Switch – A Movie about the World's Energy Outlook

This movie directed by Harry Lynch and produced by Austin's Arcos Films, stars Scott Tinker, Texas State Geologist and Director of the Bureau of Economic Geology.

The opening scene takes place at the Evanger Hydropower Plant near Bergen, Norway which is a show piece for clean energy.   The plant is in a mountain, 500 meters below the summit, and at the end of a 1,500 meter tunnel. No one is on site as operations are run from a central control station in Bergen. The generators are connected to high elevation mountain lakes by a 20-mile pipeline and capture 95% of the energy in the water. There are no huge dams. It took 70 years but Norway now gets 99% of is electricity from hydropower.

Mr. Tinker discussed how much energy individuals use (20 million watt- hours per person per year), and describes the purpose of the film. He decided to personally visit the world's energy sources, which he defines with regard to how many people would be powered per year.

Fifty percent of the USA's electricity comes from coal and 50% of that coal comes from the Powder River Basin. The Belle Ayre Mine powers 3.6 million people per year. Every day 80,000 tons of coal are shipped using 5 trains running 24/7. The Powder River Basin is the largest coal reserve in the world and the typical seam is 100 ft. thick. The mine advances about 3000 ft/year. According to Dr. Steve Koonin, the US Undersecretary of Energy, there are hundreds of years of coal left in the Powder River Basin.

The USA's largest coal fired electricity plant is the Parish plant, owned by NRG Energy, in Texas. It powers 900,000 people per year. Coal is the cheapest power source in world, but has environmental problems with sulfur emissions locally, and CO_2, globally. Carbon capture technology is a mitigation to help clean up coal. The DOE is operating such a pilot project. Clean coal could be defined as reducing carbon emissions to those equal to that produced at a gas plant. NRG has a $140 million matching grant from the DOE to reduce CO_2 emissions by 50%, which would be equivalent to a gas plant. To capture 50% of carbon from coal plants worldwide would cost trillions of dollars.

Mr. Tinker then considers oil. The oil price is set at NYMEX and it is this commodity which most affects the economy. Six of the last global recessions were preceded by a spike in the price of oil. Where will future oil come from?. Offshore is the fastest growing production area, and the Shell Perdido Platform is the deepest water platform in the world. It powers 1.7 million people per year. The difficulties of production are due to the location of the platform - 200 miles south of Galveston floating in 8,000 ft of water. Shell has a 100% safety record, but an operations manager stated that advanced technology still requires human input that is subject to error.

The Richmond Refinery near San Francisco powers 3 million people per year. Gasoline is 50 % of production, followed by jet fuel at 20%, then diesel and other products. Richmond produces 25% of the gasoline and 70% of jet fuel for the Bay area. Gasoline has very high energy density at four times that of liquid hydrogen. The largest tanker servicing the Bay area carries about 750,000 bbl of crude oil. The USA consumes 20 mil bbls oil /day. Thus one tanker supplies about 45 minutes of US consumption and world consumption is a tanker every 13 minutes. Increased demand combined with more difficult sources equates to more expensive oil.

Mr. Tinker notes that India now makes more cars than USA, and will soon be the most populated country in the world. There are 600 million people in India without access to electricity. This demand will be met in the next 20-30 yrs and service will rely on coal. In two to three decades, the energy demands of India and China will surpass that of USA and all European countries combined. Most carbon emissions will be produced by India, China, and the developing world. The USA will be a minor player. Carbon sequestration will be developed but not adopted by the developing countries and this will be a point of friction that will be not solved. There will be several degrees of global warming that people will learn to live with because there will be no alternative that is cheap and affordable to the developing world, and the developed world will not be able to subsidize the technology for these countries whose economies will be larger than ours. Coal and oil will power India and China. It will not be clean and there will be risk. The challenge is to maintain the advantages of coal and oil and minimize their disadvantages at a price we can all afford.

Oil makes up the largest part of our energy use. Biofuels are a potential oil alternative, and for 30 years the USA has been the leading producer of this energy. Biofuels are similar to petroleum and can be used in combustion engines. The US has used corn in the process, but in biofuel conversion, you are only using the kernels of the corn. In effect, food is being used for energy, which raises moral questions. Corn ethanol is also more energy intensive compared to other ways of producing biomass. It has a larger carbon footprint and uses more water and fertilizer. In Louisiana, hybrid sorghum has been specially bred for making cellulose for ethanol production. The plant can grow 18 feet in five months and the ligno-cellulose material, the stalk, the leaves, roots, are used in fuel production. Growing cellulosic crops can be productive in the optimal climate. What about in less ideal conditions? For biofuels, it is necessary to look at how all parts of the country can contribute. Switch grass can be grown in agriculture across the country and can be grown in marginal land with high yield, but the conversion technology is still being developed. Microbiology helps to liberate sugars from cellulosic material to make ethanol, but there are no large scale projects to date in the USA. Last year the US produced 25-30 million gallons of ethanol from cellulose, compared to the 10 billion gallons of corn ethanol. Biomass may be an option, but it will never replace petroleum.

Compressed Natural Gas (CNG) is another possible alternative to oil. CNG is usually compressed to around 3,800 psi. A CNG engine resembles a regular gas engine and is very clean. When it burns, CO_2 and water vapor are produced with none of the smoke and particulates associated with diesel. More transit systems are looking toward CNG. The cost of the fuel is less than diesel and has been so for several years. Natural gas is cheaper to operate per mile for buses, but there is a significant upfront cost due to the compressors. If the vehicle is used frequently, the switch becomes economic. CNG could be used for trucks and bus fleets where compression could be done centrally. Still, city bus fleets comprise a small percentage of the diesel used nationally. More savings could be made with over-the-road trucks and city delivery trucks. Conversion of these vehicles would represent an impact to oil use, but although CNG will be a valuable supplement, but it won't replace oil.

The demand for oil keeps growing. Are we running out? In the Canadian oil sands, a typical plant can power 340,000 people per year. Oil sands in the reservoir are as solid as a hockey puck; 80 % of the resource needs to be recovered by a thermal or steam methods. Natural gas heats water to steam, which is piped into an injection well to produce an oil/water mixture. The multi-stage separation process starts with a fluid that is 70 percent water and finishes with a product that is less than 0.5% water. Production from the tar sands is expensive compared to Middle East oil production. A price of $70/bbl for intermediate crude is necessary for the oil sands process to be economically competitive.

Dr. Ernie Moniz, Director of the MIT Energy Initiative, stated that if we consider oil resources that you can obtain for less than $70/bbl, we have a resource of 4 trillion bbls. Between now and 2030, we will use 1 trillion bbls at most. The quantity of oil that is considered a resource depends on the price we are willing to pay. As price goes up, people are willing to explore for more difficult resources. So we're not running out. As price climbs, so will supply. The main replacement for oil will be different sources of oil.

We've had petroleum based vehicles for 100 years and have just recently started a transition away from it toward electric. We have both gasoline-electric hybrid cars and plug- in hybrids that rely totally on electricity. Electric motors are very efficient, but batteries limit the range to about 244 miles. The base price for one option, the Tesla, is $109,000 without extras. It has good torque and performance. The standard model goes 0-60 mph in 3.9 sec   Electrification will be driven by advances in battery technology. If all cars were electric, we would need 40% more electricity and would need to determine more sources.

Iceland is a geothermal hot spot and produces 50% of its energy from geothermal. The 75MW Hellesheidi Power Plant can power 90,000 people per year using just steam and water with no chemicals. However, geothermal is very geology dependent. California has concentrated geothermal, but it is also limited in area. The average geothermal energy is 10,000 times less concentrated than solar energy.

Most homeowners install solar panels based on economics (80%) rather than environmental philosophy (20%). Many communities offer an incentive from the utility and there is also a federal tax credit. Typically a homeowner can achieve an 8-10 year payback on investment. The average solar array powers just 0.4 people per year and it is still expensive compared to coal. Solar electricity is affordable where sun, subsidies, and electric prices are high. Diablo Valley College in California has a parking lot canopy with solar panels on the rooftops, and produces about 50% of the campus' peak electrical demand. Instead of a high front end cost, the campus entered into a long-term power purchase agreement (PPA) at a rate that is less than what they were paying a local utility, so the campus reaps the savings from the beginning. The PPA is with a financial institution that actually owns the asset. The system design is done by a company that operates and maintains the project on behalf of the bank, which is selling the power to the campus for perhaps 20 years. That is where the savings are generated. This is a good example of public/private partnership and benefits the mission of the college campus. In suitable places and with creative financing, solar plants are a workable solution, but they are still limited by high price and low output. The Diablo Valley Campus Plant would power only 200 people per year.

Spain is using different solar technology. The plant at Solucar, Sevilla, Spain can power 12,000 people per year. Parabolic mirrors move to track the sun and direct its energy to a tower where it generates heat that produces steam that in turn drives a turbine to generate electricity. The Andasol Concentrating Solar Station near Granada, Spain, can supply 15,000 people. Molten salt is used to drive the system and store energy. The system has thermal inertia which means it can stay on grid even when the solar source disappears. Subsequently, there is a more stable production for utilities and the grid. These types of plants need to be sited in places with very clear direct sunshine, not reflected light, which can still be used in photovoltaics. The technology may be decades away from providing large-scale economic power.

For 40 years, Denmark has led the world in wind, which now makes up 22 percent of their electricity and they now export power. Turbine towers stand 50 m high. The turbines are fairly easy to install, are scalable in size, and do not emit CO_2 while producing power. Turbines have simple components, are reliable, and last for 20 years. The three-blade turbine that is common around the world was pioneered in Denmark. A wind farm can be built in months. However, although wind is a good source of energy, there is a problem with intermittency. Therefore, it is necessary to diversify and utilize different technologies to support it. Promoting a new energy source such as wind requires vision. Years ago when Denmark started using wind power, people paid more than for energy from traditional sources, but there was a desire for Denmark to reduce its dependency on imported energy. Denmark now has a combination of power plants and strong interconnectors with other countries that enables it to transfer electricity across borders. But Denmark has only 5 million people. All of the country's wind turbines combined power 340,000 people per year.

Mr. Tinker then visited Sweetwater, Texas where 25% of US wind energy capacity is nearby and half of US wind resources are within 500 miles of the Texas Panhandle. The Roscoe Wind Farm near Sweetwater is about 100,000 acres in size, with around 400 landowners. Landowners have done a 180 degree attitude adjustment relating to the wind and the community is very welcoming. West Texas is an economically depressed area where it is so difficult to make a living that young people don't stay. Wind has turned the community around. Landowners now have the opportunity to receive a regular paycheck from leasing their land to wind developers. However, to obtain 20% of USA electricity from wind would require another 200,000 turbines, and people may not want to look at that many turbines. In addition, people don't tend to live where it is very windy, so it is necessary to build the grid out to the wind farms to bring the electricity to the cities. The plan to bring the power from the wind farms to Dallas, Ft. Worth and San Antonio, will require 2300 miles of high capacity transmission, costing about $5 billion and the project will be completed by the end of 2013. For a nationwide project it would be necessary to determine who would underwrite this program. Then there is the placement issue, a no one wants transmission lines running through their family ranch. Placement would have to be worked out county by county. The challenges of transmission and management of intermittent power are handled by the Electricity Reliability Council of Texas (ERCOT), which has documented that electricity usage is at a daily minimum at about 3 a.m. and continues to increase till about 5 p.m., the air conditioning load. Wind output does not match the energy usage. In fact it is almost the opposite. This requires that additional conventional generation be brought on line to make up the difference between the actual renewable output and the demand. In parts of Texas, wind generation can go from several thousand megawatts to 0 in less than a minute. Gas plants can't come on line within a minute, but there are many types of gas plants that can start up within 10 minutes. With both wind and solar energy sites it is necessary is to build natural gas plants to counteract the intermittency problem.

Natural gas can support different renewable energies, and a technique known as hydraulic fracturing has produced a huge source of natural gas. Gas from the Barnett Shale in Texas can power 18 million people per year. Gas is extracted from the rock by fracturing and long horizontal drilling. After a well is drilled water, sand, and chemicals are pumped down to induce the rock to break. This creates new surface area from which the gas can flow. The USA now has reserves of 2,000 tcf gas which is about 200 years of supply at the current consumption rates and natural gas is inexpensive. There is so much supply that the cost is not expected to increase in the next few decades. As natural gas is a fossil fuel, it does produce CO_2, but only half as much as coal. A controversy with hydraulic fracturing centers on water - an average well might require 3 million gallons and a pad might contain multiple wells. Typical additives are a gel to make the fluid flow smoother and reduce friction and corrosion inhibitors. Over 99.5% of the fluid is sand and water. But this means that there are about 15,000 gallons of additives in each well.

There has not been one documented case of ground contamination from fracking in Texas. In the Barnett play, there are thousands of feet of shale to protect near surface aquifers from the fracking horizon. Most of the risks and problems occur at the surface with handling of wastewater and fracking water rather than down hole; there can be fluids that are spilled at the surface; pits for the temporary storage of fluids and waste can leak. Hydraulic fracturing is actually one of the least risky aspects of a natural gas operation. Congress is moving toward more supervision over the fracturing processes. Good measurement analysis is required to determine if environmental protection is necessary.

In other parts of the world, such as the Middle East, sources of conventional natural gas are growing. Because of the nature of natural gas, it is expensive to transport, but it can be processed and made into LNG to be shipped worldwide. The North Field in Qatar was discovered in 1976. Qatar has moved from zero production of natural gas to about 30 percent of the world market in the last 10 years. Very large scale plants are necessary to make the resource economic. The Qatar plant could power 18.5 million people per year. Up to 250,000 cubic meters of gas at -163 degrees C. can be transported one ship. Huge insulation boxes on the ship maintain the cold temperature like a giant thermos. The ships are more reliable than pipelines and can avoid much of the problems crossing national boundaries. A world market for natural gas may develop as it has for oil, providing more diversity of energy supply. Low carbon, low price, and the ability to back up wind and solar means that natural gas will likely be an important part of our energy transition.

Mr. Tinker also examined nuclear energy. The Comanche Peak Plant in Texas can power 1 million people per year. Since Fukishima, people are worried about the structural integrity of nuclear plants. The structures at Comanche are designed to resist 300 mph tornado winds. Dosimeters are used to measure nuclear worker's radiation exposure. Mr. Tinker's guide at the plant has picked up 200-300 millirems in 28 years which is equivalent to background readings. There are several backup generators running on diesel to maintain plant emergency operations. The dangers of nuclear energy are less than those of not having any energy, less than the dangers of coal. No CO_2 is released. Nuclear fuels cost about $0.10 per kilowatt-hour. But nuclear has high up front costs. Five to six billion dollars is required to build and start up a 1 gigawatt plant. The operator is relying on the revenue stream from electricity generation for the next 20-30 years to make it profitable. Nuclear is attractive as a concentrated source of electricity with low emissions. The world may not be able to meet its emissions goals without a significant amount of nuclear energy.

France has no coal or oil and relies on nuclear energy. Nuclear energy was born out of necessity. In 25 years France went from no nuclear to almost 80% of their electricity from nuclear and their safety record has been impeccable. France has the cheapest price of electricity in Europe and generates few emissions. At la Hague, the plant can power 17 million people year. Their solution for waste management is recycling. Spent fuel from France, Japan, Germany, and other countries is reprocessed into new fuel. The recycling process recycles 96 percent of the fuel, which this reduces the volume of waste and contributes to a reserve of energy. Nuclear's biggest benefit is its concentration of energy, but it is also why it must be handled with care.

In Mr. Tinker's summary conclusions from two years of travel, oil and coal are considered foundational resources. Oil reserves are dependent on price; there are 7-8 trillion bbls still exploitable at the right price. A difficulty with renewables is scaling projects to serve more people. Solar power requires significantly more sites to make a substantive energy replacement. Hydropower can only be used in an area with compatible topography and renewable precipitation. No energy source is without challenges. Oil was 50% of our energy use 30 years ago, but has decreased to 34% today. Coal currently supplies 29% of our energy; natural gas is at 23 percent and climbing; nuclear provides 5% and is climbing; hydropower is at 6% and is declining; renewables supply 2 % today and this proportion will rise substantially. If we combine nuclear, natural gas and renewables to replace foundational fuels, the crossover is projected to come 50 years out. To achieve this, the natural gas production will have to double. We will also need three times the number of nuclear reactors. Renewable sources will have to increase five times. The easiest way to meet the challenge is conservation.

Forty percent of our energy use is in buildings which could benefit from additional insulation and better hot water heaters and light bulbs. Changing how we think about energy will change how we use it.

More information can be found on the web site at: *http://www.switchenergyproject.com*