Script Key:
- **NARRATION**
- ***On Screen Visuals***
- Annotation

# TEASE

***Engaging youngsters from around the planet: kids on a beach in Rio, the Ceara "eco-kids": orbital zoom to Morocco:***

***Narrator:***

**EARTH'S POPULATION HAS NOW PASSED SEVEN BILLION.**

A United Nations estimate (PDF) had humanity passing the 7 billion mark on October 31, 2011, though the U.S. Census estimates held that milestone back until April 2012.

***Marrakech rooftop satellite dishes: a busy market square and the lights come on in San Francisco. Mass transit in the Bay Area and Portland, Oregon:***

**AND WORLD *ENERGY* CONSUMPTION IS PROJECTED TO INCREASE MORE THAN 25% DURING THE NEXT 15 YEARS, AND MAY NEARLY DOUBLE BY THE YEAR 2050.**

The Energy Information Agency of the United States Department of Energy prepared a report (PDF) in 2007 that included reference-case scenarios for 2025 and 2030, with world energy consumption totals (in quadrillion BTU) for 2010, 2025, and 2030 of 511, 654, and 702, respectively, indicating an increase of 28% from 2010 to 2025.

As to 2050, predictions are naturally less certain. The World Energy Council's 2007 report (PDF) "Deciding the Future: Energy Policy Scenarios to 2050" states (p. 8) that "At least by 2050, the world will need to double today's level of energy supply to meet increased demand." A 2006 PriceWaterhouseCoopers (PWC) study (PDF) "The World in 2050" includes four scenarios for energy consumption through 2050, passing from "green growth" to "scorched earth," with total world energy consumption ranging from 13 to 33 GTOE, which would represent increases of 2% to 158% over 2010 energy use. The study's two middle scenarios set 2050 consumption at 17 and 22 GTOE, indicating increases of 33% and 72% over 2010.

***Nighttime China street scenes, in timelapse, and the GM assembly line in Sao Paulo, Brazil, and street scenes in Copenhagen and San Francisco:***

**BUT HOW MUCH ENERGY WE *NEED*, AND HOW WE GET IT, DEPENDS ON CHOICES WE MAKE *NOW*.**

***Portland shots showing streetcars and trams:***

**AND THOSE ENERGY CHOICES HAVE CONSEQUENCES FOR EARTH'S CLIMATE.**

***Raging rivers, wind turbines and solar panels:***

**WE ALREADY SEE THE PROMISE OF *21st CENTURY* RENEWABLES…**

***Chimneys belching dark smoke, etc.***

**BUT, TODAY, MOST BIG NATIONS STILL RELY ON *19th CENTURY* TECHNOLOGIES.**

Lykke Friis was interviewed by ETOM in summer 2011, but already knew there was a good chance her party would be replaced in the then-upcoming elections. Results were announced on 3 October, and she was, indeed, no longer Minister of Climate and Energy.

***Lykke Friis, Former Minister of Climate and Energy, Denmark.***

***Lykke Friss:***

***At a global perspective, we simply know that the age of cheap energy is over.***

***Samsø turbines, Denmark:***

**INNOVATIVE PROJECTS PROVE THAT WIND *CAN* POWER ENTIRE COMMUNITIES…**

***Sunrise over the desert, and solar panels roll down a production line: nightfall over USA shot, seen from orbit:***

**…AND CONSERVATION AND EFFICIENCY CAN CUT PROJECTED WORLD ENERGY DEMAND 30% BY 2030.**

Conservation and efficiency savings for the U.S. (*Unlocking energy efficiency in the U.S. economy, July 2009*) and worldwide (*Pathways to a low-carbon economy, January 2009*) are from studies by McKinsey and Company.

***Series host Richard Alley, on the beach in Hawaii, speaks to camera:***

***Richard:***

***But how to get there? That's not just a technological question of solar cells and wind turbines, but depends on choices made by real people living in the real world…***

***Cut closer, to the medium shot:***

***…and that means economics and politics, national security, jobs… (and) why we do what we do…***

*Richard Alley speaks voice over shots of him teaching introductory geology at Penn State:*

**I'M *RICHARD ALLEY*. I'M AN EARTH SCIENTIST, A PARENT AND A PROFESSOR, CONCERNED FOR MY KIDS'—AND MY STUDENTS'—FUTURE.**

*Richard looks out of a helicopter in New Zealand, and walk over seracs, using an ice pick and walking pole: CGI shot of the retreating North American ice sheet at the end of the last Ice Age:*

**I'VE STUDIED OUR PLANET'S CHANGING ICE SHEETS AND CLIMATE HISTORY…**

*A rainbow over Iguaçu Falls, and the Sun, through leaves:*

**…AND TRIED TO COME UP WITH NUMBERS FOR HOW MUCH RENEWABLE ENERGY OUR PLANET OFFERS.**

See the Renewables Roundup sequence in ETOM program 1 and part III of the ETOM book, page 225-6, for Richard's estimates.

*Male narrator, over action shots of Richard, on glaciers and elsewhere:*

**GEOLOGIST RICHARD ALLEY IS ONE OF THE *97%* OF CLIMATE EXPERTS WHO BELIEVE CURRENT ENERGY PRACTICES *ARE* WARMING THE PLANET…**

**BUT THAT ANSWERS ARE OUT THERE…**

*Texas turbines, red skies in the morning:*

**BLOWING IN THE WIND…**

*Dunes and bright sunshine:*

***SHINING DOWN FROM ABOVE…***

*Chinese solar R&D engineers at Applied Materials in Xi'an:*

**AND IN THE MINDS OF INVENTORS AND ENGINEERS.**

*Søren Hermansen, Managing Director, Samsø Energy Academy*

*Søren Hermansen VO scenes of offshore Samsø turbines being serviced:*

***Technology is easy, we'll find solutions…***

*Søren on camera:*

***…It's a matter of making decisions.***

*Building and opening of the Hoover Dam (stock footage from the U.S. National Archives and Records Administration), using the most impressive shots of drilling, explosions and the gigantic concrete walls, and aerials:*

**BUILDING A NATION'S ENERGY *INFRASTRUCTURE* TAKES DECADES.**

**NOW SOME ENERGY *INSIDERS* WONDER IF AMERICA IS STILL UP TO THE TASK.**

*John Hofmeister, Fmr. Head, U.S. Shell*

*John Hofmeister VO:*

***You need to think of energy in a 50-year time frame…***

*On camera:*

***…And our elected officials are thinking of energy in two-year election cycles. That's ridiculous!***

*Slo-mo wave crash segues to Richard on the Hawaii beach:*

*Richard on camera:*

***But I'm optimistic we can get to a world with more people living better while using cleaner and more sustainable energy. And that's why we call this program…***

**…"POWERING THE PLANET."**

*NSF UNDERWRITER ANNOUNCE (00:15)*

*"POWERING THE PLANET—EARTH: THE OPERATORS MANUAL" IS MADE POSSIBLE BY NSF, THE NATIONAL SCIENCE FOUNDATION, WHERE DISCOVERIES BEGIN.*

*MAIN TITLES, with music:*

## *POWERING THE PLANET*
## *Earth: The Operators' Manual*

# Light Bulbs in the Desert

***An orbital view of North America: then waves crash, the wind rustles grasses, Sun glints through trees and flowers:***

***Narrator:***

**PLANET EARTH IS AWASH IN RENEWABLE ENERGY.**

***Dramatic waves race in, and crash into rocks at Point Lobos, CA:***

**THE OCEANS STORE HEAT AND OFFER WAVE AND TIDAL POWER.**

***Sun through a plantation of tall eucalyptus trees in Carbonita, Brazil:***

**PLANTS HARVEST SUNLIGHT AND STORE ITS ENERGY.**

***Abstract CU grasses and flowers (Samsø taping), clouds timelapse, and daytime Texas turbines, with Sun behind:***

**THE SUN WARMS THE ATMOSPHERE AND SETS AIR IN MOTION, AND WE'RE GETTING BETTER AT TAPPING WIND POWER.**

***The Sun over Yuma dunes:***

**BUT THE BIGGEST AND MOST PROMISING ENERGY SOURCE IS THE NEARBY STAR THAT LIGHTS OUR DAYS AND WARMS OUR WORLD.**

***TEXT TITLE:***
***"Lightbulbs in the Desert"***

***Richard Alley walks across the dunes, in wide and closer shots:***

**SUNLIGHT REACHING THE EARTH'S SURFACE OFFERS ABOUT 120,000 TERAWATTS.**

In what follows, bear in mind the difference between imagining that we spread the total energy of sunlight (122,000 TW) evenly around the Earth, and the actual interception of sunlight by the Earth. The first imagines the full area of Earth ($4\varpi R2$) receiving the total solar energy evenly, while the actual interception involves the Earth's cross section ($\varpi R2$) receiving solar energy. Half of the reduction by the factor of four comes from the day-night factor, and the other half from the fact that except at the Equator (more or less), solar energy impinges at a slant.

The top of Earth's atmosphere receives 174 petawatts (PW) of solar energy. With some variation, the atmosphere reflects about 30% of this, allowing about 120 PW, or 120,000 TW, to heat the Earth and its atmosphere.

**IF THE SUN'S ENERGY WERE SPREAD AROUND THE WORLD, IT WOULD AVERAGE AROUND 240 WATTS PER SQUARE METER.**

Since the Earth's mean radius is 6,378 kilometers, its surface area equals 511 million square kilometers, or 511 trillion square meters. If we divide this into 120,000 trillion watts, we have approximately 235 watts per square meter. But note that sunlight never really spreads around the Earth equally, even ignoring nighttime, because it radiates far more strongly near the Equator than near the poles: we're simply presenting an average.

**RICHARD ALLEY BRINGS THAT HUGE NUMBER DOWN TO EARTH.**

***Zoom down from a crane shot to a small figure walking in what looks like a vast desert. We zoom in closer to discover it's Richard:***

***"Richard A" looks to camera:***

***If I walk out into this little patch of this great desert, and I hold out my arms about like this…***

***"Richard B" appears through visual effects:***

***And then another of me does the same thing…***

***He stops and holds out both hands, palms up. CGI light bulbs appear. Seen from above, a square meter line reads on, under the two Richard's feet:***

***And each of me is holding two 60 watt incandescent light bulbs …or 10 compact fluorescents… that's 240 watts per square meter that I'm marking out here. That's a* lot *of energy.***

***See both "Richards" facing each other, CGI light bulbs in hand:***

***And averaged across the globe, day and night, summer and winter, that's how much sunlight is available to power the planet.***

***He (both "he's") look up, and cut to a majestic Sun. A figure appears over a dune crest. There's a flash from a mirror: Another flash… what's that? It's a mirror reflecting the Sun back to the camera.***

***Richard VO:***

**LET'S SEE WHAT IT TAKES TO TURN THAT VAST POTENTIAL INTO POWER WE CAN USE.**

***He stops walking: flash, flash. Cut closer: Richard to camera:***

***Doesn't take a genius to know that a mirror reflects the Sun, but it does take an inventor and engineer to make the next step.***

***He makes the following actions with the metallic water flask in his hand, and the mirror: CUs and sun flares bounce back into the lens:***

***Richard to camera and VO:***

***Use the mirror to focus the Sun's rays on a tank filled with liquid to make steam, to drive a turbine, to make electricity, and you have concentrated solar power.***

***Richard to camera:***

***That's not a new idea, but one that a little-known American inventor, Frank Shuman, pursued around 1910.***

***Non-Richard narrator picks up the story, and continues through the end of this segment:***

**IN HIS PHILADELPHIA WORKSHOP, SHUMAN INVENTED SAFETY GLASS FOR SKYLIGHTS AND AUTOMOBILES.**

According to the website "A book-in-progress about renewable energy by Jeremy Shere," Shuman was "a dead ringer for Teddy Roosevelt, (and he) shared much of the former U.S. president's energy and force of personality. Earlier success with his invention of "Safetee-Glass"—shatter-proof glass used for skylights, car windshields, goggles and machine tool guards—had made Shuman a wealthy man, freeing him to pursue his engineering passions in his Edison-like inventor's compound in Philadelphia."

The most complete account of Shuman's work on solar energy appears in F. T. Kryza's book *The Power of Light: The Epic story of Man's Quest to Harness the Sun*, which devotes Chapter 2 to "Philadelphia's Solar Wizard"—Frank Shuman. A good deal of the relevant text is available on Google Books.

Kryza states that Shuman, realizing that Pennsylvania tycoons were too deeply into coal to be interested in solar power, headed for London in 1911 to seek backing for his investment, having realized that countries with lots of sunshine and little local energy sources (as yet no Saudi oil fields!) would be the best locations to start his projects.

***Shuman in Philadelphia stills and details: see designs for the solar "hot boxes" dating from his work in Philly:***

**HE ALSO CAME UP WITH DESIGNS THAT COULD CONCENTRATE SUNLIGHT ON METAL TUBES, HEAT LIQUID, AND DRIVE A STEAM TURBINE.**

From Kryza's book *The Power of Light* we learn that Shuman's hot boxes simply contained material that absorbed solar heat; in his advanced versions, tubes carried liquid through these boxes to carry away the heat. When Shuman improved his box design, he put metal boilers inside, connected one to another by metal tubes (Kryza, p. 15).

**BUT IN PENNSYLVANIA, BACK THEN, IT WAS ALL ABOUT COAL.**

**SHUMAN HAD DIFFICULTY FINDING LOCAL BACKERS.**

**SO IN 1912 HE SET OFF FOR EGYPT.**

Kryza's book (p. 125) says that Shuman sailed from England to Alexandria in the spring of 1912. This makes sense, because his solar-power plant went into operation in June 1913, and it must have taken considerable time to choose a location, organize construction, and overcome the difficulties of getting anything done in Egypt.

***Stills and patent CGI:***

**HIS PROTOTYPE SOLAR FARM USED PARABOLIC TROUGHS TO CONCENTRATE SUNLIGHT AND BOIL WATER.**

Shere points out that "Shuman had to deal with an unwelcome intervention of the form of famed British physicist Sir Charles Vernon Boys, who'd been brought in as a consultant by Shuman's British backers to evaluate Shuman's schematics. To Shuman's annoyance, Boys suggested a major change: replacing the hotbox collectors with trough-shaped parabolic mirrors. The advantage of the mirrors, Boys argued, was that they would concentrate sunlight on the boiler on all sides, thus producing heat and steam more efficiently. The *disadvantage*, Shuman countered, was that replacing cheap hotboxes with pricey mirrors would raise the cost of the plant well beyond the initial $40,000 estimate. After all, Shuman's commercial strategy centered on building a solar plant that could compete with coal-fired plants in terms of both power and cost. Building the collectors with more expensive material without going over budget would mean including fewer collectors, thereby dramatically scaling back the plant's power output from a robust 1,000 horsepower to a comparatively measly 85. "Although Shuman firmly believed that the path to commercial success lay in demonstrating that a solar power plant could run an industrial-sized steam engine, he was forced to concede to Boys, whose opinions on matters scientific were taken as gospel in British engineering circles. And so, summoning the can-do American spirit for which he had become famous, Shuman forged ahead. Rather than build parts in Philadelphia and have them shipped to Egypt, as per the original plan, Shuman decided to build the plant from scratch in Maadi [Egypt], using local materials."

***Stills of the Maadi solar plant:***

**THE STEAM RAN A 75 HORSEPOWER ENGINE THAT PUMPED WATER FROM THE NILE TO IRRIGATE COTTON FIELDS.**

Shere's website says that "heated to just more than 200 degrees Fahrenheit, water in the boilers turned to low-pressure steam to drive a specially designed, 75 horsepower engine."

**THE IDEA WAS RIGHT, BUT AHEAD OF ITS TIME.**

*The CGI patent (Crazybridge Studios) retreats from 3D to a 2D page:*

**HOBBLED BY BOTH LACK OF GOVERNMENT SUPPORT AND ADEQUATE PRIVATE CAPITAL, THE EXPERIMENT ENDED WITH THE OUTBREAK OF WORLD WAR I.**

According to Shere, all went swimmingly through the summer of 1913, when Shuman's Egyptian solar-energy farm began to function. "Solar power truly seemed to have crossed a threshold, now standing on the brink of widespread commercial success … Although Shuman had taken solar power further than any of his predecessors, the immediate future of solar power was ultimately at the mercy of forces far beyond his—or anyone's—control."

And #1 among those forces: World War I: "As the first conflict almost entirely dependent on fossil fuel-burning trucks, tanks, ships and airplanes, WWI helped to more firmly entrench not only coal but also oil as fuels indispensable to industry. Greater production of both fuels spurred by the war lowered costs, making it more difficult for solar technology to compete on equal economic footing."

***Zoom in to one of Shuman's parabolic troughs, and cut to and pull out from one of the contemporary parabolic troughs at Solucar.***

***Place and time locator: Solucar Platform, 2010, Seville, Spain***

**THESE PARABOLIC TROUGHS LOOK VERY SIMILAR TO SHUMAN'S DESIGNS… THOUGH THEY DIDN'T COME ONLINE UNTIL A CENTURY LATER.**

***Wider shots:***

**THIS IS "*SOLNOVA 3*," AT ONE OF THE WORLD'S FIRST COMMERCIAL SOLAR POWER PLANTS.**

**JUST AS IN SHUMAN'S EXPERIMENTAL STATION, THE TROUGHS CONCENTRATE SOLAR RADIATION ON A PIPE THAT CONTAINS A HEAT-BEARING FLUID.**

**WHEN COMPLETED THERE'LL BE THREE ALMOST IDENTICAL PLANTS, EACH WITH AN OUTPUT OF 50 MEGAWATTS, LARGE ENOUGH TO SUPPORT ABOUT 26,000 HOUSEHOLDS.**

***Hot spots on the power towers of PS1 and PS2, and pillar-of-light reflections off the field of mirrors:***

**WHILE THE SUN POWERS THE SOLUCAR PLATFORM, IT WAS THE SPANISH GOVERNMENT THAT HELPED DEVELOP SOLAR POWER.**

**THE CENTRAL GOVERNMENT SET A SPECIFIC TARGET OF 500 MEGAWATTS OF CONCENTRATED SOLAR POWER AND COMMITTED TO PRICE SUPPORTS FOR 25 YEARS.**

**THAT IN TURN UNLEASHED INVENTORS AND INDUSTRY TO PROTOTYPE PLANTS LIKE THIS ONE.**

"In September 2002, Spain was the first European country to introduce a 'feed-in tariff' funding system for solar thermal power. This granted a premium payment of 12 € cents for each kWh output of a solar thermal plant between 100 kW and 50 MW capacity, which could be changed every four years. It turned out that this was not bankable and that the amount did not cover the cost and risks to make the first projects feasible. Therefore, the solar thermal premium was increased in 2004 by 50% to 18 € cents/kWh under Spanish Royal Decree 436, and guaranteed for 25 years, with annual adaptation to the average electricity price increase. This removed the concerns of investors, banks and industrial suppliers and launched a race of the major Spanish power market players to be among the first 200 MW." Further increases in government support led to increased investment in solar.

***Towers with Sun reflections: wide shots and details:***

**THE TECHNOLOGY WORKS, THOUGH CHANGING GOVERNMENT POLICIES AND THE BUDGET CRISIS HAVE IMPACTED THE INDUSTRY.**

For a good overview of the earlier growth and recent financial challenges of Spanish solar energy, see "Spain's Solar-Power Collapse Dims Subsidy Model" by Angel Gonzalez and Keith Johnson that appeared in *The Wall Street Journal* for September 8, 2009.

"Spain's hopes of becoming a world leader in solar power have collapsed since the Spanish government slammed the brakes on generous subsidies …The sudden change has rippled across the global solar industry, in a warning of the problems that government-supported renewable-energy programs can encounter …In 2008, Spain accounted for half the world's new solar-power installations in terms of wattage, thanks to government subsidies to promote clean energy. But late last year [2008], as the global economic crisis worsened, the government dramatically scaled back those subsidies and capped the amount of subsidized solar power that could be installed …Factories world-wide that had ramped up production of solar-power components found that demand for solar panels was plummeting, leaving a glut in supply and pushing prices down. Job cuts followed. "The solar industry in 2009 has been undermined by [a] collapse in demand due to the decision by Spain," says Henning Wicht, a solar-power analyst at research group iSuppli. "Spain is providing important lessons for the U.S., where lawmakers are engaged in a debate about how to support renewable energy …Reyad Fezzani, chief executive of BP Solar, a unit of oil giant BP PLC, said that despite the current crisis, the Spanish model succeeded in creating a solar industry from scratch. "Once you pay for the infrastructure, you have a skilled work force and you can expand and contract very easily," he said …Clean-energy skeptics, however, point to Spain as a cautionary tale of a government policy that created a speculative bubble with disastrous consequences."

The 2009 story in *The Wall Street Journal* cited above says that "Spain's solar capacity last year [2008] increased to 3,342 megawatts from 695 megawatts, the size of a coal plant, a year earlier [2007] …Faced with the unraveling world economy and a deepening budget deficit, the Spanish government late last year reduced the money it paid for solar electricity and capped the amount of subsidized solar power installed each year at 500 megawatts. Spain's solar-power capacity has actually shrunk this year as a result."

***Looking up at the reflection from the towers:***

**BUT, ABENGOA, THE COMPANY BUILDING SOLUCAR, IS A PART OF A CONSORTIUM BEHIND THE WORLD'S LARGEST SOLAR POWER PROJECT.**

***Earth zoom from American SW to North Africa:***

**FORMED BY A GROUP OF EUROPEAN AND NORTH AFRICAN COMPANIES AND THE *DESERTEC FOUNDATION*, THIS CONSORTIUM HAS ENERGY AMBITIONS THAT ARE REVOLUTIONARY FOR BOTH EUROPE AND THE MIDDLE EAST.**

***Morocco scenes: camels silhouetted against the Sun, rugged mountains, reddish mud "kasbahs" and deep green forests alongside rivers:***

***Place locator: Atlas Mountains, Morocco, North Africa***

***Country scenes: women and kids collect hay, and stagger up the roads under heavy burdens.***

**UNLIKE SOME OF ITS NEIGHBORS, MOROCCO HAS LITTLE OIL OR OTHER FOSSIL FUELS.**

This website/PDF provides data on Morocco's total energy production in 2000: 0.572 MTOE, compared to 1615 MTOE for the Middle East and 10,078 for the world. Morocco's production of 0.04% of the Mideast total qualifies as "little."

**BUT IT DOES HAVE SUN, SAND, AND EMPTY SPACES.**

***Camels walk, and scenes at the Auberge du Sud, solar hot water, and then out in the desert:***

**THE MOROCCAN GOVERNMENT HAS ENCOURAGED THE USE OF DISTRIBUTED SOLAR POWER BY SMALL BUSINESSES AND INDIVIDUALS.**

The United Nations Development Program's Special Unit for South-South Cooperation states that, "Since the early 1990s, the Moroccan government has sought to provide electricity to all of its citizens. The national grid is centralized, which makes it difficult and expensive to connect rural households to the system. This circumstance has led the government of Morocco to pursue alternative methods of electrical service delivery, particularly for rural areas …Morocco's Office National de l'Electricité (ONE) is the state-run operator in Morocco's electricity supply sector and the government entity that oversees the rural electrification project. In June 2002, ONE entered into a public-private partnership with a private company to electrify rural households by using solar energy to produce electricity …Using solar power to provide rural homes with electricity is a more viable option for Moroccans. The primary objective of the solar project is to provide photovoltaic kits to over 58,000 households in rural Morocco to enable them to meet their basic energy needs."

The International Finance Corporation (IFC) of the World Bank Group states that "IFC and the Government of Morocco have signed an agreement to support the development of a solar power plant to promote renewable sources of energy to meet growing electricity demands …IFC will help the Moroccan Agency for Solar Energy (MESEN) carry out a feasibility assessment of the project, with the goal of assessing the potential for private sector investment in the project. The solar power plant facility will be near the city of Ouarzazate and is planned to consist of one or more solar power plants with an aggregate capacity of 500 mega-watts …The government aims to create 2,000 mega-watts of solar-generated electricity per year by 2020. This would represent 14% of the total electricity generated in 2020, avoiding yearly emissions of 3.7 million tons of carbon dioxide."

***A line of camels, led by a blue-robed driver, walks towards a cluster of tents:***

**ALREADY, OUT ON THE EDGE OF THE SAHARA, YOU CAN SEE PHOTOVOLTAIC PANELS ON TOP OF TENTS.**

***Animated graphic shows the different components of Desertec:***

**BUT THE "DESERTEC" VISION GOES BEYOND THIS BY INCLUDING *CONCENTRATED SOLAR POWER* PLANTS…**

***PV icons pop on:***

***…PHOTOVOLTAIC INSTALLATIONS…***

***Wind turbine icons appear:***

**…AND *WIND TURBINES…***

***Transmission line grid appears:***

**…LINKED WITH *LOW-LOSS, HIGH EFFICIENCY TRANSMISSION CABLES* BACK TO EUROPE.**

***Slow zoom in on the graphic. Moving/panning down from Europe to North Africa:***

**THE "DESERTEC" PROJECT ESTIMATES THAT SOLAR POWER FROM THE SAHARA COULD PROVIDE MORE THAN *80% OF NORTH AFRICA'S NEEDS, AND 15% OF EUROPE'S ELECTRICITY*, BY 2050.**

***Cut to location footage from Morocco: Marrakech scenes:***

**IN A SINGLE GENERATION, MOROCCO'S YOUNG AND GROWING POPULATION COULD GO FROM ENERGY-POVERTY TO ENERGY INDEPENDENCE.**

"With a projected growth rate of 1.4% between 2000 and 2015, the population is expected to reach 41 million by 2029. The population is generally young, with some 23% under the age of 15."

***Shots of the solar panels at Solucar:***

**THE ENERGY CREATED BY THIS PROVEN TECHNOLOGY COULD GENERATE BOTH ELECTRICITY AND INCOME FOR SOME OF THE WORLD'S POOREST NATIONS.**

***Richard walking in the Yuma Dunes.***

**AND UPDATED VERSIONS OF SHUMAN'S CENTURY-OLD DESIGNS, AND A SMART GRID, COULD GO A VERY LONG WAY TOWARD MEETING OUR SPECIES' NEED FOR ENERGY.**

***Orbital zoom to see a glowing white square in the Sahara, approximately scaled to represent a 600x600 mile shape: zoom to white out and dissolve to a Sun flare:***

**COLLECTING JUST 10% OF THE SUN'S ENERGY FROM A 600-MILE-SQUARE OF LOW-LATITUDE DESERT WOULD SUPPLY ROUGHLY TWICE TODAY'S HUMAN CONSUMPTION OF ENERGY.**

World electrical energy consumption in 2008 was 20,200 TWh, equivalent to 2.3TW all year long. Our previous calculation for the 600-mile-square (i.e., 600 miles on a side) came from requiring 30 TW of energy, because we were talking about *all* human energy consumption (listed as 15TW in the Wikipedia article), not just *electricity*.

As we stated earlier in the script, about 120,000 terawatts of solar energy reach the

Earth's surface. To make a reasonably accurate calculation of how much area would be required actually to produce the *United States's* electrical energy requirements, we have to start with the fact that at any moment, the Sun shines only on half the Earth, which presents a cross section of $\varpi R^2$ to the sun, where R is the Earth's radius. Taking R as 6,378 kilometers, $\varpi R^2$ equals 128 million square kilometers. This leads us to the conclusion that each square kilometer, on average, receives 937 MW when the Sun is shining on that area. The United States' electrical energy consumption of about 500 GW would therefore require an area of 534 square kilometers, *if* the sun shone all the time, and if we could convert sunlight to electricity with 100% efficiency. So if we increase the required area by a factor of three to allow for nighttime and some clouds, and if we increase by another factor of 3 to allow for a 33% efficiency in converting solar energy into electricity, we come to a required area of 4,800 square kilometers, an area 69 kilometers, or 43 miles, on each side. We might round this to 40 miles on a side to allow for potentially greater efficiency than 33% in energy conversion.

By the same sort of calculation: If we want to produce 30 TW from solar power—twice total human *energy* use, and 60 times the United States' current *electrical* energy consumption—we will need an area 60 times larger, with sides nearly 8 times longer, than the 43-mile length derived above. However, if we take an efficiency of just 10%, rather than the 33% used in the calculation above, we will require not 60 but 200 times the area, with sides 14 times longer than 43 miles, or 600 miles.

***From the CGI white-out of the Saharan square, dissolve to spectacular Sun shots, and trees, plants, grasses, sugar cane, back lit by the Sun:***

## THERE ARE OTHER WAYS TO HARVEST SUNLIGHT…

## IT'S ESTIMATED THAT BIOMASS—PLANTS GROWING THROUGH PHOTOSYNTHESIS—OFFERS *11 TIMES CURRENT HUMAN ENERGY USE*.

Again, please see the Renewables Roundup sequence in ETOM program 1 and part III of the ETOM book, page 225-6, for Richard's estimates.

## AND ONE NATION HAS ALREADY PROVEN IT'S POSSIBLE TO…

***CHAPTER HEAD super, bold text over great sun and cane action:***
***"Grow Your Own"***

# Grow Your Own

***Cars, cars, cars, from NYC, SFO, and China:***

***Narrator:***

**IN THE UNITED STATES, FOR EVERY THOUSAND PEOPLE, THERE ARE MORE THAN 800 MOTOR VEHICLES—CARS, TRUCKS AND BUSES.**

Wikipedia states that "According to the U.S. Bureau of Transit Statistics for 2008 there are 255,917,664 registered passenger vehicles. Of these, 137,079,843 were classified as automobiles, while 101,234,849 were classified as "Other 2 axle, 4 tire vehicles," presumably SUVs and pick-up trucks. Yet another 6,790,882 were classified as vehicles with 2 axles and 6 tires and 2,215,856 were classified as "Truck, combination." There were approximately 7,752,926 motorcycles in the U.S. in 2008."

Since the 2010 census stated that the total population of the U.S. is 308,745,538, as of 2010 there were 0.444 automobiles per capita, or 444 cars per thousand people. On the other hand, if we include trucks, buses, et al. in the total vehicles, then in the U.S., the 255,917,664 vehicles amount to .83 vehicle per capita, so one might say "more than 800 *vehicles*, cars and trucks for every thousand people," or even, "nearly a vehicle for every man, woman, and child."

***Scenes from China and Brazil:***

**IF DEVELOPING NATIONS FOLLOW *THAT* PATH, THERE'LL SOON BE CLOSE TO SIX BILLION MOTOR VEHICLES ON THE PLANET!**

Not that it's likely to happen (nor would it be desirable) but 7 billion people would, if they followed the U.S. model, own 3.1 billion automobiles. More impressive (though perhaps even more frightening) might be to include trucks, buses, etc., in total vehicles. In the U.S., the 255,917,664 vehicles amount to .83 vehicle per capita, which for 7 billion people would produce 5.8 billion vehicles.

***Traffic jams, city scenes:***

**AND IF THEY'RE BURNING GASOLINE AND DIESEL, THEY'LL BE PUMPING OUT NEARLY TWELVE BILLION ADDITIONAL METRIC TONS OF CARBON DIOXIDE EVERY YEAR…**

**…ASSUMING THERE'S ENOUGH OIL TO KEEP THEM ON THE ROAD.**

If we look only to cars and light trucks ("passenger vehicles"), the EPA estimates that on the average, each one emits 5.2 metric tons of carbon dioxide per year—4.8 metric tons per automobile, and 6 metric tons per light truck. The current worldwide total of automobiles, according to the Wikipedia article is 600 million, and the total number of passenger vehicles is 800 million. If we stick to *automobiles*, we would say of the increase by 2.4 billion automobiles that "they'll be pumping out nearly 12 billion more additional metric tons of carbon dioxide every year."

***Brazil scenes: See Brazilian cars and begin to hear Brito:***

**ONE NATION DOESN'T HAVE THAT WORRY.**

***Carlos Henrique de Brito Cruz, Science Director, Research Foundation of São Paulo***

***de Brito Cruz:***

***If for some magical reason, every molecule of gasoline in the world would disappear, I guess that the only country that would keep its cars running normally would be Brazil.***

***Stock footage reel: scenes of the Oil Shock: offset, over-lapping boxes for the stock:***

**THAT WASN'T ALWAYS TRUE.**

**AS IN EVERY OTHER INDUSTRIALIZED NATION, THE TWO "OIL SHOCKS" OF THE 1970'S BROUGHT GASOLINE SHORTAGES TO BRAZIL.**

The "Arab Oil Embargo" of October 1973 was a true embargo, in which the Arab OPEC countries stopped pumping oil for about six months, highly constraining the availability of gasoline and diesel fuel. In contrast, the Oil Crisis of late 1979 arose when Iran stopped pumping oil after the overthrow of the Shah's regime. Although Saudi Arabia and other countries then increased their production, helping to ease the situation, memories of 1973 and (justified) fears of continuing rises in oil prices helped shoot up the price of oil.

***Stock footage:***

**ITS GOVERNMENT, THEN A MILITARY DICTATORSHIP, DECIDED TO DO SOMETHING REVOLUTIONARY.**

The military dictatorship began in 1964 and ended in 1985.

***Generals, etc. and the military parades:***

***José Goldemberg, Former Minister of the Environment, Brazil***

***Goldemberg:***

***Military dictatorships are bad for many, many things, but the military dictatorship in Brazil realized that science and technology was an instrument for development, for independence.***

José Goldemberg is an internationally recognized leading expert on energy and environment issues. He earned his Ph.D. (1954) in Physics from the Universidade de São Paulo, which he led as President from 1986 to 1989 after having directed the Energy Company of the State of São Paulo. From 1990 to 1992 he served the Brazilian federal government in various capacities: as Secretary of State for Science and Technology, then as Minister of Education, and finally as interim Minister of the Environment, during which he administered Brazil's participation in the 1992 Earth Summit in Rio de Janeiro and was responsible for ending Brazil's nuclear weapons program, which also led Argentina to shut down its program under a joint agreement. He was awarded the Volvo Environmental Prize (2000), the Blue Planet Prize (2008) from the Asahi Glass Foundation (Japan), and was honored by *Time* magazine (2007) as one of its "Heroes of the Environment."

***Footage of the VW Bugs powered by "Alcool":***

***de Brito Cruz:***

***In 1975, the Brazilian government created the "Pro-Alcohol," an ethanol substituting gasoline program.***

***Goldemberg:***

***I think it did it for nationalistic reasons, too, which was one of the characteristics of military regimes…***

***As wide a shot of José as we have in our footage: scenes of biological and agronomic labs:***

**ALTHOUGH A NUCLEAR PHYSICIST, JOSÉ GOLDEMBERG WORKED WITH AGRICULTURAL COLLEAGUES AND WROTE A PAPER FOR THE JOURNAL "SCIENCE," PROPOSING ETHANOL MADE FROM SUGAR CANE AS AN ALTERNATIVE TO IMPORTED GASOLINE.**

The paper mentioned was published in *Science* magazine in 1978. The paper's Abstract reads, "Brazil's energy options and current outlook are examined, and a summary of known reserves of fossil and renewable energy resources is given. Brazil has abundant renewable energy resources but very modest reserves of fossil fuels. Consequently, the emphasis in the future will have to be on the utilization of solar energy, hydroelectric power, and biomass in a program designed to preserve local traditions and culture."

***Goldemberg:***

***People were quite surprised that there were options to gasoline, you know. Until that time, gasoline dominated completely the picture.***

***Cane shots, then fermenting vats on the top floor of the refinery, as bubbly and yeasty as possible:***

All cane processing and harvesting shots were filmed at the Fazenda São João, operated by the USJ Group. For information, in Portuguese, click here.

***de Brito Cruz, VO and to camera:***

***Producing alcohol from sugar is something that humanity has done for more than 3,000 years. So it's not really a new idea.***

***Best Sun through cane shots, and José speaks:***

***Goldemberg VO:***

***Ethanol from sugar cane is really solar energy turned into liquid.***

***WS refinery and plantation:***

***Goldemberg, on camera:***

***Sugar cane proved to be the best raw material for the production of ethanol. That doesn't have to do with Brazil or nationalism or anything. It has to do with photosynthesis.***

***A cane truck zooms by, and we see the machine harvesters at work:***

**THOUGH NATURE MAY HAVE BLESSED BRAZIL WITH RAIN AND SUNSHINE, IT TOOK HIGH-LEVEL POLICY AND INVESTMENT FOR THIS NATION TO GROW ITS OWN FUEL SUPPLY.**

***Goldemberg:***

***That took a decision from the government. So it was not only natural resources, but a deliberate attempt by the government which created the conditions to do that.***

***Stock footage of the 1970s and 80s, and a B&W mural of a Model T beside a busy modern highway, at the end of his statement:***

***Goldemberg:***

***Of course, in the beginning ethanol was expensive. And the government understood that. But everybody knows that in the beginning, technologies are expensive. Automobiles were very expensive when Ford came into the game.***

This excerpt from "Henry Ford And The Model T" (PDF) asserts that Ford drove the price downward by an impressive extent: "I'm going to democratize the automobile," Henry Ford had said in 1909. "When I'm through, everybody will be able to afford one, and about everybody will have one." The means to this end was a continuous reduction in price. When it sold for $575 in 1912, the Model T for the first time cost less than the prevailing average annual wage in the United States. Ignoring conventional wisdom, Ford continually sacrificed profit margins to increase sales. In fact, profits per car did fall as he slashed prices from $220 in 1909 to $99 in 1914. But sales exploded, rising to 248,000 in 1913. Moreover, Ford demonstrated that a strategic, systematic lowering of prices could boost profits, as net income rose from $3 million in 1909 to $25 million in 1914. As Ford's U.S. market share rose from a respectable 9.4% in 1908 to a formidable 48% in 1914, the Model T dominated the world's leading market.

**AND, MORE OR LESS, IT WORKED.**

The Wikipedia article "History of Ethanol Fuel in Brazil" provides more information.

***Stock footage of cars and "Movido A Alcool" signs:***

***Goldemberg:***

***For 10 years, then, Brazil was the only country in the world that had automobiles that could use 100% ethanol. That required a complete distribution system for pure ethanol.***

***de Brito Cruz:***

***And at some point, by the end of the 80s, most of the cars were pure ethanol cars.***

***Entry gate of the São Paulo factory, and scenes of the GM production line:***

**MANUFACTURERS LIKE GM BRAZIL RESPONDED, AND TOOLED UP TO SUPPORT PURE ETHANOL.**

***Henrique Basilio Pereira, General Motors São Paulo***

***Pereira:***

***We were selling about 97% of our cars during that period on ethanol.***

***Stock footage, cars line up at ethanol filling stations:***

**THEN OIL PRICES CRASHED, AND SUBSIDIZING ETHANOL NO LONGER SEEMED SO WISE.**

A useful graph (Figure 1 from a PDF, "Understanding Crude Oil Prices," by James D. Hamilton) shows the peak price of 1979-1980 at something over $100 per barrel (in 2008 prices), which was followed by a decline almost to $20 in 1986, with fluctuations up to $40 during the remainder of the 1980s.

***Plantation and then GM scenes:***

**BUT BRAZIL WAS STILL A MAJOR SUGAR PRODUCER.**

***Scenes of the GM production line:***

**COULD *ENGINEERING INNOVATIONS* FIND SOME WAY TO BUILD CARS THAT COULD USE EITHER GASOLINE OR ETHANOL?**

***Pereira:***

***In the end of the 80s, beginning of the 90s, we started thinking about having a car that could run on both fuels. But during that period we did not have a technology sufficient to run a flex car.***

***GM production line, and shots of the Flex logo on the engine:***

**A NEW KIND OF DUAL-FUEL ENGINE HAD ALREADY BEEN INVENTED—IN THE UNITED STATES—BACK IN THE 1980s.**

**BUT IN 2003 THE FIRST MASS PRODUCED FLEX CAR, A VW "GOL," ROLLED OFF PRODUCTION LINES *NOT* IN THE U.S., BUT IN BRAZIL.**

The key problem in the U.S. was the fact that only a few hundred prototypes were made, naturally at much greater expense per car than the cost of a mass-produced vehicle. Bottom line: The flex-fuel engine was first developed in the U.S., but only in Brazil did they produce a version that made economic sense for most cars.

For more, see "Flexible Fuel Engine Technology" in a PDF by Henry Joseph Jr., which states that "Flex-fuel vehicles were not really invented in Brazil. The first automobiles able to run on different kinds of fuel were unveiled in the United States back in the 1980s. The technology used by U.S. automakers, however, was based on a sensor that identified which fuel was being used and instructed the onboard computer to adjust the fuel injection and ignition systems to make better use of that particular fuel. Efficient as it is, that technology is expensive, complicated, and entirely dependent on the useful life of that identifying sensor. The cost was such that it could only be used on expensive vehicles

without unduly impacting showroom prices… [when Brazil] began to discuss the possibility of building a local version of such a vehicle, the first requirement was to avoid using a fuel-identification sensor. At that point, the vast experience acquired over 25 years of producing alcohol-fired vehicles combined with Brazilian ingenuity to yield a solution."

A fascinating article in Wikipedia actually says that "The first commercial flexible fuel vehicle was the aforementioned Ford Model T, produced from 1908 through 1927."

**ONCE AGAIN THE BRAZILIAN GOVERNMENT—BY NOW CIVILIAN—HAD STEPPED IN.**

The Brazilian military overthrew the civilian government in 1964 and ruled for the next 21 years, until 1985.

***Start him on camera, and then more scenes of the GM plant:***

***de Brito Cruz:***

***In 2002 the Brazilian government organized an initiative for reducing taxes for the automakers if they would make Flex-fuel cars.***

***On camera:***

***So you see the government policy reversed and changed, and still the policy worked.***

***Cars roll off the end of the production line:***

**AND, ONCE AGAIN, NATURAL RESOURCES AND HUMAN PLANNING CAME TOGETHER.**

***Pereira:***

***Here at General Motors do Brasil we are producing, right now, a hundred percent of the passenger cars as flex fuel.***

***Customers at the Petrobras gas station.***

**NOW BRAZILIAN CONSUMERS HAVE A CHOICE, TRADING OFF THE *HIGHER COST* BUT *HIGHER ENERGY* OF A TANK-FULL OF GASOLINE AGAINST THE *LOWER COST*, BUT *LOWER ENERGY* OF ETHANOL.**

***Endless streams of traffic, from a big city overpass. Filling up at the gas station, and we see frothing "liters of gasoline" from the bio-refinery:***

***de Brito Cruz:***

***And 95% of the automobiles sold every month in Brazil are flex fuel cars. That makes Brazil a very unique country in terms of substituting gasoline.***

*Churning fermenting biofuels:*

***Brazil, last year, used more liters of ethanol than liters of gasoline.***

*On camera here:*

***So it's not a small experiment, it's a* large *experiment.***

*Harvesting shots: wide open fields, loading up the tractors, etc.*

**BRAZILIAN RESEARCHERS CLAIM THEY COULD EXPAND THEIR NATION'S PRODUCTION OF BIOFUEL TEN TIMES OVER, USING ONLY ABANDONED FARMLAND AND UNDER-UTILIZED PASTURES…**

*Aerials from Iguaçu, swooping around the treetops:*

**…WHILE STILL PROTECTING THE NATION'S FORESTS.**

*de Brito Cruz:*

***Biofuels will only be a sustainable alternative, not only if they do not compete with the production of food, but also if they do not cause harm to the environment.***

Under Former Brazilian President Luiz Inácio "Lula" da Silva the rate of deforestation, particularly in the Amazon, fell by close to 50%. This remains high, but is significant progress.

*Stock footage of Generals, VWs, protesting drivers, GM plant, harvesting:*

**LOOKING BACK IT MAY SEEM LIKE A STRAIGHT PATH FROM IMPORTED OIL TO ENERGY INDEPENDENCE… BUT THE *PROALCOOL* PROGRAM WAS AN "ON-AGAIN, OFF-AGAIN" PROCESS, BEFORE ENDING UP WITH "FLEX" CARS USING "FLEX" FUELS.**

*Waterfalls, ethanol bubbling and fermenting:*

**WHAT WAS *CONSTANT* WAS A NATION FOCUSING ON ITS UNIQUE CAPABILITIES AND NATURAL RESOURCES, ASSETS THAT INEVITABLY VARY NATION BY NATION.**

*Continue iconic shots of cane production and harvesting:*

**FOR JOSÉ GOLDEMBERG, PRESENT AT THE CREATION OF THE PUSH FOR SUGAR-CANE ETHANOL, THE STORY HAS ONE MAIN LESSON.**

***Goldemberg:***

***You have to adopt a solution, and then have the courage to stick to it.***

***Earth orbital shot:***

**ARE THERE OTHER EXAMPLES OF COMMUNITIES AND NATIONS THAT HAVE BEGUN THE TRANSITION AWAY FROM FOSSIL FUELS?**

**WHAT DOES IT TAKE TO WELCOME THE TURBINES AND SOLAR FARMS OF THE NEW ENERGY SYSTEM, AND SAY… "YES, IN MY BACKYARD."**

***The title of this segment (rather obviously) is meant to play against "NIMBY," standing for Not In My Backyard.***

***CHAPTER HEAD over action footage:***

***"Yes, In My Backyard"***

# Yes, In My Backyard

***Classic Samsø scenes: the lighthouse, harbor, fishing boats, windmill: slide wipe to dry and dusty Texas: a pump jack pumps!***

**THIS IS THE STORY OF TWO COMMUNITIES THAT AT FIRST LOOK *VERY* DIFFERENT.**

***Slide wipe back to Samsø:***

**SAMSØ IS A SMALL ISLAND OFF THE DANISH MAINLAND.**

***Slide transition: Dry… harsh… TX road in a small town, with a U.S. flag blowing in the strong wind:***

**WEST TEXAS IS A VAST, DRY EXPANSE IN AMERICA'S SOUTH.**

***Blowing flowers and the U.S. and Danish national flags:***

**WHAT BOTH HAVE IS …ABUNDANT WIND.**

***Danish flag blowing at the Energy Academy: and best shots from the on-shore turbines, and an electricity sub-station:***

**AT TIMES SAMSØ PRODUCES MORE ELECTRICITY THAN IT USES, EXPORTING SURPLUS POWER TO THE DANISH MAINLAND.**

A good summary mentions that exporting excess power occurs only at certain times, presumably when the wind blows most strongly.

***Daytime Texas turbines, many more than seen in Samsø:***

**…AND TEXAS WIND NOW GENERATES AS MUCH POWER AS THE NEXT THREE U.S. STATES COMBINED.**

According to a Department of Energy website, the data for installed wind generation capacity as of the end of 2010 gives Texas 10,089 MW, followed by Iowa (3,674), California (3,253), Minnesota (2,205), Oregon (2,103), and Illinois (2,045). Thus as of 12/31/2010, Texas indeed had more installed wind generation capacity than the next three states (10,089 vs. 9,132 MW).

***Intercut stunning turbine shots from both locations, and in Texas, a brown cow stares towards camera:***

**SAMSØ AND WEST TEXAS BOTH SOLVED THE "NIMBY"—"NOT IN MY BACKYARD"—CHALLENGE THAT HAS STYMIED SO MANY RENEWABLE ENERGY PROJECTS.**

*"High School Champs" sign in Roscoe, in front of a line of turbines:*

**IT'S NOT EASY, BUT WITH PATIENCE, AND PERSISTENCE—AND THE EFFORTS OF THE RIGHT PEOPLE—IT CAN BE DONE.**

*Rainy driving shots, Søren (also a TIME Hero of the Environment) is driving while speaking on a cell phone, and walking outside an old-fashioned windmill:*

*Søren:*

***OK, my name is Søren Hermansen, and I am the Director of the Samsø Energy Academy.***

*Earth orbit to overhead view of the island, and zoom closer:*

***Samsø means, in Danish, means the "Meeting Island"… when you make a circle around all of Denmark, then Samsø is right in the center of the circle.***

*Søren shows the Minister around the Energy Academy:*

**BUT IT WASN'T GEOGRAPHY THAT BROUGHT LYKKE FRIIS, THEN DENMARK'S MINISTER OF CLIMATE AND ENERGY, HERE IN MID-2011.**

**IT WAS WHY AND HOW THIS COMMUNITY HAD TURNED "NIMBY" INTO "YES, IN MY BACKYARD."**

For an excellent backgrounder on Samsø and Søren's work, check out Elizabeth Kolbert's "The Island in the Wind," in *The New Yorker*. And for a visual tour, please see this photo gallery, from the Guardian.

*Lykke Friis, former Minister of Climate and Energy, Denmark*

*Lykke begins VO shots of the on- and off-shore turbines, and then speaks to camera, her hair blown about on a typically windy day:*

*Lykke:*

***Well, Samsø is a pioneering project, in the sense that Samsø, way back, decided that Samsø should become independent of fossil fuels.***

*Summer tourists near a fish stand, and then rainy, empty shots:*

**BEFORE ITS TRANSFORMATION, PEOPLE THOUGHT OF SAMSØ AS JUST A "CUTE" *TOURIST COMMUNITY*, BUSY IN SUMMER… EMPTY AND DESOLATE IN WINTER.**

*From rain and low cloud, to summer turbine shots:*

**NOW PEOPLE COME HERE NOT JUST TO SEE THE TURBINES, BUT TO UNDERSTAND THE PROCESS THAT GOT THE COMMUNITY TO *WELCOME* WIND ENERGY.**

*Academy staff and local politicians meet with Lykke Friss at the Academy: then riding with the Siemens engineers out to the offshore turbines:*

**AFTER A NATIONAL COMPETITION, SAMSØ WAS SELECTED BY THE DANISH GOVERNMENT TO BE A PROOF OF CONCEPT FOR HOW TO TRANSITION FROM FOSSIL FUELS.**

*Søren, in the rain, walks up to the historic windmill: tilt up to the old blades and dissolve to contemporary turbines:*

**BUT IT WAS UP TO *INDIVIDUALS* LIKE SØREN HERMANSEN, WITH THE PASSION AND SKILLS TO EFFECT CHANGE, TO FIGURE OUT JUST HOW.**

*Søren:*

***So when we won, the normal reaction from most people was, "Yeah, you can do this project, that's OK, but just leave me out of it."***

*Church scenes and elderly parishioners: the young, female, pastor officiates at a baptism:*

**SAMSØ HAS A DEEP ATTACHMENT TO ITS PAST AND VALUES ITS TRADITIONAL WAY OF LIFE.**

*We see potatoes being processed and cows being milked:*

*Søren, VO:*

***But gradually we won their confidence in establishing easy projects to understand, and also easy projects to finance. Because basically it's all about what's in it for me. Because it's not convinced idealists or green environmental hippies who live here.***

*Island scenes, turbines, a family group on a sunny hillside:*

**SØREN, A NATIVE OF THE ISLAND, CONVINCED SOME OF HIS NEIGHBORS TO BECOME EARLY ADOPTERS. THEY FOUND SUCCESS, AND SPREAD THE WORD.**

*Jørgen works on his tractor, and we see the red cow with the Danish flag:*

**JØRGEN TRANBERG OPERATED A LARGE AND PROFITABLE HERD OF MILK COWS.**

*Turbine spinning over cows munching in the foreground:*

**AFTER INITIAL RESERVATIONS, HE INVESTED IN A TURBINE ON HIS OWN LAND.**

*See Jørgen and the crew servicing one of the offshore turbines:*

**WHEN THAT WENT WELL, JØRGEN BECAME PART OWNER OF ONE OF THE OFFSHORE TURBINES.**

*Søren on camera intercut with scenes of Jørgen and the engineers up in the cabin of the turbine:*

*Søren, VO:*

***Farmers… they have to invent new things and be ready for changes. So when they see a potential, they look at it, no matter what it is. They look at this, say, "Could I do this?"***

***And if they see fellow-farmers do the same thing, they are quick to respond to that.***

***So even being very traditional and conservative in their heads, I think they have this ability of making moves and do things, because they have this independency in them.***

*Søren turns, and smiles:*

***A farmer is a free man: maybe he owes a lot of money to the bank, but he's still a free man in his thinking.***

*From rain to bright sunshine, and a musical transition. Texas driving scenes, with Cliff in his pickup truck:*

**IT WAS SEEING WHAT WAS "IN IT FOR THEM" *AND* FOR THEIR COMMUNITY, THAT WON OVER LANDOWNERS IN WEST TEXAS…**

**AND IT TOOK ONE OF THEIR OWN, A MAN WHOSE FAMILY HAD DEEP ROOTS IN ROSCOE'S COTTON FIELDS, TO EDUCATE THEM ABOUT WIND FARMING.**

*Cliff:*

***Well, I'm really a farmer farmer, (broad laughter) you see. I farmed for almost over 40 years.***

For an early (2007) story on Roscoe, see this excellent NPR report.

*Cliff to camera, and aerials and surface shots: driving and flying shots emphasize the extent of the wind farm:*

*Cliff Etheredge, Farmer/wind energy entrepreneur*

*Cliff:*

***We're in… right in the middle of the Roscoe Wind Farm. And we've got about 780 megawatts of production, that's per hour, enough electricity for about 265,000 average homes.***

As of Spring 2012, when POWERING THE PLANET premiered, Roscoe was still the largest on-shore wind farm on Earth. A story published in *The Scotsman* on 21 November 2011 states that "The world's biggest offshore wind farm is set to be built in Scotland with a multi-billion-pound investment, securing hundreds of jobs and further cementing the country's position as a global leader in renewable energy …The £4.5 billion project (not due for completion before 2020! ETOM) envisages up to 300 turbines in water 200 feet deep more than 13 miles off Caithness, generating enough power for more than a million homes …The wind farm would cover about 114 square miles and could produce up to 1,500MW of wind power, about the same as a conventional power station." The champion wind farm on land appears to be one under construction in Oregon, as described in a story at greentechmedia.com: "At 845 megawatts, it will be the biggest on-land wind installation in the world, taking leadership away from Texas' 781.5-megawatt Roscoe Wind Farm (owned and operated by E.ON Climate & Renewables). Roscoe, according to CBS News, has "627 towering wind turbines churning out electricity across 100,000 acres of West Texas farmland." Since there are 640 acres to a square mile, this wind farm covers about 160 square miles, a larger area than the one offshore of Scotland, though its output is just over half of the Scottish farm's.

***A pickup truck hauling cattle food drives past: we see a turbine out of focus beyond a cactus:***

**ROSCOE HAD NO OIL AND FACED HARD TIMES IN THE EARLY 90'S, BUT IT DID HAVE WIND.**

The Department of Energy offers intriguing maps showing the wind resource potential of different US regions, and clearly indicating that West Texas sits at the base of a strong wind corridor stretching all the way to Canada.

***Cotton flowers blown about by the wind:***

***Cliff:***

***When this land was acquired there was absolutely no value to the wind. Fact is, it was a severe detriment, because of the evaporation of the moisture.***

***Dawn at a Roscoe diner: Cliff and neighbors gather for coffee:***

**CLIFF, LIKE SØREN, HAD TO WORK WITH HIS NEIGHBORS TO GET THEM READY TO ACCEPT WIND TURBINES.**

***Cliff speaks voice over the somewhat skeptical faces of the coffee drinkers:***

***The first thing farmers want to know is, "Well, how much is it going to cost me?" It costs them nothing.***

***See the cows under the turbines, and Cliff to camera:***

*Cliff:*

*"What's it going to hurt?" Three to five percent of your farmland is all it's going to take up. You can do what you want to with the rest of it.*

*Then it came down to, "Well, how much money is this going to make me?"*

*See Cliff in his office, pecking away at his computer keyboard:*

**CLIFF DID HIS RESEARCH AND CHECKED HIS NUMBERS WITH WIND EXPERTS AND THE FARM BUREAU.**

*Cliff VO driving scenes:*

*Cliff:*

*Then I was able to go to our Landowners' Association and show them, where they had been receiving 35 to 40 dollars an acre, then the landowners could expect somewhere in the neighborhood of three times that…*

*Turbines, diner scenes and the entrance to the Double Heart ranch:*

**IN FACT, FARMERS STAND TO MAKE 10 TO 15 THOUSAND DOLLARS A YEAR, PER TURBINE, JUST FROM LEASING THE WIND RIGHTS.**

*Cliff VO aerials:*

*There was no guarantees in it from the very beginning, but sure enough we've got, I think, in the neighborhood of 95 or more percent of our area that accepted the wind farm.*

*A classic Samsø-like shot, the lighthouse, signals that the next few shots are back in Denmark:*

**IN BOTH SAMSØ AND WEST TEXAS, INDIVIDUALS SAW ECONOMIC BENEFITS.**

*Street sounds, Samsø traffic, people chatting:*

**BUT THE WHOLE COMMUNITY, BEYOND THE INVESTORS AND LANDOWNERS, BENEFITED TOO.**

*Scenes at "Vicky's Gift Shop," in Roscoe, and the young couple swing dancing at "The Lumberyard":*

*Cliff:*

*Because of the wind farm, now, and the people working in the wind industry, now we've got jobs available and opportunities for young people to come back from college or from technical school or from whatever. It's just been a Godsend.*

This site claims "Wind Energy Jobs Grow Despite the Slow Economy" and provides a state-by-state list of wind farms.

***Roscoe school and Kim Alexander sync & VO: school shots, kids milling (stairs, and alternate angles), working in the computer lab, and studying in class.***

**FOR KIM ALEXANDER, SUPERINTENDENT OF THE ROSCOE SCHOOL DISTRICT, THAT "GODSEND" TRANSLATES INTO DOLLARS.**

***Kim Alexander, Superintendent, Roscoe ISD.***

***Kim Alexander:***

***In 2007, prior to the wind values coming on our tax roll, our property values were at about $65 million. And then, that wind development, they jumped to approximately $400 million, to $465 million.***

***Pan to entrance with sign "Roscoe Collegiate":***

**THE SCHOOL DISTRICT WILL GET MORE THAN $10 MILLION DOLLARS OVER A DECADE.**

A story in the *Texas Tribune* states that Roscoe will receive a projected total of $11 million over 10 years. A more recent story in the *New York Times* backs up these estimates of economic benefits.

**THAT GUARANTEED REVENUE STREAM UNLOCKED ADDITIONAL FUNDING.**

***The EON entrance, and school shots: students work at computers:***

**SCHOOL BUILDINGS, SOME DATING FROM THE 1930'S, COULD BE UPDATED, AND COMPUTER LABS ADDED.**

***Cliff:***

***This is an indication to me of what can be done for rural areas, and will be done, all the way to Canada… bringing life and prosperity back to these rural communities that are suffering just like we have.***

***Slide transition: we're not in Texas anymore. We see wind turbines over the harbor, Copenhagen:***

**THE SAME OIL SHOCK THAT GOT BRAZIL STARTED ON ETHANOL, GOT DENMARK STARTED ON MANUFACTURING WIND TURBINES …JUST IN TIME TO COMPENSATE FOR A DECLINE IN ITS SHIP-BUILDING INDUSTRY.**

***Lykke:***

***And it's also good for the economy in terms of export. I mean 10% of Danish export comes from the cleantech area.***

According to one summary, "Since 1979, the Danish government, through intelligent, sustained investment, has mobilized the nation in the development of next-generation wind energy, and the results have been impressive. Today, Danish firms account for one third of the global wind power market and have driven the creation of a booming multi-billion dollar industry …From 1979 to 1989, the Danish government covered 30% of wind investment costs, and later implemented loan guarantees for large turbine export projects. It also guaranteed the domestic wind market by mandating that utilities purchase all generated wind energy at a consistent, above-market price."

***Landscape scenes in Samsø: tilt up from farm field to white turbines:***

**ENERGY AND ENVIRONMENT ALWAYS REQUIRE TRADEOFFS, SUCH AS CLEAR VISTAS VERSUS CLEAN ENERGY.**

**IT'S SOMETHING THAT COMMUNITIES HAVE TO MAKE TIME TO WORK THROUGH.**

**CLIFF, FOR ONE, BELIEVES IT'S WORTH IT.**

***Scenes of dancing, both older and younger couples, and folks socializing at "The Lumberyard" on Friday night:***

***Cliff:***

***Everything, the schools, the churches, the civic organizations, all the businesses will benefit from this. It will increase, hopefully, our town's populations, and our economics.***

***Sunrise over turbine shots, and then to Kim for the "Grandad" sync:***

***Kim Alexander:***

***My granddad used to say, not realizing he was prophetic, but "If we could sell the wind, we'd be wealthy." Well, who would have ever thought we'd be able to sell the wind?***

***We see both communities:***

**FOR SAMSØ, DENMARK AND TEXAS, CLEAN ENERGY BROUGHT ECONOMIC BENEFITS AND ENERGY SECURITY.**

**BUT REPLACING FOSSIL FUEL EMISSIONS WITH WIND POWER HAS OTHER ADVANTAGES.**

***Lykke:***

***And let's not forget, also good for climate and health, and such, and that's a very important argument.***

***Cliff:***

***We've got a constant wind resource here that's tremendously valuable and as opposed to oil and gas, it'll last forever. And it doesn't pollute anything.***

***Dark smoke pours from chimneys:***

**BURNING FOSSIL FUEL EMITS BLACK SOOT AND OTHER POLLUTANTS THAT FALL OUT OF THE ATMOSPHERE QUITE QUICKLY.**

**BUT IT ALSO RELEASES CARBON DIOXIDE WHICH REMAINS IN THE AIR MUCH LONGER TO INFLUENCE EARTH'S CLIMATE.**

**RICHARD ALLEY'S ICE CORE RESEARCH SHOWS THAT SOMETIMES THE EARTH EXPERIENCES ABRUPT CHANGES IN CLIMATE, KNOWN AS "TIPPING POINTS."**

For Richard's ice core research, see his award-winning book, THE TWO MILE TIME MACHINE, and the CO2 in the Ice Core Record sequence in the first ETOM special. And for more detail on tipping points, please see the overview of Richard's contribution to the National Academy study of abrupt climate change in the Issues section of the ETOM website.

**AND IF WE KEEP ON BURNING FOSSIL FUELS WITHOUT CAPTURING CO2 EMISSIONS, WE MAY INCREASE THE RISK OF PUSHING EARTH'S CLIMATE OVER THE EDGE.**

**IT MIGHT BE WISE TO "LOOK BEFORE YOU LEAP."**

***CHAPTER HEAD graphic: "Look Before You Leap"***

# Look Before You Leap

*Richard to camera, near the bridge at Kawarau Gorge, Queenstown, NZ:*

***The Earth's climate system is usually well behaved. A little more Sun, a little more CO2, and we get a predictable amount of warming.***

*The animated chart shows CO2 levels in blue, and changing temperature, in red:*

**THIS IS THE PATTERN OF *NATURAL VARIABILITY* OF THE CLIMATE THAT OUR PLANET HAS EXPERIENCED OVER THE PAST 400 THOUSAND YEARS, AS RECORDED IN THE PHYSICS AND CHEMISTRY OF ICE CORES.**

**THE REGULAR "UPS" AND "DOWNS" IN TEMPERATURE ARE THE RESULT OF CHANGES IN EARTH'S ORBIT AROUND THE SUN, AND THEIR SUBSEQUENT EFFECTS ON LEVELS OF CARBON DIOXIDE AND OTHER HEAT-TRAPPING GASES.**

*The CGI roller coaster is superimposed over the ice core chart, with a running glow as it appears:*

**YOU CAN THINK OF THIS NATURAL VARIATION AS THE "ICE AGE ROLLER COASTER."**

*The CGI roller coaster appears, and the "cartoon Richard Alley" rides along:*

**AS A GEOLOGIST, I'M AT HOME IN THE VAST EXPANSES OF TIME.**

**SO, LET'S TAKE A RIDE, CRESTING HILLS AND ROLLING THROUGH VALLEYS, FOLLOWING THE MORE-OR-LESS REGULAR PATTERN OF CHANGING CLIMATE, OVER HUNDREDS OF THOUSANDS OF YEARS.**

*Rather like speed signs beside the highway, we see 180 at the bottom of a "hill" and 280 at the top of a slope:*

**HERE WE'RE DOWN AT 180 PARTS PER MILLION OF CO2, AND IN AN ICE AGE.**

**NOW WE'RE CLIMBING TO 280 PARTS PER MILLION… A WARMER INTERGLACIAL PERIOD.**

**THEN DOWN TO A COLD 180… AND UP AGAIN, TO A WARMER 280.**

**THEN REPEATING… 180… 280 …THE NATURAL CYCLING OF THE CLIMATE ROLLER COASTER.**

The 400,000 year graph is replaced by a 100,000 year close-up, and we see that the relatively smooth curve is, in reality, a series of spiky ups and downs in temperature, derived from isotopic ratios in the GISP-2 (Greenland Ice Sheet Project) ice cores: for a fuller explanation of "paleothermometry," please see Richard's TWO MILE TIME MACHINE, pages 61-65:

**BUT IF WE LOOK IN GREATER DETAIL AT ONE HUNDRED THOUSAND YEARS OF EARTH HISTORY, AND SPECIFICALLY AT THE ICE CORE RECORD FROM GREENLAND, IT'S OBVIOUS OUR PLANET'S CLIMATE HASN'T ALWAYS HAD SMOOTH *UPS* AND *DOWNS*.**

***Location scenes with place locator: Kawarau Gorge, Queenstown, New Zealand***

***Richard to camera on the Kawarau Gorge bridge:***

***Occasionally, we cross some sort of a tipping point, and the Earth evolves really rapidly to a new state, which is very different.***

***VO Richard edging closer to the lip of the jumping platform:***

***Over the last 100 thousand years of the Ice Age cycling, we've had a couple of dozen of these large, abrupt, widespread climate shifts, almost as if the Earth was… bungy-jumping off the climate roller coaster.***

Bungy jumping was invented here at this bridge, and AJ Hackett remains the leading company offering bungy (that's how they spell it, in preference to "bungee"!) jumps here and elsewhere.

***The flesh-and-blood Richard jumps and begins to bounce on the bungy cable. From a bounce we cut to a GoPro POV shot, and then to the CGI roller coaster, riding the 100K climate pattern, from which the CGI Richard then bungies, with appropriate, tongue in cheek, sound effects:***

**OF COURSE, YOU'D HAVE TO BE A *LITTLE* NUTS TO BUNGY OFF A ROLLER COASTER, WHICH IS WHY I'M LEAVING THIS TO MY COMPUTER AVATAR.**

***Dissolve to blowing snow, howling wind, and an ice sheet:***

**BUT THESE ABRUPT CLIMATE CHANGES ARE REAL.**

**HERE'S *ONE OF THE LARGEST AND MOST RECENT*.**

***Dissolve from the CGI to a windy ice sheet: snow snakes blow towards camera: the images refer to the Younger Dryas event, described more fully on pages 110-118 of TWO MILE TIME MACHINE.***

**ABOUT 13,000 YEARS AGO, AS THE EARTH WAS CLIMBING OUT OF THE LAST ICE AGE, THE NORTH PASSED A TIPPING POINT AND RAPIDLY SLID BACK INTO A COLD MILLENNIUM…**

*CGI map dissolves into desert landscapes, and then torrents of water:*

**…DRYING MONSOON REGIONS OF ASIA WHERE HUGE POPULATIONS NOW RELY ON RAIN, AND WARMING THE SOUTH.**

*A mix of floods, and waterfalls:*

**THERE WAS WEATHER AND CLIMATE DISRUPTION WORLDWIDE.**

*Younger Dryas chart, with the sudden rise emphasized by color animation:*

**THEN, ANOTHER TIPPING POINT WAS REACHED, AND IN TEN YEARS OR SO, TEMPERATURES IN GREENLAND ROSE BY ABOUT 10 DEGREES CENTIGRADE, 18 FAHRENHEIT, NUMBERS WE KNOW WITH HIGH CONFIDENCE FROM THE ICE CORE RECORD.**

*Various IPCC and other projections of the future upward slopes of temperature, re-rendered by CrazyBridge as CGI, appear over a series of under-dissolves of water, drought and clouds:*

**TODAY, WHATEVER CLIMATE MODEL WE USE TO PROJECT THE IMPACT OF RISING LEVELS OF CO2, YOU SEE A RELATIVELY SMOOTH CURVE… HEADING UPWARD, BUT IN PRINCIPLE A CHANGE WE COULD ADAPT TO.**

*The CGI Richard bungy jumps with the 18F figure sliding on for emphasis:*

**BUT *EARTH'S HISTORY* SHOWS US THAT *EARTH'S CLIMATE* DOESN'T ALWAYS WORK THIS WAY.**

*Reprise of one of the CGI bungy jumps:*

**SOMETIMES IT REALLY DOES GET AS *CRAZY* AND UNPREDICTABLE AS… "BUNGY JUMPING OFF THE CLIMATE ROLLER COASTER."**

*A series of location bungy jumps with the orange-parka'd Richard as the last:*

*Richard to camera:*

***An abrupt climate change could be really bad for people. We're optimistic that we won't have one, but we're not certain. And the science suggests that the harder and faster we turn the CO2 knob, the more likely we are to cross a tipping point and trigger one.***

*Now, our point of view in the computer graphic roller coaster shifts, and we are on board, looking upward to uncharted territory, as we see a 380 indicator whizz by to our right… and we leave it behind us.*

**YET HERE WE ARE TODAY, RACING UP A HILL TO WHO KNOWS WHERE…**

**AS BURNING FOSSIL FUELS MEANS WE'VE BLOWN PAST 390 PARTS PER MILLION, WITHOUT SLOWING DOWN.**

*We hear the crunching ratchets of a Coney Island roller-coaster:*

**WILL OUR ASCENT BE SMOOTH AND MANAGEABLE?**

**OR WILL OUR RIDE COME OFF THE RAILS?**

*Richard on camera:*

***If we wanted to take out insurance against the possibility of such a change, we could look at slowing down now before we tip over the edge.***

To see how some of the world's largest insurance companies are, in fact, convinced that it makes sense to consider climate change, see this report from Swiss Re.

*Reverse zoom out of New Zealand, and then dissolve to orbital shot to arrive in China:*

**ONE WAY OF ENSURING A MORE MANAGEABLE CLIMATE IS TO RESEARCH AND DEPLOY WAYS TO BURN FOSSIL FUELS *WITHOUT* RELEASING MASSIVE AMOUNTS OF CARBON DIOXIDE.**

**AND, SURPRISING AS IT MAY BE, SOME OF THE MOST INNOVATIVE WORK TO MEET THAT URGENT 21st CENTURY GOAL IS HAPPENING IN THE LAND OF ONE OF EARTH'S MOST ANCIENT EMPIRES.**

*CHAPTER HEAD graphic:*
*"The New Empire of CleanTech"*

# The New Empire of CleanTech

*A violinist plays in the early morning light at Behai Park, in Beijing. Dissolve to faces of the Warriors, in the vast excavated pit in Xi'an:*

**CHINA WAS FIRST UNIFIED AS A NATION IN THE THIRD CENTURY B.C. BY THE EMPEROR WHO HAD THIS ARMY OF "TERRACOTTA WARRIORS" BUILT TO GUARD HIS TOMB.**

*See more faces and figures: archers, charioteers, and commanders:*

**THESE FIGURES REPRESENT STATE CONTROL, AND MASS PRODUCTION IN THE SERVICE OF A MASTER PLAN, EXTENDING FROM THIS LIFE INTO THE HEREAFTER.**

The famed terracotta warriors at Xi'an, buried by Qin Shi Huangdi, the first emperor of China, date from the end of the 3rd century B.C. and were buried about 210 B.C.

*Tilt up to the roof covering the huge series of pits and excavations:*

**THIS IS A WONDER OF THE *ANCIENT* WORLD…**

*EXPO scenes: Dolly shots past the Chariot, seeing visitors as well:*

**BUT WHEN CHINA WANTED TO SHOWCASE ITS "NATIONAL TREASURES" FOR A CONTEMPORARY AUDIENCE, IT PLACED ONE OF THE EMPERORS' MAJESTIC CHARIOTS AS A CENTERPIECE AT THE *2010 SHANGHAI WORLD EXPO*.**

**THIS EXPO, HOWEVER, WAS FOCUSED MORE ON THE FUTURE THAN THE PAST.**

*Exterior shot of the red-painted, upside down pyramid of the main China pavilion:*

**ONE ENTIRE FLOOR OF THE MASSIVE CHINESE PAVILION WAS DEVOTED TO RENEWABLE ENERGY AND LOW-CARBON LIVING.**

**HERE THERE WAS NO DOUBT THAT CO2 EMISSIONS WERE DRIVING CLIMATE CHANGE…**

*Signs emphasize the connection of CO2 and pollution, and we see smiling Chinese youngsters posing proudly beside futuristic, electric "concept cars":*

**AND THAT CLEAN ENERGY WAS THE SOLUTION.**

*Tilt up to see a sign reading "Land of Hope"*

**ALL WORLD'S FAIRS ARE EXERCISES IN SELF-PROMOTION, IF NOT PROPAGANDA, BUT HARD NUMBERS TELL THE STORY.**

**IN 2010 CHINA INVESTED MORE ON RENEWABLE ENERGY THAN ANY OTHER NATION ON EARTH.**

**GERMANY WAS NUMBER 2, AND THE U.S., NUMBER THREE, COMMITTING ROUGHLY HALF AS MUCH AS CHINA.**

Figure 9 of the Pew Report (PDF) from 2011 "Who's Winning The Clean Energy Race? Growth, Competition and Opportunity in the World's Largest Economies" shows that so far as "clean energy" investment (biofuels, wind, solar, other renewables. and efficiency is concerned, in 2010 China invested $54.4 billion, Germany $41.2 billion, and the U.S. $34.0 billion, securing the top three ranks (Italy was number four with $18 billion invested). On these data, the U.S. invested 62.5% as much as China. For 2011, and for the U.S., there's good news and bad news: the good is that in 2011 the U.S. invested more in clean energy than China, but the bad news is that this was from programs that have now expired.

***Julio Friedman starts speaking over the EXPO, and then scenes from Applied Materials, and Shanghai Electric wind turbine manufacturing:***

***Julio Friedman, to camera and VO:***

***China's being aggressive on all the clean energy fronts. They're building 100,000 megawatts of wind. They're putting up 10,000 megawatts of solar PV (photovoltaics)…***

***On camera:***

***…50,000 megawatts of nuclear.***

***Zoom down from space and see the LLNL entry sign:***

**AT THE U. S. DEPARTMENT OF ENERGY'S "*LAWRENCE LIVERMORE NATIONAL LABORATORY*" IN CALIFORNIA, GEOSCIENTIST *JULIO FRIEDMAN* IS IN CHARGE OF ITS CARBON MANAGEMENT PROGRAM.**

***Julio and a technician walk between banks of computers, lights blinking: cut to a simulation of underground rock formations and fissures:***

**HE USES SOME OF THE WORLD'S FASTEST SUPERCOMPUTERS TO STUDY HOW TO STORE CO2 UNDERGROUND, AND HE'S AN EXPERT ON U.S.-CHINA ENERGY COLLABORATION.**

***Julio Friedman, Carbon Management Program, Lawrence Livermore National Lab., U.S. DOE.***

***Julio:***

***They're not putting all their eggs in one basket, either. They're trying to cover, comprehensively, all the clean energy options.***

***City scenes, and power plant smokestacks:***

**AND THAT INCLUDES AN OLD AND DIRTY FUEL THAT CHINA BOTH MINES AND IMPORTS AT WORLD-RECORD LEVELS.**

Coal is Earth's most abundant hydrocarbon. It is also the dirtiest because in addition to the carbon dioxide, and the nitrogen and sulfur oxides, coal burning releases far more particulates than burning oil or gas—the latter two produce relatively little dirt. Without pricing the externalities (miners' deaths, environmental destruction, pollution, etc.) and factoring in those significant costs, coal has also been regarded as the "cheapest" fossil fuel. For now, coal wins in the electricity-generating cost battle against other fossil fuels, although wind and hydro compete well—when available—and specialized natural-gas plants can do better than coal.

***Julio:***

***China is the world's largest coal producer. It's the world's largest coal user. They're not going to abandon coal any time soon.***

***Shock cut to coal-burning stoves in the night market in Xi'an, and in a restaurant. After the excitement of the visual "feast," Xi'an city scenes of the Bell and Clock Towers and the Goose Pagoda at dawn:***

**THE CITY OF XI'AN IS HOME TO THE TERRACOTTA WARRIORS, AND WAS ONCE THE CAPITAL OF CHINA… STARTING POINT FOR THE SILK ROUTE.**

As the silk trade developed, so did various "silk routes" naturally sprang up, often collectively referred to as the "Silk Road." Since the trade began when Xi'an (Chang'an) was the capital of China, the silk road began there in a practical sense; as time went on, China declined in various ways, and the silk road came to supplanted by sea routes, but during the T'ang Dynasty (6th through 8th centuries A.D.), the glory days of the silk road, Xi'an was the great city and definitely the point of origin. For more, please see Peter Hopkirk's *Foreign Devils on the Silk Road*.

***"Hi-Tech Development Zone" signs, and the university gates:***

**NOW IT'S A MODERN CITY THAT ILLUSTRATES THE FORCES THAT WILL SHAPE CHINA'S ENERGY FUTURE… AND, INEVITABLY, IMPACT THE ENTIRE PLANET.**

Modern Xi'an has become a center of energy innovation, as well as space studies, in part because of the high quality and large number of graduates from its science and technology schools: it boasts "…47 universities and other higher-education schools, and the going rate for engineers with master's degrees is about $730 a month."

***Red star on the TPRI gate:***

## XI'AN IS ALSO HOME TO THE "THERMAL POWER RESEARCH INSTITUTE," T-P-R-I.

As *Bloomberg Businessweek* put it, "Xi'an Thermal Power Research Institute Co., Ltd. operates as a research organization in the field of thermal power engineering in China. The company offers R and D programs/projects in the fields of thermal power plant operation, automation and information management, clean coal power generation, and nuclear power generation and renewable power generation technologies. It also provides technical and consultation services, which comprise feasibility studies, quality supervision, unit commissioning, performance test, operation optimization, technical consultation, system diagnosis, failure analysis and handling, and technical modification/retrofitting; product development services; and engineering contracts."

***See the bags of coal, and dust, and grime, used in past experiments and still kept on hand:***

## "THERMAL POWER" IN CHINA IS SHORTHAND FOR COAL, WHICH SUPPLIES THREE QUARTERS OF THIS NATION'S ELECTRICITY SUPPLY.

## IN THE U.S., IT'S ABOUT HALF.

## AND WORLDWIDE, BURNING COAL PRODUCES ABOUT ONE QUARTER OF ALL GREENHOUSE GAS EMISSIONS.

According to the World Nuclear Association, "Electricity consumption in 2010 increased 14.56% to 4,190 billion kWh, according to the China Electricity Council, corresponding with a 10% growth in GDP. Some 3,090 billion kWh of this was in industry. Installed generating capacity increased 10.06% to 962 GWe. At the end of 2010, fossil fuelled capacity (mostly coal) reached 707 GWe, hydro capacity was 213 GWe (up 16.6 GWe in the year), nuclear capacity was 10.8 GWe and wind capacity reached 31 GWe." This implies that China generated 707 GWe from coal, out of a total of 962 GWe, so coal produced 73.5% of the total electricity power generated.

According to the U.S. Energy Information Administration, in 2010, 45% of the nearly 4 trillion kilowatt hours of electricity generated in the United States used coal as its source of energy.

The Skeptical Science website states that coal consumption "account[s] for 30% of total anthropogenic carbon dioxide (CO2) emissions worldwide, and 72% of CO2 emissions from global power generation. In addition, non-power generation uses increase its contribution to global human CO2 emissions to a whopping 41% (as of 2005)." Greenhouse gases include more than CO2, of course, and it is not trivial to measure one against another.

According to the EPA (PDF), in the United States, CO2 from fossil fuel combustion produces about 78% of the total greenhouse gas emission. Since coal provides 27.5% of the energy from fossil fuels, assuming that all three fossil fuels (coal, oil, and gas) release the same amount of CO2 per MTOE, coal provides about 21.4% of total CO2 emission. Worldwide, coal burning amounts to 33% of the total fossil fuel combustion, which, if the same 78% contribution holds true, means that coal produces 25.7% of the total greenhouse gas emission.

***Julio to camera and VO B&W archival scenes:***

***If you look in the past, coal is mighty: built our country.***

***It is filthy: soiled our land and atmospheres.***

***In the future, I think coal can be mighty, and can be clean, and can be benign.***

***Truck and smokestacks at Shidongkou power plant:***

**"*CLEAN COAL*" MAY SEEM LIKE A CONTRADICTION, BUT IF IT'S *REAL*, IT HAS IMPLICATIONS NOT JUST FOR CHINA, BUT ALSO FOR THE U.S. AND MANY DEVELOPING NATIONS.**

***Hi-tech TPRI shots:***

**TPRI IS OWNED BY *HUANENG POWER*, ONE OF THE LARGEST UTILITIES IN THE WORLD.**

The world's largest utility appears to be Électricité de France (EDF), which operates in many countries. Huaneng Power's 2010 annual report (PDF) states that "As at 29 March 2011 the Company is one of China's largest listed power producers with equity-based generation capacity of 50,935 MW and controlling generation capacity of 54,402 MW." The EDF website states that in 2010 the EDF group produced 630.4 TWh of power. Since there are 8700 hours in a year, this amounts to a power generation of 72.4 GW (72,400 MW). Duke Power's website says that "We have approximately 35,000 megawatts of electric generating capacity in the Carolinas and the Midwest." There is an implication (by no further mention) that this is their total, which is about half of EDF's and two-thirds of Huaneng's.

**THEY'VE RENAMED THIS KEY NATIONAL LABORATORY THE "CLEAN ENERGY RESEARCH INSTITUTE."**

**XU SHISEN IS THE DIRECTOR.**

See interesting articles in the *Wall Street Journal* and *The New Yorker* for more on China, coal, TPRI and Dr. Xu.

***TPRI gates, and then inside: Coal dust and the older machinery:***

***Xu Shisen, Director, Clean Energy Research Institute.***

***Xu to camera and then VO power lines:***

***Coal-fired power plants account for 74% of China's energy production. It's the main source of power generation.***

**THE INSTITUTE'S NEW MISSION IS TO DEVELOP INNOVATIVE TECHNOLOGIES AND PROCESSES THAT CAN BURN THIS HYDROCARBON IN CLEANER, SAFER WAYS.**

***Julio:***

***Coal is half of the world's power today. It's half of the emissions that the U.S. and China put into the atmosphere. We just have to tackle coal directly.***

***Continue with smoggy city shots and Shidongkou smokestacks:***

***There is no solution to climate change that doesn't involve China reassessing its coal markets, and its coal conversion technology. And they're doing that.***

***TPRI labs and archival test footage:***

***Dr. Xu, with second track in English:***

***China started researching and developing clean coal technology back in the early 1990s.***

***Place locator: Shidongkou #2 Power Plant, Shanghai***

**TECHNOLOGY DEVELOPED AT THE INSTITUTE IS USED IN THIS PILOT CARBON SEQUESTRATION FACILITY, OUTSIDE SHANGHAI.**

***See multiple signs attached to pipes and buildings indicating their role in the CO2 capture process:***

**IT'S ATTACHED TO THE GIANT "SHIDONGKOU #2" GENERATING STATION, ALSO OWNED BY *HUANENG POWER*.**

**THIS PLANT USES A PROCESS CALLED "*POST COMBUSTION CAPTURE*," "P-C-C," WHERE COAL IS FIRST BURNED IN A MORE OR LESS TRADITIONAL MANNER, AND THEN THE CO2 IS CAPTURED.**

***Julio to camera and VO Shidongkou shots:***

***So Shidongkou is remarkable in every way. They're capturing 150,000 tons of carbon dioxide, and they've been doing that now for about 18 months successfully.***

**SHIDONGKOU SELLS THE CAPTURED CO2 FOR USE IN SOFT DRINKS AND CHEMICALS, TURNING IT INTO A RESOURCE.**

**IN THE FUTURE, THEY'LL SCALE UP AND BEGIN *SEQUESTERING* THE CO2 DEEP UNDERGROUND.**

***Julio:***

***Already, that means that it works and that the cost and performance are pretty well understood. So if it can be widely applied, then it creates the new benchmark that will define whether or not this works anywhere else.***

**IF THIS NEW TECHNOLOGY WORKS, ANY EXISTING COAL PLANT CAN BE RETROFITTED AND RUN MORE CLEANLY**

***Dr. Xu:***

***But it is more about the economic feasibility because the cost is very high which increases the price of electricity by about 20%.***

***Julio to camera and then VO city scenes, Shidongkou and to camera:***

***Nobody wants to pay more for power, but nobody wants to have contaminated rivers and skies.***

***If we can pay 20% more to get Carbon Capture and Sequestration deployed at scale in today's fleet, I would be a very, very happy guy if we could get away for that.***

***Shidongkou shots:***

**"SHIDONGKOU NUMBER 2" DEMONSTRATES WHAT CAN BE DONE AT MANY *OLDER* POWER PLANTS.**

***Place locator: GreenGen IGCC plant, Tianjin, China***

***Slide wipe to see construction sights and sounds at GreenGen:***

**BUT THE "*GREENGEN*" CONSTRUCTION SITE, NEAR TIANJIN ABOUT 70 MILES SOUTH OF BEIJING, REPRESENTS A COMPLETELY NEW APPROACH TO TURNING COAL INTO ENERGY WITH MINIMAL POLLUTION AND EMISSIONS.**

***Walking shots of Lin, Douglas, and Chinese colleagues as they inspect the site:***

***ALBERT LIN* IS AN AMERICAN VENTURE CAPITALIST.**

**TOGETHER WITH HIS COLLEAGUE, BILL DOUGLAS, FROM HOUSTON, TEXAS, THEY'VE LICENSED *HUANENG* TECHNOLOGY FOR WHAT THEY HOPE WILL BE A "CLEAN COAL" PLANT IN PENNSYLVANIA.**

***See Albert and Bill in ETOM footage from 2010:***

**THEY VISITED GREENGEN IN JULY 2010.**

***To camera and then construction shots:***

***Albert Lin, CEO, Emberclear***

***Albert Lin:***

***A year and a half ago when I was here this was just cleared land. And so this kind of a project, of this size, at this pace, is unprecedented…***

***Stills taken in mid-2011, showing the outer shells of buildings near completion:***

***Place and time locator: Greengen, October 2011***

**BY OCTOBER 2011, THE PHYSICAL STRUCTURE WAS COMPLETED, WITH COMMISSIONING TESTS ONGOING.**

***Crazybridge re-render of technical animation showing the operation of the gasifier, and continues over Lin interview:***

***Lin:***

***This is the world's most advanced coal gasifier.***

**THIS STRUCTURE, AT THE HEART OF GREENGEN, BURNS COAL CONVERTED INTO WHAT'S CALLED "SYN-GAS" AND EMITS FAR FEWER POLLUTANTS THAN A TRADITIONAL PLANT.**

As of April 23rd, 2012, Lin's company published a release from *Huaneng* announcing the successful startup of the gasifier. Although delayed from initial plans, this still puts GreenGen ahead of the entire world in the practical operation of this technology.

***Continue with Xu over construction scenes and graphics:***

*Xu:*

*The ultimate goal for GreenGen is to generate 400 megawatts of electricity.*

*On camera:*

*At the same time, we want to capture 90% of the CO2.*

*CGI animation: Greengen:*

**ONCE GREENGEN IS FULLY OPERATIONAL, THE CO2 WILL BE PUMPED OFFSHORE TO BE USED IN *ENHANCED OIL RECOVERY*.**

*Julio:*

*If it works as advertised and if the costs are competitive with other clean energy, it creates a technology option that's new for the world.*

**AND GREENGEN SHOULD COST ABOUT ONE HALF OF THE SIMILAR PROJECT PLANNED FOR PENNSYLVANIA.**

*Julio, VO construction shots:*

*It's not just "green washing." They expect these things to operate for thirty years, they expect them to perform as advertised, they expect them to be clean. And they expect them to be a solution to the country.*

*People, on foot, in buses, and traffic scenes from all over China:*

**IT'S NO SECRET, ESPECIALLY TO ANYONE LIVING IN A BIG CHINESE CITY, THAT AIR QUALITY IS OFTEN DANGEROUS.**

*GreenGen construction, Shidongkou in operation, polluted cities:*

**AND "CLEAN COAL" PROPONENTS LIKE LIN AND FRIEDMAN RECOGNIZE THE HARM THAT INCREASING LEVELS OF CARBON DIOXIDE DO TO CLIMATE. THEY THINK THAT *PAYING NOW* IS BETTER THAN *PAYING LATER*.**

*Lin on location at GreenGen, and VO hazy cityscapes and power plant smokestacks:*

*Lin:*

*The reality is that if climate were not important or were not a factor, we would not be doing any of this. Because it is cheaper to pollute and do it the old-fashioned way…*

*People, pollution, traffic shots:*

***Lin VO:***

***…but what we're saying is there's a better way out for everyone. Because sooner or later we are going to have to address the climate issues, and the pollution issues…***

***Lin on camera:***

***…and the things that have been associated with a growing population.***

***Workers at GreenGen push a wheel barrow towards camera: VO some of shots above, best and most dramatic Shanghai Electric:***

***Friedman:***

***I think it's pretty clear to everybody that China is going for the gold. They want to be number one in all these areas…***

***On camera:***

***…and they're committing to it in the same way that an Olympic athlete commits to that goal.***

***Julio to camera over Applied shots, Shanghai Electric, EXPO, etc. etc:***

***They're using every resource they have to move ahead for their population's needs, and for their economy's needs.***

***Female traffic cops in Xi'an, smartly uniformed, on platforms amid crazy traffic, whistling and signaling, symbolizing the goal to create order out of chaos:***

**CHINA'S BREAKNECK DEVELOPMENT MAY SEEM CHAOTIC.**

***Whistle, gesture, traffic signal. Pedestrians walk on command, bikes and electric scooters pulse:***

**BUT BEHIND THE SEEMING CHAOS THERE'S LITERALLY A "PLAN" IN THEIR ENERGY POLICIES.**

**CHINA'S 12TH 5-YEAR PLAN, ANNOUNCED IN 2011, SET AMBITIOUS GOALS FOR HOW MUCH POWER MUST BE GENERATED BY RENEWABLE ENERGY.**

The 12th five-year plan covers the years 2011-2015. Its website (PDF) states that "China aims for 15% of total energy consumption from renewable [sources] by 2020." Nuclear power is included among the renewables, but since nuclear power now provides only 0.3% of the total final energy used, it cannot make a significant contribution without the lapse of at least several years. Noting the target year of 2020, it seems highly unlikely that renewables can contribute as much as 10% of the total energy consumption by 2015.

Nevertheless, these goals are indeed ambitious. For example, Figure 15 on page 35 of the website cited in this paragraph shows that the large, highly developed European countries (Germany, UK, Italy) have targets of 15-18% of energy obtained from renewables by 2020 (the 2005 percentages ranged from 2 to 6%). Denmark, however, has a goal of being entirely free of fossil fuels by 2050.

***Female cop waves people onwards:***

**OF COURSE, TOP DOWN DIRECTION IS EASIER IN AN AUTHORITARIAN STATE, BUT CO2 EMISSIONS PER UNIT OF ECONOMIC OUTPUT ARE TARGETED FOR A 17% REDUCTION BY 2015.**

The 17% figure is indeed in the plan, but it is important to note that this reduction is per unit of GDP, although this is still pretty impressive. The plan sets a target of 7% annual growth for GDP, while KPMG, the source for this number (PDF), cites "industry analysts" who estimate that actual growth will be 8% annually. Even at a 7% annual increase, five years of growth will increase GDP by 40%. In that case, the 17% reduction per unit of GDP would correspond to an actual increase of 16.4% in CO2 emissions. Hence China's interest in renewables to cut back on imported sources of fossil fuel energy, particulate pollution and as a source of export revenues.

***VO Expo scenes, with electric buses having their batteries exchanged: crowds on the Bund in Shanghai:***

***Julio:***

***I think the most important thing to learn from what China is doing these days is that it's good to have a plan. You can quibble with their plan …but they have one.***

***Julio on camera:***

***Having that plan, having that long arc of commitment, is what's really going to deliver the goods.***

***In Behai Park, Beijing, we see early morning exercises and once more hear the violin that began the sequence:***

**WILL THE RESULT OF ALL CHINA'S PLANS, AND INCENTIVES, AND SUBSIDIES, BE MORE "BLUE SKY DAYS" WHERE TRADITIONS ENDURE, AND PEOPLE EVENTUALLY ENJOY CLEANER AIR?**

***At a Xi'an workshop making Warrior replicas, close-ups of the craftsman applying the clay:***

**WILL SUSTAINED POLICY AND STATE PLANNING RESULT IN ABUNDANT ENERGY AND TECHNOLOGICAL ACHIEVEMENTS TO RIVAL THOSE OF THE FIRST CHINESE EMPEROR?**

*The craftsmen place heads onto Warrior bodies:*

**BUT ALL THAT WON'T MATTER MUCH TO THE PLANET'S CLIMATE IF CHINA, THE UNITED STATES, INDIA AND OTHERS DECIDE TO KEEP COAL AND OTHER FOSSIL FUELS A MAJOR PORTION OF THEIR ENERGY MIX, WITHOUT PAYING THE PRICE TO BURN THEM CLEANLY.**

*From an orbital shot, dissolve to see Richard, speaking to camera in early evening, on a hill in Edinburgh, overlooking the Castle:*

***So the Earth provides lots of choices for clean, low carbon energy. And Brazil, China and Texas show there are ways forward. But can we afford it? Can society make the kinds of changes needed?***

***Well… we've done it before.***

*Bagpipes begin to play, and Richard rises and walks out of shot:*

*CHAPTER HEAD title:*
*Toilets and the Smart Grid*

# Toilets and the Smart Grid

***Crowds on the street. A bagpiper plays on the High Street:***

***Richard VO:***

**LET'S TAKE A WALK THROUGH HISTORY IN EDINBURGH, SCOTLAND, BUT IT COULD BE MANY OTHER BIG CITIES A COUPLE OF CENTURIES AGO.**

***Richard enters a narrow close through a stone archway:***

**HERE'S WHAT A VISITOR FROM LONDON WROTE IN 1754:**

***Dissolve to B&W period prints of Edinburgh: many are from Memorials of Edinburgh in the Olden Time, by Sir Daniel Wilson.***

***English-accented actor VO:***

**"WHEN I FIRST CAME INTO THE HIGH STREET OF THAT CITY, I THOUGHT I HAD NOT SEEN ANYTHING OF THE KIND MORE MAGNIFICENT… THE EXTREME HEIGHT OF THE HOUSES, WHICH ARE, FOR THE MOST PART, BUILT WITH STONE, AND WELL SASHED."**

Birt's book (he's the English visitor referred to above) was first published in 1754. Google Books has a facsimile of the original edition online, with the most relevant text at pp. 19-20. H/t to Jack Repcheck, Richard Alley's editor at Norton for the ETOM book and author, in his own write (sic), of "*The Man Who Found Time: James Hutton And The Discovery Of Earth's Antiquity*," in which this story of chamber pots and taverns appears.

***Richard enters a tavern: to camera:***

***It's evening… time for a wee bite.***

***Prints of Scottish tavern life:***

***Richard VO:***

**SCOTTISH TAVERNS, THEN AS NOW, WERE NOISY PLACES, BUZZING WITH GOOD CONVERSATION AND HIGH SPIRITS.**

***Richard to camera, putting down his goblet: he lights a piece of parchment:***

***The visitor from London dined well and drank a few glasses of fine French claret, but then his new friends did something that was second nature to them in the 18th Century, but seems very strange to us today.***

*Hands strike matches and light pieces of parchment, as the color video becomes period B&W, and set them on beat-up pewter plates to allow the smoke to rise:*

*Actor VO:*

**"…THE CLOCK STRUCK TEN …THEN THE COMPANY BEGAN TO LIGHT PIECES OF PAPER, AND THROW THEM UPON THE TABLE TO SMOKE THE ROOM…"**

*Richard VO and to camera:*

**LIGHTING THOSE PIECES OF PAPER WAS MEANT TO "MIX ONE BAD SMELL WITH ANOTHER."**

*A chamber maid dumps a chamber pot out the window shouting "Gardee loo!"*

*Richard VO:*

**YOU SEE, TEN O'CLOCK WAS WHEN YOU COULD EMPTY BRIMMING CHAMBER POTS DOWN INTO THE STREETS.**

*Slow motion water hits the ground. Overlapping shouts of "Hud your haunde" and "Gardeeloo":*

*Richard walking uphill and talking to camera in a steep passageway off the High Street:*

***The London visitor safely dodged the "terrible shower," but then he was forced to hide between his bed sheets to avoid the smell pouring into his room from the filth. And yet, the people had gotten used to this, to the inconvenience and disease, and some people made a living hauling away the human waste.***

*Richard VO architectural details and period prints: tilt down from top floors to the streets: CU of people on the street.*

**THE ENGLISH VISITOR THOUGHT ALL THIS SIMPLY HAD NO REMEDY.**

*Actor VO:*

**"ANYTHING SO EXPENSIVE AS A *CONVEYANCE* FOR THE WASTE DOWN FROM THE UPPERMOST FLOOR COULD NEVER BE AGREED ON. NOR COULD THERE BE MADE, WITHIN THE BUILDING, ANY *RECEIVER* SUITABLE TO SUCH NUMBERS OF PEOPLE."**

*Richard halts and speaks to camera:*

***So, what do chamber pots have to do with carbon dioxide and sustainable energy? Not to mince words, we're pouring CO2, another form of human waste, into the public space, and we'll have to deal with the consequences if we don't clean it up.***

*Details of sinks and WCs in an architectural salvage yard, in Edinburgh:*

**TODAY, OF COURSE, MOST OF US HAVE "CONVEYANCES" DOWN FROM BATHROOMS, AND SINKS TO WASH IN, AND "RECEIVERS" FOR OUR WASTE.**

*Richard to camera: camera pans right to favor the pedestal, which is the starting shot for CGI animation:*

***What happened? Look around your house. How much did the porcelain throne in your bathroom really cost?***

*From one of the WCs, we see a stylized network of toilets in houses, sewers running under streets, a network of pipes to and from waste treatment facilities, zooming rapidly back out, ending on the location WC:*

*Richard VO:*

**IT TOOK A CONSIDERABLE INVESTMENT FOR ALL THOSE PIPES BRINGING WATER TO WASH WITH, AND TO TAKE THE WASTE AWAY.**

**THE REVOLUTION IN HYGIENE INVOLVED AN EXTENSIVE "INFRASTRUCTURE" OF TOILETS IN HOMES, SEWERS UNDERNEATH OUR CITIES, WATER TREATMENT PLANTS.**

**TODAY WE MIGHT CALL IT THE SANITATION "SMART GRID."**

*Richard to camera beside racks of sinks and pedestals:*

***So how much did all this cost? Not that much, if you consider the millions of lives saved with clean water, prevention of diseases like cholera and typhoid—something like 1% of the economy, in very round numbers. And that's more or less the estimated cost of switching the world to a sustainable energy system that doesn't dump fossil fuel CO2 into the public space.***

For more on the revolution in public health, see *Earth: The Operators' Manual* (the book), chapter 16, "Toilets and the Smart Grid," page 209 ff, and the discussion of the science and statistics that led to the conclusion that cholera and bad water supplies were linked. Richard writes, "The optimal economic path outlined in chapter 15 would cost well under 1% of the world economy per year, with benefits outweighing the costs. But that path allowed a lot of warming to occur. Enhanced national security, insurance against disasters, and fairness to others were among the additional arguments that favored more action sooner. Several groups ...have attempted to estimate the costs of stabilizing the climate while still supplying abundant energy. These estimates generally ignore the benefits of avoiding climate change and present only the costs. Those costs depend a lot on how rapidly the stabilization is made. For plans that stop the warming at no more than a few degrees within a few decades, costs generally are in the neighborhood of 1% of the world's economy (gross domestic product, or GDP.)"

Other estimates, including those of the IPCC, are higher, from 2-5%. Lord Stern's review on the Economics of Climate Change, initially estimated a 1% figure, but later, as time passed by, increased that to 2%. Most economists agree, however, that whatever the actual cost, it'll be higher the longer we wait to start.

***Cut to side angle, and Richard walks to camera:***

***Cleaning up the cities took decades and even centuries, and we're trying to do things a little faster… but the revolution in waste management shows that we can do big things to get benefits that none of us would ever walk away from.***

***Earth orbital view, with lights coming on across North America:***

**OLD ENERGY TECHNOLOGIES CAN BE CLEANED UP. NEW ONES CAN COME ONLINE. *OTHER* NATIONS ARE MOVING AHEAD.**

**WHAT WILL IT TAKE TO KEEP THE LIGHTS ON IN THE UNITED STATES, AND…**

***CHAPTER HEAD title:***
***"Avoid The Energy Abyss"***

***…AVOID THE ENERGY ABYSS*.**

# Avoid The Energy Abyss

***Red dawn over Texas turbines:***

**THERE'S NO QUESTION THAT TRANSITIONING TO CLEAN AND RENEWABLE ENERGY IS GOING TO BE A HUGE TASK.**

***The building of the Hoover Dam, as seen in "Uncle Sam: The Greatest Builder," a film from 1937, and Interstate highways stock footage from the National Archives:***

**BUT AMERICA HAS DONE SIMILAR THINGS BEFORE.**

**TAKE THE *HOOVER DAM*, AND THE *ELECTRIFICATION PROGRAM* OF THE 1930s.**

***Aerial of cloverleaf junction and I-95 signs:***

**…OR THE BUILDING OF THE *INTERSTATE HIGHWAY SYSTEM*.**

***See Hofmeister, and then some of the Houston refinery shots:***

***Under: "Well, I am optimistic…"***

**JOHN HOFMEISTER IS A FORMER OIL MAN, BASED IN TEXAS. HE HEADED UP *SHELL IN THE UNITED STATES*.**

***Back to him for a blip, voice under, and then the sun "setting" over the refinery:***

**HE ALSO WROTE A BOOK ENTITLED "*WHY WE HATE THE OIL COMPANIES*," AND HE'S WORRIED THAT TODAY AMERICA ISN'T MAKING THE RIGHT DECISIONS ABOUT ENERGY.**

***John Hofmeister VO:***

***You need to think of energy in a 50-year time frame.***

***On camera:***

***And our elected officials are thinking of energy in two-year election cycles. That's ridiculous! And it is going to take us, as a nation, to an energy abyss, because you can't design an energy system…***

***Refinery details:***

***…to replace the 20th century which is growing old, and running out in some cases, you can't replace that with two year cycles of decision making.***

***Copenhagen shots: prosperous, busy, dynamic, modern:***

**OTHER NATIONS *HAVE* CHANGED.**

**LOOK AROUND COPENHAGEN, AND YOU SEE PEDESTRIAN WALKWAYS AND BIKES AS A MAJOR FORM OF TRANSPORTATION.**

One not very official website quotes a City of Copenhagen estimate of 37% bicycle commuters (in 2009), with a hope of getting to 50% by 2015. Another U.S. visitor to Copenhagen "Lasse Lindholm of the City of Copenhagen's traffic department" who says "55% of Copenhagen residents commute to work or school by bike." On the other hand, the organization Bike City Copenhagen states that "Today, 36% of all Copenhageners travel on bicycle to work or school. That is one of the highest percentages in the world and the ambitious target for 2015 is 50%. Furthermore, 1.1 million kilometers are ridden on bicycle in Copenhagen—every day."

**IN RESPONSE TO THE OIL SHOCKS OF THE 1970S, DENMARK TURNED *AWAY FROM* FOSSIL FUEL AND *TOWARD* SUSTAINABLE ENERGY.**

***Søren driving on Samsø, Denmark:***

***Søren:***

***In Denmark we had car-free Sundays where nobody was allowed to drive their cars on Sundays. And there was a rationing of fuel and gas.***

***Start Lykke Friis, former Danish Minister of Climate and Energy, VO shots of Danish citizens, cyclists and pedestrians.***

***Lykke:***

***These are sort of things that people remember…***

***Back to her on camera, as she raises her hand for emphasis:***

***"Well, we need to change."***

***U.S. gas line shots, 1970's stock footage:***

**THE U.S. ALSO EXPERIENCED THE *OIL SHOCKS*, WITH GAS LINES AND ANGRY CITIZENS.**

**AND, FOR A WHILE, AMERICA GOT SERIOUS ABOUT EXPLORING ALTERNATIVES TO IMPORTED GASOLINE AND FOSSIL FUEL.**

***Zoom in to see just the energy R&D, based on the AAAS/CBO graphic:***

**HERE'S THE ENERGY SHARE OF ALL FEDERAL NON-DEFENSE R&D INVESTMENT FROM 1957 THROUGH 2011.**

*The camera pans along the CGI graphic:*

**INVESTMENT RAMPED UP IN THE OIL SHOCK, BUT THEN WENT DOWN, DOWN, DOWN…**

*And pulls back to see the ARRA (aka "stimulus") funds, which flash white for emphasis:*

**AND WITHOUT SERIOUS NEW COMMITMENTS, THE 2009 STIMULUS FUNDS FOR ENERGY WILL HAVE JUST BEEN A TEMPORARY UPWARD BLIP.**

ETOM's graphic is based on AAAS's analysis, described as follows: "by Function (OMB data). The relative priority of different areas of R&D has varied over the years, reflecting changing national priorities. Spending on defense R&D has exceeded all other R&D spending for most of the past four decades, but the first chart below shows that the relative size of the two sectors has varied considerably over the years. The second chart shows how priorities in nondefense R&D have shifted. Space was the dominant mission in the 1960s; energy R&D has fluctuated in importance; health R&D, meanwhile, has shown practically uninterrupted growth and now represents the largest single share of the nondefense R&D portfolio." (PDF)

ETOM contacted AAAS, OSTP and OMB to attempt to add accurate figures for energy R&D from the 2009 stimulus funds, with results as follows: the figure of $80 billion from the Recovery Act refers to the total investment in clean energy, which covers a lot of ground, much more than energy R&D. If we look at the chart at the website just cited, it appears that in 2009, the Recovery Act led to an appropriation of "just" $1.5 billion in renewable and alternative energy, and the number for 2010 is probably not much larger.

*Hofmeister:*

***We're not making the decisions at the national level that need to be made in terms of the next decade, and the next several decades after that.***

*Earth from space shot, zooming to China:*

**HOFMEISTER AND OTHER EXPERTS LOOK AROUND THE WORLD AND SEE OTHER COUNTRIES MOVING AHEAD TO DEFEND THEIR NATION'S ENERGY SECURITY.**

*Hofmeister, VO scenes of Shanghai Electric and a high tech etching machine at Applied Materials:*

***Places like China have a clear plan, and they are driving forward. And they are building an energy infrastructure for the 21st century…***

*Hofmeister on camera:*

*…which will perhaps one day supply energy to the world's largest economy—China, not the U.S..*

*Montage of stills of Carter, Reagan, George H.W. Bush, Clinton, George "W" Bush and Obama:*

**IN AMERICA, ENERGY POLICIES CHANGE WITH EACH NEW ADMINISTRATION, IF NOT SOONER.**

*Lykke on her tour of the District Heating Plant:*

**SINCE OUR INTERVIEW, DENMARK'S GOVERNMENT HAS CHANGED PARTIES, BUT NOW *FORMER* MINISTER OF CLIMATE AND ENERGY LYKKE FRIIS DOESN'T EXPECT ENERGY POLICY TO CHANGE THAT MUCH.**

*Lykke:*

*Even if we are kicked out of office this will not lead to a huge change in our energy policy.*

*Hofmeister:*

*We need decisions that go beyond a single term of a President. That go beyond a single Congress, with a Republican or a Democratic majority. And we're not doing it. Other parts of the world are.*

*Lykke, VO prosperous Copenhagen shots:*

*All countries have to embark upon this transformation. And the lesson is, it can be done, because …Denmark, we've had also growth rate, by 80% since the '80s…*

*On camera:*

*…but our energy consumption and our CO2 emissions have been more or less stable.*

*Hofmeister VO New York City street scenes, and to camera:*

*We're going to find ourselves, as a nation, entering third world status when it comes to the reliability of our energy system within a decade if we don't get with a different program…*

*Hofmeister:*

*And I don't see any inclination now to make hard decisions. I see divisiveness, I see partisan paralysis, I see short-term political time thinking, and I see dysfunctional government.*

*Montage of the various places we're about to see: Alaska, Kansas and Baltimore:*

**AMERICA MAY LACK CONSENSUS ON A *NATIONAL* CLIMATE POLICY, AND ABOUT BUILDING A NEW ENERGY SYSTEM, BUT SOME STATES AND CITIES ARE MOVING AHEAD, WITH NEW IDEAS AND NEW TECHNOLOGIES.**

*Bernia Karl at Chena Hot Springs, voice under.*

*CHAPTER HEAD, as for the other sections, over high-speed river travel, up the Yukon River, Alaska:*

*"Laboratories of Low-Carbon Living"*

**CALL THEM, "LABORATORIES OF LOW-CARBON LIVING"**

# Laboratories of Low-Carbon Living

***Tanana: river travel, trees falling into the water, log piles on the river bank, wood into the boiler, and scenes from "Take Charge! Challenge" events in Kansas:***

**HERE ARE THREE EXAMPLES OF COMMUNITIES ACTIVELY ENGAGED IN REDUCING THEIR CARBON FOOTPRINT.**

For more in-depth stories about all three communities, and for links to web resources on each city or state, please see the relevant sections of ENERGY QUEST USA.

**IN RURAL ALASKA, TREES ARE HARVESTED FROM RIVERS TO POWER BIOMASS BOILERS, CUTTING THE COST OF SHIPPING IN DIESEL, GENERATING LOCAL JOBS, AND KEEPING DOLLARS IN THE COMMUNITY.**

***Dennis Charley, City of Tanana, Alaska***

***Dennis:***

***The community cuts wood and brings it in and everything. So instead of all the money going to the oil companies, it's a community thing now.***

***Slide transition to Baltimore: dynamic scenes of the "Energy Captains" walking through the neighborhood: CFLs being handed out: lively nat SOT:***

**BALTIMORE, MARYLAND, IS TAPPING WHAT SOME CALL THE "FIFTH FUEL," CONSERVATION AND ENERGY EFFICIENCY.**

**EXPERTS THINK SAVING ENERGY CAN COVER ALMOST *ONE QUARTER OF U.S. NEEDS BY 2030*.**

***Robbyn Lewis, Patterson Park Energy Captain, Baltimore***

Robbyn is one of ETOM's Energy Heroes of the Week, and is profiled here.

***Robbyn speaks to the guitar dude:***

***We want Patterson Park neighborhood to be the most energy efficient, greenest, most sustainable neighborhood in the city, and by signing this pledge you join like 120, 130 other people who already signed.***

**IN THEIR SECOND YEAR, THE "BALTIMORE NEIGHBORHOOD ENERGY CHALLENGE" SAVED MORE THAN TWO MILLION KILOWATT HOURS, AND NEARLY 7% ON GAS AND ELECTRIC BILLS.**

*Slide transition to scenes of harvesting crops in Kansas, and herding cows. Then scenes from all phases of the "Take Charge! Challenge," from kick-off events to the awards ceremonies: big signs with 100K, volunteers pitching in, etc.:*

**IN KANSAS, IN AMERICA'S HEARTLAND, THE "CLIMATE AND ENERGY PROJECT" USED FEDERAL STIMULUS DOLLARS TO FUND FOUR PRIZES OF ONE HUNDRED THOUSAND DOLLARS, TO BE AWARDED TO THE COMMUNITIES THAT SAVED THE MOST ENERGY.**

*In an energy-saving version of the Oscars and Emmies (or Publishers' Clearinghouse!), we see winners jump from their seats and race to pick up their checks. Folks high five, one woman yelling "Yes, yes, yes!" and "winners" hold up the giant 100K checks for commemorative photos:*

**THAT RESULTED IN SAVINGS OF MORE THAN *TWO MILLION DOLLARS* IN 2011, SAVINGS THAT ARE EXPECTED TO CONTINUE EACH YEAR FOR THE NEXT DECADE.**

*Nancy Jackson, Climate+Energy Project, Kansas*

*Nancy Jackson:*

***We're looking at energy efficiency and presenting it as a "win-win-win," because it allows people to save money in their homes and their churches and their businesses and their communities.***

*Gardner City energy auditors, fluorescent bulb recycling:*

***It allows them to build their local economies because it employs lots of people, installing insulation and windows and appliances.***

*Nancy on camera:*

***And at the same time, it insures a much more robust and healthy energy future.***

*Richard VO starts here, over shots from Tanana, Baltimore and Kansas:*

**BUT BUILDING A CLEAN AND SUSTAINABLE FUTURE TAKES A SUSTAINED AND NATIONAL EFFORT.**

*CGI of Shuman's parabolic mirror and hi-res images of the local Egyptian workers:*

**IT TOOK MORE THAN *ONE HUNDRED* YEARS FOR SHUMAN'S IDEAS OF CONCENTRATED SOLAR POWER TO COME TO SCALE.**

*Petrobras gas station and GM factory:*

**IT TOOK *THIRTY* YEARS FOR BRAZIL TO DEVELOP A NATIONAL INFRASTRUCTURE FOR SUGAR CANE ETHANOL.**

Ethanol production boomed in Brazil during World War II and was then forgotten until the oil shock in 1973, which led to the Pró-Álcool program described earlier in the program. Hence "thirty years" seems correct, given that Brazil set the current ethanol standards in 2003. The Wikipedia article states that "Flexible fuel cars were 22% of the car sales in 2004, 73% in 2005, 87.6% in July 2008, and reached a record 94% in August 2009." So the mid-2000 decade was indeed a crucial transition period.

***Xi'an countryside, or Beijing village, and then Shanghai Electric turbine factory:***

**CHINA NEEDED SIX FIVE-YEAR PLANS TO GO FROM A POOR AGRARIAN SOCIETY TO A WORLD LEADER IN CLEAN TECHNOLOGY.**

China's 12th five-year plan began in 2011; the preceding 11 five-year plans cover the 55 years from 1956 through 2010. The *eighth* five-year plan (1991-1995), the first to begin after the Tiananmen suppression, marked the beginning of economic reform under Deng Xiaoping Of course, this was not the first attempt at reform. The previous (seventh) five-year plan (1986-1990) marked, according to Wikipedia, "the first time in China's history that an all-round plan for social and economic development was created at the start of a new five-year plan."

***Richard to camera, beside the Willamette River, in downtown Portland:***

***And the choices we make today will shape America's energy future. And what happens in China and Chicago, India and Indiana, will shape the planet. The clock is ticking.***

***Cut to MCU:***

***The longer we ignore what's needed to move forward with non-polluting sources of energy, the more it'll cost, in cold cash …and a warmer planet.***

***VO shots of the climbing temperatures projections based on alternative scenarios, seen superimposed on dramatic landscapes, and cut to the majestic Iguaçu waterfalls:***

***Earth history and solid physics tell us what climate our kids and grandkids could see if we keep burning fossil fuels and releasing the CO2.***

***But all of us are able to make the plans and choices we know will work… to discover and develop new ways of… "Powering The Planet."***

***For "Earth: The Operators' Manual," I'm Richard Alley.***

***Underwriter announcement (as at head of show) and End credits.***