"Initiative to Save America's Jobs"
Maintain our Coal-fired Electric Generating Fleet and Protect the Electric Grid

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Authors: Melbourne F. Giberson, Ph.D., P.E., President,
Turbo Research, Inc., d.b.a TRI Transmission & Bearing Corp.
Keith Moore, President,
CastleLight Energy Corp.

Abstract:

In just the past few years, 1,000 U.S. coal-fired power plants (and some nuclear plants) have been - or are scheduled to be - mothballed, shut down or abandoned, and along with them comes the loss of many thousands of jobs that support the electric generating industry: coal mining, transportation, plant operation and maintenance and electricity management and distribution. These plant closures were driven largely by Obama's "War on Coal" through multiple means, such as EPA regulations and promotion of Wind and Solar renewables to meet his Climate Change initiative.

This loss of base load electricity generation raises serious concerns about what must be done to maintain a reliable electricity supply that is needed to grow the U.S. economy and jobs in the Trump administration. Clearly, our existing fleet of prized coal and nuclear capacity has not been valued nor recognized as being necessary to supply the demands for reliable electricity.

The recent political favors that provided intermittent renewable Wind and Solar energy sources (Federal Production Tax Credits and State Investment Tax Credits,) now make dispatchable coal and nuclear plants financially "unsustainable." Further, the cost of renewable energy is determined to be very expensive (two to three times the cost of coal) when the necessary coal plant "backup carrying charges" are included.

To support the growth of American economy and jobs, and to continue to deliver clean, low-cost electricity, we propose a program to re-engineer existing coal-fired electric generating plants with 21st century technologies. These coal-fired plants may then continue to dispatch competitive electricity for another 20 years or more with higher efficiencies, lower operating costs, and very low pollution emissions.

The following is our assessment of the electric grid, its energy sources and their cost. Our objectives are to:

1. **Provide American citizens reliable low-cost electricity to support the growth of the economy and jobs.**
2. **Protect and preserve the coal industry, its jobs and the existing fleet of coal-fired power plants.**
3. **Re-engineer existing coal-fired plants with 21st Century technology for higher efficiency, lower operating cost, and low-pollutant emissions.**

I. Proposed Objective and Plan:

Our proposed plan is to preserve coal industry jobs and stop the shut down and destruction of America's existing fleet of coal-fired electric generating stations and along with them, the loss of many thousands of jobs that support the electric generating industry; coal mining, transportation, plant operation and maintenance and electricity management and distribution. We propose that by re-engineering existing power plants with 21st Century technologies we can maintain our coal-fired fleet for many more years of competitive dispatch with increased efficiency, lower operating costs, and very low pollutant emissions.

In summary, this program will support the growth of jobs and continue to provide the American economy clean, reliable low-cost electricity.

A. Introduction:

Owners and operators of coal-fired electric generating plants (~336,000 MW) in the U.S. are facing daunting challenges to continue to supply power to the Electric Grid.

Coal is a crucial fuel for generating electricity because it is cheap and reliable with long-term price stability. However, Obama's "War on Coal" through multiple means has placed all coal-fired plants in jeopardy by:

- Elimination of coal program funding by any bank or investment institution,
- The Sierra Club's and Bloomberg's $30 million "Beyond Coal Campaign to Retire coal plants,"
- EPA's stringent air quality and water regulations,
- The present low-cost of natural gas.

By 2023, the Energy Information Agency expects ~25% of coal-fired power plants (sized from 70 to 600 MW), comprising over 1,000 plants or ~ 85,000 MW, to close if they are not already closed.[1] This number could rise further depending on whether President Obama's climate change push to reduce CO_2 emissions, the "Clean Power Plan," survives legal challenges.[2]

The loss of base load electricity generation raises serious concerns about what must be done to maintain a reliable electricity supply that will be needed to grow the U.S. economy and jobs in the Trump administration. Clearly, our existing fleet of prized coal and nuclear capacity has not been valued nor recognized as being necessary to supply the demands for reliable electricity.

Less understood are the market distortions created by intermittent wind and solar electric generating sources. The recent political favors to promote intermittent renewable Wind and Solar energy sources, such as the Federal Production Tax Credits and State Investment Tax Credits now make dispatchable coal and nuclear plants financially "unsustainable." Further, the cost of renewable energy is

[1] http://www.sourcewatch.org/index.php/Coal_plant_retirement
[2] US Energy Information Agency

determined to be very expensive (two to three times the cost of coal) when the necessary coal plant "backup carrying charges" are included.

1. So What's Happening?

The principle in play is simple: We throw away reliable "paid-for power plants" in favor of new power plants that aren't, which comes at high cost to the electric consumer.

Ignoring renewables and energy efficiency mandates (CO_2 reduction) for a moment, note that replacing existing paid-for coal-fired power plants with new natural gas-fired power plants (at ~$1,000/kW) will hurt the US economy.

Even assuming that the future average delivered cost of natural gas to power plants were the same as coal, the cost of electricity must rise (plus any tax-funded incentives), as the fixed costs of new power plants greatly exceeds that of the existing power plants' fixed costs going forward.

Separately, the recent lower prices of natural gas have placed additional pressures on all coal-fired plants. This innately healthy competition also deserves careful consideration and monitoring because we do not want to make long-term capital decisions about our future power plant capacity fuel mix based on short term natural gas fuel price signals alone.

In competitive markets for most consumable and durable goods, we allow supply shortages/gluts and risk capital to seek their own level.

2. Electric Power is Different[3].

The grid system is the vascular system of our economy, its productivity, our standard of living, and even our human health and safety. Electricity is the nutrition delivered through this system.

Allowing (or forcing) inefficient boom and bust cycles in capital investment in the electric energy sector has leveraged implications on our entire economy. One row of dominos that splits into two is that over-capitalization of renewables results in under-utilization on average, across the coal-fired power plant fleet, which leads to either:

a. Higher electricity rates (i.e. through regulated rate of return arrangements in regulated states) to ensure fixed cost recovery at lower capacity factors, or

b. Refinancing (at higher rates) and eventually financial default of the nuclear and coal-fired power plants (i.e. in deregulated states).

The financial defaults and higher Debt/Equity ratios then lead to steeply higher risk profiles and corresponding expected rate of returns on fixed costs of future power plant projects, which result in even higher Levelized fixed costs for the next wave of new power plant capital requirements.

[3] Communications with Tom Stacy [tfstacy@gmail.com], Nov 30, 2016

One must take ample time to understand more than the static economic implications of energy policy decisions in order to remain prudent on policy on behalf of our nation as a whole.

Obama's "War on Coal" and the promotion of Wind as a replacement energy source has done just the opposite, and the fallout is just beginning to trickle in.

We see it in the fact that even though electricity fuel prices have declined over the past ten years, our electricity rates are beginning to increase.

Obama's reign has set a time bomb for the coal-fired fleet and the US electricity sector through multiple means, such as the prohibited funding of coal programs by any bank or investment institution, by providing generous federal wind production tax credits, initiating stringent new EPA air quality rules, and the push to reduce CO_2 emissions – a bomb which must be defused by the incoming Administration and Congress.

To defuse it, the situation first must be recognized and understood.

3. Is Electricity Deregulation A Failed Experiment?

A report by Gifford & Larson[4] states that **"**Coal and nuclear base load power are exiting or threatening to exit - ISO New England, NYISO, MISO, PJM, and ERCOT.

First, the exit of base load coal and nuclear power from wholesale power markets is happening and continues to happen, raising serious questions about electric reliability in organized markets.

Second, states continue to develop 'around market' solutions despite the setbacks encountered at FERC and the U.S. Supreme Court, using these outcomes as guidance to craft policies that provide incentives for base load power to remain in the markets.

……But that intuition must recognize the susceptibility of those market mechanisms to "taxation by regulation" and other rent-seeking pressures where the price system is sacrificed to other goals; i.e. Wind and Solar PV.

…..But if regulatory and legal obstacles continue to foreclose these legislative or administrative actions, then the only remaining option is to vertically reintegrate [power markets.]

……Reregulation may represent the rule rather than the exception and could cause the entire edifice of organized [wholesale power] markets to crumble."

4. Is the US Electric Grid at Risk?

The Federal Energy Regulatory Commission (FERC) is an independent agency that regulates the interstate transmission of natural gas, oil, and electricity. Its Mission

[4] **"State Actions in Organized Markets" – Gifford & Larson, 9-2016**
http://www.wbklaw.com/uploads/file/White%20Paper%20-%20Market%20Design%20Issues%20%28September%202016%29.pdf

is to assist consumers in obtaining reliable, efficient and sustainable energy services at a reasonable cost through appropriate regulatory and market means.

In August, 2003, North America experienced a major blackout when 50 million people lost power in the Northeastern and Midwestern United States and Ontario, Canada. As a result the North American Electric Reliability Corporation (NERC), a nonprofit corporation was formed by the electric utility industry and approved by FERC, to develop and enforce compliance with mandatory reliability standards to "ensure the reliability of the North American bulk power system."

The discussion herein results from the concern that loss of coal and nuclear base load electricity generation may again place the US Electric Grid at risk:

1.) From the severe over-capitalization of new wind and solar renewable generation driven by Federal Production Tax Credits and State Investment Tax Credits.

2.) Resulting in an underutilized and financially "unsustainable" coal-fired fleet at current wholesale electricity rate and demand charge levels, which by design have a secure and consistent source of fuel on demand: namely, coal, natural gas and nuclear.

2.) Causing skyrocketing electricity prices (industrial and retail) required to maintain redundant dispatchable generation capacity to back up the wind and solar - for periods when the wind doesn't blow and the sun goes down.

5. Maintain our Coal-fired Electric Generating Fleet

We propose a program to save the coal fleet by dissuading power plant owners from retiring units prematurely, and instead invest in their existing coal-fired plants by deploying 21st Century technologies for many more years of competitive dispatch to the electric grid.

Our plan has two main pillars:

1. Ensure that the recovery of the fixed cost necessary to maintain existing coal-fired capacity is bolstered in a way that is true to the intent of FERC and NERC reserve margin requirements (and that energy market margins are reduced commensurately), and
2. Provide "legislated insurance" to power plant investors so that any future power plant environmental regulations will only apply to new units.

   We note that new environmental regulations applied to existing power plants are essentially legalized extortion from power plant owners in the short term, which is repaid across our economy through higher electricity prices and lower global competitiveness, and lower viability for US manufacturers.

II. Introduction to the Electric Grid:

The Electric Grid is a vast system of electricity generation, transmission, and distribution assets that covers the US and Canada in three sections: an eastern grid and a western grid (generally divided by the Rockies), and a Texas grid. By many measures each of these three grids is essentially a single machine.

Each single grid is also called an "interconnect." The Eastern grid covers the eastern two-thirds of the US and Canada;

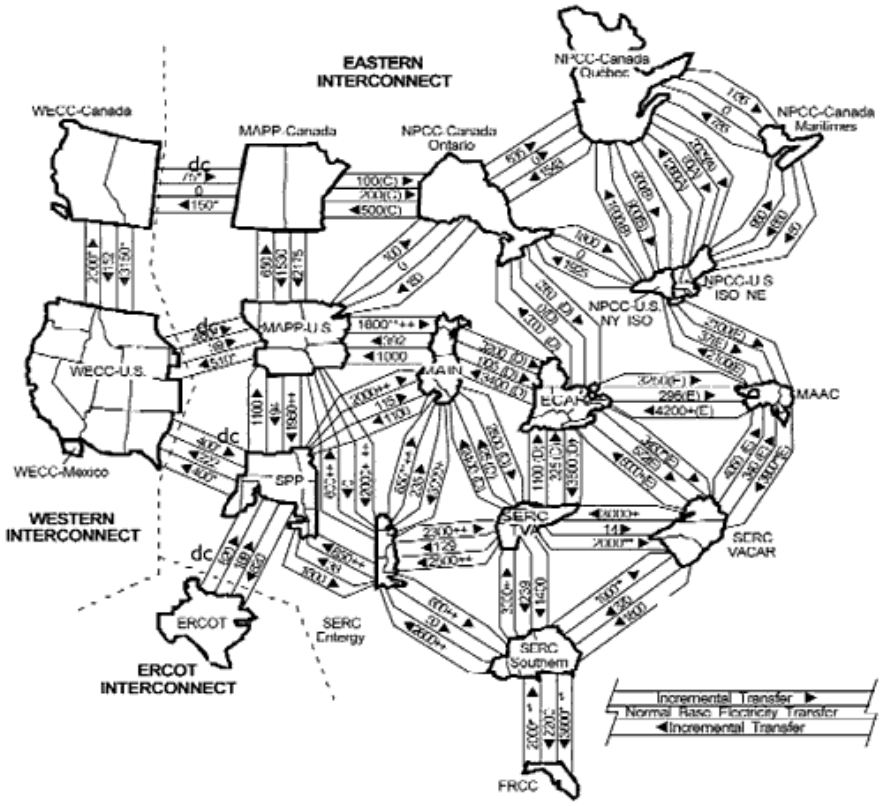

Figure 1. Normal U.S. base electricity transfers and incremental transfer capabilities; in MW [5]

The Western grid encompasses most of the rest of the two countries; the Electric Reliability Council of Texas (ERCOT) covers most of Texas (see Figure 1.).

When utility A agrees to send electricity to utility B, utility A increases the amount of power generated while utility B decreases production or supplies an increased demand or load. The power then flows from the "source" (A) to the "sink" (B) along all the paths that can connect them.

<u>This means that changes in generation and transmission at any point in the system will change loads on generators and transmission lines at every other point—often in ways not anticipated or easily controlled</u>[5].

For an AC power grid to remain stable (avoid blackouts), the "frequency and phase" of all power generation plants in a single grid must remain synchronized to each other "within narrow limits." But even small frequency changes can indicate grid instability. Further, if certain parts of the grid are carrying electricity at near capacity, a small shift of power flow (current) can trip circuit breakers, which then sends larger energy flows onto neighboring lines that can overload them, thus resulting in a chain-reaction Electric Grid failure.

5. North American Electric Reliability Council

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For reasons amply demonstrated in Figure 1, experts are concerned that as wind capacity continues to be added to the grid, more coal plant retirements are induced. A generating fleet without ample dispatchable capacity and sufficient ramping capability would then become far more vulnerable to Electric Grid disruptions as percentages of higher wind capacity to generation develop, especially under current grid operator market and procedural rules.

The critical issue is: "When is the **Electric Grid Stability** at risk?" (*That ability to supply reliable electricity at the 60 Hz frequency*).

B. Electricity Supply to the Grid

Electrical energy is delivered to America's electric grid from many electric generating plants: Nuclear, Coal-fired Plants, Hydroelectric, Natural Gas-fired Gas Turbines, Wind Turbines and Solar Panels. Figure 2. shows the percentages of electricity generated from each of these energy sources.

An important measure of a power plant's productivity (or utilization rate) is reported as the plant's "**Annual Capacity Factor**" (*The ratio of its actual output over one year, to its potential output if it were to operate at full nameplate capacity continuously over the same period of time.*)

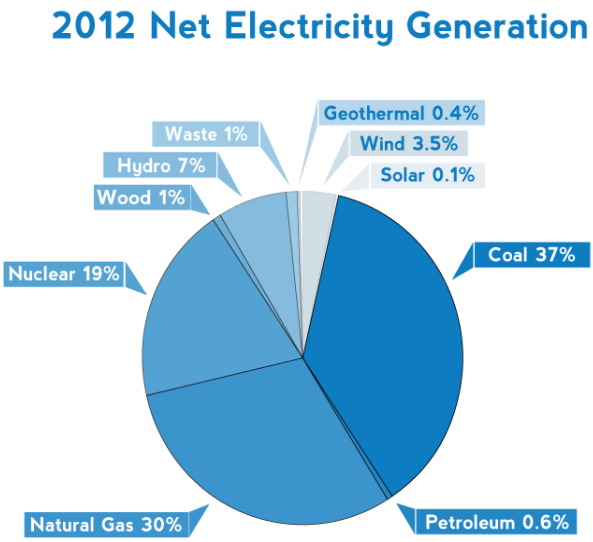

Figure 2. Percentage of Electricity Generation

For example, a 100 MW plant that delivered 50 MW continuously for twelve months of the year would report a 50% capacity factor.

C. The Levelized Cost of Electricity (LCOE)

The Levelized Cost of Electricity (LCOE) is an estimate of the cost of electricity supplied to the grid ($/kW-h) by a power plant. The LCOE is derived from a plant's annual estimates of capital cost, capacity factor, fixed and variable O&M costs, fuel and transmission costs. The LCOE provides a reference with which to compare the cost of different electric generation resources

For the renewable Wind and PV Solar with "zero energy cost," LCOE calculations are special cases. Renewables are not reliable sources of energy. Clearly, they require backup electricity from dispatchable coal-fired plants to assure reliable electricity when the wind doesn't blow or the sun goes down.

Stacy and Taylor[6] have determined that proper LCOE for Wind and Solar PV must also include the "fixed standby costs" required to maintain the power plants; i.e., to recover the plant's capacity carrying cost and the reduced utilization rates of production when the power plants are displaced by the renewable sources.

These uncompensated fixed costs are termed "Imposed Costs." Table 1. list the Levelized Coast of Electricity for Existing Generation power plants.

Levelized Cost of Electricity for Existing Generation	$/MW-h
Nuclear	$ 29.1
Natural Gas Turbine Combined Cycle	$ 34.4
Hydroelectric	$ 35.4
Conventional Supercritical Coal	$ 39.9
Natural Gas Fired Combustion Turbine	$ 88.2
Intermittent Wind w/ Cost Imposed on CC Gas	$ 107.4
Intermittent PV Solar w/ Cost imposed on CC Gas	$ 140.3

Table 1. Levelized Cost of Electricity for Existing Generation

This list illustrates that when all known "Imposed Costs" are accurately included in Wind and PV Solar LCOE calculations, their resulting costs to the electric grid are two to three times that of the existing dispatchable capacity power plants!

Also note that when dependable coal-fired capacity is properly valued, and the historical price volatility of natural gas relative to coal is taken into account, the existing coal fleet is well justified continuing competitive operation.

Applying the LCOE process, we can also access new technologies and their potential fit in the electric generation mix.

[6] IER - Levelized Cost of Electricity from Existing Generation Sources - July 2016, T. Stacy / G. Taylor
http://instituteforenergyresearch.org/wp-content/uploads/2015/06/ier_lcoe_2015.pdf

III. Electric Generating Plants

1. Nuclear:

Nuclear electric generators comprise the largest power plants. Nuclear energy supplies approximately 19% of all electricity to the US Electric Grid. These plants are usually operated continuously at or near their maximum output to generate low-cost electricity (for base-load energy supply). These plants are operated either fully on or fully off, as it is not easy to vary their output. Nuclear plants report capacity factors of ~90%, the highest in the industry.

2. Coal-Fired Electric Generating Plants:

In 2012, coal-fired electric generating plants, numbering about 2,850 generating units, supplied ~336,000 MW or about 37% of U.S. electricity.

By 2023, the Energy Information Agency expects ~25% of the U.S. coal-fired power plants comprising over 1,000 plants (~ 85,000 MW) will have been closed or are now scheduled to close. Today, due to closures, coal-fired plants supply < 30% of U.S. electricity. With the recent low prices of natural gas, new gas-fired turbine combined cycle (NGCC) systems are being installed to compete with the coal fleet.

Coal-fired Power Plants – Size vs. Efficiency:

The measure of a coal-fired plant's efficiency is its "Plant Net Heat Rate" - *the net amount of energy in Btu's absorbed by an electrical generator to generate one kilowatt hour (kWh) of electricity*.

Large Super-critical Power Plants

The better, more efficiently performing coal-fired plants are the large (greater than 600MW) "super-critical steam pressure furnace designs." These plants report combustion efficiency (heat rate) below 9,500 Btu/kW-h and, in a few cases, can have a heat rate below 9,000 Btu/kW-h and achieve high (80%) capacity factors.

Such plants produce the greatest quantity of electricity with the fewest pounds of coal burned, and emit the least amount of CO_2 per kWh of electricity. These large coal-fired plants are not easy to start, nor can they "swing or follow" customers' quickly changing electricity demand easily, so they typically operate at or near their nameplate rating. Nearly all of these large power plants have already installed the very expensive Flue Gas Desulfurization (FGD) and Selective Catalytic Reduction (SCR) (SO_2 and NO_x) pollution control systems to meet EPA's air quality environmental regulations.

Sub-critical Power Plants

The smaller (<400MW) "sub-critical steam pressure boiler designs" coal-fired plants comprise about half (in number) of the coal-fired fleet. These plants show a nominal heat rate of ~10,750 Btu/kW-h. These plants are simpler to operate and the easiest to start. They are best-suited to swinging generation up and down throughout the day to maintain stable grid power, i.e., current, voltage, and frequency. As these

plants are less efficient, they burn more pounds of coal and produce more carbon dioxide (CO_2) emissions for the same amount of electrical power generated.

The utility industry has not retrofitted many of the smaller plants with pollution control equipment. The cost of this equipment cannot be recovered at current / projected capacity factors and wholesale energy and capacity market clearing prices. As a result, many of these plants are subject to being mothballed, shut down, and/or demolished.

*In numbers (of generating plants), these older and smaller plants represent the largest portion of the total fleet of coal-fired electric generating plants in the U.S. and comprise a market for Re-engineering Plants with 21st Century Technologies***.**

A. Coal-Fired Plant Spinning Reserves:

Coal-fired electrical generating plants comprise a number of different designs and fire a variety of coal fuels. About 40% of the coal fired in the US is the low-cost, low-rank sub-bituminous coal from the Montana Powder River Basin (PRB).

A power plant furnace generates high-pressure steam to drive massive rotating steam turbines that power the electric generators. The turbine/generators rotate at 3,600 RPM to generate a stable, 60 Hz AC frequency.

With the development of an ever larger number of solar and wind generation sources, a critical item that provides the "60 Hz AC frequency stability" of the Electric Grid is to have many coal-fired plants spinning turbine/generators at 3,600 RPM – a term called "Maintaining Spinning Reserves;" that is, to have many smaller plants operating at between 60% and 90% of maximum generation. Therefore, when wind or solar energy generation changes, the coal-fired plants are able to swing their generation in the opposite direction to maintain stable frequency and voltage. While these coal-fired generators may not be able to maintain a perfect balance and a completely uniform match between generation and customers' loads, they do provide the best option to sustain delivered power with minimal variability of voltage and frequency to maintain Electric Grid Stability.

The lesson for the US is that premature shutdown of coal-fired power will strongly increase the risk of Electric Grid failure. To provide Electric Grid Stability, we must continue to maintain and operate our Coal-Fired Generation Fleet.

3. Natural Gas-Fired Turbine / Combined Cycle (GT/CC):

The natural gas-fired turbine / combined cycle (GT/CC) plants are designed for very efficient electric generation at full-load power (7200 Btu/Kw-h = ~47% efficiency). While they can operate at lower power output, they rarely do as they become very inefficient. Therefore, GT/CC plants produce most of their electricity during the day operating at full load when electricity demand and price are the highest. At night, when the demand for and price of electricity are far lower, many of these plants will typically shut down.

The recent low prices for natural gas make these GT/CC plants very competitive with coal-fired plants. However, natural gas prices are historically volatile and are increasingly subject to global commodity pricing. Because natural gas is a premium clean fuel, it is expected that the price of natural gas will increase as higher and better uses are found for it, such as chemical feedstock's and perhaps transportation fuel.

4. Renewable Energy:

In 2015, all renewable energy sources (Hydro, Wind, and PV Solar) in the United States accounted for 13.44% of US electricity capacity. The recent political trends have promoted further increases in renewable resources (operating with free fuel) to "make them competitive" with the fossil fuels. *As noted earlier, this is the critical set of wires which must be found and cut to defuse the Obama's administration's electricity system time bomb.*

In 2013, federal government energy-specific subsidies for renewables were $15.043 billion; fossil fuels $3.431 billion; and nuclear $1.66 billion.[7]

a.) Hydroelectric:

Hydroelectric power is currently the largest producer of renewable power in the U.S., producing around 6.14% of the nation's total electricity. Hydroelectric plants report capacity factors of up to 50%. When hydroelectric plants have water available, they may be useful for "load following" because a plant's operator can bring a unit from a stopped condition to full power in just a few minutes. A hydroelectric plant's generation may be affected by other requirements, i.e., to keep the water level of the upstream lake from getting too high or too low, or to provide water for fish downstream. Note also that drought periods can seriously stress the Electric Grid, as was illustrated by the year 2,000 "brown-outs" in California.

We note that there are very few remaining locations for good hydro as they are concentrated in regions that already have a lot of hydro. The possibility of adding Pumped Hydro electricity storage capacity is another matter – a cost (and benefit) that may be considered to be a part of a hybrid wind and/or PV solar system for storage of excess energy. The cost of a hybrid system may then be compared with the going forward levelized cost of electricity from dispatchable (thermal) generators – new and existing.

b.) Example of the Inherent Randomness and Unreliability of Wind and PV Solar Generation:

The chart of Figure 3 presents an actual historical record of electricity generated by wind and solar sources in Arizona. During the daytime, from 08:30 to 18:00 hours, both solar and wind generation are shown, and at nighttime, there is only wind generation. Clearly, both solar and wind generation are highly erratic, or

7. US Energy Information Administration, 2016-3-8.

random. Solar cannot contribute generation to meet the 18:00 to 20:00 hours period of maximum load (not shown here), and wind generation is not reliable. Wind generates electricity more or less randomly, and is not assured when needed to meet the peak electric demand period from 18:00 to 21:00.

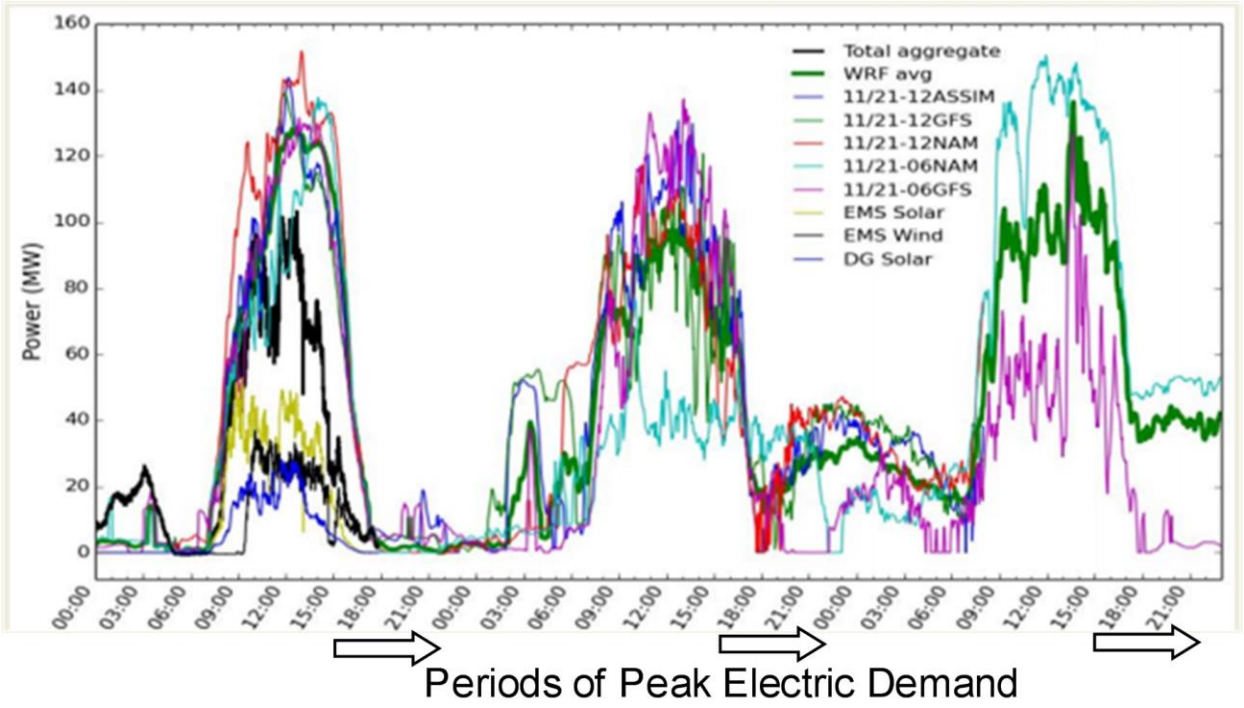

Figure 3. Actual Electrical Power Produced by Solar and Wind in Arizona for a 3-day Period. Note the Variability and Lack of Wind Power on Some Nights as Compared to the Period of Peak Demands (18:00 to 20:00 hours).[8.]

c. Wind Generation:

The installed Wind Turbine nameplate generation now exceeds 72,000 MW. As of 2015, typical wind farms report a 23% capacity factor and supply 4.6% of the nation's electricity.

Wind turbines are intermittent power producers that are neither reliable nor dispatchable because they are dependent on the variability of wind. They start producing a small amount of electricity with a wind speed of about 6 or 7 miles per hour (mph), reach 'rated' capacity around 31 mph and cut out at around 56 mph. Note that when the wind speed drops by half, the power output drops by a factor of eight. Wind turbine output is inherently *intermittent, volatile and unreliable, and most likely to be produced when least needed* See Figure 3.

In fact, the "real capacity value" (vs. capacity factor) of a wind turbine is the kW of generating capacity that can meet the actual demand to serve the electric grid

8. Schileed at http://www.nepa.org/pub/ba/ba467/ba467.pdf

for electricity. Generally, the real capacity value of a "wind farm" is less than 10% of nameplate capacity and often about 0% ……..simply because at the time of peak electricity demand, the wind is not blowing strongly enough for the turbine(s) to generate much, if any, electricity to meet the grid's demands.

Unfortunately, wind farms simply cannot supply the base load power requirements of the electric grid. As an intermittent energy resource, wind farms must rely on conventional power plants to back up their supply.

This results in far larger economic implications than are obvious.

d. Tax Credits for Wind Power Production[9]:

The federal production tax credit (PTC) for renewable electricity, enacted as part of the Energy Policy Act of 1992, is just one of the federal government's policy tools for subsidizing and promoting renewable energy development. And the federal government is only one of numerous important layers of "policy" support garnered by the wind energy lobby.

The PTC gives electricity producers a tax credit for each kilowatt-hour of electricity generated from qualifying renewable energy sources (currently 2.3 cents per kilowatt-hour for the next ten years of operation), regardless of real-time market signals such as negative prices that indicate that the electricity is unwanted.

Relative to the wholesale price of electricity, which in 2012 hovers between 3 and 5 cents per kilowatt-hour for most markets, the PTC represents a lucrative direct subsidy of around 50 to 75% of the wholesale price of electricity. In terms of pre-tax value, the PTC is worth approximately 3.4 to 3.7 cents per kilowatt-hour, often making the federal subsidy 100% as valuable to the owner of wind facilities as the market price of electricity. Further, because the PTC is not tied to the wholesale price of electricity, owners of wind facilities can afford to pay the Electrical Grid to take their power! (PTC / (1 – fed corporate tax rate) or $23/ (1-0.35) = $35.38/MW-h).

The PTC, while incredibly valuable to owners of wind farms, hurts US taxpayers and undermines the economic sufficiency and physical reliability of the US Electric Grid.

e.) PV Solar Generation:

As of 2015, 11,600 MW of solar systems have been installed, yet they report only a 22 % capacity factor and 0.57% of the electricity generated.[9.]

Referencing the example shown in Figure 3., solar energy is produced only during periods of sunlight, and it peaks about midday. Maximum solar generation is variable because of the daily rotation of the earth, seasonal changes, and weather. Because of clouds, solar generation can swing rapidly in a random and uncontrolled manner up or down. Because there is little to no solar generation to meet peak demands, the "capacity value" of solar is very low. The consequence is that the

[9.] Electric Power Annual" 2016-3-6

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Solar PV LCOE is $140.30, the highest of all generation sources when coal plant "backup carrying charges" are included.

In conclusion, for wind at any market share penetration, (and for solar above a few percentage points of energy market share,) the low to zero Capacity Value of these renewable sources necessitates that they are redundant capital outlays which undermine the fixed cost recovery of Capacity Bearing (dispatchable power plants).

IV. Re-Engineer Coal-Fired Plants with 21st Century Technologies

A. Improve Plant Heat Rate / Efficiency:

The typical older sub-critical coal-fired power plants have a heat rate of ~10,750 Btu/kW-h or an efficiency of ~32%. Most of these plants fire the low-rank, low-sulfur Powder River Basin (PRB) coals from Wyoming, which contain about 30% water. We propose to make several modifications to the plant's Turbine-Generator and other Rotating Machinery to eliminate wasted energy, and to also remove the water from the coal with a safe, fast coal-drying step. We expect these modifications will improve the plant's efficiency by 15% to ~9,090 Btu/kW-h, near that of a new super-critical coal-fired plant, providing ~36% efficiency. The old plant's new efficiency will generate more Net Electricity (MW per hour) for the same Btu per hour of coal fired, resulting in a significant fuel cost savings and a 15% reduction in CO_2 emissions.

1. Modifications to Plant Turbine-Generator and other Rotating Machinery:

The recommended efficiency modifications to the existing plant subject to site specific conditions are as follows:

a. Each station should be enclosed (as an "indoor station") to enable recovery of waste heat from the boiler and equipment in the building. This modification and new ducting will allow the forced-draft fans to draw pre-warmed combustion air from the roof area of the building. Other recommended structural features are multiple elevators or man-lifts installed to optimize labor efficiency, and provisions for permanent overhead cranes with suitable rated lifting capacity.

b. If possible, revamp sub-critical boilers to operate at 2,400 psig or 2,520 psig, or as close to these pressures as can be done safely.

c. If possible, install one or two reheat steam cycles from the boiler to the steam turbine.

d. If possible, install a more efficient feed-water heater system; for example, a total of 8 feed-water heaters, one being the De-Aerator.

e. If possible, retrofit the steam turbine with the reheat and extraction points as needed. This may involve reworking the foundation.

f. If possible, install "Variable Speed Fluid Drives" on the large horsepower pumps and fans. "Variable Speed Fluid Drives" provide reliable mechanical speed control of fans and pumps to improve efficiency.

g. If possible, it is recommended that the Main Boiler Feed pump be re-located and driven via a Variable Speed Fluid Drive from the Main Steam Turbine or Generator shaft, for higher efficiency.

h. If possible, install electronic "Variable Frequency Electronic Drives" (aka Adjustable Speed Drives) on every 200 hp or larger pump or fan that is not driven by a Variable Speed Fluid Drive.

i. If possible, resize existing fans and pumps for maximum efficiency over the operating load range to match new re-engineered mass-flow and heat balance conditions.

j. If possible, install a heat recovery system to recover waste heat from the Variable Speed Fluid Drives and transfer it to preheat the feed-water condensate as it leaves the condenser and moves toward the boiler.

2. Dry the Coal:

The low-rank, low-sulfur PRB coals from Wyoming supply nearly 40% of the nation's coal. PRB coals contain about 30% water. Our program includes a safe, fast (about one second) process that dries the PRB coal while the coal is being pulverized in the coal mill; coal's energy per pound increased by ~20% (from ~ 8,500 to ~10,500 Btu/Lb). This drying step improves the plant's combustion efficiency significantly (energy loss due to the latent-heat-of-water vaporization) and reduces the plants CO_2 emissions by ~6%. The expected payback for this modification is about two years from savings in coal consumption.

B. Modify the Plant's Boiler with a "Hybrid of Coal-Gasification" to Control Air Pollutant Emissions:

1. Conventional Air Pollution Control Technology

All coal-fired power plants will soon need to control air pollution emissions to meet EPA air quality regulations.

The conventional approach is to retrofit the plant boiler exhaust with **Selective Catalytic Reduction Systems – SCR** for NO_x control (using ammonia (NH_3) injection) and **Flue Gas Scrubbers - FGD** for SO_2 emissions control (with limestone). An Electrostatic Precipitator (ESP) or **Bag house** provides control of the fine fly-ash particulate emissions, Trona may be added to control SO_3 emissions, and Activated Carbon may be injected to control the trace emissions (parts per trillion) of mercury. See Figure 4.

It should be noted that the SCR and FGD environmental-control equipment requires very large fans. The parasitic loads reduce the plants' Net MW output and net efficiency. This equipment is also very expensive to install, maintain and operate. The smaller <400MW coal-fired plants cannot afford this equipment and therefore have not been retrofitted. As the EPA continues to tighten the air quality regulations, such as the recent HAZE Rule for very low NO_x emissions, these plants may be shut down, mothballed or abandoned.

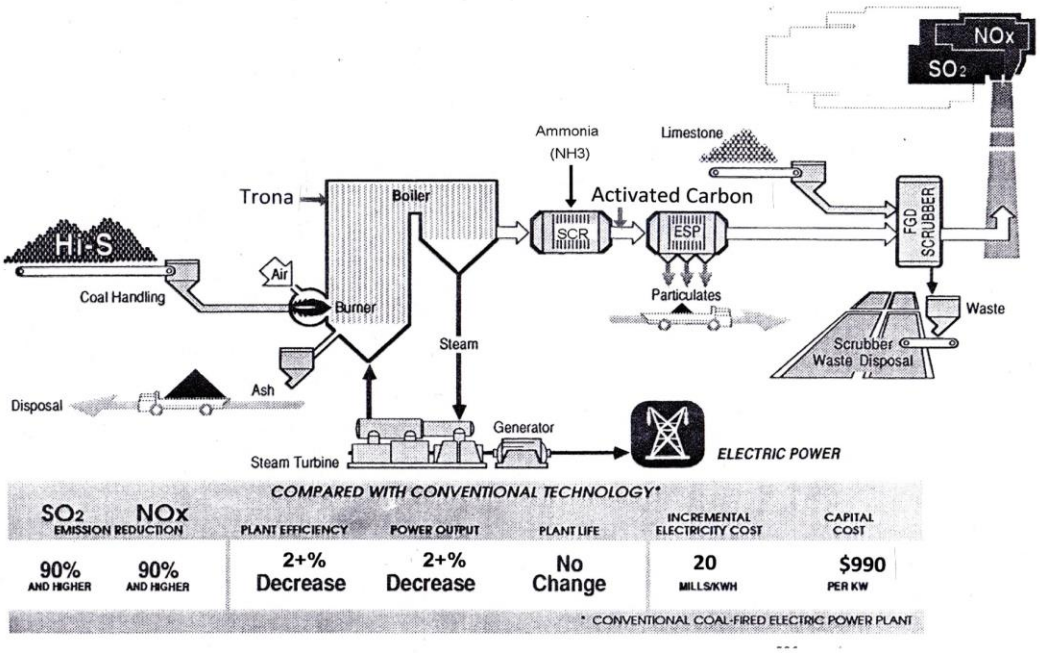

Figure 4. Typical Pulverized Coal-Fired Power Plant:

SCR + Ammonia=NO_x; ESP= Particulate; FGD+ Limestone= SO_2; Trona=SO_3; Activated Carbon= Hg; Clean Power Plan = CO_2 Reduction

2. Plant Boiler Modified with a Hybrid of Coal-Gasification to Control Air Pollutant Emissions:

Existing coal-fired power boilers can be re-engineered with a "hybrid of coal gasification and combustion" called the Clean Combustion System (CCS). This technology replaces the boiler's coal burners and wind box with a coal Gasification Chamber (GC) mounted on the furnace wall. The coal is fired in the GC with very little air to create a hot fuel-rich gas where the pollutants of SO_2, SO_3, NO_x, and coal fly ash are reduced to very low levels right in the combustion step. The now clean hot fuel-rich gases exit the GC into the boiler. Additional stages of air are added in the boiler to complete the combustion and make steam as was originally designed. A bag house or electrostatic precipitator provides control of fly-ash particulates out of the smokestack. See Figure 5.

When firing PRB Sub-bituminous coals, the CCS has demonstrated SO_2 emissions of ~0.2 Lb. SO_2/ MMBtu), NO_x emissions ~0.1 Lb. NO_x/ MMBtu) to meet the strict EPA Cross State Air Pollution Rule (CSAPR) and The Haze Rule (very low NOx emissions) for existing coal-fired power plants.

The CCS has been field-demonstrated at $30MW_T$ on a stoker boiler. It can retrofit all boiler types and sizes including cyclone, wall-fired, and tangential designs. The only "chemical" required for sulfur capture is limestone. There are no hazardous or toxic chemicals required. As a CCS technology installation qualifies as a 1990

Clean Air Act emissions reduction program, construction permits are available with waivers of NSPS & PSD with no New Source Review (NSR) trigger.

For more information, please visit: www.Castle-Light.com

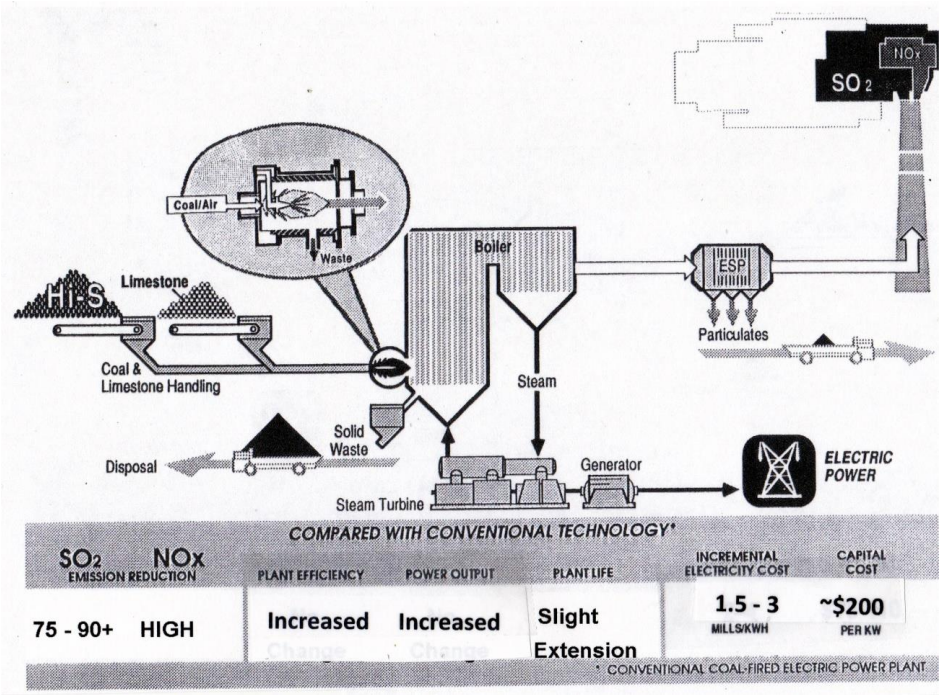

Figure 5. Re-engineered Coal-Fired Power Plant: Coal Beneficiation + Hybrid of Coal-Gasification (SO_2 & NO_x Control Right in the Combustion Step)

a.) Re-engineered Plant SO_2 and NO_x Emissions Performance:

When firing PRB type coals, the plant's pollutant limits are expected to meet **EPA's Cross State Air Pollution Rule (CSAPR)** for existing coal-fired power plants:

- SO_2 <= 0.2 Lb SO_2/ MMBtu
- NO_x <= 0.1 Lb NOx /MMBtu
- Particulates <= Bag house to control fine particulates
- HAPS (Mercury) <= 40 parts per billion

Cost Comparisons: Conventional vs. 21st Century Emissions Control

Table 3 lists the capital equipment cost and estimated operating cost of an existing coal-fired power plant with conventional FGD + SCR + bag house air pollution control technology added compared to being re-engineered with the 21st Century technology + bag house.

Table 3. Existing Coal-Fired Power Plant - Emissions Control Cost (PRB Coal - 80% CF)				
Control Technology	CAPx ($/kW)	Fuel ($/MW-h)	O&MX ($/MW-h)	OpX ($/MW-h)
FGD + SCR + Baghouse	$ 1,327	$ 17.4	$ 4.6	$ 22.0
CCS + Baghouse	$ 345	$ 13.2	$ 3.2	$ 16.4
Delta Savings	-74%	-24%	-32%	-26%

For example, the equipment cost to install the conventional FGD+SCR+baghouse emission controls of Figure 4 on a 400 MW coal-fired power plant would be 400,000 x $1,327 = $530.8 million, assuming there is sufficient real estate for the equipment. The cost for the front-end Clean Combustion System + bag house technology of Figure 5 is 400,000 x $345 = $138 million and results in significantly lower operating cost.

The Re-engineering of a typical (paid-for and depreciated) sub-critical coal-fired power plant as described herein is expected to competitively dispatch clean electricity for another 20 or more years..

b.) LCOE for Re-Engineered Coal-Fired Power Plants

Table 4. provides the LCOE for electric generating plants, including a comparison of an existing coal-fired plant Re-engineered with 21st Century technology vs. a plant retrofitted with the conventional FGD + SCR + bag house pollution control systems.

Levelized Cost of Electricity for Existing Generation	$/MW-h
Re-engineered SubCritical Coal Plant + Baghouse	$ 27.7
Nuclear	$ 29.1
Natural Gas Turbine Combined Cycle	$ 34.4
Hydroelectric	$ 35.4
Conventional Supercritical Coal	$ 39.9
Retrofit SubCritical Coal Plant w/ FGD+SCR+Baghouse	$ 40.5
Natural Gas Fired Combustion Turbine	$ 88.2
Intermittent Wind w/ Cost Imposed on CC Gas	$ 107.4
Intermittent PV Solar w/ Cost imposed on CC Gas	$ 140.3

Table 4. LCOE for Re-engineered Coal-Fired Plant vs. FGD+SCR+Baghouse

V. ADDENDUM
Draft of Proposed Legislation for U.S. Congress:

Objective:

- **Provide American citizens reliable low-cost electricity to support the growth of the economy and jobs.**
- **Protect and preserve the coal industry, its jobs and the existing fleet of coal-fired power plants.**
- **Re-engineer existing coal-fired plants with 21st Century technology for higher efficiency, lower operating cost and low-pollutant emissions.**

A. Protect and preserve the existing fleet of Coal-Fired Power Plants and protect the Electric Grid.

We seek legislation to place all energy sources on a level playing field:

- **Remove energy tax breaks for renewable sources.**
- **Remove financial restrictions and prohibitions to fund coal programs (that have been imposed on almost all lending institutions by the Obama Administration).**

Upon approving this legislation, no entity, whether federal, state, or local, shall force closure or attempt to close any coal-fired generating station with a current "operating license" within the USA or its territories for a period of facility's license and/or economic lifespan following the date of approval.

Each generating unit must decide whether it wishes to participate in this "Plan" or not, and if so, such unit shall begin the "Plan Process." For sites with multiple generating units, the plan process may provide for sequential re-engineering of units until all units at that site are updated.

The declaration of the "Plan Process" protects and extends the unit's operating license through the re-engineering, commissioning, and continued operation period, and further waives:

- New Source Performance Standards (NSPS),
- Prevention of Significant Deterioration (PSD) and
- New Source Review (NSR),

and/or any similar rules or regulations that might be imposed by any regulatory body: federal, state, or local.

"Initiative to Save America's Jobs" – Maintain our Coal-fired Electric Generating Fleet and Protect the Electric Grid

1. Re-engineer existing coal-fired plants with 21st Century technology for high efficiency and low-pollutant emissions.

It is expected that almost all coal-fired power plants can be re-engineered with 21st Century technologies and thereby provide competitive dispatch without the need for enabling/incentive tax breaks. For necessary re-engineering funding, one choice is to establish **Industrial Development Bonds** with a 30-year life.

- 10-year call protection.
- Interest payments every 6 months.
- No government money is to be involved.

2. Provide Immediate Expensing of Capital Payments for Materials and Labor:

Any and all payments, including down payments, progress payments, payments to purchase a manufacturing sequence spot, and the like, payments for materials and/or labor for refurbishing work shall be deductible in full from income in the year the payments are made. If there is a loss, the loss can be carried forward year to year and applied fully without limitation to income until the payments are fully deducted.

3. Bidding Re-engineered Projects:

The typical competitive bidding process typically requires three bids for a particular product and requires accepting the lowest price bid. This process is a major reason for the lack of reliability and poor performance of many electrical generating plant projects.

Because of the problems resulting from the above "low-bid process," Professional Engineers strongly prefer **negotiated bidding** in the context of this Plan. This means that a contractor may obtain one or more bids for a block of work, but the primary evaluation must be based on the strongest technical content, and not on lowest price.

4. Promote operation of coal-fired plants with 21st century technologies

a. Plant Performance Criteria at Maximum Design Generation (MDG):

An objective of this Plan is to maximize the electricity generated (MW) per Btu of coal fired at the plant's rated maximum BTU/hr design.

In order to improve the efficiency, maintainability, and operability of generating units that are refurbished per this Plan, where necessary, enclosures should be built to surround a unit to make it an "Indoor unit". As such structures are often taxed as real estate improvements, it is recommended that states and localities resist the temptation to tax such structures; the Federal government has no jurisdiction over this matter.

However, should owners of generating units that are or become "indoor stations" be assessed a real estate tax on the structure surrounding a unit, then these owners shall be entitled to take that tax portion of the entire real estate tax bill that represents tax on the outer structure and shall be entitled to include all of that tax portion as operating expense against income when calculating taxable income. If a loss occurs in any tax year when this tax portion is included as expense, the loss due to the tax portion may be carried forward and applied fully year after year until it is exhausted.

b. Improve Plant Efficiency / Heat Rate:

The typical older sub-critical coal-fired power plants have a heat rate of ~10,750 Btu/kW-h or an efficiency of ~32%. Most of these plants fire the low-rank, low sulfur Powder River Basin (PRB) coals from Wyoming, which contain about 30% water. We propose to make several modifications to the plant's Turbine-Generator and other Rotating Machinery to eliminate wasted energy, and to improve combustion in part by removing the water from the coal with a safe, fast coal drying step. We expect these modifications will improve the plant's efficiency by 15% to ~9,090 Btu/kW-h, near that of a new super-critical coal-fired plant, providing ~36% efficiency. The old plant's new efficiency will generate more Net Electricity (MW per hour) for the same Btu per hour of coal fired, resulting in a significant fuel cost savings and a 15% reduction in CO_2 emissions.

c. Emissions Criteria:

The emissions criteria are targets that the unit is expected to meet upon completion of the re-engineering program. If the emissions are met, they are fixed for that unit for the indefinite future. If they are not met, the EPC contractor and the owner must continue to work to meet these goals with financial responsibility to be determined by the owner and the EPC contractor. If after numerous attempts, the criteria are still not met, then negotiations with the respective environmental bodies are each to be performed.

When firing PRB sub-bituminous low-rank type coals, the plant's pollutant limits shall be controlled to meet **EPA's Cross State Air Pollution Rule (CSAPR)** and the **Haze Rule** (Very low NO_x) for emissions from existing coal-fired power plants:

- SO_2 <= 0.2 Lb SO_2/ MMBtu
- NO_x <= 0.1 Lb NOx /MMBtu
- Particulates <= Bag house to control fine particulates
- HAPS (Mercury) <= 40 parts per billion

d. "Re-engineered Plant" Program:

A re-engineered plant program includes any and all design modifications and installation of the following: renewal parts or processes, upgraded parts or processes, modified parts or processes, purchased parts or processes, or parts or processes made on site. There are to be no exclusions on the existing parts that

remain, or replaced parts or processes. For the purposes of this Plan, they are all considered “refurbished.”

e. Owners of the Candidate / Participating Units:

Plant owners may be domestic or multi-national corporations (see definitions in Section VI). However, the type of ownership has no bearing on which corporation or worker is permitted or not permitted to do the work involved.

f. EPC Contractor:

For the purpose of this Plan, the entity that has overall responsibility for the re-engineering project is considered to be an EPC Contractor, that is, a contractor responsible for the Engineering and Design of the content of the project, Procurement of all hardware and software items, and for the Construction Permits and Supervision for the re-engineered project. For some projects, the overall responsibility for re-engineering a unit may be split into several distinct parts, and in that case, the contractor for each part of the work is considered to be an EPC contractor.

The EPC Contractor MUST BE a domestic American entity:

g. Preferential Treatment:

This Plan is intended to be an opportunity for American companies to restart facilities, if possible. Some materials typically used in re-engineering critical components of a power plant cannot be purchased in the US today. These include very large rotor forgings or pump barrel forgings, or very large steel castings. In any event, it may be necessary for the largest steel forgings, steel castings, or other raw materials to be purchased from one or more multinational corporations, but any work to be performed on the raw materials that can be performed in the USA must be performed in the USA. The work on raw materials is to be performed on a preferential basis. For example, if it is determined that a certain forging cannot be manufactured in the USA, then Multinational Company A may forge or manufacture the raw material (steel forging) in a foreign country, and then if it can be processed to a final product here in the USA, preferably by a domestic US Corporation, then this is to occur, or if a domestic US Corporation cannot be found to process it, then a facility of Multinational Company A in the USA is to be utilized.

h. Plan Administration and Responsibility:

The EPC Contractor is the primary party responsible to ensure that the work is performed by American Domestic Corporations and their workers who are American Citizens. The EPC Contractor must perform an audit every 3 months, and if a violation (whether first or subsequent) is found, the violating company is to be penalized by losing the contract and having to repay to the EPC Contractor twice the amount already paid to the violating company. The unit owner is responsible to perform an audit every 6 months and if he finds a violation, he is to notify the EPC Contractor who must take immediate action as described above.

VI. Definitions:

Worker: For the purpose of this Plan only, any individual who is employed by any company participating in any way under this Plan is considered to be a "Worker." This includes, for example, members of the Board of Directors, Executives, Administrators, Engineers, Designers, Technicians, Skilled and Unskilled Labor, and everyone who is receiving a paycheck, whether full-time, part-time, or as a sub-contractor. At the same time, this paragraph cannot be used to establish who is and who is not an "Employee" or who is a "Contractor," as may be of interest for other reasons to other parties.

A Multinational Corporation is an entity that has any one or more of these characteristics:

- Stock is listed or traded on stock exchanges in countries other than the USA, or
- Has manufacturing operations in countries other than the USA.
- Operating Divisions or Subsidiaries in the USA of Multinational corporations are themselves considered to be Multinational Corporations.

A Domestic Corporation has these characteristics:

- Owned entirely by one or more American citizens or
- Stock is listed or traded on stock exchanges in the USA and nowhere else
- The corporation has all of its operating facilities (management, engineering, design, manufacturing, and shipping) in the USA and nowhere else.

Labor Agreements:

This Plan is intended to be fully compatible with the **"Right to Work."** Each company that is providing materials or labor remotely, or on site, has the right to determine its own labor relations with its employees or any subcontractors to the exclusion of any other company that is providing materials or labor. Further, there is no requirement for uniformity of wages or salaries from one company to another for the same or different work.

New American Corporations:

Intent of this "Plan" is to have new American corporations established, or possibly to have prior companies re-established, to carry out any of the various parts of this plan, for one or more generating units simultaneously or subsequently.

Financing must come from American sources such as Americans with personal wealth, domestic banks, or sale of stock or bonds, privately, or publicly, such as via a domestic underwriting company. Foreign entities and banks cannot participate in this Plan. To do so would be a serious violation of the objectives of this plan, designed to benefit the American citizen.

AUTHOR RESUMES

Melbourne F. Giberson, Ph.D., P.E.
President / Owner – Turbo Research, Inc.
d/b/a TRI Transmission & Bearing Corp.

TRI Bearings support over 50,000 MW of Electrical Generation.
TRI designs, manufactures, install, all Sizes and Types of Bearings;

- Large & Small Steam Turbine-Generators;
- Almost All Types of Rotating Machinery;
  -Compressors: Oxygen, Natural Gas, Air, Hydrogen;
  -Pumps; Motors; Gears; Fans; Etc.

* *

Rotor-Bearing Simulation:
Developed Models to Predict Rotor Vibratory Behavior. The mathematical, computer-based models use Nonlinear Bearing Films with Variable Viscosity and Turbulence.

- Synchronous and Non-Synchronous Vibration
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OEM Heavy Duty Fluid Drives: Provided Major Technical Advances in Fluid Drives,

- Variable Speed for Boiler Feed Pump and Fan Service:
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- Speed Ranges from 300 rpm to 15,000 rpm.
- On/Off Fluid Drives for Crushers, Mills, Pumps.
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Design and Supply:

- Lube Oil Pumping and Conditioning Systems; Bearings, Fluid Drives.
- Vibration Monitoring and Diagnostic Cabinets.
- Field Balanced Tandem-Compound Steam Turbine-Generators - up to 12 bearings.
- Field Tests; Rotating Machines & Structures; Vibration, Performance, Stress/Strain.

Education:

- B.S. - ME, University of Pennsylvania, 1963
- M.S. - Applied Mechanics, California Institute of Technology, 1964
- Ph.D. - Applied Mechanics, California Institute of Technology, 1967
- Ph.D. Thesis: *Response of Nonlinear Multi-story Structures Subjected to Earthquake Excitation.*
- Minor: Business Economics.
- Professional Engineer: Licensed in Pennsylvania, USA.
  Over 20 Patents and Applications: Apparatus to Balance Shafts While Rotating; Fluid Drives; Fluid Drive Impellers; Oil Systems; Brake Arrangements

Contact: TRI Transmission & Bearing Corp. Engineering Services and Products:
P.O. Box 454, Lionville, PA Tel: 610-363-8570
E-mail: mel.giberson@turboresearch.com
www.turboresearch.com

Keith Moore

Principal – Castle Light Energy Corp.

Business Development &Technology Management

Environmental / Regulatory Compliance (Air Quality)

Mr. Moore focuses on strategies to mitigate / control pollution emissions from coal-fired electric generating plants to meet U.S. EPA’s stringent air quality regulations.

As a prime contractor, a recent re-engineering project included the design, engineering, equipment supply, and supervision of construction and start-up of an industrial 30 MW_T coal-fired steam generator for low SO_2 and NO_x emissions with improved efficiency and reduced operating cost. Programs in development include advanced coal beneficiation and CO_2 mitigation processes.

Mr. Moore is conversant with EPA’s stringent air quality regulations per the 1990 Clean Act Amendments, including EPA’s recent Cross State Air Pollution Rule (CSAPR) for SO_2 and NO_x emissions, the proposed Maximum Achievable Control Technology (MACT) standards for control of SO_2, Mercury, HAPS, and Particulates, and the proposed Clean Power Plan, including California’s recent AB-32 Global Warming Regulation (CO_2 reduction).

Mr. Moore has 30 years of technical, business development and management of advanced environmental control technologies; this includes development and commercialization of the Dry Flue Gas Desulfurization systems (Dry FGD scrubber), the Clean Combustion System (CCS: a field-demonstrated hybrid of coal-gasification and combustion for control of SO_2 and NO_x emissions with improved efficiency, Coal Beneficiation Processes, Continuous Emissions Monitoring System (CEMS), and CO_2 reduction / mitigation and sequestration. He holds patents in sulfur capture and coal beneficiation.

B.S., Electrical Engineering, Virginia Polytechnic Institute
General Contractor - “B” License, State of California
Pilot – Commercial / Instrument)

CONTACT:
Castle Light Energy Corp.
3401 W 5th Street, #200, Oxnard, CA 93030
E-Mail: keith@castle-light.com
Phone: 805-551-0983