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SECTION REPORT OF THE

OIL, GAS & ENERGY RESOURCES LAW
SECTION OF THE STATE BAR OF TEXAS

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IN THIS ISSUE

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Chair's Message

On behalf of the entire Council of the Oil, Gas and Energy Resources Law (OGERL) Section of the State Bar of Texas, we welcome our members for the 2020-2021 year! Thank you for renewing your membership (or joining for the first time) during these challenging times for our industry. If you, or others you know, have delayed renewing their membership with the State Bar and the OGERL Section, this is an ideal time for them to renew their membership.

This year, OGERL is pleased to bring you a first. This Section Report is dedicated exclusively to cutting edge legal issues in the renewable energy field. OGERL recognizes renewables as an important and expanding area within its scope. We are quite happy that one of our council members, Brent Stahl, has dedicated his career to the practice of law in this area and agreed to spearhead this endeavor. This issue exists because of his work. Thank you, Brent!

This special issue of the OGERL Section Report covers the gamut – from preparing and negotiating the actual instruments that set up operations to agreements relating to the purchase of the power generated from these activities. The list of authors reads as a veritable "who's who" in the industry.

As a final note, the Council again expresses its sorrow over the passing of Mike McElroy, our good and trusted friend and the man who was slated to be the OGERL Chair this year. We lost Mike to the scourge of cancer this summer, and we dedicate this issue in his memory.

Jeff Weems
Chair, OGERL 2020-2021

Editor's Message

Welcome to the inaugural edition of an OGERL Section Report focusing on renewable energy law topics. We are excited to publish this group of ten articles, with a mix of introductory, overview and advanced topics. Some essays focus solely on legal issues, while others include discussion of commercial and practical subjects. Paper topics include long term ground lease issues, power purchase agreements, tax equity investment structures, mergers and acquisitions, construction contracts, recent case law, property tax incentives, and mineral estate impacts on solar development. You may be particularly intrigued by some of the global energy projections and data in the first article, and you may be inspired to action by its discussion of energy poverty and energy insecurity. If you would like to see a renewable energy focused Section Report periodically repeated, please let us know – we're considering publishing a Section Report like this once a year if the membership finds it helpful.

Thank you to all of the contributors to this Section Report – they put in a huge amount of work to prepare the materials compiled for this Section Report. I really appreciate the dedication, hard work and finesse that the all of the authors have brought to us.

Finally, I want to point out that if you are receiving this Section Report, it is because you are a member of the OGERL Section. As a member of the Section, I want to remind you that you can always access past Section Reports and many CLE presentations via the Section's website: www.oilgas.org.

If you are interested in contributing an article for future Section Reports, please contact Gregory C. Cox, the Section Report Editor for OGERL at (832) 366-9224.

Brent Stahl
Editor for Vol. 44, No. 3
Inaugural Edition on Renewable Energy Law

STATE BAR OF TEXAS

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A CONVERSATION WITH DR. SCOTT TINKER ABOUT TWO FILMS: *SWITCH* AND *SWITCH ON*

Interviewed by Brent Stahl on August 21, 2020

Brent Stahl: I'm here today with Dr. Scott Tinker (www.beg.utexas.edu/people/scott-tinker) to discuss two films on important global energy issues. *Switch* from 2012 and *Switch On* released in 2020 (switchon.org/films). Dr. Tinker, I'll be asking you about the large-scale energy transitions discussed in the film, *Switch*. Then we'll talk about energy poverty and energy insecurity issues found in less developed regions as examined in *Switch On*. First, I'd like to take a moment to try to understand some of the things that led to these two films. As Director for the Bureau of Economic Geology at the University of Texas at Austin (www.beg.utexas.edu), what are the goals of the Bureau?

Dr. Scott Tinker: Well, first thanks for inviting me and I look forward to our visit. I speak often with different kinds of groups, and I particularly enjoy speaking with those who work on the legal issues. So, I really appreciate the invitation. I was in the energy industry for 17 years before I came to UT. I knew about the Bureau, which is the first organized research unit at the University of Texas. It was formed in 1909. We're 111 years old this year, and there's only been eight directors. It doubles as the state geological survey of Texas, and the Director is also the State Geologist of Texas. The Bureau presented a nice opportunity over 20 years ago. I'm now in my 21st year here, and the Bureau's role has evolved. For the last couple of decades, we have refined our mission to bring Energy, the Economy and the Environment together. We do research, both applied and basic, that underpins the intersection of the three Es, as we call them. We strive to have a good basic understanding of scientific and engineering issues in these areas. Our results help those who work in policy, regulatory, industry, academia, and non-governmental organizations (NGOs) -- to do what they do better.

We have about 250 people, and we do research all over the World. It's a lot of fun. It can be daunting at times. An example of where that intersection is quite lively right now in Texas is earthquakes, -- where industry, policy makers, regulators, academics and NGOs all come together with a keen interest in earthquakes. The Bureau built and runs the major seismometer network in Texas (constructed just six years ago), called TexNet, for collecting data and making it available for everybody to use. https://www.beg.utexas.edu/texnet-cisr/texnet. When done well, the intersection of people, data and ideas is very powerful. It allows for compromise, civil discourse, and access to data. At the Bureau we try to build on facts and data. Those are our goals.

Brent Stahl: Well, I'm glad you mentioned data. A lot of the questions we'll discuss today are about getting at the data and understanding what is possible and what is realistic. Before we jump to the films, one more question about your work. If you could achieve one significant milestone from the work and the research you do, what is the one thing you would like to accomplish more than anything else?

Dr. Scott Tinker: Personally?

Brent Stahl: Yes.

Dr. Scott Tinker: I formed a 501(c)(3) a few years ago called the Switch Energy Alliance (switchon.org). I call it my night job, because I donate my time and my wife Allyson and I put money into it. The vision and mission of the Switch Energy Alliance is to inspire an energy-educated future. If I could have some feeling that we'd actually accomplished some of that, I would be able to ride off into the sunset with a smile on my face. But it's not easy. Energy is so wrapped up in all aspects of our lives. There's a lot of opinions and passion, and misinformation. You don't have to look any further than the Democratic and Republican Conventions to see it. There's a lot of passion and politics in energy. I believe an energy-educated future will be a better future. If I can help inspire an energy-educated future, that will be a great feeling.

Brent Stahl: That's a good segue to the first question about *Switch*. In the beginning of the film, you say these words: "I speak around the world to governments, to industry, and to universities trying to build a common understanding of energy. That's my passion." Would you explain the big picture goals of this film?

Dr. Scott Tinker: I want to mention upfront, Harry Lynch (www.imdb.com/name/nm0528314). Harry is a documentary filmmaker, UT grad, and he makes wonderful films on many different subjects. He is my partner in all things Switch. He is the brains. I'm just the pretty face.

When we decided to make the film, it was actually 2009, just before The Great Recession. Harry Lynch had read some of my writing and he was making a short piece on the Barnett Shale at the time - and he interviewed me for that. And then afterwards he said, "You know, you're not bad on camera. Would you like to think about making a bigger film on energy?" I asked him what it would take to do that and Harry explained: "Well, to make a decent film, this much money, a really good one this much, and a great film this much." The Great Recession hadn't hit yet, and so I said sure, we can raise that much. Let's go do it. And we did, but it took a lot longer than we originally planned to raise the money.

We set out to shine a light on Energy, to make Energy the star, show the pros and cons of all major forms of Energy, in their best light. We ended up filming in 11 countries, with over 20 site visits, and did more than 50 interviews. We shot 500 hours of footage to put together an hour-and-a-half film called *Switch*. We agreed we would be objective, nonpartisan, and not try to make anyone look bad or good. We were determined to be nonpartisan. I think we accomplished these things. *Switch* has grown in its appeal and viewership to over 50 nations, 15 million viewers. It still plays on thousands of university, high school and middle school campuses around the world. They start classes with it in policy, business and sciences. It was a lot of fun and a lot of work. We filmed in 2009 and 2010 post-production in '11, and then released it in 2012.

Brent Stahl: Let's talk now about the types of Energy you looked at in the film – it described Biofuels as costly, perhaps too difficult to produce in large quantities globally. Do you see Biofuels growing, plateauing, or perhaps diminishing as we go forward?

Dr. Scott Tinker: Growing… no pun intended, right?

Brent Stahl: Right, right (laughs).

Dr. Scott Tinker: You hit it on the head. Scale is the challenge with Biofuels. And scale is the challenge with all forms of Energy. We just consume so much Energy in the world, we humans. So, you have to meet a certain production level to have an impact. There are a few parts of the world that make Biofuels work, where they have the land and water resources, can grow crops that are dense enough to harvest and convert into liquid fuels. But the process is chemically converting a carbohydrate, one form of hydrogen and carbon, to a hydrocarbon, a different form.

And it takes a lot of Energy to grow, harvest, transport, convert, and transport again. And in doing that, you're using a lot of natural resources--land, soils, water and fertilizers. It's not easy. Western Europe would argue, "But they're carbon neutral," because plants take up CO_2 from the atmosphere, and when you burn them it puts CO_2 back, so it's carbon neutral. But that's a fallacy that ignores everything that goes on between growing the plants and burning the fuel: harvesting, transporting, processing into pellets, transporting. There is just so much that happens along the way --the challenge with Biofuels is scale.

We filmed at a farm in Louisiana. Very fascinating, huge growth of cellulosic material. When you're using food like corn for ethanol, that's a tough sell. You're only using a little bit of the plant and the rest is wasted. But Cellulosics use all the plant –roots, stems, leaves -- everything. You can make a case it works pretty well for Brazil with sugar cane. We went to New York and looked at switchgrass, shrub willow, miscanthus and others. They have about a million acres of dormant farmland in New York. And you think, "Maybe it could be used." The challenge after you grow it is to harvest it, move it, convert it, move it again. Some people are interested, and some less so.

When you harvest that plant, you have to move it to a facility and convert it into liquids. They call those conversion facilities. They're better at naming things than the oil industry, who calls their equivalent refineries. Conversion facilities are a chemical plant that converts agriculture to liquids. To have the energy equation work out, you can't move much farther than about 50 miles, otherwise the hauling truck is using more energy than the harvest will produce. Plants are very low density. So, every 50 miles, you have to have a conversion facility. In New York, they won't even build a new natural gas pipeline, or develop their Marcellus Shale gas, so the chances of building a couple of dozen chemical conversion facilities, I would say, are pretty low. Biofuels have a small role to play, but it's not going to be a big role.

Brent Stahl: Let's talk about Hydroelectric and Geothermal. I saw scenes in *Switch* about the Hydroelectric plant in Norway and the Geothermal facility in Iceland, and in *Switch On*, there was the newer Hydroelectric plant under construction in Ethiopia. What percentage of the world's Energy needs do you project can be met by Hydroelectric and Geothermal facilities.

Dr. Scott Tinker: Start with Hydro. It's a wonderful resource. The Environmental impacts are flooded lands, displacement of plants and animals, including humans, river flows, and lots of cement. The Grand Ethiopian Renaissance Dam—the GERD—is featured in *Switch On*. It's almost three times bigger in generation capacity than our Hoover Dam in the U.S., just to give you a feel for scale. One of the top 10 in terms of generation capacity in the world. Massive. And it'll power, at least in current consumption rates, 50 million people, about half of Ethiopia. Ethiopia will be able to sell power to neighboring countries, feed it into a trunk line that goes to Southern Africa, make money for Ethiopia, et cetera. So, it's a big deal. In terms of environmental and human impacts, a lot of land will be covered in water. GERD will change the silt and seasonal water flow in the river. There are indigenous people in the valley who had to be moved down the valley below the dam. It's on the Blue Nile, which flows North, merges with the White Nile, and becomes the Nile river flowing into Egypt. Colonial law put the control of the Nile in the hands of the Egyptians, and the Ethiopians said, "Well, maybe not." Pick up *The Economist* magazine every so often and you'll see a story on the GERD -- Cairo is threatening to bomb it one week, or coming to the table to negotiate the next. It's changing the balance of power in North Africa.

If you define clean as atmospheric emissions, dams are very clean, once they're built, and they're renewable as long as the rain falls. In times of drought, you don't get as much power from dams. So, it's only renewable as long as there's good rainfall. Dams generate electricity, at probably a 40 to 50 percent capacity factor, that's a typical average for hydro. It's not bad. About like the best wind turbines, and better than solar panels. There are just not many more sites to build dams. Some in Africa, South America, parts of Asia. But there are others being torn down in the U.S and other places. So, as the demand for Energy globally continues to grow, Hydro is going to be in the four to five percent range, probably, for a long time.

On Geothermal, its output has been very small to date, but its potential is larger. The heat of the earth is powerful. We featured Iceland in *Switch*, and that's one of the best places in the world for it geologically. There are other places where the geology is great, subduction zones where the heat of the earth comes near the surface. But there are other kinds of geothermal, like near surface heat exchangers, deep wells, and more. The Bureau of Economic Geology, and others at UT and beyond, are looking at it again. I think Geothermal has the potential to be a contributor, maybe even in the five percent range for global energy. Geothermal has low emissions and it's always on. That's the important difference between Hydro and Geothermal compared to Solar and Wind. They are not intermittent and can provide steady electricity. In other words, they don't need the economically and environmentally impactful redundant backup (batteries and power plants) like solar and wind. And that's very important.

The unavoidable cost of that backup is not put into the calculus with intermittent energy. Even in the LCOE (Levelized Cost of Electricity). They're seeing some of this in California right now with rolling brown and blackouts. It's hot. Demand for energy is high. But there is too much intermittent energy in the grid and not enough available from neighboring states or redundant backup. Thus, the blackouts. It's mostly policy, and Governor Newsom is not being particularly transparent with the people when he blames it on climate change only.

Brent Stahl: It will be interesting to see, after this summer, if the policy shifts a little bit.

Dr. Scott Tinker: It will be interesting, especially after November. I don't see it shifting before November -- you have to attract and retain voters. But maybe we'll see some policy changes longer-term with an energy educated future.

Brent Stahl: So, it sounds like we may see global energy needs being met four to five percent from Hydroelectric, and perhaps as much from Geothermal over time.

Dr. Scott Tinker: Yes, where the resource is good around the world. Hydro and Geothermal are not good everywhere, but no resource is.

Brent Stahl: When *Switch* was released in 2012, Coal was meeting about half the world's electricity needs. What do you see in the short run years for Coal, and then I'm curious what you see beyond that, 20, 30, 40 years out for Coal? And as a practical matter, what percentages of the world's electricity needs do you see coming from Coal?

Dr. Scott Tinker: It's very important when we talk about Coal to understand it's a carbon fuel. It's essentially plants that have been compacted through time and made into a dense form of carbon. And not all Coal is created equal -- the stuff in Vietnam is really dense, hard Coal called anthracite. In Texas we have something called lignite, which is essentially black dirt -- the quality is much lower.

Oil is also generated naturally, but it's complex molecules of carbon and hydrogen, hydrocarbons. And Natural Gas, methane, one carbon and four hydrogens per molecule, so it's mostly a hydrogen fuel. So, we call these fossil fuels, but coal, oil and natural gas are very different in their composition. One all carbon, one mixed, and one mostly hydrogen.

The United States built our electric economy on Coal, so did England, Germany, so is China. And then there are other countries that are starting to, and you see that in *Switch On*, where we visited Vietnam -- 50 new 400-Megawatt Coal power plants in the next 20 years. India is building Coal. And the reason is because Coal is available, it's affordable, it's very reliable. You can baseload with it. You fire up a Coal plant and it runs, and runs, and runs. Keep bringing the trains of Coal in and feeding the burner, boiling water, making steam and turning a turbine. It's hard to argue with people that are building their economies, especially manufacturing economies, like Southeast Asia, that Coal is a bad thing.

In fact, you could argue, it's a good thing, because it builds the economy, and then... a healthy economy allows you to invest in the environmental regulation and policies needed to clean it up. And that's a very strong and real relationship that some policymakers brush past when they're talking to the public. You've got to have a healthy economy to clean up the environment. If you look at where the cleanest air in the world is, or the cleanest soil, or where you can drink the water from a tap -- it's where it's wealthy, in developed nations. I've been in 65 countries in the world on six continents, and the worst environments are where it's poor. Always. They just can't afford to do the clean-up. Bad water, bad soil, poor air quality.

So, this little Energy, Economy, Environment waltz is so vital, and Coal lifts economies up and allows for that. You almost have to push through Coal to get to the next options, like we've done in the United States with Natural Gas replacing Coal as baseload, Nuclear steady, and then growing a renewable portfolio. The same in England and Germany. The other reality of Coal today is that developed economies have exported much of our manufacturing to Southeast Asia -- half of the world's "stuff" is getting made in Southeast Asia now. The emissions are happening over "there," and we pretend like we're low emissions. It's kind of a joke. Except it's not very funny, because there's only one atmosphere. The CO_2 emissions are going into our single, global atmosphere, and we're pretending like we're clean. Some states have similar "you make our stuff" policies. 39 states are net energy importers, running energy deficits, some in a big way. California only produces a third of the energy that it consumes, New York, 25 percent, and Florida, 11 percent. They bring in the energy, and products, from the 11 states in our country who are actually energy exporters. Texas is one of those.

This whole energy deficit--zero emissions--buy credits and offsets--other people make your energy and other stuff--doesn't help the single atmosphere. By exporting to Southeast Asia, the result has been major increases in greenhouse gas emissions. If you put a dot on Bangkok, Thailand, and draw a circle that includes part of India and China, and Southeast Asia (it's a big circle, but not relatively) – that circle contains half of the world's population today, close to four billion people. And they get half of their Energy, not electric fuels, total Energy, from Coal. That's more than the rest of the world's Coal combined, times three! It's a massive amount of Coal consumption led by China, and growing in other states and nations in that region.

So, is Coal going away? No time soon. A Coal power plant will last 50 to 80 years. And most of those newer plants are scrubbing the particulate emissions, sulfur, nitrogen, and mercury, but not the CO_2. And some of those new plants have the scrubbers on sometimes, and off other times. Because each scrubber runs on Energy…an energy penalty, and that makes it more expensive. They're trying to generate the cheapest electricity they can, to build their economies. There's the dilemma.

Coal is globally plateauing, because you're seeing big decreases led by the United States and Western Europe. Natural gas has been replacing coal in power generation remarkably quickly in the United States over the last 10 years, because natural gas is now cheap and abundant. Why? "Fracking" which is shorthand for hydraulic fracturing in long horizontal wells.

Fracking has made natural gas abundant and affordable in the United States. As a result, the United States will meet our power sector emissions targets for Paris this year. Let me say that again. The Paris power sector emissions reductions target in the U.S. was 32% decrease by 2030 from a 2005 base year. We're going to do that this year, a decade early. No other major economy has done that. Who knew that? Inspiring an energy educated future!

Brent Stahl: Mostly because of Natural Gas?

Dr. Scott Tinker: Natural Gas replacing Coal, that's a big wedge. Renewable portfolios in some states, that's a decent sized wedge. Some efficiency, that's a decent wedge. And then there's exporting our manufacturing to other nations over the last decade -- that's a significant wedge, but that doesn't count in the one atmosphere.

And by the way, why was our base year 2005 when the Paris Accord happened in 2015? Because it was our highest emitting year, tied with 2007! We were almost halfway to our target in 2015 when the target was set. You can't make this stuff up.

Brent Stahl: A bit of gamesmanship?

Dr. Scott Tinker: A lot of gamesmanship. But every nation did it. The point being we're down 700 million tons a year in 2020 from where we were in 2005, and that's a lot. Now, we can still do more, but if the world were to follow us, we could meet the climate objectives, just by replacing Coal with Natural Gas, accelerating some Renewables, and becoming more efficient. Of course, there is that little shell game of exporting manufacturing.

Brent Stahl: If you're really counting all of that in the mix, it's not quite as much of an improvement?

Dr. Scott Tinker: Correct. And so, you have to then say, what do we do with the emissions that come from Coal power, Natural Gas power (Natural Gas makes CO_2 as well, just less than Coal per unit of electricity), and other forms? We have to either capture them from the emissions stack and put them back in the Earth -- that's called carbon capture and storage (CCS) -- and/or extract them out of the atmosphere. You literally build big facilities that pull CO_2 out of the atmosphere and put it back into the Earth. Oxy has a big plant they're permitting to do just that. There is an energy penalty for those scrubbers, and that costs money.

Brent Stahl: You mentioned a few moments ago, efficiency issues. I'd like to share a memory from my childhood that I always think about when people talk about trying to be more efficient. I grew up in the 1970s and I remember the Energy Crisis of that decade -- I remember public announcements and discussions in school and at home -- we were supposed to keep the thermostat in the summer at 78 or higher, and in the winter at 68 or lower—and lots of talk about lighter more efficient cars. That all lasted 8 to 10 years, and then things changed as the Energy Crisis subsided. I'm curious if you see the world at some point embracing more of an energy conservation approach, to make the most out of the resources that we have, the oil and the natural gas supplies, and the infrastructure that's already there. Do you see energy conservation at scale in our future?

Dr. Scott Tinker: I hope so. I'll use the word efficiency to describe that combination of things from conservation to just doing more with less in terms of Energy, across the board. Energy used per unit of GDP is called Energy Intensity. Wealthy nations have been flat in energy intensity for a few decades. That's a good trend. It usually comes with a rebound effect. Quite often the more efficient something gets, then the more "somethings" we get. I have one refrigerator, it becomes more efficient, so I get two refrigerators, and now I'm actually using more energy for my refrigeration than I used to, but I'm doing a lot more refrigeration. Same with televisions, computers, cars--pick your favorite toys of the wealthy. So, do you really end up saving that much if you keep adding more things? That's an ongoing conversation.

Nonetheless, efficiency is important. We ended the first film *Switch* with 7 or 8 minutes on efficiency. A bit of filmmaker's inside information here. The ending of a film, if they don't remember anything else, is what they will remember, so ending the film with efficiency was a big deal.

There's a lot of headroom to improve the way we use Energy. Smart meters, smart grids, computers that turn things on and off when you're not there, more efficient cars. Or driving less -- conservation in addition to being more efficient. Unfortunately, a lot of things we think should save energy, don't. Like Uber and Lyft. It doesn't necessarily save energy because your car isn't on the road, because the Uber car is on the road all the time. And it might be delivering one person to one place, inefficiently.

Take Amazon. Is it efficient when they're bringing a product to your door, one item at a time? Well, that item comes on a plane, a boat, a truck, a van, and then a drone, and all those things are using Energy. The cloud itself isn't a cloud -- it's massive data centers. The cloud alone consumes 3% of the world's electricity. Three percent the electricity in the world just for the cloud, and it's growing! Amazon, Google, Facebook and others are some of the biggest energy consuming companies around. They're making all of these "zero emissions" promises for a reason.

That all said, there are a couple billion people in the world today with little to no Energy – their energy intensity is low, but that's not a good kind of efficiency. Their lives are not the kind of lives that humans should live in a modern world. Poor education, polluted water and soil, limited food, and a whole suite of other derivative impacts of having little to no energy. For example, rights and the freedom of women going for the water and cooking indoors with biomass; immigration and migration away from impoverished regions. Endless examples. Poorer nations need access to energy before they can begin to do the kinds of things that wealthier nations do.

Brent Stahl: I have a few more questions on the film *Switch*, and let's then discuss a lot more about energy poverty. In *Switch* you took a look at the wind farm in Roscoe, Texas, that provides electricity for about 100,000 people -- and there are some large-scale solar plants you visited in Spain. I'm curious what realistic portion of the world's energy do you see being met by wind and solar?

Dr. Scott Tinker: Roscoe was a fun shoot for *Switch*! Almost a decade ago now. Wind and solar are resources, just like hydro, geothermal, coal, oil and natural gas. In some places there's a great solar resource, and in some places it's terrible. Same with the wind. West Texas has great wind. It's steady and it's predictable. It comes in the evening, so ERCOT can manage it. Intermittent gusty wind isn't so great. If you have good resources you can maximize performance.

You can only get so much electricity out of sunlight (photovoltaic) or heat from the sun, and you can only get so much electricity out of wind turning a turbine. There are losses that go on. We've been improving on that, which is terrific. There are wind capacity factors now approaching 40%, which is remarkable. And solar is in the 20-25% range now, again remarkable. To add more efficiency costs a lot of money. The materials are very expensive.

The sun and the wind are renewable (when the Sun is gone, we have a much different problem!). Solar resources are predictable, and wind patterns tend to remain steady over decades to centuries -- good things. But the panels and the turbines, and the batteries and redundant power plants are not renewable. You have to mine materials to make solar panels, wind turbines and batteries, and you have to mine a lot of it, because it takes a lot of stuff to collect enough energy to feed our ravenous demand. The amount of mining that will be needed to build solar panels, wind turbines and batteries is unprecedented, and I'm not talking about a few percent more—rather orders of magnitude more. Especially for batteries. So, this is non-trivial, Brent. Then there is manufacturing the panels and the turbines. A lot of manufacturing needed to make the stuff to capture low density solar and wind. And then there is disposal, when they wear out. Wind turbines are mostly inert: metals; copper, composites. But they are big structures. Turbine blades wear out, they get abraded. Solar panels and batteries are not inert. They use materials that are toxic. The panels get scratched. They have to be refurbished or disposed. And batteries wear out. Where do they all go? Mostly in landfills, or dumped in the oceans if they're offshore.

Wind, Solar and Battery facilities, the collection systems, are not renewable. You have to mine, manufacture, dispose, and then they wear out, and you do it again, so there's nothing renewable. Like anything, it's a resource that come from the Earth. We have conflated "green" with zero emissions and renewable. Wind and solar have no emissions at the source, but big environmental impacts on the land. A thought experiment…ask people, "Is mining green? Is chemical manufacturing green? Is landfill disposal green?" Nobody ever says yes. Then ask, "Well, why are wind and solar and batteries for electric vehicles green?" It always elicits interesting looks. Inspiring an energy educated future!

Brent Stahl: A lot more goes into it besides just the actual operations?

Dr. Scott Tinker: Correct. By the way, all that has to happen in the Oil and Gas industry, too. You've got to make the drilling rigs and the pump jacks and the pipelines and the refineries. All that is stuff from the Earth too. They're not getting a free pass. Nothing is. No form of energy is perfect, unfortunately.

Dr. Scott Tinker: The second challenge of wind and solar is intermittency, which we've talked about. The wind doesn't always blow and the sun doesn't always shine. That's important, because the Sun isn't shining at night or on cloudy days, and is less intense in high latitudes. There are a lot of places on earth that aren't windy, and even in windy locations, there are times when it's not blowing

In Texas, we are the largest producer of wind, by far, of any other state in the country, and ERCOT, The Electric Reliability Council of Texas, has managed to keep the power on each summer, but every day is a bit of a brownout panic. It turns out our modern economy doesn't like our electricity going off. It affects a lot of things in a negative way. If the wind slows down or stops unpredictably, what do you back it up with? You've got to have either redundant power plants, which are very expensive, because they're not running a lot of the time, and/or batteries, which are very expensive -- and both of those add to the cost of Renewable Energy, and as we have discussed, they're not accounted for – not even by the approaches that seem like they should account for them, like the levelized cost of electricity (LCOE). The word levelized seems to imply that it's being equally compared, but it's not. And that's why the end user in Germany pays \$0.25 to \$0.30 a kilowatt hour. That's 3X what we pay in Texas, even with all of the wind. California is 2x Texas. New York is about to become 2x Texas, because they won't develop their own natural gas or build a \$1 billion gas pipeline. Instead they are going to build a \$3 billion power line to bring in electricity from Canada. Is a major powerline "greener" than a pipeline?

To add insult to injury in Germany, they were on a nice CO_2 decline for many years as they increased their Natural Gas and Nuclear, decreased their Coal, and increased their Wind. Then they put moratoria on Natural Gas and Nuclear based on a misplaced fracking scare and nuclear fears following Fukushima. They had to start burning more Coal in order to get base load power, and importing more electricity from neighboring countries. So, their CO_2 emissions stopped declining and went flat. Unintended consequences.

Brent Stahl: You just mentioned Gas and Nuclear. In *Switch*, there's a good amount of discussion about how both of those things can be done at scale and can provide base load power and reduce emissions. I was particularly fascinated by what France did over time in terms of an efficient Nuclear system that seems to account for waste storage and safety issues. And so, I'm wondering if the world, at some point, will embrace Nuclear and Natural Gas, either by choice, or by necessity.

Dr. Scott Tinker: I see both Natural Gas and Nuclear growing globally for quite some time. Again, it's going to vary geographically and geopolitically, as with all energy resources. Do you have a methane resource or can you get it? Do you have uranium and thorium or access to them? Are the political philosophies against natural gas or nuclear, as we see in Germany, California and New York? Then what's the demand? China is building or has plans for plus or minus 50 new Nuclear power plants. The United Arab Emirates just opened its first Nuclear power plant this week. They've been building it for years. \$20 billion for a 5.4-Gigawatt plant. Zero emissions energy, always on. They're looking at solar, as well. The parts of the world that are emerging and growing are deploying Natural Gas and Nuclear. Global Natural Gas consumption has grown more than 500% in the past 50 years. It's very versatile. You can run cars on it, make electricity, cook with it, make petrochemicals and other products. It's used in every demand sector. Natural Gas is priced geopolitically and geographically, not fungible like Oil, because we don't move it around in tanker ships in nearly the volumes that we do Oil. Global pricing depends on LNG (liquified natural gas) lanes opening up.

And Nuclear –those economies that have growing, dense cities, need dense energy, and they're building Nuclear.

Globally, I think we're going to see both Natural Gas and Nuclear continue to increase. And that's good for emissions, Gas replacing Coal. Nuclear has zero emissions at the source. It's expensive to build the facilities, but once the plant's built, Nuclear electricity is very affordable. Of course, because of the communist system, China is able to build less expensive power plants. That worries a lot of people in terms of safety.

Brent Stahl: Can you sum up the global energy mix for us?

Dr. Scott Tinker: I see natural gas growing for reasons of access, affordability and versatility. It also has lower environmental impacts than oil and coal. Nuclear will grow because it is remarkably dense and has no emissions. It is one of the few energy sources that can scale fast enough to impact climate change. Fission products will need to be managed, likely in geologic repositories. Solar and wind will grow in rural distributed settings, where no other forms of energy are accessible, and on the grid to a point where the intermittency becomes an issue. The scale of mining and landfill disposal for solar, wind and batteries, and intermittency, will begin to hinder their growth. Coal will plateau in the coming decades globally and begin to decline. Southeast Asia will be the last to leave coal and as such will have the greatest impact on the climate, unless they deeply CCS (carbon capture and storage) at scale. Oil will also plateau in the coming decades, as demand for electric, compressed natural gas, and fuel cell vehicles increases. Hydro will play a supporting role, limited by topographic opportunity and rainfall. Geothermal will grow as it is recognized for low emissions and ability to baseload.

Brent Stahl: Let's shift over to talking about the more recent film that came out this year, *Switch On*. For those of us who have watched the film, you've helped us empathetically understand that a third of the world's population is suffering from some form of energy poverty, or some form of energy insecurity. I'll ask you about a couple of segments in the film, and about solutions that you see, short term and long term. The beginning of the film focused on places in the world where the main way of cooking is dependent on burning wood or burning charcoal. You had examples in Columbia, Nepal, Kenya, and I'd like you to take a moment to describe some of the health issues faced by those populations.

Dr. Scott Tinker: It's one of those "who knew" moments. As you start to look at the numbers, it blows your mind that over two billion people still cook indoors with Biomass of some kind -- wood, charcoal, dung, hay. And the health impacts on the people that live in the home, it's like smoking a couple packs of cigarettes every day. Mothers with lung cancer and cataracts and neurological challenges. Kids with pneumonia and other related smoke inhalation diseases. Three million people a year dying. Brent, so far in the world today, about 750,000 people have died from COVID-19. One quarter of what will kill people in the world this year from smoke inhalation inside the home. And that happens every year, not once every so often with a pandemic.

I'm blown away by this, and it's so solvable. We don't have to have a miracle vaccine coming out. Or shut down the global economy with all of the unaccounted health impacts of that. We just need to put some LPG (liquified petroleum gas), local biogas systems, or electric cooking in these homes, and it changes instantly. And it's not more expensive in most places. In fact, in some places it's cheaper than buying wood. It's an amazing story, and one that needs to be told over and over. And that's why we tried to shine a light on it in *Switch On*. There's so much that can be done for human health today in that area alone.

Brent Stahl: One curious segment in the film is the part set in Nairobi

–where it seems like a lot of people are on the verge of getting better access to reliable and safe electricity, but there are issues with local cartels, and I wonder if you would talk about that?

Dr. Scott Tinker: Well, we've created… I think you'll like this… we've created seven episodes that dive deeper into the stories of *Switch On*. You can't show everything in a 79-minute film. So, we made 20 to 30-minute episodes where we take the story deeper, and one of those is Kibera, Nairobi. Also, Gunchukwa (Columbia), Coal in Vietnam, cooking in Nepal, Hydro in Ethiopia. And it's a little bit different story than the film allows.

What we learn is that one of the biggest inhibitors to getting access to energy is corruption. It happens at the federal, state, local, and even the business level, in these small communities. Every community of any size has a government structure to it. And most slums are run by cartels --let's just use that word, which sounds bad, and it can be, but it's really just the local people who run the village or the community or the slum. In this case, Kibera, which has between 300,000 and 1.2 million people in it. We don't know. Those are the range of answers we got. So, that's a city in and of itself, and the cartel is the power structure. When Kenya Power brought electricity into Kibera on power lines and poles, they co-opted the local leadership to put in the poles and put up the wires, and paid them to do that. That was a good thing, and now there's electricity. People start to establish credit, use a token, and buy electricity, and things are going in a good direction, but the cartel got cut out of the picture. So, the cartel went in and tapped around it and put stolen electricity into the homes, and they charged about the same, or less. The person living in these homes pays less, but it's dangerous because the stolen electricity is not grounded properly. It's killing people. And this is the paradox. No easy solutions.

Dr. Scott Tinker with children in the Kibera slum - Nairobi, Kenya.

The challenge is to figure out how to have the community itself gain the benefit from this new electricity. We try to feature this, subtly, in our film. The new markets that form from access to energy that weren't there before, the woman selling the electric cook top in a little store in Nepal. They're selling popsicles out of the freezer in the mud hut thatched-roof village in Gunchukwa, where we brought solar energy -- and they're going to put that money aside for 10 years and try to replace their solar microgrid battery when it wears out. In Kenya, getting lights, a radio, and a TV into the homes of the Maasai changes their lives. They can now have lighting and read at night, and education begins in earnest. Selling those solar systems is a new market. The villagers that were displaced in Ethiopia -- you saw the grandfather who I was talking with through double translation say, "My kids and my grandkids have things I never had." He was my age, and he'd never had anything that energy provides. So, they're starting to see these things change. But it has to be in the way that the community wants it. Not what I think is good for them, but instead what they want. And then that becomes sustainable. They invest in it, and it continues to grow.


Dr. Scott Tinker with village residents in Gunchukwa, Columbia.

That's one of the great challenges, getting around or working with the often-corrupt power systems because often these poor regions are under the rule of autocrats. The leader says, "We want them to have these things," but they really don't, because the people get educated and they get opinions and they start to vote, and the power structure changes. It's one of the great challenges to lifting the world out of energy poverty.

Brent Stahl: A difficult, and frustrating, obstacle. The film goes on to discuss off-grid solutions – it has examples in Columbia, where there was a community-based off-grid solution. You had some other examples for farming irrigation in Nairobi, and then there was the example in Kenya at the single-family dwelling scale –all off-grid solutions to bring electricity to very poor people in remote areas. And I wonder, what do you see as the potential numbers, in terms of really changing people's lives in those remote areas –via basic access to electricity. What's affordable? What's realistic? How many people do you see benefiting from that over time?

Dr. Scott Tinker: It's a billion people. And potentially close to two billion who have just a little bit of Energy today. A billion people is the equivalent of all of North America and South America combined, Brent. Changed lives for a billion people. And it could be done quickly, in a couple of decades. It is not going to be on the scale of electricity that you and I consume. A rooftop panel in Kenya is enough to put a light in each room, and power a small TV and a radio. If they want a refrigerator, a dishwasher, dryer, stove or an oven, that's a different scale. But it starts small at first and then grows, usually with access to a grid. For example, farmer John put in a few hundred-watt panels to run his pump for fresh water to irrigate. He sells those vegetables and fruits in markets now, so he has started a small family business. Eventually he'll get other things for his home that aren't just lights or ceiling fans. That's the virtuous growth cycle.

A billion people in the world today with no electricity. There's no pipelines or power lines or roads to speak of. Distributed energy is the only way – a biogas system, solar panels, pico-hydro in rivers, micro wind turbines, small scale geothermal systems. These are all ways to begin to get energy when you're off the grid.

Brent Stahl: I saw the example in the film about the liquified petroleum gas (LPG) canisters and the wider distribution. Is that method of providing better cleaner burning energy available worldwide or does it require a certain amount of development infrastructure before it can be implemented?

Dr. Scott Tinker: In the film, we show a bicycle with a couple of heavy LPG canisters for the last leg of delivery. Almost everybody in the world has a bicycle or a work animal of some kind. But you've got to go from producing natural gas, through transporting it on a tanker truck, bottling it, trucking it on a smaller truck to local distribution centers, and then final distribution. But that's true of any energy. Grid electricity goes from massive transformers down to ever smaller, where it eventually transforms down to 110 or 220 volts in your home. That happens with liquids, too. Big ships or pipelines to tanker trucks, to local trucks, to the gas station, to your car.

The exception to that is distributed renewables. A small panel on a roof with an inverter from direct current to alternating current are local. However, the materials that made the panel collecting the sun came from a mine, to the manufacturer, right on down to the panel delivered to the home. Not a local process And I think that's lost on people when they look at a solar panel. They think, "Oh, it's right there. It's local." Well, sure, the sun's local, but the panel isn't.

We've got a lot of other things we're doing at the Switch Energy Alliance. We made a five-minute, Hollywood quality film for energy halls and to run between IMAX and other large screen films at museums. I won't give the story line away, but in five minutes, you understand that Energy underpins your whole world. The Houston Museum of Natural Science and Denver Museum of Nature and Science are lined up. We are visiting with the Smithsonian. Very exciting.

Brent Stahl: And what is that film called?

Dr. Scott Tinker: Probably something like *Energy in Our Lives*.

We just released another big product called SWITCH classroom. It has been in development for two years. We're working with AP Environmental Science (APES) teachers to develop energy content for their year-long class. Critical thinking, pros and cons, non-partisan objective energy, in five different energy units to meet the AP standards. Some 6000 teachers teach it and 200,000 students a year take it in high schools across the country. We have developed curriculum and a platform to serve the energy component of that course. There are films, quiz questions, exercises and activities. We released version 1.0. in the last couple of weeks, and already had 500 have signed up to use it.

The platform itself can be used for other courses, and in colleges and universities. These are a few of the things we're doing at Switch Energy Alliance, the 501(c)(3), to inspire that educated future. Bringing film-based, objective materials to museums, classrooms, and the public.

Brent Stahl: That sounds fantastic. In a minute or so, I'm going to ask you to predict that future. Before I move onto that, I want to ask you to sum up the *Switch On* film for us. And my question here is -- what would you suggest as the top three or four things the world could be doing to meaningfully reduce energy poverty and energy security? Looking at a next 10 years' time horizon.

Dr. Scott Tinker: We featured three areas of energy poverty, indigenous rural, "under the grid" urban slums, and clean cooking. First, indigenous rural involves working with communities to bring distributed energy to them, without judgment as to what kind, in ways that they want, and that they will use and maintain. It's a wonderful opportunity for volunteerism. But again, the goal is to teach to fish, rather than give fish. Improvements in cooking would change the lives of over a billion people, and impact can be in a decade or two. It gets the ball rolling.

Second, under the grid involves urban people living near or under a grid, but who cannot afford it. These are mostly urban slums. There are 150,000,000 people moving to cities every year globally, Brent, and a lot of them are living in poverty. They're looking for opportunity to get out of poverty. Sadly, corruption is one of the biggest inhibitors. So, shining a light on corruption, and getting federal, state, city, and business leaders to act in transparent ways, so that we can actually begin to bring the Energy that is all around them to these slums in an affordable way.

It's going to require that we not label energy "clean and dirty" or "good and bad." This false set of labeling, that renewables are clean and fossil energy and nuclear dirty, is not productive. Poor communities and slums are the densest forms of humanity and require the densest forms of energy. Nuclear, Coal, Natural Gas, Hydro, potentially Geothermal. These are the baseload, affordable, dense forms of electricity. They will be supplemented by renewables, for sure. But you could cover all of a slum in solar panels, and it won't generate the electricity needed to run that dense community. So, the partnerships between governments, industry, and academics, in many ways, help bring affordable energy into these very dense, urban regions. And it takes an investment, but then the communities begin to build their own micro-economies, and grow themselves. So, the investment pays out. It's not just gifts.

Finally, the third area is clean cooking, which is so solvable. Deforestation is most prominent in places where they're burning wood for everything. Options for electricity vary. Home biogas system, Natural Gas (LPG), power lines for small-scale induction cooktops or other electric cook stoves. Again, it's partnerships, with local governments, perhaps state governments, and small industries that are needed to deliver the final mile. It creates jobs, industry, and health benefits.

So, those are the three big areas. We need to recognize that every one of these things will improve the health of nearly four billion people. If you look at emerging and developing economies, and those that don't have much at all, it's over four billion people–more than half the world's population. The health effects of improving access to energy are phenomenal. And, ironically, the environmental impacts are improved --when you get wealth, you begin to clean things up.

Brent Stahl: Dr. Tinker, thanks so much for sharing your thoughts about both of these films, *Switch* and *Switch On*. I'd like to conclude here by asking you tell us what you expect, between now and 2050, and after 2050 -- your predictions about what is realistic in terms of how global energy needs will be met at scale.

Dr. Scott Tinker: So, 2050, 30 years…dense energy matters. In order to meet the demands of, let's say, 9 billion people by 2050, we have to have dense energy. That trend has been happening naturally, from the days of hay for our oxen, and wind for our windmills that pump water, all the way up through Coal, Oil, Natural Gas, Hydrogen, and Nuclear. That dense trend has been happening. It's going to need to continue in order to provide dense energy for 9 billion people, and probably growing to 10 billion by the end of the century.

Very doable, as I discussed before. Natural gas growing for reasons of access, affordability and versatility. and lower environmental impacts than oil and coal. Nuclear growing because it is dense, has no emissions and can scale fast enough to impact climate change. Solar and wind will grow in rural distributed settings, where no other forms of energy are accessible, and on the grid to a point where the intermittency becomes an issue. The scale of mining and landfill disposal for solar, wind and batteries, and intermittency will be a challenge. Coal will plateau in the coming decades globally and begin to decline with Southeast Asia the last to leave. Oil will plateau in the coming decades as demand for electric, compressed natural gas, and fuel cell vehicles increases. Hydro will play a supporting role, limited by topographic opportunity and rainfall. Geothermal will grow as it is recognized for low emissions and ability to baseload.

So, that's a century long transition away from carbon, to lower-carbon fuels, but in a natural way driven by physics and economics, and perturbed by policy. For Coal, Oil, and Natural Gas, we will likely see capture and storage of CO_2 at scale. It's expensive, but it can be done. Intermittent, low-density fuels like solar, wind, waves and tides have a significant impact on nature, from mining to manufacturing to landfill disposal, for 10 billion people to build the non-renewable panels, turbines, and batteries to back them up. There could be black swans, for sure. In any future, you have to store Energy. The greater the percentage of intermittent Energy, the more you have to store the intermittent Energy to use it later, when it's needed, or to have back up for intermittent Energy. And that's the great challenge of solar and wind, and at some level, waves and tides

Brent Stahl: Well, that's a fascinating look at what we have ahead of us. I want to thank you for taking the time today to sit down and talk about these films. I really appreciate it.

Dr. Scott Tinker: Absolutely. We're working on a third film called *Making the Switch*, and it's going to be about a sustainable energy transition. The two primary goals being to lift all people from poverty, and to minimize environmental impacts of all forms of energy. We all have a lot of work to do. But it's doable.

Brent Stahl: Great goal for all of us -- I'm glad you and your team are doing the work, and helping us all get there. Thank you.

To see the films, and a tremendous suite of other energy education videos and materials, go to https://switchon.org.