because about 2005 there were all kinds of books about peak oil supply. "We're running out of oil and gas so we've got to find other alternative energy sources." So, the environmental community latched on to that and thought "well we don't need to worry about oil and gas because that's going to decline anyway. What we need to concentrate on is coal." Well, what happens in 2008 is that everybody wakes up to the shale revolution and we now start thinking about peak demand. In other words, maybe off in the future there will not be sufficient demand for oil and gas. But we'll have more than enough supply. So, the environmental community switches its strategy and starts to campaign to reduce oil and gas supply and demand. One of these strategies concentrates on bottlenecks such as pipelines. They also of course advocate things like CCUS, they want to replace a lot of energy with renewables. Some do I think realistically support nuclear as a necessary evil. Then we get radical proposals like the Green New Deal, total divestment from fossil fuels, even shaming people because they drive a big car or something. We get this net zero, now, for those of you who may not be real familiar with net zero, it doesn't really mean that we quit using fossil fuels. What it means is that we offset the use of fossil fuels so that the net effect of the fossil fuels emissions is zero.

A little word about bottlenecks. What is a bottleneck to attack? Well, pipelines. They attack pipelines because they want to reduce the use of oil and gas. It's really not because they fear pipelines. If you look at shipments by rail vs shipment by pipeline, I guarantee you pipelines come way out on top without question. Cost, safety, environmental impact, etcetera. But, if you want to stop fossil fuel use, you concentrate on bottlenecks and pipelines is a bottleneck.

Nuclear. We're going to need smaller, cookie cutter nuclear plants. Like it or not, I think this is going to be necessary.

Now we come to renewables and fossil fuels. This is going to be an evolution not a revolution. So long as we don't pass a climate change tipping point.

What's the problem with solar and wind? Well, deliverability is a problem because it's only a fraction of actual capacity. Now that's true of any fuel but it is much more of a problem with solar and wind because the wind doesn't always blow and sun doesn't always shine. We can only produce a fraction of what we have capacity for, so let's not forget that. The problem with solar energy, it peaks when demand is medium and not when its high. And wind is more intermittent than solar. Renewables have a problem. In fact, let me go back to this slide for a minute and comment about some of these other things.

Wind has a problem with killing migratory birds, not more probably than the oil and gas industry does but it is a problem. They take up lots of surface, particularly solar does. Outside of putting solar panels on roofs in urban areas, solar farms – and we have them here near me in Georgetown – there's very little additional use of the land that you can make. So multiple use of land is hampered by solar. Biomass such as corn-based ethanol requires intense agriculture, drives up food prices, and it's not very efficient. Sugarcane works quite well in Brazil but it's much better, much more efficient than corn. Geothermal is only isolated in very small parts in the world. Often located in very pristine areas. Imagine if we proposed developing geothermal resources in Yellowstone National Park. Ditto for hydro. Imagine proposing to dam the Grand Canyon. Where else can we put hydro? Well, we can put a lot of it in northern Canada, unfortunately then we've got a big transmission problem which is of course another bottleneck problem. Now I'm not poo-pooing wind, solar, and biomass. They're all important and can make significant contributions to our energy supply. I just want you to understand that there are limitations.

So, what do we need to do? Well, we need to have better energy conservation. That is, doing more but using less energy. And we need to have better efficiency. Those two are likely to contribute much more than renewables. You don't hear much about this stuff because it's not very fun to talk about, it's not very sexy. But it's really, really important.

Let me show you this slide. In 2019 the US consumed about 100 quadrillion BTUs of primary energy. Primary energy does not include electricity because that's not primary. You have to have a source like coal to create the electricity. About 37% of this came from petroleum; 32% from natural gas; 8% from nuclear; about 11% from coal but that's declining; about 11% came from renewables, that's accelerating. That 11% includes hydro, which is the biggest chunk of the renewables. But look at the upper gray box. The renewables by the way, what I did, I put kind of aqua colored arrows on the left-hand side, so my figures are a summation of those terms to get to that 11% figure. But look over here now at rejected energy. Consumed doesn't mean used. Because 67% of what we consumed is actually wasted. Only about a third of it is actually used. Which is about the same as if we had used 100% of the natural gas. Not consumed but actually used 100% of natural gas over here on the left.

We have to become more efficient. It's a simple illustration of the second law of thermodynamics. Energy content doesn't change when we transform it but the problem is the transformation process wastes some of it. A lot of it, actually. So, we have to try to eliminate some of that. Here I give you the figures for efficiency of laboratory conditions for gasoline and diesel. Actual real-world conditions are much less, so in other words a typical automobile uses about 20% of the heat for actual operations. The rest of that is lost through friction or goes out the tailpipe. Land, sea, and airport are about the same; they used about 21% of the fuel for actual work. Coal fired power plants use about 32%, gas fired about 44% but the good news about gas is if you have a combined cycle plant, which is actually now more competitive than coal, you can actually use about 90% of it. Now, another 5% of usable electricity is lost during transmission; it's called line loss.

If we could increase that grid efficiency by 5%, in other words 5% of the 5%, this is what it is equivalent to. So, efficiency is the greater green.

Now waste is not all bad because if you transform energy and you waste some of it, but you make the resulting energy more useful, then that can be actually a net good. So, we could use, for example, electricity, assuming its green electricity, to create hydrogen. And we can use hydrogen, we can store it, and we can use it in transportation and a variety of other uses. That efficiency is about the same as coal.

Here's our global energy flows for 2018 compared to 2050. The world is electrifying. And we show a 225% increase in electricity usage projected to 2050. Why is this? Well because over a billion people have no access to power, mostly in Africa and Asia. We hope to reduce that number by half in 2040 and by 60% in 2050. And electricity is key to tackling climate change because some electricity can be generated without greenhouse gas emissions with less greenhouse gas emissions on a unit of energy basis, and the greenhouse gas emissions resulting from the use of hydrocarbons can be reduced by carbon capture and storage.

This tells you why electricity is so important. It directly relates to the quality of life. All the electrified companies are up here at the top. They have a high quality of life. The countries without reliable electricity are down here at the bottom have a low quality of life.

This is a slide that shows our energy mix from 1850. Look over here at our current mix and how dependent we are on hydrocarbons. Now again electricity isn't shown here because it isn't a primary source of energy. Biomass of course is organic, think of wood and peat and what hydrocarbons used to be millions of years ago. But just look at how dependent we are on hydrocarbons. And I also superimposed on this slide where India and China are today. This is their energy mix so they have a lot more to be concerned about.

This is actually a better slide because this latter slide suggests that our volumes are the same. This is just the mix. This shows the mix and the volume. And look at how our energy consumption has gone up. Exponentially since about 1900. Why? Well, man is inventive. We want to reduce our daily burdens. We increase our population. We want economic growth. And all of that means more energy consumption. In fact, it tracks world population growth.

Population – the rate of growth is slowing but it's still growing. India likely being the leading population growth country in the future. World GDP growing, notice how it tracks that primary energy. The similarities from these three slides are really quite astonishing. 50% of the GDP growth in the future is likely going to come in India and China. Now some good news – energy intensity is going down, in other words we are increasing GDP while using far less energy per unit of GDP. So, we're making progress.

In fact, this slide shows that GDP is going up faster than population, energy demand is about the same as population, CO2 emissions are flat, and it's projected out here, and CO2 intensity is falling per unit of GDP. That's all pretty good news, but probably not good enough news.

I am showing you only a very few energy outlook slides. There are more in the appendix when you get the slides but comparing the recent outlooks is interesting because there is a wide divergence of opinion. IEA of course is one of the most respected. I show in here three IEA scenarios. One is business as usual. One is sustained development which basically gets us to a two-degree temperature increase and one is net zero emissions to get us to one and a half.

Oil demand flattens in business as usual, so it's not going to go up much. It'll go down in the other scenarios, but that can be offset if we have carbon capture utilization and storage and solar radiation management. That may yet prove to be a very good solution. COVID-19 is probably going to have a temporary effect, but it could have a little bit of an effect at changing people's work habits and also our willingness to travel long distances. Public transit has really suffered during COVID because people don't want to ride public transit. We're likely to have a big increase in natural gas usage in business as usual.

But here's the scary part. If we look at just existing and under construction fossil fuel energy infrastructure, we're going to have 1.65 degree centigrade increase in temperature. If we continue to add to our fossil fuel energy infrastructure by opening up new coal plants for example, and I'm talking about a worldwide basis. We're going to reach 2.7 degrees which could be catastrophic. So rather than having 36 gigatons in 2030, we need to get down to 20 or 27.

This is where you have to make the reductions if we don't have significant carbon capture utilization and storage. If we want to look at an extreme, well, I don't want to say it's extreme. It's a very optimistic view if you are concerned about the long term. And this is a professor at Stanford University, his name is Tony Seba. You can look at the website, it's really interesting. He thinks we are on the cusp of a huge disruption in food, transportation, energy, and associated materials. He says that they're going to fall by 10 times their current cost. The processes of manufacturing the food, transportation, and energy is going to become 10 times more efficient, use 90% fewer natural resources, and we move away from an extraction economy to a creation economy. And all of this happens in 10 to 15 years by market forces alone, absent some government intervention to shore up traditional forms of food, transport, and energy. I'm not sure, I don't actually believe this, but he does. He's a credible person and Stanford University is a credible university.

Now I'm going to skip the food because this is not about food. Transport, we're going to have transport as a service. The vehicles are going to be electric. They're going to have a life of 500- to a million miles. Not a range but a lifetime of 500,000 to a million miles. And they're going to be much lower cost than an internal combustion engine vehicle, says Seba. It's going to have a huge effect on the oil and gas industry but an even bigger effect on the automotive industry.

Energy. Solar, wind, batteries, sensors, and artificial intelligence is going to give us energy when we need it on an instantaneous real time basis. It's going to be more localized. We're going to have electricity costs of about 1 cent per kilowatt hour. Well, they're about 8 to 12 in the United States right now, a little more than that in some places. And of course, he says fossil fuel production is going to be stranded. Including the Bakken and other areas including large parts of the Permian.

In other words--he also says electric grids are going to go the way of the landline telephone. He likes to show this slide, about how rapid this is going to occur. 1900 there's one motorized vehicle and the rest are all horse drawn carriages at the annual New York City Easter Parade. In 13 years there's now one horse drawn carriage and the rest are all automobiles. That's how quickly he thinks this is going to happen. It's like oil saving the whale, I like to emphasize that when I talk to my students that oil was considered to be a very green thing at one time. Electric lights almost doomed oil but the internal combustion engine and automobiles saved it. They went on to doom the buggy whips. Digital cameras, a little bit different, doomed Polaroid and Kodak. Cellular phones doomed landlines. He thinks that transportation as a service is going to doom the oil and automotive industries.

There are skunks at the picnic. Bitcoin. This could hugely increase electricity use. I sometimes think Bitcoin is a solution in search of a problem, but one Bitcoin transaction, just one, is equivalent of 28 gallons of gasoline or enough electricity to power an average home for two weeks. And think about it, 2/3 of that energy comes from fossil fuels. I have a good friend, an engineer at Minnkota Power in Grand Forks. They sold their old office building to a company some years back and the company put in servers. And that one building which was the old Minnkota office, with the servers, was the single biggest draw on Minnkota power. Of all the businesses and entities that Minnkota power serves through of course its distributed electricity through rural electric power, that was the single biggest draw. I say it was because the building burned down. 390,000 Bitcoin transactions occurred in 2019 consuming energy roughly the equivalent of Switzerland's total energy consumption for the year. Now there's maybe a potential bright spot here. There's the thought that one solution to natural gas flaring where it's hard to get the gas to a place where it can be generated and used is to convert it to electricity at or near the wells and use it very specifically to power servers to handle Bitcoin transactions. So that's a possibility, that's a possible use of some of this gas that's currently being flared.

But look for the appendix to see some other outlooks here. I've only got a minute left, I want to get to oil. There's going to be another oil boom. This time keep your promise, okay? Don't piss the money away, not that you necessarily did so beforehand. Long term supply and demand doesn't look good, this is Rystad's very recent prognostication. But I'm more optimistic than that, and I think it's going to be better, because we have this problem. This is not to scale, but we have to replace existing declining reserves just to keep up with current demand. If demand does continue to increase at least in the short term, we're going to have to refine new reserves. So, I think we're going to have a new oil boom at least in the near future.

And Rystad actually believes that. Notwithstanding its long-term outlook, it is bullish on oil in the short term because we're going to have an oil shortage problem if we don't invest massive amounts of money now at about double the current rate. Well, that of course has an impact on climate change, which takes me back to carbon utilization and radiation management. Why are we so oil and gas dependent? Because it's so doggone efficient. This is the energy in various hydrocarbons compared to the lithium battery. Only hydrogen beats it. And hydrogen is very difficult to store because it is a very small molecule, it leaks very easily, and hydrogen I think has a bright future but we're a little bit off.

Can we build a better battery? Well, I think so. I think a much better battery is three to four years off. It's probably not going to be a lithium battery. It'll probably be a solid-state battery. It could even be a battery that uses salt. But here's a little thing about why hydrocarbons are so useful. That little, it would take thirteen of those little cell phone batteries to equal one Bic butane lighter, to equal the energy in one Bic butane lighter. If you could power your cell phone with a Bic butane lighter, it probably wouldn't be a good idea because it would probably burn up on you, but if you could do it your cell phone could last you two weeks without a charge. So, can we build one? I think we can, and I think it's going to occur sooner than later.

This is a little bit about problems with hydrogen, I'll skip over that. There's wildcards of course, a lot of things that could change my outlook and other outlooks. Let's move to North Dakota. My biggest fear for North Dakota and for any oil and gas producing state are politicians, who think they can boost the state's oil industry. You can't do it, because global supply and demand is way bigger than North Dakota, it's even way bigger than Texas. The best thing that North Dakota politicians can do is safeguard North Dakota's long-term future. Now there's a minor aside about Biden's ban on federal leasing. I think that has a de minimis impact on North Dakota, but it certainly could have a bad impact on states like New Mexico. I think it's a short-term issue and I think it's going to be worked out.

But politicians can do bad things, but they really can't do good things. In other words, oil is just too big to be impacted by anything the state legislature can do. Here's a book that I would encourage all of you to read. Professor Collier is a professor at Oxford University, he is a fan of exploiting natural resources. He just thinks countries do a bad job of it, and the thesis of his book is that you should exploit your resources, you have to be blessed with them by mother nature, and you have to allow use of the most modern technology like fracking, you can't ban it. And you have to have regulation, including taxes.

So, how are we doing? Well, globally we're doing really bad. The United States is doing better by some measures, but globally there's lots of countries that do a very poor job of this. But I want to focus on, just briefly, are sovereign wealth funds, because North Dakota has a legacy fund. This is Norway's, it's the biggest in the world, it is hydrocarbon based. And Norway has saved its money, and it's used to support pension plans in Norway. Now you wouldn't have to do that, you could support, you could use money for capital investments that would be equal to or better than the oil, gas, and coal resources that they replace. Norway copied Alberta. Alberta had one of the earliest sovereign wealth funds, established way back in 1976. But what they did initially was use it for capital expenditures to improve their health, education, and research facilities. But then, they stopped transferring money to the fund out of royalties, out of the direct oil and gas income, and then they dedicated all of the income to the general fund, flattening the fund's growth, and what's the current state of Alberta? It's broke. In fact, it's worse than broke, its 18 billion budget deficit. It's going to have 115-billion-dollar debt and is projected to get worse over the next few years. The lesson here is, save your money. We don't know for sure when demand will peak. But it will peak at some time in the future.

That said, we're going to have a super cycle, in all commodities. There's going to be lots of work for governments and investors and etcetera. Going to be a lot of new technologies that are going to require new legal solutions. Lots of disputes. Lots of work for lawyers and landmen. What's the most attractive place to be the next ten to fifteen years if you're an oil company? Offshore deep water like Brazil, West Africa, that's the only place you're going to get huge, massive new discoveries. Where else do you want to be? The Permian and the Bakken. Because it's a known resource, it can be tapped quickly to respond to high prices and delayed to respond to low prices. It's a roller coaster ride which is why taxes should tax oil resources progressively and invest, not spend the money. Remember there are wildcards, I mentioned a few. Some wildcards could increase oil demand while others could decrease oil demand. After all, remember ship happens.

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