

Chapter Ten: Transforming Energy:

We are like tenant farmers chopping down the fence around our house for fuel when we should be using Nature's inexhaustible source of energy—sun wind and tide. I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait until oil and cola run out before we tackle that

Thomas Edison

Dr. Jeremy Leggett started his profession conducting research on shale oil as an earth scientist funded by British Petroleum and Royal Dutch Shell. What he learned convinced him to pivot and became a renewable energy entrepreneur. Now Chair of Carbon Tracker, a financial-sector think-tank that warns investors of the risk that investments in carbon-fuel assets will be stranded, he is also a great storyteller. His most recent book, *The Winning of the Carbon War* reads like a thriller as it chronicles the transition from the recent past when a fossil future seemed inevitable to the cusp of the greatest energy transformation in history. Jeremy writes,

A Saudi Prince talks of his nation's "dangerous addiction" to oil, and sets out a plan to kick dependency within just a few years. A Bloomberg guru talks of renewables "crushing" fossil fuels around the world. Arguably the most successful entrepreneur ever turns the unveiling of an electric car not due to be delivered for 18 months into the most successful product launch in history. A revered Silicon Valley futurist ponders the seven doublings of the global solar market since 2000—one roughly every two years—and advises doubters in the technology not to ignore the arithmetic of exponential growth: six more doublings over the next 12 years would mean 100 percent of global energy from the sun.ⁱ

Official energy prognosticators aren't worried. The International Renewable Energy Agency predicts that solar will comprise, at most 13 percent, of global electricity by 2030.

Bloomberg New Energy Finance disagrees, stating,

The best minds in energy keep underestimating what solar and wind can do. Since 2000, the International Energy Agency has raised its long-term solar forecast 14 times and its wind forecast five times. Every time global wind power doubles, there's a 19 percent drop in cost and every time solar power doubles, costs fall 24 percent.ⁱⁱ

Leggett is not alone in calling 2014 as the year of the shift. Paul Gilding, an Australian corporate consultant, in a paper titled, "The Fossil Fuel Industry Is Now Entering Terminal decline, writes,

"It's time to make the call—fossil fuels are finished.... The rest is detail...and once everyone wakes up to that reality, it will die faster because the market will discount it, taking away capital and shifting it to the future winners. This process will drive scale deployment and innovation of renewables while denying capital to fossil fuels, constraining their options.... The fossil fuel energy industry ...will be all but gone within

15-30 years. The key driver is not what most see as their greatest threat—future climate change policy. It's that competing energy products of renewables and batteries, in a system with electric vehicles, will behave as a disruptive technology always does, delivering ever lower prices and ever higher quality in a decades' long period of innovation and deployment, which fossil fuels can't match. ⁱⁱⁱ

Jeremy Leggett worries, in fact, that the transition is happening so rapidly that the fossil industries may implode before the ascendancy of renewables is ready. ^{iv} He cites the Chinese retreat from coal, the divestment movement, the bankruptcies of coal and oil companies around the planet and the fall of Venezuela. At the same time that the price of oil falls, the cost of extraction rises. This, he fears, will result in what Carbon Tracker is now calling a “disorderly transition.” ^v

The economic slowdown after 2018 worsened the fundamental dynamic that it now costs more to pull resources from the ground than they are worth. This puts banks holding debt paper of extractive industries at risk. The 2008 economic collapse was triggered in part by high oil prices. ^{vi} The next banking emergency may be triggered by low prices. An analyst writing in Forbes concluded,

Persistently low oil prices represent a risk on par with the housing bust. And in recent days we're seeing the signs of another global financial and economic crisis creeping uncomfortably closer to a 'round two.' As we've said, this time would be much worse because governments and central banks have exhausted the resources to bailout failing banks, companies and countries. But central banks, namely the Bank of Japan and/or the European Central Bank do have the opportunity to step-in here, become an outright buyer of commodities (particularly oil), as part of their QE programs, to avert disaster. But time is the oil industry's worst enemy and therefore a big threat to the global economy. The longer policymakers drag their feet, the closer we get to the edge of global crisis—a crisis manufactured by OPEC's price war. ^{vii}

The global economy remains dependent on the dwindling supply of fossil energy. In 1955, the Paley Commission in the U.S. urged an immediate transition to renewable energy as a matter of national security. ^{viii} Had we done it, the transition would already have been achieved. We have left it until essentially the last moment, and so concerns about resource security, the issue that motivated the Paley Commission, are more acute.

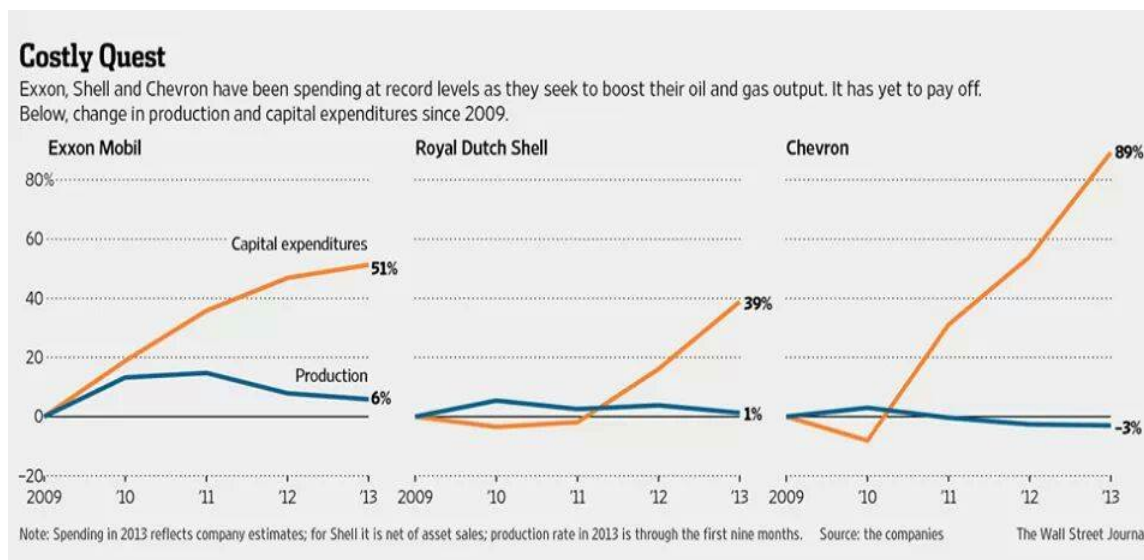
This is not to say that we are running out of oil. A Shell oil geophysicist named M. King Hubbert, writing in the mid-1950s pointed out that if you have a finite resource—and it is a corollary of the round earth theory that oil is finite—and exponential demand for a resource—which human desire for petroleum has certainly been since the 1950s—then you fall off the production curve as steeply as you went up when you have exhausted half of the resource. Peak oil, named for what was called “Hubbert's needle,” or peak, has many adherents, who herald every run up in oil prices as the beginning of the end. ^{ix} It is more likely, however that we are facing peak demand. It is true that new oil discoveries are at a 70-year low and declining, ^x and the costs of extraction are rising, but the cost of oil continues to fall, because demand is

falling, and alternatives emerging. The success of U.S. shale oil extraction from hydrofracturing swamped the world market with cheap oil and gas. And this is only the latest example of a durable phenomenon of oil price volatility.

Daniel Yergin^{xi} has long been an advocate of the position that oil is effectively economically infinite: as soon as shortages begin to bite, the price rises, and the enormous overhang of efficiency brings demand back down. If this dynamic exhausts itself, then the substitutions (electric cars, renewables) become attractive as soon as prices get much above \$50 a barrel.^{xii} The trouble with the belief that we are on the verge of running out of oil is that at higher prices other alternatives become attractive, too, most especially energy efficiency, and now the various renewables.

Rising costs of extracting more of the ever-scarcer fossil resources^{xiii} depress demand. Investor Jeremy Grantham^{xiv} warns that because of this, the era of economic growth may be over, entirely. He argues that the years of low economic growth are not an aberration, but the durable result of exhaustion of productivity gains that cheap energy, and the entry of women into the work force had made possible, as well as the rising capital expenditures needed to extract ever scarcer ore bodies, oil and gas. Before the recent fall in oil prices, Grantham stated, "Resource prices are now rising, and in the last eight years have undone, remarkably, the effects of the last 100-year decline!"^{xv}

This projection may seem at odds with predictions of low prices for oil and gas, and to some extent it is, but it is precisely the volatility phenomenon discussed above.



The price of oil, and to some extent gas, is a function not only of supply and demand, but of the political forces at work. Can OPEC can keep prices high by constraining its members' desires to meet their budgets by extracting more?^{xvi} Are the Saudi's cashing out of oil and investing in renewable energy?^{xvii} They built up a huge war chest to enable themselves to weather extended low oil prices, but even with this, they will run out of money in five years.^{xviii} To meet current accounts,^{xix} they need oil to be at more than \$100 a barrel. Countries like the Emirates

can make it on \$50 a barrel oil, but Venezuela requires a price of almost \$150 a barrel to break even, and has collapsed into a failed state.^{xx}

What matters, however, are the long-term dynamics. If the costs of extracting more resources, particularly fossil energy and minerals, are higher than the revenues derived from selling the resulting oil, coal or metals, they will stay in the ground. Which is a very good thing, because if fossil energy continues to fuel the economy, we truly are lost.

The Climate Crisis

Scientists agree that to avoid total system collapse it is essential to cap global warming at no higher than 2° Celsius (C) above pre-industrial levels. Our current trajectory will result in a world that warmed 5° to 6°C or more.

The International Energy Agency's (IEA) World Energy Outlook^{xxi} calculated various scenarios that would result in a world able to hold warming to 2°C (2DS). This scenario, the focus of the IEA's Energy Technology Perspectives "sets the target of cutting energy-related CO₂ emissions by more than half in 2050 (compared with 2009) and ensuring that they continue to fall thereafter." The 2DS acknowledges that transforming the energy sector is vital, but not the sole solution. The goal can only be achieved, in this scenario,^{xxii}

provided that CO₂ and GHG emissions in non-energy sectors (agriculture, waste disposal, industrial activities) are also reduced. The 2DS is broadly consistent with the World Energy Outlook 450 Scenario through 2035. This is consistent with an emissions trajectory that climate science indicates would give an 80 percent chance of limiting average global temperature increase to 2°C.

In contrast, a middle scenario would see the world warm by 4°C. This is where the world is likely to get to if no greater action is taken than the voluntary pledges made by countries to cut emissions and improve energy efficiency prior to the Paris Climate Summit in December of 2015. That may seem easy, but it is a relatively ambitious scenario compared to the emissions reductions achieved to date and will require significant changes in policy and technologies over current practice.

Worse, a 4°C world says, World Bank President Jim Yong Kim, is still a "doomsday scenario."^{xxiii} The Bank's report, "Turn Down the Heat," shows that a 4-degree increase in temperature would drive extensive crop failures and malnutrition. Rising seas would inundate vast areas, dislocating large numbers of people.

The 6°C Scenario, an extension of current trends, is the nightmare. By 2050, energy use almost doubles (compared with 2009) and total GHG emissions rise even more. This scenario is pronounced by many scientists as unsurvivable.^{xxiv}

Bear in mind that IEA is an intergovernmental organization whose board is composed of delegates from OECD (the rich countries). There is reason to question strongly whether

their scenarios are bold enough. Leading climate scientists like Johan Rockström, Malte Meinshausen, John Schellnhuber, believe they are far too inadequate, and call for rapid decarbonization.^{xxv} They state that “although the Paris Agreement’s goals are aligned with science and can, in principle, be technically and economically achieved, alarming inconsistencies remain between science-based targets and national commitments.” They fear that long-term goals will be trumped by political short-termism.

The Paris goals, they say, must translate into a finite planetary carbon budget:^{xxvi}

A 50 percent chance of limiting warming to 1.5° C by 2100 and a 66 percent probability of meeting the 2° C target imply that global CO₂ emissions peak no later than 2020, and gross emissions decline from roughly 40 gigatons (metric) CO₂/year in 2020 to roughly 5 gigatons/year in 2050.

To make this happen, Rockström et al introduce a global roadmap based on a simple heuristic—a “carbon law”—of cutting gross anthropogenic carbon-dioxide emissions in half every decade. If such a reduction pathway is combined with carbon removal and efforts to cut land-use emissions, “this can lead to net-zero emissions around mid-century, the path necessary to limit warming to well below 2°C.”

The roadmap affects all sectors and suggests much more rapid action than hitherto discussed. Fossil fuel subsidies have to be abolished no later than 2020. Coal has to

exit the energy mix no later than 2030. A carbon levy of, at minimum, \$50/ton must be imposed. Combustion engines should no longer be sold after 2030. After 2030, all building construction must be carbon-neutral or carbon-negative—a daunting task. Agro-industries must develop sustainable food strategies and massive reforestation programs be launched. Removal of CO₂ from the atmosphere will have to complement efficiency in the form of biosequestration (BECSS) and/or direct air carbon capture and storage (DACCS). Direct carbon capture, however, remains an expensive proposition.^{xxvii} As described in Chapter Nine, using smarter agriculture to take carbon out of the air and return it to the soil makes great sense.

But what really is needed is a new energy economy.

[The Chronology of Change Over the Last Four Years Is Inspiring](#)

In June 2014, Citi Group released its “Energy Darwinism” report, warning of the “alarming fall in the price of solar.” Alarming to who?

Citi stated that this was now the Era of Renewables, predicting that within 10 years solar, even without subsidies, would be the cheapest way to generate electricity.^{xxviii} Actually, in much of the world, it already is.^{xxix}

And if we did the economics honestly it already would be everywhere:

Subsidies are a two-edged sword. They have been instrumental in the shift to clean energy, but we also subsidize the continued use of fossil fuel. Free marketeers would prefer eliminating ALL

subsidies and letting the technologies fight it out in the market. This isn't going to happen. But the magnitude of the subsidies makes clear the economic advantage of eliminating them. In 2015 the International Monetary Fund reported that fossil subsidies had reached \$5.3 trillion a year, or \$10 million every minute, more than all spending in the world for health care.^{xxx} The IEA has repeatedly called for an end to such market distortions.

Such economies as Egypt, India, Indonesia, Malaysia, Mexico, Thailand and the United Arab Emirates are doing just that: cutting or abolishing fuel consumption subsidies. It's not easy. These hold prices of fossil fuels lower on the argument that poor people cannot afford higher prices, and from China to Indonesia to Iran to Africa, efforts to cut such subsidies have resulted in riots.^{xxxi}

It would at least be better to eliminate the worst subsidies and use the money to make poor people less poor.

[Chart:]

1 kiloWatt (1KW) about the amount of power used by a hairdryer. A typical middle class home uses somewhat under 10 KW on average.^{xxxii}

1 megaWatt (1MW) about the power. About enough to power 164 homes from solar photovoltaics. The actual amount depends on where you are (how much sun you get, and how efficient the solar panels are).^{xxxiii}

1 gigaWatt (1GW) is a billion Watts, roughly the amount of power produced by a nuclear plant.

1 kiloWatt hour (1kW/h) the energy to run a hairdryer for an hour. Typical electric rates in the U.S. are 11¢ kW/h. Energy efficiency in well-run programs costs ½¢ kW/h.

Running a natural Gas plant costs 4 to 6¢ kW/h. Building a new nuclear plant can cost upwards of 20¢ kW/h.^{xxxiv}

In January 2015, Deutsche Bank analyst, Vishal Shah, predicted that rooftop solar will be the cheapest electricity option for everyone in the US by 2016.^{xxxv} In April 2016, the average cost of rooftop solar was 12.2¢ per kiloWatt hour (kW/h). The average cost of grid electricity was 12¢ kWh.^{xxxvi}

Only one month later Agora Energiewende, a German think-tank, reported that solar electricity was already a low-cost renewable energy technology in many regions of the world.^{xxxvii} It stated that by 2025 solar will be the cheapest form of electricity everywhere. The report described how large-scale photovoltaic installations in Germany fell from over 40 cents per kilowatt-hour (c/kWh) in 2005 to 9 c/kWh in 2014, with even lower prices reported in sunnier regions of the world.

Even with no technological breakthroughs, the report concluded, there is no end to cost reduction, with costs of 4 to 6 c/kWh (competitive with just the running cost of a natural gas plant, heretofore the cheapest option) expected by 2025, and 2 to 4 c/kWh by 2050. In spring

2016 a consortium of solar developers led by Abu Dhabi committed to build the 800 MW Mohammed bin Rashid Al Maktoum Solar Park at an unsubsidized price of 2.99¢ kWh.^{xxxviii} At that price, solar competes with energy efficiency. The German study warned, “Most scenarios underestimate the role of solar power in future energy systems.”

The National Bank of Abu Dhabi now says that even at \$10 a barrel, oil no longer competes with solar.^{xxxix} Wind has even cheaper. Dong Energy’s latest unsubsidized offshore wind farm is bid at less than the running cost of a natural gas plant. UNSUBSIDIZED.^{xl} The report’s projected 2025 price was achieved for utility scale solar four months later when Austin, Texas, announced that its utility had:^{xli}

received offers for 7,976 megawatts of projects after issuing a request for bids in April. Out of those bids, 1,295 megawatts of projects were priced below 4 cents per kilowatt-hour.

Change rolled on. In March 2015 Bloomberg Business reported that from 2013 to 2014, California went from utility-scale solar installations supplying 1.9 percent of its electricity to five percent.^{xlii} And that number is not even counting the private roof-top solar, which would increase the figure by almost half again.^{xliii} The National Bank of Abu Dhabi report stating that solar energy is on track to achieve grid parity in 80 percent of countries by 2017.

In April, 2015, Michael Liebreich of Bloomberg New Energy called the time of death, saying, “Fossil fuel just lost the race with renewables....The world is now adding more capacity for renewable power each year than coal, natural gas, and oil combined. And there's no going back.”^{xliv} By late 2016 he declared that solar was now cheaper than coal, and even more surprising, cheaper than wind.^{xlv}

In late 2016 the CFO of Royal Dutch Shell stated that the company expects demand for oil to peak by 2020.^{xlvi}

In 2017, the amount of electricity generated by nuclear in the US fell below that generated by renewable energy. Solar and wind are now cheaper in most of the world than the cost of running an existing coal, gas, or nuclear plant. Nuclear is dying, solar, wind and the other renewables are increasing. It’s only a matter of time before the old nuclear plants are shut down and a brighter future dawns.^{xlvii}

If humanity is in a horse race with catastrophe, we may just be witnessing the winning move.

[The Rest of the World](#)

In June 2015, the Institute for Energy Economics and Financial Analysis reported slowing demand globally for coal and rapidly rising investment in renewables. Tim Buckley, the Institute’s Director of energy finance stated,

Globally, 2014 was the year of the renewable energy juggernaut.... Wherever you look around the globe, be it China, India, Europe or the U.S., the trend of a rapidly-expanding renewable energy industry is the same. 2015 will inevitably see this gather pace.^{xlviii}

He was right. In 2014, South Africa began using solar and wind to meet its capacity shortfalls because doing this was cheaper and faster than building new coal or nuclear facilities.^{xlix} This saved the country \$69 million that year,^l created jobs^{li} and local industrial capacity. With proposed coal plants on hold because of soaring costs,^{lii} South Africa then commissioned 79 renewable energy projects, totaling more than 1 GW. A gigawatt is roughly a nuclear power plant-sized chunk of capacity, but a new nuclear plant would take 10 years to build and cost \$6 per Watt according to one recent estimate.^{liii} Coal, long thought of as dirt cheap, comes at \$2.30 per Watt. Top Chinese manufacturers were producing solar panels for 42 cents per Watt.^{liiv}

South Africa's renewable capacity hit 5.24 GW in 2015, and 7 GW by 2016,^{liv} up from nothing in 2012.^{lvi} Another 6.3 GW is already commissioned.^{lvii} No fossil technology can scale this quickly.

Across the Atlantic, Brazil's commitment to biofuels and hydroelectricity made it independent of imported oil in 2006.^{lviii} Since 2009, Brazil has added solar and wind energy, contracting 14 GW of wind at prices below any other option. In 2014, at prices only a bit higher, Brazil also brought on almost 1 GW of solar energy. As a severe drought drives Brazil's electricity prices higher, industries eager for access to reliable and affordable power are turning to renewables that do not require dams and abundant rainfall.^{lix}

The biggest user of energy, China, is becoming the world's renewable energy powerhouse.^{lx}

As described in Section Two above, China is coupling energy efficiency with renewable energy to shift away from fossil fuels. The IEEFA study agrees: "While real economic growth in China exceeded seven percent, electricity demand grew by less than four percent." Rapid supply diversification saw China's coal consumption drop two percent and coal imports fall by 11 percent in 2014. China's coal demand may have permanently peaked in 2016 and will decline thereafter, the report predicted.^{lxi}

Growing its installed solar capacity by twenty-fold within only four years, China went from a capacity of 0.3 GW in 2009 to 13 GW by 2013^{lxii} and added 30.5 GW of renewable energy in 2015, 16.5 GW of that solar. It plans to grow its renewables 21 percent in 2016.^{lxiii}

The transformation has only begun. The "China 2050 High Renewable Energy Penetration Scenario and Roadmap Study" released in 2015 found that renewable energy could economically provide China the majority of its energy by 2050.^{lxiv} Wang Yimin, representing the State Grid Corporation of China, told the United Nations Global Compact meeting on pricing carbon in June 2015 that by 2050 China would be 80 percent renewable.^{lxv}

Even India, the world's fourth largest emitter of greenhouse gasses, and long seen by the coal industry as their last great hope, is entering the solar age.^{lxvi} As described in Chapter Four, India pledged to cut the energy intensity of its economy up to 35 percent by 2030, and get 40 percent of its electricity from non-fossil sources by then.^{lxvii} India's Power Minister, R.K. Singh, observed, "This is a matter of worry for those who produce coal or oil. But, this (growing use of renewable energy) cannot be stopped as it makes economic sense."^{lxviii}

At the Paris Climate Summit in 2015, Indian President Narendra Modi joined French President Hollande in launching the International Solar Alliance, a union of countries with abundant sun.^{lxi} India, like Pakistan, has long declared that it has every right to burn coal, or build nuclear plants (the latter clearly for military purposes in both cases) to deal with energy poverty. International energy experts have, however, pointed out for years that the fastest, cheapest way to reduce energy poverty is to enable villagers to use the biomass they now burn (dung or wood) far more efficiently in better cookstoves, or in biogas plants, and to leapfrog to renewable energy as soon as possible.^{lxx}

Modi pledged to enable India to exceed its 2016-17 target of 30 GW of renewable energy to 175 GW of renewables, most of it solar, by 2022. To achieve this, India increased its subsidy for roof-top solar five-fold to \$3.7 billion in late 2017.^{lxxi} If successful, it would cut 326.22 million tonnes of carbon dioxide equivalent per year. States such as Punjab and Karnataka are shuttering coal plants and building solar, instead.^{lxxii} India also has a significant wind resource, estimated at 70 percent of India's renewable potential.^{lxxiii}

Companies like SELCO (the Solar Electric Light Company^{lxxiv}) are delivering this future today. SELCO sells solar electric panels that provide lighting and electricity to poor villagers, at monthly prices comparable to what they would pay to use traditional, less effective sources. Through its network of 25 centers across India, SELCO provides solar lighting and electricity, clean water and wireless communications to underserved households and businesses with advanced but inexpensive lighting, electricity, water pumping, water heating, communications, computing, and entertainment. The systems do not require connection to a larger network. SELCO meets its customers where they live, partnering with rural banks, leasing companies, and micro-finance organizations to provide necessary credit. It has brought reliable, environmentally sustainable electricity to 200,000 homes and businesses since 1995. SELCO empowers its customers by providing complete packages of products, services and consumer financing.

With solar electricity comes communication technology, clean drinking water, refrigeration, power for clinics and other development technologies. Lighting even one bulb enables villagers to provide light for silk worms, for looms, and moveable lights that can go room to room as needed. This gives them an income source to power sustainable development.

SELCO's market based system, requiring no government subsidies, lifts thousands of people from poverty vastly more effectively than many aid programs. The company's founder, Dr. Harish Hande, suggests that development experts rethink their definition of what poor people can afford. He argues that the poor actually spend a great deal of money on kerosene lamps, diesel for generators, and batteries for flashlights. With fair financing, they are capable of paying for a solar installation to displace the more wasteful options. If people are told that the solar installation will cost them \$30 a month, they tend to say that it is too expensive. But if asked to pay \$1 a day, they agree, "Yes, we can do that." In the SELCO model, the purchaser pays 20 percent down. SELCO provides financing that enables the buyer to pay off the system in 4 years at \$10 - \$20 per month. The financing matches a person's ability to pay.

President Modi has realized that conventional western grid-based systems will never meet the needs of the 360 million people in India without electricity. Only distributed renewables can meet his goal of electricity in every household. According to the Climate Group and Goldman Sachs this approach can overcome projections that, business as usual, only 10 percent more households will get power over the next 10 years.^{lxxxv}

The Profound Transformation:

Massive change is coming to the energy sector. Entrepreneur Elon Musk created a car company that now threatens the car, oil, gas, coal, nuclear and utility industries.

In early 2016 Tesla's market capitalization was \$30 billion, compared to \$47.7 billion for GM.^{lxxxvi} despite selling 300 times fewer cars. By spring 2017, the company's market cap exceeded \$52.7 billion, beating both Ford Motor Company and General Motors.^{lxxxvii} Tesla also pulled off the entrepreneuring coup of the century, selling \$10 billion worth of orders in one day for cars that would not be built for at least a year.^{lxxxviii}

OK, it's a market darling, but what makes it such a threat?? Because Tesla, as its Master Plan Part Deux, released July 2016, makes clear, is not a car company, it's a battery company. More than that, it's an integrated energy company. In 2016, Tesla bought Solar City to integrate all of the energy solutions customers want. Combining rooftop solar with home battery storage with electric cars^{lxxxix} will eliminate pretty much any rationale to dig up and burn ancient sunlight in ways that are dirty and dangerous. If battery costs come down as they have been—dropping 70 percent since 2009^{lxxx}—then the game really is over for the fossils.

Advocates of last century's energy options think this is nuts. OPEC believes that in 2040, electric vehicles will make up just one percent of all vehicles.

They'd best watch out: Bloomberg New Energy Finance sees 2025 as the peak year for oil, coal and gas.^{lxxxxi} In 2009 there were essentially no electric cars on American roads, compared to nearly one billion gasoline cars. Today there are more than 2 million cars with a plug, and electric car sales are increasing ten times faster than purchases of fossil fueled vehicles.^{lxxxii} China, representing one quarter of the world automobile market mandated that eight percent of cars sold there be electrics by 2018.^{lxxxiii} In 2017, it announced that it would begin phasing out sales of internal combustion vehicles.^{lxxxiv}

Cheaper oil prices in 2017 engendered one last American explosion of sales of urban assault vehicles. But by fall 2017, EVs sales regained their American momentum, increasing almost 50 percent over 2016.^{lxxxv} Globally, sales rose 63 percent in the third quarter of 2017 over the year before, with China representing a half of the increase.^{lxxxvi}

Such numbers are impressive, but the increases are over a very small base. EVs have only just reached the one million sold per year mark, one percent of global car sales. Like many new technologies, they are also very sensitive to policy shifts. But globally, policy seems to be going in the right direction: like China, countries from the UK to France, India and the Netherlands say they will ban sales of fossil fueled cars, with California likely to follow suit.^{lxxxvii}

In Norway, a combination of tax relief, free parking and ability to drive for free on toll roads brought electric vehicles to almost half of all new car sales. Almost 40 percent of Norway's cars are now electrics, and they expect that to be 100% within eight years.^{lxxxviii} And they are cheaper to operate: a grid charge costs the Norwegian equivalent of a couple dollars. A fill-up of gasoline would cost \$6.^{lxxxix} In the U.S. the money you spend on monthly payments for a Nissan Leaf is what you would have paid in gasoline. In effect, the company has given you a free car.^{xc}

Bloomberg believes that EVs will constitute half the cars on the road by 2040. But long before this, by 2023, it predicts, reduction in demand for gasoline will cause another oil price collapse.^{xc} With transportation responsible for 30 percent of carbon pollution, soon a bigger problem than power plants,^{xcii} displacing oil for vehicles will be as big a deal for climate protection as bankrupting coal, but it will be a far bigger deal economically.

Whole new business models are emerging. One of Solar City's co-founders, believes that well before 2020 there will be a "sharing economy for electricity."^{xciii} Battery costs will have come down so much that houses will all have battery banks like the Tesla Wall, capable of powering them through the night from the solar energy stored during the day. These smart storage units will be able to trade power with electric cars, and share electricity across the grid, earning their owners extra cash every time they do and further stabilizing a renewable grid.^{xciv}

This means that traditional utility companies face the "Death Spiral."^{xcv} Their old business model of building large fossil plants is no longer viable. Former Energy Secretary, Dr. Stephen Chu warned, "The utilities are in danger of getting 'Fed-Exed' just like the Post office got 'Fed-Exed' as roof-top solar modules drop in price."^{xcvi}

In Europe, where feed-in tariffs allow farmers, cooperatives, communities and citizens to make money from installing renewable energy, RWE and Eon, two of the biggest European utilities lost 60 percent and 91 percent of their profits respectively in the first nine months of 2014. Declaring themselves to be distributed renewables companies, they divested of ownership in fossil and nuclear facilities.^{xcvii}

Most utilities, however, still fight the transition. All things equal, they claim, gas is cheaper than renewables and battery storage, and gas is the transition fuel to a renewable future.

They're wrong. A report from Lazard^{xcviii} proves it:

The levelized cost of utility-scale solar power with storage is \$92 per megawatt-hour (MWh). This means that solar-plus-storage can be highly competitive, even after dark, with natural gas peaking plants, which have levelized costs ranging from \$165 to \$217 per MWh. It is even competitive to a degree with gas-powered reciprocating engines, whose costs are from \$68 to \$101 per MWh....Both onshore wind and solar PV have seen insane drops in cost over the past eight years—66 and 85 percent, respectively....And, in ... emerging nations ... electricity demand (is) rising quickly. They need new electricity generation, and when one surveys the options for new power plants, renewables look really good.

In Australia that became true in 2016: storage plus solar is cheaper than gas-fired generation.^{xcix}

In late 2017, the coal dependent Public Service Company of Colorado released the numbers from its request for bids to supply energy for its utility customers. Thousands of MW of wind, solar and solar with battery storage were offered at prices far below competing fossil options:^c

Median wind price below 2 cents/kwh
Median solar below 3 cents/kwh and
Median solar and storage median price at 3.6 cents/kwh.

The future has arrived.

In late 2016, the Financial Times^{ci} reported that Fitch Ratings agreed that gas plants were unlikely to have much of a future, but warned that utilities are not the only ones at risk:

“Widespread adoption of battery-powered vehicles is a serious threat to the oil industry....The oil sector would not be the only industry affected. Big electricity utilities burning fossil fuels such as gas or coal face the risk of batteries solving the intermittency problem of wind or solar plants that cannot generate on windless days or at night.

Utilities with a lot of gas “peaker” plants that deliver power quickly at times of peak demand, when prices are generally high, could be more at risk. If batteries start supplying this peaking power, prices could eventually fall to the point where “traditional peakers can no longer compete....But the impact of batteries on the oil industry may be profound.... transportation accounted for 55 per cent of total oil use in 2014....An acceleration of the electrification of transport infrastructure would be resoundingly negative for the oil sector’s credit profile....In an extreme scenario where electric cars gained a 50 per cent market share over 10 years about a quarter of European gasoline demand could disappear.

It endangers the banks, as well: a quarter of all corporate debt, perhaps as much as \$3.4 trillion is related to utility and car company bonds that are tied to fossil fuel use. Fitch, the ratings agency warned that low cost batteries could

“...tip the oil market from growth to contraction earlier than anticipated. The narrative of oil’s decline is well rehearsed—and if it starts to play out there is a risk that capital will act long before” and in the worst case result in an “investor death spiral.”

Tesla and other battery companies are working hard to make it so. In 2016, Tesla teamed with four other battery companies to set the world record for fast installation of utility-scale battery storage.

The speed was driven by crisis. In 2015, the natural gas well and storage facility at Aliso Canyon operated by Southern California Gas Company failed. For 119 days, gas spewed out, forcing thousands of nearby residents to evacuate, hospitalizing many and emitting as much climate damage as a year’s worth of 2 million cars, the burning of a billion gallons of gasoline or the

corporate emission of 9 million tons of CO₂.^{cii} This loss of gas cast into doubt utilities' ability to meet summer peak demand. Southern California Edison and San Diego Gas and Electric companies commissioned Tesla, Samsung, AES and others to meet the shortfall with the largest utility-scale battery storage facility ever built.

In early 2017, six months later, 20 megawatts of battery storage went live, capable of delivering 80 megawatt hours.^{ciii} In contrast, competing gas peaking plants would have taken years to build and required far more land. The exercise was driven by need, but soon such facilities will simply be cheaper.^{civ}

Tesla immediately bet that it could install 100 MW of storage in South Australia, creating the world's largest battery, in 100 days or the rig would be free. It won that bet, proving not only that grid-scale storage is faster, but now cheaper than any other option.^{cv}

Elon then signed a deal with South Australia to give 50,000 low income households solar panels and Tesla Wall battery packs, creating a 250 megawatt virtual power plant, the world's largest. Smart meters will dispatch the power from the distributed renewable and battery storage systems, giving the utility the ability to react to load fluctuations instantly, and reliably, giving the residents a 30 percent discount on power.^{cvi} South Australia plans to greatly expand the system in the coming years.

Battery technology continues to improve and prices fall. They've dropped by almost half since 2014. In Ojai California, SimpliPhi Power is producing lithium ferrous phosphate batteries for the U.S. forward operating bases in Afghanistan,^{cvi} as well as for homes in the U.S. and aid operations in Africa.^{cvi} Unlike the lithium cobalt batteries produced by Tesla and most other battery companies, SimpliPhi's product is non-toxic (cobalt, a conflict mineral, is highly toxic.)^{cix} The military likes them because they do not get hot, and without a heat signature are far less likely to attract a heat-seeking missile. In home applications they are far less likely to catch fire. They don't care if they get cold, hot or are deployed in inhospitable conditions.

Organic flow batteries of the sort now being prototyped are safer, cheaper and capable of being scaled to backup renewable technologies.^{cx} Similarly, vanadium flow batteries are safe and scalable for utility applications. Vanadium is an abundant material, and because of the nature of the system, the batteries do not degrade over time, or develop "memory."^{cx}

Lithium air batteries being developed in the lab use far less lithium and can store five times as much energy as today's lithium-ion batteries.^{cxii}

Going all the way

With cheap, ubiquitous batteries, solar and wind become firm power and replace all fossil power plants. Already a growing number of companies and cities are committing to become 100 percent renewably powered

Launched during Climate Week in 2014, the RE 100 is a consortium of more than 119 companies who have pledged to go 100 percent.^{cxiii} They range from Unilever and WalMart to Google and Goldman Sachs, Coca Cola to BMW and Apple. Most companies pledging to go

entirely renewable have set target dates of 2020, but commitment dates range from “soon” to 2016 in the case of Microsoft and Pearson, to 2050, the date set by the world’s scientists as needed for decarbonization. Alstria, a large real estate company in Germany, has committed to power all of its portfolio buildings with renewables by 2025.

Google became 100 percent renewable in 2017 through purchasing energy from installations in five countries on three continents.^{cxiv} Unilever, promising to be 100 percent renewable by 2020, has also pledged to be energy positive by 2030—making more renewable energy than it needs and giving power to the communities in which it does business.^{cxv} Corporate buyers make up 50 percent of the purchases for renewable energy in the U.S, even in the face of historically low prices for grid electricity (from the natural gas bubble.) The second biggest buyer is the U.S. military, which has found that renewable energy enhances its warfighting ability.^{cxvi}

In the wake of the historic agreement by all of the world’s nations in Paris in late 2015 to cut carbon emissions and drive the transition to renewable energy, more than 1,000 cities have committed to become 100 percent renewable powered. Since the U.S. announcement that it will not honor its Paris commitments, this movement has gained strength.

Author and technology investor, Ramez Naam agrees. Asking how cheap solar can get,^{cxvii} he reviews the falling prices for solar, wind,^{cxviii} battery storage^{cxix} and electric vehicles^{cxx} to predict that renewables can provide at least 90 percent of American energy by 2030. His answer: very cheap indeed.

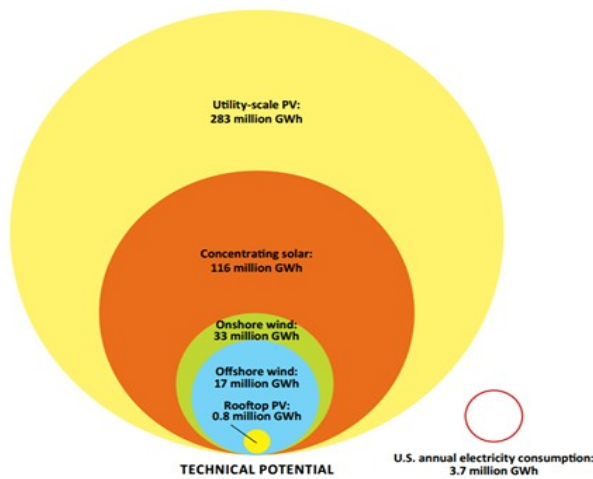
Naam believes that three changes to the current electricity supply system will make this possible: increasing capacity factors for solar and wind, far lower prices for battery storage and grids that span continents.^{cxxi}

Entrepreneur and financier Jigar Shah believes that the only things stopping all of this is a lack of effective business models and financial innovation. His book *Creating Climate Wealth*^{cxxii} issued the 100 x 100 =10 challenge: a worldwide challenge to solve climate change by unleashing the equivalent of 100,000 companies each selling \$100 million worth of climate change solutions by 2020, creating a new \$10 trillion economy.^{cxxiii}

“Solving big challenges have always resulted in wealth creation. Think about the challenges of transportation, and then the economic and societal impact of the railroad, automobile and airlines. Or think about any other industry like telecommunications. Then let’s think about big goals we have had like curing polio, or landing a man on the moon. Addressing all of these issues had much more of an impact on our society and our lives than just solving the problem or taking on the challenge. Each changed our lives, created jobs, and made life better. We have always been able to make problems into opportunities. So, I look at climate change as the biggest opportunity in our lifetime, in fact the largest wealth creation opportunity on the planet.”^{cxxiv}

Shah’s business model innovation of “no money down solar installations” is one of the three reasons that solar is now adding more new energy generating capacity each year than coal, oil

and natural gas combined. He believes that 50 percent of greenhouse gas emissions will always be profitable to eliminate due to continuous technology innovation.



The shift is already creating wealth where it is being implemented. In California, which, as described above, has committed to cut its carbon emissions 80 percent below its 1990 levels by 2050, there are already more people employed in the solar industry (64,000 people) than in the electric utilities. Manufacturing is expanding in the state, and the economy is booming, with state gross income increasing 17 percent from 2003 to 2013, while greenhouse gas emissions fell by 5.5 percent.^{cxxv}

In his early article declaring the end of fossil fuels, Paul Gilding wrote,

With renewables already competitive today without subsidy in some markets and the above trends playing out, it is inevitable that before long—maybe a decade—virtually all new electricity generation will be from renewables. Add in the need to be clean—not just for climate change reasons but for local air quality—and the choice developing countries will face will be between large, old, dirty, hard to finance infrastructure that requires heavy government support or small scale, easy to finance, more convenient, popular and clean energy and transport that will get even cheaper over time. Tough choice?

So the very thing that the fossil fuel industry had relied on for its growth—the rapidly expanding need for energy in the developing world—is the very thing that will drive the competition to wipe them out.^{cxxvi}

Change will not come easily. President Jimmy Carter once stated that energy was not a commodity, but the entity on which the entire economy depends. Thus, he said, any attempt to limit America's supply of it was, "The Moral Equivalent Of War." Such beliefs derive from extremely powerful forces and will not cede global power gracefully. The Union of Concerned Scientists study, *The Climate Deception Dossiers* showed that for decades the fossil industry

conducted a coordinated campaign to spread climate disinformation and block climate action to protect its profits.^{cxxvii}

A common way of arguing for the continuation of the status quo is to claim that renewables cannot possibly meet our energy needs until after said fossil company executive, or incentivized legislator has safely retired. Despite the evidence listed above, they can find plenty of analysts like the U.S. Energy Information Administration to say that coal will provide a third of the world's electricity by 2040, and renewables only 17 percent.^{cxxviii}

If that is true, say fossil advocates, and if climate change is a threat, then it will be essential to make all that coal clean, using carbon capture and sequestration (CCS). It is tempting to say that, well, China will burn a lot of coal, regardless, and therefore perhaps we *should* invest in this technology. Sure, it has never worked on a commercial scale, but shouldn't we put more research dollars into one more go...?

No. We shouldn't. The trouble is that, like nuclear power, it will take a LOT of dollars, assuming you can ever get it to work. .

Bill Becker, Executive Director of the Presidential Climate Action Project described why carbon capture can never deliver:^{cxxix}

Despite the years of research and spending, CCS is not yet ready for large-scale commercialization. So, part of the price is further delays in the urgent job of cutting emissions. Electric customers will pay a significant price: Researchers say that CCS would add between 35 percent and 80 percent to consumer electric bills initially, and only slightly less in the long term.

Power plants equipped with CCS would increase water withdrawals by 83 percent to 91 percent depending on the type of technology used to generate electricity. That makes CCS problematic in arid and drought-affected places and in places where power production must compete with agriculture and city water consumption.

It's time to stop nibbling at this bullet and invest in the triumph of the sun.^{cxxx} This change can happen fast. Globally renewables have been increasing dramatically. In Chile^{cxxxi} and Germany^{cxxxii} recently, so much solar energy was produced that the utility gave it away for free. Germany has pledged to be 80 percent renewable by 2050, Scotland 100 percent by 2020. In the U.S. since 2009 solar costs have dropped 80 percent and installations increased 20-fold^{cxxxiii} to more than 42 GW in service. In 2016, annual installations grew 95 percent over the number of only a year prior.^{cxxxiv}

Is it enough? Is it too much?

Some predictions say that all this is just the beginning. As described in Chapter One, Stanford Professor, Tony Seba, believes that by 2030 the entire world will run on renewable energy—not just for electricity, but for all forms of energy. If this is true, oil companies, gas, coal, uranium extractors, the nuclear industry, utilities, the auto industry and the banks that hold the loan

paper for all of these industries will either become part of the solution or they won't be a problem, because they won't exist.

Seba's book, *Clean Disruption*,^{cxxxv} describes why he believes the transformation will come so fast. He credits the convergence of disruptive technologies and business models, especially four factors: the fall in the cost of solar, the fall in the cost of storage (batteries), the electric car and the driverless car, to make a renewable world inevitable.

This will have profound implications for, well, everything. But particularly for transportation. Transportation as a Service using autonomous electric vehicles will be ten times cheaper than current private ownership of internal combustion cars. Seba points out that whenever in history a new technology has enabled ten-fold savings, it has driven disruption of the dominant industry.^{cxxxvi}

He reminds doubters that experts totally underestimated sales of mobile phones. In the 1990s, McKinsey told ATT that to expect 900,000 mobile subscribers by the year 2000. They were only off by 108 million.^{cxxxvii} By 2014 there were more mobile phones on earth than the seven billion people, increasing five times faster than humans.^{cxxxviii}

Seba cites what is called Swanson's law^{cxxxix} (named for Richard Swanson, founder of the solar company Sun Power) which holds that for every doubling of solar photovoltaics made and shipped, the price declines 20 percent.

Seba's colleague at Singularity University, Ray Kurzweil, calculates that it would only take six more doublings to power the entire world with solar:^{cxl}

"In 2012, solar panels were producing 0.5 percent of the world's energy supply. Some people dismissed it, saying, 'It's a nice thing to do, but at a half percent, it's a fringe player. That's not going to solve the problem.' They were ignoring the exponential growth just as they ignored the exponential growth of the Internet and genome project. Half a percent is only eight doublings away from 100 percent.

Now it is four years later, [and solar] has doubled twice again. Now solar panels produce 2 percent of the world's energy, right on schedule. People dismiss it, '2 percent. Nice, but a fringe player.' That ignores the exponential growth, which means it is only six doublings or [12] years from 100 percent."

It's not true we're running out of energy. We're only running out of resources if we stick with 19th century technologies.

That's fast. And it's possible. Dr. Mark Jacobson of Stanford demonstrated in 2009 that renewables could power the world by 2030.^{cxli} His Solutions Project has shown how to do that for every U.S. state.^{cxlii} More recently, scholars like Christian Breyer have shown how to do this with photovoltaics alone.^{cxliii}

Seba warns that falling costs will see solar achieving not only global grid parity by 2018, but soon what he calls "God parity." This means that the cost to put solar on your roof is cheaper

than just having the utility ship power to you and maintain its lines. In this scenario, which Seba believes could come as early as 2020, even free electricity at any central station would be more expensive than distributed solar. Tony writes: ^{cxliiv}

Don't believe in the Clean Disruption? The IEA wants you to invest \$40 trillion in conventional energy (nuclear, oil, gas, coal) and conventional utilities. It's their Kodak moment. It's your money. ^{cxlv}

OK, a new solar array goes up in the U.S. every 150 seconds, ^{cxlvi} but can the whole world be renewable by 2030? No way, you say....

Or will it?

In August China announced that it had already eclipsed its 2020 goal in solar installations. It now adds 45 GW of solar (more than the entire installed solar capacity of Germany) every year. ^{cxlvii} California predicted it will hit its declared 2030 target of getting 50% of its power from renewable energy by 2020—10 years early ^{cxlviii}—and, as described earlier, is debating resetting the goal to 100 percent renewable power.

In April 2017, an industry journal predicted that solar power would fall below 2¢ per kilowatt hour (kWh) that year. ^{cxlix} In October, Saudi Arabia announced the new world record low price: 1.7¢/kWh. ^{cl} When the Kentucky Coal Museum puts solar on its roof rather than plug into the coal fired electric grid at its doorstep, ^{cli} you know that the fossil era is over.

Well, OK, we CAN run our society on solar energy, but what if the sun isn't shining or the wind blowing?

Storage technology to make renewable energy available 24/7 is only in its infancy as an industry, but, as described above, it is coming on fast, and its prices are collapsing, too. ^{clii} Combinations of renewable energy and storage are now cheaper than the fossil alternatives. ^{cliii}

Then there are electric vehicles. Two days after Jerry Brown, Governor of California, announced that he intended to follow China's lead to ban internal combustion engines, General Motors, which had reclaimed its coveted status of the world's leading automobile manufacturer on the strength of its Bolt electric car, announced that its future is electric. Meanwhile, Daimler, Volkswagen and Volvo had already committed to electrifying their entire product portfolios. ^{cliv}

Within a month, Elon released an all-electric long-haul truck and China announced the launch of the world's first all-electric cargo ship.

Hmmm, that looks like three for three. But in Seba's scenario, it's the driverless, autonomous electric vehicle (AEV) that drives the real reduction in cost he claims will make the disruption inevitable. Are AEVs more than just science fiction? Didn't Tesla's self-driving car kill a guy?

To get the straight story, let's talk to Tom Chi, ^{clv} the brilliant head of Product Experience at Google X and one of the designers of the self-driving Google car. Is what Tony's saying possible?

“Within ten years?” asked Tom. “Easy.” Tesla, he said, released its driverless vehicle when it was as safe as a human driven car. Remember, hundreds of thousands of people die every year in car crashes. Teslas have driven more than 5 billion miles in autonomous mode,^{clvi} en route to the company’s 10 billion mile safety proof point. In fact, all Teslas are now capable of full autonomous mode. The Tesla Autopilot car fatal crash, one of several accidents now accumulated was caused by a flaw in the detection system: the car failed to distinguish a white tractor-trailer rig pulling out in front of it while driving into a brightly lit sky. Even so, the Tesla car is far safer than human driving. This one fatality came after 130 million miles of testing. Humans crash once every 60 million miles.^{clvii} The Google car has driven four million real miles, and 2.5 billion simulated miles.^{clviii} Waymo, Google’s spinoff, threatens to have its service on the road very soon.

It better. GM just announced that it is pivoting its business model to offer autonomous electric vehicle Transit as a Service by 2019.^{clix}

Does that make it four for four? Is Tony right?

You decide.

But realize that if the evidence laid out here is true, it will mean the dissolution in value, likely complete loss, of the oil, gas, coal, uranium, nuclear, utility, auto industries, the banks that hold the loan paper for all of these companies, the pension funds and insurance companies that are invested in them. Just the self-driving cars will drive significant changes. The war between taxi and ride-sharing drivers will be over soon. Both will lose.^{clix} That’s 4.1 million jobs.

Unless managed well, the changes that are already upon us will mean an economic collapse on a scale you’ve never seen, coming at us within about 10-years.

So, let’s get serious about managing the transition well. Contrary to popular belief, switching to the regenerative economy would create millions of jobs. It is obvious to anyone with empathy that the shift needs to give people time to adapt. Millions of people working in 'dirty' sectors will lose their jobs, especially those working in the fossil fuel business today. But those numbers are not as big as many think. By early 2017 you were twice as likely to have a job in solar as in coal.^{clxi} That’s right solar employs twice the number of people as the coal industry.^{clxii} These are good paying jobs that cannot be outsourced to machines or offshoring. The workforce is diverse, featuring women and minorities, and spread across the country. Massachusetts has more solar installers than Texas despite being a lot less sunny.

In 2015, only 184,500 Americans worked in oil and gas extraction, a number 17,000 fewer than it was a year before. The number of U.S. mining jobs had decreased to 191,000 from the 203,700 it had been a year prior. Coal extraction actually increased between 1980 and 2015 but coal jobs fell 60 percent because of automation.^{clxiii}

The International Renewable Energy Agency (IRENA) stated that in the U.S:

Solar employment continued its rapid expansion—growing by almost 22 percent to reach 209,000 in 2015. Jobs in the solar industry grew 12 times as fast as overall job

creation in the U.S. economy, and surpassed those in oil and gas extraction (187,200) or coal mining (67,929). Most solar jobs (194,200) are in solar PV.

IRENA, noted in mid-2016 that renewable jobs were growing at five percent a year globally, then exceeding 8 million.^{clxiv} By 2015, China, alone, had created 3.5 million renewable jobs. By 2017, there were more than two and a half times more clean energy jobs than fossil employment,^{clxv} and almost 10 million people employed in renewable energy industries globally, with the number expected to grow to 24 million by 2030.^{clxvi}

Bob Keefe, Executive Director of Environmental Entrepreneurs cited the obvious:

In a short amount of time, clean energy has become a huge part of our workforce and our economy. Smart policies helped jump-start this industry, and smart policies will keep these made-in-America jobs growing—and help our environment along the way.

Dan Smolen, managing director of The Green Suits echoed:

“Clean energy is no longer a niche business—it’s a big-time job creator. Our lawmakers need to realize that—and put policies in place, right now, to help the sector grow even more.”

The jobs are also more satisfying than many today. This fact is not lost on young people, who want a greener and more responsible world. Johnson Controls found that 96 percent of workers aged 18-35 want to work for a responsible and green-minded company.^{clxvii}

Interestingly, it appears that if the renewable energy projects are locally owned they create twice the number of jobs, and deliver up to three times the economic value to the community.^{clxviii}

These figures focus on jobs in renewable energy, but the principles applies even more to the transition to a regenerative economy. More sustainable approaches create more not fewer jobs.^{clxix} A greener economy could create between 15 to 60 million jobs worldwide over the next two decades. Achim Steiner, Director of the UN Development Programme estimates that by 2030 at least half of the global workforce will be in the green economy.^{clxx} The discussion earlier in the section on the speed with which the transformation in energy is coming suggests that the UN’s numbers are conservative.

Stranded assets

Carbon Tracker neatly summed up the situation facing the fossil companies:^{clxxi}

A trend in US coal risk disclosures:

1. Assume no new technology & policy
2. Go bankrupt

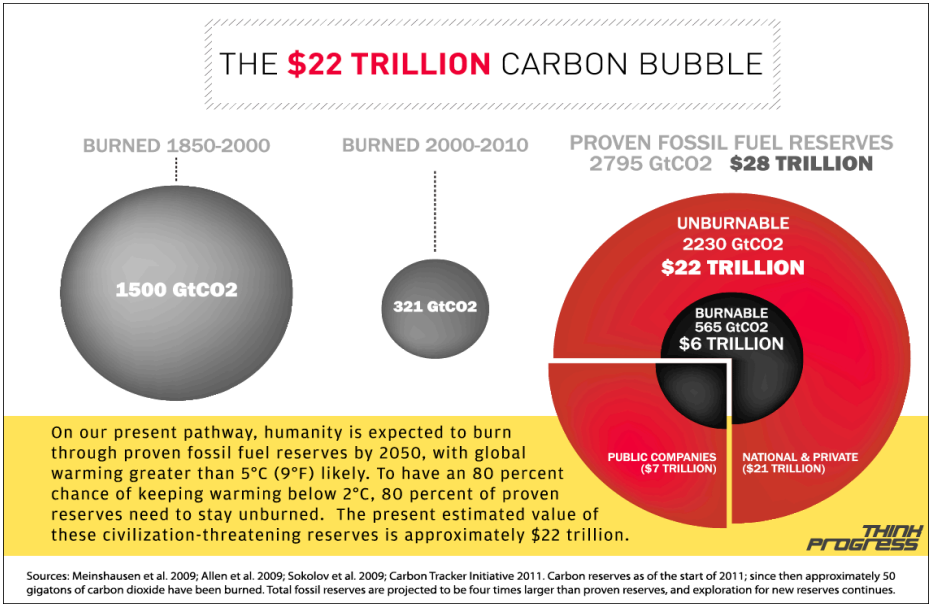
In 2011, Mark Campanale and his colleagues at Carbon Tracker published the first of its series of reports, “Unburnable Carbon—Are the world’s Financial Markets Carrying a Carbon bubble.”^{clxxii} Carbon Tracker calculated that at least 80 percent of the fossil deposits still in the

ground would have to stay there, if the world is to avoid warming beyond 2 degrees C more than pre-industrial levels.

On the basis of that, John Fullerton published an article titled “Big Choice,” describing the financial implication of Carbon Tracker’s numbers.^{clxxiii} Given that those fossil assets are on the balance sheets of some of the world’s wealthiest companies and sovereign wealth funds of the nations of the world, Fullerton estimated, this implied a write-off of at least \$20 trillion dollars. In contrast, he warned, the 2008 financial collapse was triggered by the stranding of only \$2.7 trillion in mortgage assets. We’re looking at an order of magnitude more dislocation.

A year later Bill McKibben, founder of the climate activist group 350.org, popularized the math in a Rolling Stone article titled, “Global Warming’s Terrifying New Math.”^{clxxiv} Bill was less concerned about the financial health of the fossil companies, but alarmed that to keep that much carbon in the ground would require instant and massive mobilization. By bill’s numbers, we can burn 565 gigatons more carbon. Period. Ever. That’s our carbon budget.

But the companies have five times that: 2,795 gigatons of fossil assets in reserve, and it is their business model to dig them up and burn them. If they do, the scientists warn, we roast. Between 60 to 80 percent of all coal, oil and gas reserves of publicly listed fossil companies are unburnable if we are to keep within the 2° C limit. And yet the companies spend enormous amounts of money continuing to search for more. This is a somewhat puzzling, as the rising threat of climate change means that they will not be able to burn what they already have on hand, let alone more of it—Carbon Tracker estimates that such companies as Royal Dutch Shell, Pemex, Exxon Mobil, Peabody Energy, Coal India and Glencore are wasting \$2.2 trillion of investment—old habits obviously die hard.



John Fullerton described the risk of carbon bubbles and stranded assets and set forth fundamentals that should guide investors in the age of climate crisis.^{clxxv} Short answer: fossil energy is no longer a safe place to put your money.

In 2014 Bloomberg New Energy Finance estimated coal stocks had lost 50 to 90 percent of their value since 2005.^{clxxvi}

This sobering conclusion was joined by the 2015 report by Mercer analyzing the portfolio risk to investors who hold stocks of fossil companies.^{clxxvii} It found:

Average annual returns from the coal sub-sector could fall by anywhere between 18 percent and 74 percent over the next 35 years, with effects more pronounced over the coming decade (eroding between 26 percent and 138 percent of average annual returns). Conversely, the renewables sub-sector could see average annual returns increase by between 6 percent and 54 percent over a 35-year time horizon (or between 4 percent and 97 percent over a 10-year period).

Bank of America stated in May 2015: Coal mining companies pose an increasingly risky investment.

“Going forward, Bank of America will continue to reduce our credit exposure to coal extraction companies.” It also committed to increasing lending to renewable energy, energy efficiency and carbon capture and storage. The spokeswoman said the bank’s renewable energy portfolio was currently more than three times as large as its coal extraction portfolio.^{clxxviii}

“Coal companies’ underperformance against the global equity market is unprecedented,” said IEEFA’s Tim Buckley. “A more than 50 percent decline in coal prices has seen most listed coal companies globally lose 80-90 percent of their equity market value in the last four years. While the sun will undoubtedly rise for renewable energy in 2015, for coal, there remains a lot further to fall.”^{clxxix}

Change came fast. By Feb 2015 an analyst observed, “Shares in Peabody, the world’s biggest private-sector coal company, have sunk 84 percent since 2010. Its debt has slipped to three rungs below investment grade. The company lost \$525 million in 2013 and hemorrhaged \$787 million in 2014.”^{clxxx}

Peabody Coal’s 2015 filing with the SEC signaled this, warning that, “Divestment could significantly affect demand for our product.”

This turned out to be a bit of an understatement.

By 1 July 2015, Peabody Coal, which had traded at \$60 a share in 2011, fell to \$1.68.

In August 2015 Hunter Lovins called out the behavior of Peabody Coal, and its marketing muscle, Berson Marsteller,^{clxxxi} for mounting a campaign to get Bill Gates and Bjorn Lomborg to trumpet that coal was the answer to energy poverty.^{clxxxii} It was thus gratifying to watch on 13 April 2016 as Peabody Coal, once the world’s largest private sector coal company, filed for bankruptcy.^{clxxxiii}

In covering Peabody's demise, Bloomberg noted "Recovery prospects for unsecured notes are poor."^{clxxxiv} This turned out to be true when the judge approving Peabody's exit from bankruptcy rewrote many longstanding legal provisions, including requirements that all classes of creditors be treated alike.^{clxxxv} The deal, being challenged by investors left holding the sack, means that the CEO will net an estimated \$15 million in stock bonuses, with \$3 - \$5 million each going to five other executives.^{clxxxvi}

As stated above, oil is not much safer. A Financial Times article from 2013 described the performance of international oil and gas companies as "lamentable from a shareholder perspective" over the last decade. Since June 2014, big oil has lost \$200bn.^{clxxxvii} According to Tom Sanzillo, who served as Deputy Comptroller of New York State, Exxon was, until the fall 2017 run-up in oil prices, borrowing to pay dividends.^{clxxxviii}

Goldman Sachs warned that nearly \$1 trillion worth of oil projects in the U.S. were effectively stranded, costing more to continue operation than any oil that might be recovered would be worth.^{clxxxix} The study, which found that \$930 billion worth of projects (more than two-thirds) would be unprofitable at Brent crude prices below \$70, was conducted when oil prices were at \$70 a barrel. Through much of 2017 they hung around \$50. They will go up. It would surprise no one to see an attack on oil facilities that drive prices over \$200 a barrel. Or sudden claims of oil curtailment. Day traders now make the same arguments that they did about coal, before that crashed. But if the dynamics laid out above are at all right, it's not a market for amateur investors—like most of the people now owning oil stocks.

Early in 2016, the consulting company Deloitte predicted that more than 35 percent of independent oil companies would go bankrupt, with another 30 percent to follow in 2017. This came on the heels of 50 North American extractors bankrupted in late 2015.^{cx} Ernst and Young warned that 64 percent of the 365 oil and gas megaprojects they surveyed were over budget, with 74 percent behind schedule.^{cxci}

The International Energy Agency, generally very conservative in such matters, warned the oil industry that more than \$1.3 trillion in oil assets and another \$300 billion in natural gas were at risk of being stranded as companies and countries move to clean energy.^{cxcii}

Mark Campanale recently warned that it's even worse: an October 2017 CitiGroup report calculated that if you count the foregone revenues from not digging up, selling and burning all that fossil fuel, the looming loss is \$100 trillion, or more than global GDP.^{cxci}

It is essential that a just transition be found for the mining communities and all of the working people abandoned by fossil energy companies. In addition, resource extraction has massive impacts on the environment, but because of the complicity of regulators for decades, the companies have typically been allowed to self-bond for clean-up costs. Who will pay those, if the companies are gone? Peabody Coal, previously the world's biggest coal miner, is expected to default on its environmental obligations and on lease payments to various governments. Peabody was the fourth such company to crash, but it will not be the last.

Fossil companies are highly leveraged (which means that they owe a lot of debt). The high and rising costs of extraction mean that they borrow to punch new holes in the ground to find ever more oil, gas and coal. If oil prices rise, it all works out, But if they don't...?

Nafeez Ahmed, in an article titled "This Could Be the Death of the Fossil Fuel Industry—Will the Rest of the Economy Go With It?"^{cxciiv} wrote:

Oil and gas companies most at risk are those with the largest debt burden. And that burden is huge -- as much as \$2.5 trillion, according to *The Economist*. The real figure is probably higher.

At a speech at the London School of Economics in February, Jaime Caruana of the Bank for International Settlements said that outstanding loans and bonds for the oil and gas industry had almost tripled between 2006 and 2014 to a total of \$3 trillion.

This massive debt burden, he explained, has put the industry in a double-bind: In order to service the debt, they are continuing to produce more oil for sale, but that only contributes to lower market prices. Decreased oil revenues means less capacity to repay the debt, thus increasing the likelihood of default.

This \$3 trillion of debt is at risk because it was supposed to generate a 3-to-1 increase in value, but instead—thanks to the oil price decline—represents a value of less than half of this.

Ahmed concludes that if oil company projects are rendered unprofitable, it would cut oil and gas extraction by eight percent of current world demand, posing the risk of crashing the global economy. He also shares the belief supported by a paper in the journal *Applied Energy* from a team at Oxford University's Institute for New Economic Thinking, "that the 'stranded assets' concept applies not just to unburnable fossil fuel reserves, but also to a vast global carbon-intensive electricity infrastructure, which could be rendered as defunct as the fossil fuels it burns and supplies to market."^{cxcv} This is precisely the fate that befell the two big European utilities RWE and Eon, above.

Of course, the costs of continued fossil use are even higher. A variety of studies going back to the Stern Review in 2006^{cx cvi} found that unmitigated climate change poses financial risks. Lord Nicolas Stern, previously the Chief Economist of the World Bank, was commissioned by the government of the UK to consider the economic impact of global warming on the global economy. In a massive, data rich tome of 700 pages, Stern showed that approximately one percent of global GDP will need to be invested to hold warming to below 4° C, but that costs of failing to limit climate change would rise to between five and 10 percent of world GDP. Clearly, he argued, there's a business case to act.

Deutsche Bank's 2013 study supported Stern.^{cx cvii} Following the release of the Intergovernmental Panel on Climate Change's 5th Scientific Assessment, it observed:

If governments do not implement policies that sufficiently reduce GHG emissions, this could reduce economic growth and increase volatility.... More and more potential

investors now consider companies' sustainability risk management as part of their investment decisions. Sustainability rating used by investors are starting to ask questions about whether banks' own lending and financing leads to higher greenhouse gas emissions. Over the next two years, the financial sector will develop new tools to measure the emissions that arise from bank business activities.

This is of particular concern to insurance companies, for several reasons. One, they are, at root, investment companies, seeking sufficient returns to pay claims from their policy-holders over time. Insurance companies own large fossil holdings. With the risk to the solvency of these companies, this is uncertain.

Second, climate change worsens the risk of fire, floods, extreme weather, crop failure, and many other risks against which these companies insure. Bloomberg Briefs reported that insurance companies' refusal to consider these risks threatened the financial system.^{cxviii} A report from the Asset Owners Disclosure Project (AODP)^{cxix} showed that only 14 of the 116 insurance companies surveyed are taking action to screen climate risk from their portfolios. Quoting the AODP Chief Executive, Julien Poulter, Bloomberg reported,

"Investors in insurance companies must start to care" about climate risk in insurers' investment portfolios, Poulter said. "I don't think it's any accident that [Bank of England Governor] Mark Carney gave his speech last year on climate risk to the insurance sector at the Lloyds of London event. If the insurance sector gets climate risk wrong, there is a financial stability problem for everybody."^{cc}

The Global Risk Institute agrees. Their 2016 report, "Climate Change: Why Financial Institutions should take note," warns that insurers now face annual losses of \$50 billion from climate change driven weather events (increased from \$10 billion a year over the past decade); as well as "transition risk" from a lower-carbon economy. It also urged banks to cut exposure from "High carbon industries" and other assets that may suffer from efforts to curb climate change, and "pursue new green opportunities in commercial and investment banking."^{cci}

A case in point is the recent fires in California. Severe drought, record winds and high temperatures fanned the biggest wildfires ever in state history. Several appear to have been caused by failing utility company infrastructure. The California Public Utility Commission ruled that the utility at fault could not recover its costs, and liability for the fire, from its ratepayers. The CEO of San Diego Gas and Electric stated,^{ccii}

if these wildfires become the new normal, if these wildfires become endemic and part of the effects of climate change day in and day out, I don't think it's sustainable for utilities to afford that on a long-term basis.

A month prior, that is precisely what Governor Jerry Brown said, calling California's fire situation, "the new normal. California is burning up." He said, "The fire season is not a couple of months in the summer; it's virtually year-round."

2017 was only the third hottest year on record, but climate change driven impacts set a new record for devastating, and expensive “natural” disasters, with almost a third of a trillion dollars in damages.^{cciii}

Investing in a Finer Future

Milton Friedman famously admonished, that the “social responsibility of business is to increase its profits.”^{cciv} Throughout history there have been corporate leaders who have rejected this fixation on profit maximization, but they have been a minority. In the late days of the Presidency of George Bush, the U.S Department of Labor issued a guidance to discourage investors managing employee pension funds from considering environmental and social factors in the companies and funds in which they invest.^{ccv}

Churches and other moral leaders ignored this. They had begun in the 1960s to, refuse to own so-called “sin stocks:” weapons, tobacco, alcohol and what they saw as companies producing degenerate products. Even they believed that such a philosophy, while noble, was going to result in lower returns on investment. Professional investors just thought it was foolish. Why mix the work of making money with Sunday School?

But a funny thing happened on the way to the counting house: investors who blended money and morality out-performed the market. It turns out that companies that fail to respect people and the planet are a risky business.

Early in the 21st Century, a group of investors and sustainability experts convened Bottomline 2001 in San Francisco. They invited several of the largest institutional investors to consider whether there might be a business case for shifting their investments to more sustainable options.^{ccvi}

Pension funds have substantial resources. OECD estimates that in 2013 institutional investors held \$92.6 trillion in assets. In contrast, the 34 countries that comprise OECD have \$47.3 trillion in GDP. Exxon-Mobil’s capitalization was only \$334 billion.^{ccvii} Traditionally, pension funds invested their money without any particular concern for social and environmental criteria, despite the fact that the invested money came from constituencies such as workers, teachers, churches, charitable organizations, and educational institutions who often are value-driven.

The neoliberal belief held that portfolios screened to exclude any class of investments must under-perform financially, because they, by definition, are not playing with a full deck. Adherents say that trustees have a fiduciary duty to earn the highest possible return over the short term, therefore it would be irresponsible to limit their investment options.

But what if it’s not true that screened investments always underperform? What if they often outperform less socially conscious companies? When presented with the business case for behaving more sustainably, the pension fund managers and state and municipal treasurers who attended Bottomline 2001 began to redefine their fiduciary responsibility and as a result, reorient their portfolios.

Such speakers as the Treasurer of California, the Chair of California Public Employees Retirement System, one of the world's largest pension funds, and many other representatives from institutional investors generally agreed that their funds must, by definition, be interested for the long-term success, and overall sustained upturn of the entire economy. They agreed that it matters little to a pension fund if one company does well in the short term, especially if it does so at the expense of natural and human capital, the health of which underlies the health of the economy. Pension funds are so large that they are invested in essentially every large company in the economy. Further, unlike day traders, next quarter's profits do them little good. What matters to them is ensuring that the whole of the economy is healthy in 20 years when they will be paying out the pensions for which they are investing the money today. These investors realized that they may turn out to be the institutions with the greatest vested interest in sustainability.^{ccviii}

They were right. US Forum for Sustainable and Responsible Investment (US SIF) now states,

The past 25 years have shown that environmental, social and governance (ESG) factors can affect shareholder value and corporate and investment portfolio risk and return, discrediting the longstanding perception that fiduciary duty precludes consideration of ESG criteria in institutional investment decisions. In 2005, international law firm Freshfields, Bruckhaus, Deringer found, after examining fiduciary law in nine developed markets, including the United States, that, "...the links between ESG factors and financial performance are increasingly being recognized. On that basis, integrating ESG considerations into an investment analysis so as to more reliably predict financial performance is clearly permissible and is arguably required in all jurisdictions."

Two years later, Bob Massie, founder of CERES, one of the most effective group working to get institutional investors to become active in countering climate change, created the Investor Network on Climate Risk.^{ccix} Mindy Lubber, his successor at CERES, has worked tirelessly to engage 120 institutional investors (with assets of more than \$14 trillion) in countering climate change and all other forms of unsustainability. Her Clean Trillion initiative seeks to close the investment gap between what is spent on clean energy and what is needed to protect the climate.

In 2007 Mindy and former CalPERS Chief Investment Officer Russell Read organized investors with \$1.2 trillion in assets to petition the Securities and Exchange Commission to issue guidance on how companies should report their risks from climate change.^{ccx} More than 100 investors with \$7.6 trillion supported the effort. In 2010 the SEC issued such a guidance, and climate reporting became mainstream.

In 2016 the Department of Labor repealed its anti-responsibility bulletin, stating,

Environmental, social, and governance issues may have a direct relationship to the economic value of the plan's investment. In these instances, such issues are not merely collateral considerations or tie-breakers, but rather are proper components of the fiduciary's primary analysis of the economic merits of competing investment choices.^{ccxi}

This happened in part because Socially Responsible Impact Investing (SRI) is the fastest growing investment field. The US SIF reported that:^{ccxii}

assets managed using strategies that consider environmental, social and governance (ESG) issues in investment analysis, portfolio selection or shareholder engagement totaled \$6.57 trillion at the start of 2014. This represented one out of every six dollars under professional management in the United States and growth of 76 percent over 2012.

By early 2016, global sustainable investment assets reached \$22.89 trillion, a 25 percent increase from 2014.^{ccxiii} This shift is itself changing how business is done. The US SIF^{ccxiv} found that: SRI investors have created four key impacts:

1. Changed the investment industry and investors
2. Influenced companies through active ownership and engagement strategies
3. Assisted communities, and
4. Achieved progress on various environmental, social and governance issues by influencing public policy and by supporting the development of US and global organizations to promote sustainable investment.

The importance of SRI is reflected in the statistic that 73 percent of all investment managers globally use ESG criteria for making investment decisions.^{ccxv}

The Stranded Assets discussion above brings even greater urgency for investors to ensure that the companies in which they are placing their faith and their money are taking sustainability seriously.

As Chris Davis, the senior program director at the sustainability consultancy Ceres, puts it, “If climate trashes the economy, they’re not going to be able to meet their pension-fund obligations.”^{ccxvi}

Ellen Dorsey, the Executive Director of the Wallace Global Foundation created the “Divest - Invest movement to enable investors to begin voting with their dollars.”^{ccxvii} Asking what she could do after the 2009 failure of the UNFCCC Climate Summit in Copenhagen, Ellen shifted her foundation’s endowment away from fossil fuels and into clean investments, pointing out, “if you own fossil, you own climate change.”

In the cold and rain in November 2012, Bill McKibben, who had helped call global attention to the issue of stranded assets, boarded a bus to tour the U.S. on what he called the “Do the Math Tour.”^{ccxviii} Using his Rolling Stone article, he toured almost every corner of the United States, speaking at sold-out shows on college campuses, calling on students to protect their future by demanding that their college endowments divest of ownership of fossil companies.

No one gave him a prayer of success.^{ccxix}

But a funny thing happened on the way to the bank. Thousands of people started calling for a fossil free future. Divestment started to catch on. The Oxford’s Stranded Assets Programme’s

report concluded, “Divestment outflows, even when relatively meagre in the first wave of divestment, can significantly and permanently depress stock price of a target firm if they trigger a change in market norms.”^{ccxx}

In early 2015, the movement got international support from Alan Rusbridger, the courageous and visionary Chief Editor of the Guardian. Alan called an array of advisors to his office overlooking the Regent’s Canal and asked how the newspaper might be most effective in the fight against climate catastrophe in the run-up to the Paris Summit. After extensive consultations, he launched a Guardian campaign to Keep It In the Ground, calling for divestment by such entities as the Gates Foundation and the Wellcome Trust.^{ccxxi}

Values-oriented investors heard the call and began pulling their money out of the fossil industry. Ordinary investors began to realize that the economic fundamentals of the fossil industry had turned against them.

Fossil fuel divestment scaled rapidly. In September, organizations with \$2.6 trillion in assets under management had joined the divestment movement.

Prior to the 2016 Paris Summit activists announced that holders of \$3.4 trillion in assets had pledged to divest from coal or other fossil fuels. Shortly after, 70 new institutions joined.^{ccxxii} By the end of 2016 Arabella Advisors reported:^{ccxxiii}

To date, 688 institutions and 58,399 individuals across 76 countries have committed to divest from fossil fuel companies, doubling the value of assets represented in the last 15 months. Pension funds and insurance companies now represent the largest sectors committing to divestment, reflecting increased financial and fiduciary risks of holding fossil fuels in a world committed to stay below 2° Celsius warming.

The increase comes, in part from evidence that fossil-free portfolios have outperformed fossil heavy ones.^{ccxxiv} FTSE’s North American fossil fuel-free index has consistently outperformed the conventional benchmark index.^{ccxxv} MSCI, a stock market index company, found that fossil-free funds have earned a higher return than conventional ones over five years.^{ccxxvi}

Norway recently announced that it is considering divesting of ownership in fossil industries.^{ccxxvii} BNP Paribas, the large French bank sold its holdings in a tar sands pipeline.^{ccxxviii}

On 7 November 2017, the little company Change Finance,^{ccxxix} rang the opening bell in the New York Stock Exchange on Wall Street as 3.5 million eyeballs watched the launch of the first truly fossil free exchange traded fund.^{ccxxx} For the price of a pizza, ordinary individuals can now invest in companies that are not subject to the looming fossil risk.

The death knell of fossil investing came a bit more than a month later when the Governor of New York and the City Comptroller of New York City both announced a freeze on fossil investments and proposals to divest their collective \$390 billion from fossil fuel companies and reinvest in renewable energy. Bill McKibben wrote,^{ccxxxi}

The dam has broken: after years of great activism, New York has taken a massive step towards divesting from fossil fuels. Coming from the capital of world finance, this will resonate loud and clear all over the planet. It's a crucial sign of how fast the financial pendulum is swinging away from fossil fuels.

Funding the New Energy Economy

Christiana Figueres is the wickedly bright, inspirational leader of the UN's Framework Convention on Climate Change, who masterminded the success in delivering an internationally binding accord to limit global warming in Paris in 2015. Now head of Mission 2020,^{ccxxxii} she has stated, "Where capital goes over the next 15 years is going to decide whether we're actually able to address climate change and what kind of a century we are going to have."^{ccxxxiii}

How money is invested—whether by companies, by colleges or by you—determines whether we trash the planet or save it. What you do with your money *does* make a difference.

In 2015 investors from around the world poured \$348 billion into clean energy, a new record,^{ccxxxiv} and up from \$60 billion a year in 2004.^{ccxxxv} The amount invested fell 18 percent in 2016, in part because falling costs of renewables meant that more could be built for less money. Acquisition of clean energy companies rose, however, to 117 billion, up from \$97 billion in 2015.^{ccxxxvi}

The report, "Carbon Clean 200: Investing in a Clean Energy Future"^{ccxxxvii} reported that the 200 leading clean energy companies returned triple the profits of fossil fuel companies in the last 10 years.^{ccxxxviii}

Again, new business models are being created. Green bonds (debt instruments offered to raise money to finance clean energy and other green initiatives) more than doubled from \$93.4 billion in 2016 to an expected \$208 billion in 2017, according to the rating firm, Moody's, doubling the record set in 2016.^{ccxxxix} China was responsible for a third of this, a number that is expected to rise, as the country seeks to fund a projected \$308 billion in projects to cut air pollution, meet its climate targets and ensure abundant energy for prosperity.

The market has grown by 163 percent a year since 2011, with consecutive issuance records every year from 2013 to 2017. Created initially by the European Investment Bank in 2007, they are now being used by a variety of nations,^{ccxli} and such states as Connecticut and New York who have created Green Banks. Apple issued a billion dollar green bond to finance its efficiency and renewable projects after the U.S. announced its withdrawal from the Paris Accord.^{ccxlii} The bonds are being joined by such green money-market securities as short-term commercial paper, and preferred stock, structured as securitized transactions.

As impressive as this is, it represents a small part of the \$6.7 trillion a year global debt market. And it is miniscule compared to \$44 trillion that the International Energy Agency projects needs to be spent on energy deployment by 2040.^{ccxliii}

Still, remember the logic of exponential growth that Kurzweil described above. The green bonds market grew by 42 percent in the first quarter of 2017, with more than \$20 billion offered in the first three months. This is almost 7 times the amount offered in the entire year in 2012.^{ccxliii}

What can you do?

For starts, figure out where YOUR money is. It appears unwise to have any of your assets in the industries that will be disrupted. Bevis Longstreth, former Securities and Exchange Commissioner, observed,^{ccxliv}

“It is entirely plausible, even predictable, that continuing to hold equities in fossil fuel companies will be ruled negligence.”

Think about where your energy comes from. Are you dependent on an industry that is at risk? Are you part of the millions of people, communities and cities that are implementing renewables?

Is your job at risk? Companies will either become part of the solution or they will face stiff headwinds. The emerging industries are creating millions of jobs, but millions are at risk. Figuring out how to deal with this is discussed more in the Fourth Section, but it's time to begin discussing it in your community. Will we entrepreneur our way to a Well-being Economy? Will we substitute a Universal Basic Income? Will we descend into unimaginable darkness? Or will we create a Finer Future?^{ccxlv}

What is increasingly clear is that we will totally transform the global economy. The crises we face, and the inevitabilities of change described here WILL drive change.

The change is here. How will you change to deal with it?

Conclusion

Standing at the bottom of any S curve of adoption of a new technology, it may seem impossible to get there from here.

When change comes, however, looking back, it will seem inevitable and incredibly rapid.

The speed with which renewable energy, especially solar, is growing means we have a shot at solving the climate crisis, creating jobs, reinvigorating manufacturing and buying the time needed to do the more fundamental work of implementing a Regenerative Economy. Let's return the energy sector to Nature's principles. Nature runs on sunlight, not huge flows of fossil energy. We can too.

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