Research Paper re. FPSC Annual Review of Docket NO. 080148-EI

EXECUTIVE SUMMARY

Nuclear ventures such as that proposed for Levy County are classified by financial institutions as inherently too risky for commercial financing. Moreover, escalating capital costs of the nuclear plants render unsustainable their recovery either from consumers in advance or by including capital debt service charges in electricity tariffs charged to consumers. Affordable electricity is a prerequisite to the creation of new jobs in Florida today. The nuclear facility proposed for Levy County just cannot fulfill that essential requirement.

The State of Florida would be better served by reducing the need for overly large centralized power generation plants and their associated expensive distance transmission line losses by employing distributed power generation systems which better survive hazardous weather events, yield improved energy efficiencies, while avoiding longer term used fuel hazards of all kinds.

Subsequent events have seriously compromised the premises upon which the Determination of Need was approved by Order Number PSC-08-0518 issued on August 12, 2008.

Addressing Page 24 of the docket number 080148-EI:

First, the electric power price of natural gas actually reduced by 43% over the following two years from 2008, instead of increasing as testified to the Commission.

The price reductions followed technical advances allowing access to the reserves of natural gas, previously trapped in shale rock deposits. This event, added a supply source forecast to last for more than a hundred years, which negates the assertion made on pages 8 and 9 of the said docket, that an additional base load nuclear energy capacity would be needed to protect consumers from the high costs of increased natural gas base load generation. It also facilitates chemical rather than combustive conversion of gas to electricity for vital installations such as hospitals and other intensive vital uses.

Next, the increased cost of natural gas energy generation (up by 56% in 2018 -

Docket Page 6) has proved to be false prophesy. Moreover, in view of the high unit costs of nuclear power from the proposed Levy Units 1 and 2 they no longer comprise a critical component of PEF's efforts to maintain a diverse fuel mix intended to stabilize fuel costs over time and enhance the reliability of the electrical system.

This would remain the case even if natural gas combustion were used to generate electricity at a centralized plant. Should, however, the natural gas be converted using fuel cells in a distributed generation system, not only would carbon dioxide emissions be reduced by a factor of 45%, but electricity supply would be more reliable and efficient as described in this paper.

In addition, PEF's assumptions and predictions for providing electricity at a reasonable cost using the proposed Levy Units 1 and 2 are no longer valid. As opposed to the figures quoted on docket page 10, forecast in- service costs of the Levy Units have risen to an unreasonable $22.5 billion, with overnight costs estimated to double for Unit 1 and be commensurately increased for Unit 2. With the result that recovery of the capital service costs for the nuclear option in customer tariffs would be both imprudent and untenable.

By employing the more modern technologies advocated by the Department of Energy in distributed generation systems, PEF would be enabled to avail themselves of benefits from more effective demand side management (DSM) and more efficient and renewable energy systems each having lower risk for the grid.

Lastly, although nuclear fuel costs may well be proportionately less than centralized combustion fossil fuel costs and extend beyond the analysis presented by PEF, the burden of servicing the increased capital costs of the nuclear option far outweigh any fuel cost savings of benefit to their consumers.

Based upon the foregoing it is urgently represented that the matters raised be considered as part of the 2011, long term feasibility analysis, ordered by PSC-08-0518-FOF-EI issued on August 12, 2008.

BACKGROUND

Admiral Hyman Rickover - On the hazards of nuclear power. in Testimony to Congress (28 January 1982); published in Economics of Defense Policy: Hearing before the Joint Economic Committee, Congress of the United States, 97th Cong., 2nd sess., Pt. 1 (1982), testified as follows:

> *"I'll be philosophical. Until about two billion years ago, it was impossible to have any life on earth; that is, there was so much radiation on earth you couldn't have any life — fish or anything. Gradually, about two billion years ago, the amount of radiation on this planet—and probably in the entire system—reduced and made it possible for some form of life to begin... Now when we go back to using nuclear power, we are creating something which nature tried to destroy to make life possible... Every time you produce radiation, you produce something that has a certain half-life, in some cases for billions of years. I think the human race is going to wreck itself, and it is important that we get control of this horrible force and try to eliminate it... I do not believe that nuclear power is worth it if it creates radiation. Then you might ask me why do I have nuclear powered ships. That is a necessary evil. I would sink them all. Have I given you an answer to your question?"*

Nuclear Reactors

During the 1960s' Cold War period, uranium was the nuclear fuel of choice presumably because of its path to higher power plutonium weapon systems. and possibly due to issues with the durability of materials employed in the reactor vessels. The legacy today is potential weapon proliferation, terrorism threat, used fuel hazard, groundwater contamination by radionuclides, and exposure to catastrophic risks which are difficult if not impossible to adequately insure against.

A Thorium nuclear reactor operated in the United States but was abandoned in favor of Uranium after five years in operation. Thorium, in use elsewhere today, is said to be more plentiful than Uranium, yields more electrical energy per single ton than 200 tons of Uranium or 3,500 tons of Coal, is not a terrorism objective, and reportedly can be made to fail safe automatically. Reportedly thorium nuclear power is again being addressed in the United States but requires a long program of development.

Nuclear power draws capital from preferable alternatives. Possession of a nuclear weapon is seen as a power to be sought by many who possess them and many that desire to have them.

Used uranium fuel rods are several million times more radioactive after irradiation in a reactor than before such use. The existence of hazard and extensive costs to clean up any accidental or deliberate radioactivity release has been amply demonstrated by such cases around the world. There is no safe depository anywhere for such material. Provision for safe storage in the United States is a federal responsibility such that utility corporations are paid millions of dollars for local storage on reactor sites pending a national depository such as the recently abandoned Yucca Mountain project. Reprocessing of used fuel on a large scale is not seen as a viable option.

Any release of radiation from a nuclear power plant is classed as a nuclear accident for the purposes of the Price Anderson Act (PAA), 1957. For that reason U.S. loss policies exclude "nuclear accidents". The PAA limits of claim per reactor do not appear to provide adequate cover for a major event.

CONSUMERS' COST of ELECTRICITY

<u>Nuclear Financial Risk</u>

Cash flow metrics of utility corporations pursuing nuclear options reduce their Credit Ratings by between 25 and 35% (from A to Baa rating) raising loan rates and reducing market demand for their "paper". In 2005, Federal Credit Guarantees (FCG) were introduced to encourage lenders to loan to utilities to meet the then perceived energy needs (at taxpayer expense of any default in repaying the loan). Since 2005, EIA reports that that capacity need has reduced by 94GW.

Reliable cost estimates are not available absent of any experience of building the Levy reactor type. The EIA, Annual Energy Outlook 2011, shows nuclear to be the most expensive option for Florida by far, costing $22.5billion over a period of ten to fifteen years, during which the overnight costs are expected soar. [See Figure 1.]

Seeking to reduce the unsustainable corporate debt cost burden by passing on in consumer tariffs even before any federal licensing approval to build is issued, transfers the burden from those who receive benefit from taking such risk (eg PEF shareholders) to those who do not (e.g. PEF ratepayers), By law a public utility supplier is allowed to recover from ratepayers only costs which are *prudently* incurred, meaning avoiding high-risk options when a lower risk option will "get the job done". (Note, for example: Union Electric Company Opinion #279, Docket No.ER84-560, July 20, 1987, Federal Energy Regulatory Commission (FERC), with respect to expenditures on its Callaway nuclear plant).

Wall Street's Jim Hempstead, a Moody's Senior V.P., in the Wall Street Journal on 18 February 2010, observed that, *"We think the probability that things will go wrong with these large projects is greater than the probability that things will go right."* This and the nuclear industry proclivity to under assess and over-run both cost and time estimates prompted twelve financial analysis firms in the wake of the Fukushima Daiichi experience to down rate nuclear industry corporate prospects. At a public meeting in Crystal River in 1998 a federal official announced that a force five hurricane coming ashore would put thirty five feet of water over US19.

Major European countries have announce their abandonment of nuclear power generation. When doing so on 30 May, 2011, Germany's Chancellor Merkel is quoted as saying,

> *"As the first big industrialized nation, we can achieve such a transformation toward efficient and renewable energies, with all the opportunities that brings for exports, developing new technologies and jobs."*

Utility corporations when faced with insufficient income from consumer billings to cover ongoing costs of servicing a utility corporation's plant debt (termed as "stranded" capital), can either close down and decommission the plant, disposing of toxic waste and restoring contamination or sell the loss making facility to a competitor at a low justifiable price.

<u>Public Utility Business Model</u>
No rational business model can sustain a capital costs burden at too high a proportion of product cost. The financial burden for the proposed Levy nuclear facility has been calculated to exceed three quarters (75%) of total costs per kWh(e) exclusive of profit, which is not a viable proposition in face of a competitive alternative. [See Annex A].

The uranium nuclear energy option has become simply too expensive and too risky. Ever increasing costs of building new nuclear reactors have rendered it unable to compete with falling natural gas prices that could stay low for decades. Moreover, lower cost alternatives that are now more widely available afford utilities much more flexibility in providing energy consistent with changing demand curves for electricity. The decline in demand growth for electricity has negated petitions made years earlier for determination of need,

Public policy cannot supplant the economic reality that nuclear economics are so bad that risk cannot be entertained by the traditional capital markets, Only upon the false premise of taxpayer subsidies (federal loan guarantees or unfunded mandates) or ceding sovereignty to infusion of capital from foreign equipment vendors or their governments, can reactor construction even be kick started. The nuclear industry is demanding state ratepayers to subsidize and guarantee to pay the construction costs, even if the reactors are not built or are abandoned prematurely.

Neither the federal nor the state government should force tax and rate payers to fund another many-billion dollar stranded capital bailout of an industry that is totally uneconomic and has no chance of standing on its own shareholder and bondholder shoulders (attributed to a utility corporate spokesperson on 24 February, 2011 in the local press).

So long as a utility corporation can simply generate electricity and sell it with no heed to how efficiently it is consumed nor account taken of environmental costs there is no incentive for the industry to change the way it behaves. Should the performance measure of distributable profits reflect both supply and demand side energy efficiency an essential change would be stimulated. Emphasis upon distributed as opposed to centralized generation would appear to be a step in the right direction - at least as a focus upon reality.

A BASELOAD PREFERABLE ALTERNATIVE

DOE recently announced that a photovoltaic system should become a utility scale candidate by 2016. A Thorium nuclear reactor is not on the horizon at this time. Florida could not accommodate an IGCC CCS plant, and any other centralized (hydrocarbon) fossil fuel plant would emit harmful greenhouse gases (GHGs).

Natural gas (a fossil fuel) is now being piped into the region with the possibility of it being used as lower cost fuel for either central or distributed electricity generation lasting for many decades. More efficient use of installed centralized plants could be made by adopting Renewable Electrolysis whereby generated electricity is stored, say, as compressed hydrogen gas, and reprocessed using utility scale fuel cells to satisfy peak demands.

However, radically fewer GHG emissions result from using electrochemical fuel cell systems instead of hydrocarbon fuel combustion.

Adopting a fuel cell distributed electrical generation strategy would offer several advantageous features:

- generation close to point of use avoids need for costly and power loss inducing transmission lines.

- very high energy efficiency with low noise and minimal pollution enables even higher energy efficiencies from fuel cells with combined heat and power (CHP)applications.

- a variety of fuels can be used from hydrogen to methane gas from waste.

- creative integrated industrial applications save both money and manpower.

- typically, for every 1,000 kWh(e) produced less than one ounce of pollution results as opposed to the twenty five (25) pounds of pollution produced from central grid systems.

Distributed Generation (DG)

DOE aims by 2020, to have one fifth of all new commercial building powered by DG, supplying extremely reliable power for critical commercial, industrial, communication and health care facilities. Every DG application relieves load from centralized generation facilities.

The state of Connecticut estimates that conserving its resources and curbing emissions presents a 35,000MW energy market with 7,000MW (20%) employing fuel cell systems - principally combined heat and power (CHP) applications.

Today a DG FuelCell Energy Inc. CHP facility comes on stream 12 to 14 months after agreeing project financing at, say, $4,350 per kW and (assuming fuel cost of

$6.00 per MMBtu) yielding $0.14 per kWh(e) with the latter reducing by between one and two cents when utilizing CHP. (This compares with more than $11,000 per kW over nigh cost for the Levy nuclear proposal extending over eleven more years).

<u>Efficiency Comparisons</u>:

a. Plant Capacity Factor (CF) - Percent achievable of nameplate rating:
   i. Fuel Cells - CF up to 95%,
   ii. a pulverized coal plant (PCP) - CF up to 95%,
   iii. Wind - CF 25 – 35%, Solar - CF 15 – 25%.

b. Plant Energy Efficiency (EE) - Percent energy conversion. :
   i. Fuel Cell (DFC ™) EE 47%, DFC-hybrid EE 55 - 65%, DFC/CHP EE 60 -80%.
   ii. Micro-turbine EE 25 – 30%, Small Gas Turbine EE 25-35%, Natural Gas Engine EE 30 – 42%,

c. Plant Effective Utilization (EU) - Percent operating at Peak output:
   i. DFC-hybrid EU 93%.
   ii. PCP EU 70.44%,

d. GHG emissions - FC percent emitted of PCP, saving tons per year:
   i. Nitrous oxides 0.06% saving 249 tons
   ii. Sulfurs 0.001% saving 3,500 tons
   iii. Carbon dioxide 45% saving 357,000 tons

Conclusions of the EIA in regard to fuel cell applications in context of DG are reproduced below *(emphasis added)*:

> " Distributed generation technologies, particularly fuel cells and PV, have received a great deal of attention from the energy community regarding their potential to save energy, increase the reliability of electricity supply, and decrease the cost of extending the current electrical grid. The tax incentive cases with resulting high penetrations also demonstrate the potential for distributed generation technologies with waste heat recovery to lower total carbon dioxide emissions from combined building sector and utility electricity generation. While the reductions in carbon dioxide emissions are not large enough to make what could be characterized as a major contribution toward stabilizing greenhouse

gas emissions, *distributed generation can contribute to that goal by helping to offset projected growth.* Other conclusions are:

- The role of new, emerging technologies (PV, fuel cells, and microturbines) is critical to the projected growth of distributed resources. However, if given similar incentives, more traditional gas-fired technologies would also contribute.
- Technology cost reductions, as assumed in the advanced technology case for PV and fuel cells, *lead to projected increases in total distributed generation in the buildings sector of more than 25 percent compared with the reference case projections by 2020.*
- Net metering implemented in the model has a larger effect on the projections than that for the advanced technology cost case.
- Purchase incentives (including tax credits, lowered installed costs, and net metering) tend to reduce the projected marginal generation efficiency of installed distributed resources. *These incentives increase the applicability of distributed generation by easing the requirements for utilizing waste heat and thus spur penetration into additional applications*.
- The potential for distributed generation to mitigate carbon dioxide emissions depends on two key elements. First is the efficiency of displaced central station generation units: the more efficient the central station units are, the smaller will be the reduction in carbon dioxide emissions as a result of increases in distributed generation. The second is the efficiency of the distributed generation technology: PV makes direct carbon dioxide reductions with no offsets, whereas fuel-based distributed generation technologies create carbon dioxide emissions that depend on total efficiency, which can vary widely.
- "Standalone" estimates of reductions in carbon dioxide emissions derived from analysis of the buildings sector only (i.e., isolated from the electricity supply sector) should be avoided. *Such estimates do not include the impacts of increased distributed generation on the central station generation and can overstate the amount of savings*."

Fuel Cell System examples

See also Annex C in regard to Renewable Electrolysis (RE) applied to improving operating supply side efficiency of centralized electricity generating facilities.

A FuelCell Energy Inc., DFC™ versatile power plant has three modules - Fuel Cells (FCM). Mechanical Balance of Plant (MBOP) and, Electrical Balance of Plant (EBOP).

- the FCM reforms Hydrogen from the source fuel and combines it with air in the fuel cell stack producing electricity, water and heat. (Many Fuel cells are operated in parallel).
- the MBOP provides outside air, preheats and humidifies the source fuel, and extracts heat energy from the the FCM reaction process converting it into a usable form.
- the EBOP inverts and conditions DC electrical power into utility grade AC power, interconnecting with necessary switching and protection functions.

Waste water Treatment (WT): methane fuel produced from the WT plant's anaerobic digester is used in a DFC to generate ultra-clean process power while heat from the fuel cell is used to heat the sludge to help anaerobic digestion. Up to 90% efficiency is achieved from this CHP application. The methane gas qualifies as a renewable fuel for incentive funding. The plant can be designed to automatically blend digester gas with natural gas, allowing continuous operation with different gas yields from the digester.

Gills Onions, California (GOC):- GOC produces 300,000 lbs of onion waste per day which was once interred as fertilizer at considerable costs for transportation and labor.

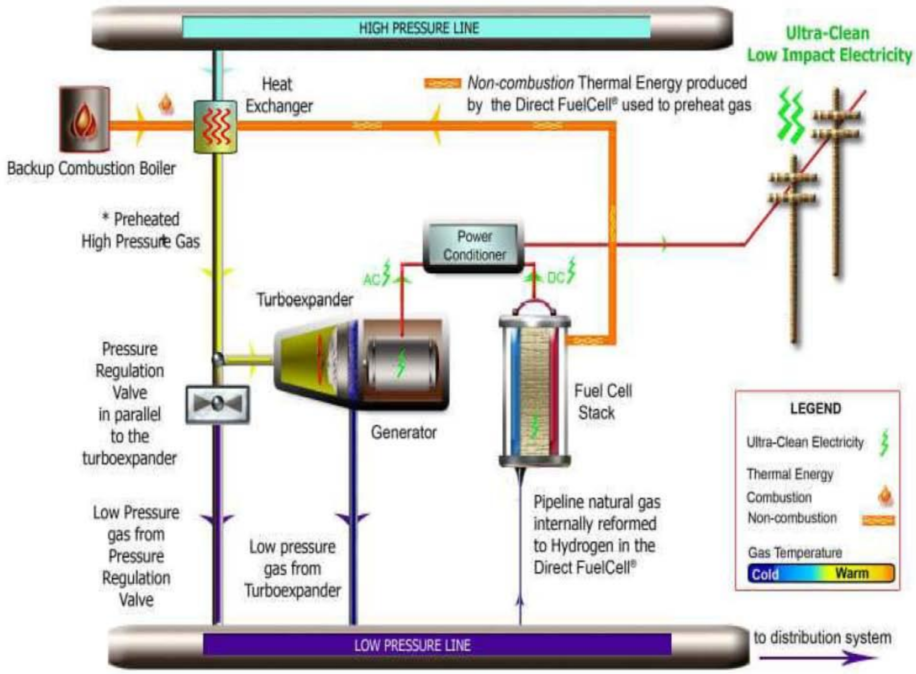
In 2009, GOC introduced fuel cell systems in a process to extract juice from the waste, converting it to a bio gas via anaerobic digestion, where fuel cells provide base load ultra clean process power 24/7. Annual verifiable savings amount to $700,000 in electricity costs, plus $450,000 in labor, diesel and insurance from eliminating waste interment (residual fiber from a crushing process is also sold as cattle feed), plus 14,500 tons of carbon dioxide emissions a year were eliminated.

Investment payback is expected over six years.

Natural Gas Distribution:- Combining a DFC™ power plant with an unfired gas expansion turbine and a generator enables recovery of energy normally lost in gas distribution pipeline pressure step-down operations to supply both process heat and electricity to the grid, as illustrated on the next Page.

Direct FuelCell Energy Recovery Generation

Enbridge, Inc. Canada



<u>Home Heating and Power:</u> Micro combined heat and power (m-CHP) delivered in quantity in Japan by Panasonic, together with the very many competing systems exhibited at Hanover Messe, Germany, (April, 2011), emphasize the extent of the world market for these fuel cell applications employing natural gas of various kinds as the fuel source. Systems producing up to 5kW electricity and 12 kW heat are expected to come to market within the forthcoming two to four years.

Annex A

Discussion of the Financial Fallout of the Levy County Nuclear Proposal.

A utility that builds a nuclear power plant may well experience a 25 % to 30% deterioration in cash-flow-related credit metrics, with cash flow from operations as a percentage of debt falling from 25% to the mid teens range. Meaning a fall from an A credit rating to a Baa rating incurring an increased loan interest rate coupled with an inability to sell the downgraded bonds in the credit markets.

Note that federal credit guarantees protect the lender and not the utility corporation nor its shareholders or ratepayers. As a private company the utility is not immune from bankruptcy. Credit ratings of both utilities and their customers suffer.

Central utility corporations supply power from a variety of sources having different price points for grid energy imports. Nevertheless, focusing on the nuclear plant costs, and considering that most households and small businesses carry high interest debt loads and try to pay them down, charging higher rates for electrical energy restricts the ability of consumers to make minimum payments on their debt balances which affect their credit ratings.

Excessive rate increases can result from the utility's attempt to defray construction by charging consumers in advance or charging them excessive rates for kWhs actually delivered from the nuclear facility.

Independent evaluations by the EIA of the economic competitiveness of new nuclear power conclude it to be the most expensive. Whereas utilities campaigning for new nuclear power claim it is the least expensive electricity source. No one has actually built a nuclear facility as that proposed for Levy County and no firm cost experience exists. Typically, an assessment is made of the cost to build a plant at today's (same day build) prices as an "overnight" cost usually expressed as per kilowatt (kW) rated capacity in nominal dollars allowing for different sized plants and for inflating construction costs during the build period. [See Figure 1.]

In Fig. 1, Annexe B, the EIA, Annual Energy Outlook Reference Case 2011, (Richard Newell) shows that nuclear is the most expensive plant to build in terms of Overnight costs per kW(e), together with Coal Integrated Gasification (IGCC) with Carbon Capture and Sequestration (CCS), albeit, the latter would not be appropriate in Florida.

Local rates charged for domestic electricity supplies have increased by about two thirds over the past twelve years to more than $0.13 per kWh(e). Calculations modeled upon those of Craig A. Severance CPA, in "Business Risks and Costs of New Nuclear Plants", January, 2009", "Due Diligence on The Economics and Business Risks of New Nuclear Power" delivered on March 4, 2010, to the Global Public Policy Conference in Potsdam, Germany, and using data from the EIA, Energy Outlook 2011, Reference Case, and several other sources indicate that electricity costs from the proposed nuclear facility in Levy County would likely exceed $0.33 per kWh with respect to service of capital debt costs (see the attachment to this Annex).

The starting point for the assessment of construction costs is the sum of construction costs at today's prices referred to as "overnight costs". The Power Capital Costs Index (PCCI) published by Cambridge Energy Research Associates tracks "hard costs" of construction of power plant in America and Europe since the year 2000 from which an average yearly cost escalation of such hard costs accounting for about 51% of overnight costs can be derived at 12.76 %. Other costs, accounting for 45% of an "Overnight" cost estimate – e.g. fees, owners' costs including licensing and legal, and transmission integration, may be less affected by such rapid worldwide cost escalation. The Handy-Whitman "All Steam Plus Nuclear Generation Plant" average of 4.85% per year may be the more appropriate factor. The remaining 4% of "Overnight" Costs is assumed to inflate at the 3% general economy inflation rate. The average weighted escalation factor has been derived at 8.81% per year of the assessed overnight costs.

As both equity and borrowed funds are used to fund the cost of finance during the planning and construction period and both expect to earn returns, an average weighted cost of capital of 14.5% is assumed. Some utilities propose to "lower costs" by charging financing costs to ratepayers during or even prior to construction. However, "early recovery" charges simply force ratepayers to pay extra financing costs to make ends meet instead of raising capital in the markets where costs are reflected in returns available to shareholders, bond holders and executive remuneration.

Several factors affecting construction costs and expected kWh tariffs are taken into account including the history of industry cost over-runs, difficulty in securing firm, reliable cost estimates, escalating construction costs during the years required to approve and build the plant, and cost increases due to construction delays. Additional risk factors reflect the massive sunk costs to be sustained before any electricity can be generated, giving rise to a prospect of stranded capital, difficult to quantify decommissioning and clean up costs including restoration of contaminated soils and groundwater, consequent variations to credit ratings of the utility and consumers, and burdens placed upon consumers from advanced recovery of anticipated costs.

Such an assessment of financial risks relating to nuclear power facilities caused six Wall Street Investment Banks in 2007, to withhold finance from any nuclear power venture as being too risky.

There is no place in Florida to sequester carbon dioxide from an IGCC CCS coal fueled plant. Any nuclear plant located in a region having poorly or unconfined aquifer systems will contaminate groundwater with cancer causing tritium. Carbon costs to be levied on coal fueled generation for directly polluting the biosphere and upon nuclear plants for polluting the biosphere with effluents from uranium fuel cycle processes will bear upon their economics. Both involve massive downside risks of sunk capital before a single kW of power is produced - blind to any actual demand curve needs.

Appendix to Annex A

New Nuclear Power "Most Likely" All-in Construction cost -Thousands of nominal dollars

Year	AP 1000 Unit 1 Pct Constr.	AP 1000 Unit 2 Pct Constr	Escalation Factor Constr	Brick&mortar Costs $thousands 2009 dollars	Cumulative Costs $ thousands		Annual Cost of Capital $ thousands	Cumulative Capital Cost Equity + debt $ thousands	Cumulative Total "All-in" costs $ Thousands
2011									
2012	0.4	0.4	1	46	46		3.288	3.288	49.763
2013	3	3	1.08	376	423		29.922	33.210	456.132
2014	2	0	1.17	136	559		39.540	72.750	631.611
2015	3	2	1.26	366	925		65.434	138.184	1063.035
2016	5	1.5	1.36	514	1438		101.768	239.952	1678.351
2017	10	1.5	1.47	982	2420		171.250	411.202	2831.674
2018	36.6	5	1.59	3843	6263		443.113	854.315	7117.334
2019	27	10	1.72	3697	9960		704.684	1558.999	11519.098
2020	10	36.6	1.85	5008	14968		1059.022	2618.020	17586.374
2121	3	27	2	3486	18454		1305.632	3923.652	22377.625
2122	0	10	2.16	1255	19709		1394.411	5318.063	25026.860
2123	0	3	2.34	408	20117		1423.265	6741.327	26857.942
	100	100		5.34	9	<<per kW>>		3.018	12.012
						per kWh>>>			$0.25

Assumptions:		Comment
Overnight cost per KW	$5,339.00	1
Escalation weighted Average	8.81%	2
Percent debt	55.00%	3
Average capacity Factor	80.00%	4
Construction delays	none	5

Comments:

1,EIA, Annual Energy Outlook Reference Case 2011, page 17(Table 2) – by Richard Newell

2. Uses Cambridge Energy Research Associates press release 21 December 2010 – Index for North America average cost growth trend. showing cost downturn from the recession and a flat 2010.
3. Conservative estimate (lower cost of capital)

4..Uses MIT 2003, Future of Nuclear Power, Overview and Executive Summary - mid point values of two scenarios.

5. Delays would increase costs further.

Total Generation Costs "Most Likely Scenario" - Costs per kWh – in nominal Dollars for first year generation in 2023

Cost Component:	$per kWh
CAPITAL Cost	$0.25
OPERATION and MAINTENANCE w/o FUEL	$0.01
PROPERTY Taxes	$0.02
DECOMMISSIONING and WASTE costs reserve	$0.02
FUEL CYCLE costs	$0.03
TOTAL	$0.33

Cost escalation factor rates		Pct of Constr	Nominal Wghtd Avg
HW 00-07 Avg	4.85%	45.00%	2.18%
PCCI 00-07 AVG	12.76%	51.00%	6.51%
GEN. INFLATION	3.00%	4.00%	0.12%
Weighted Avg. Escalation			8.81%

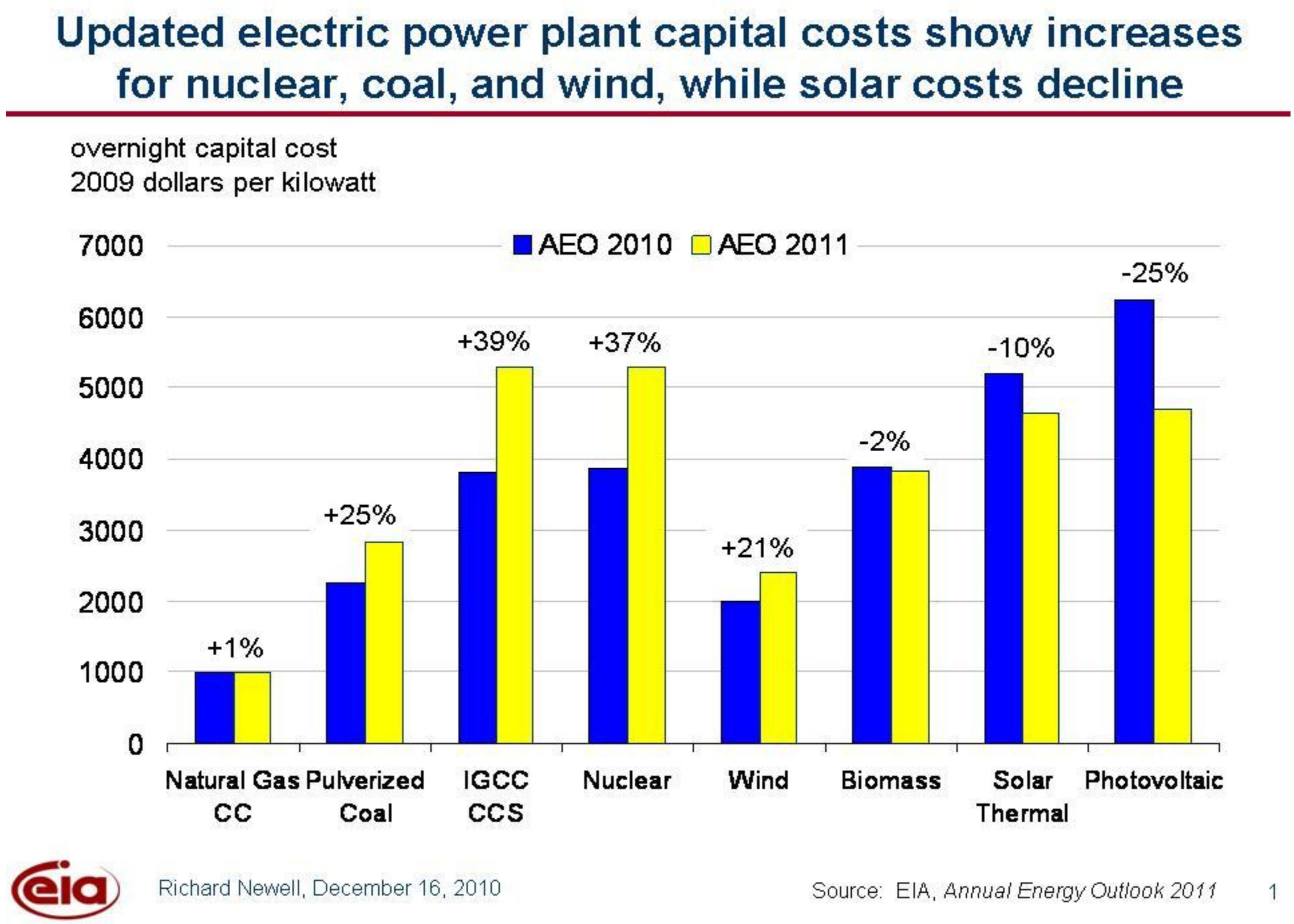
Assumptions for Weighted Average Cost of Capital

	Net of Corpn Tax	Before Tax Gross	Pct of Funding	Weighting
Equity	15.00%	24.59%	45.00%	11.06%
Interest	6.25%	6.25%	55.00%	3.44%
	Weighted AVG. Cost of Capital =			14.50%

Annex B

Figure

Figure 1.



Overnight Capital Costs expressed per KW of "nameplate" plant capacity.

Annex C

Renewable Electrolysis (RE) - Taken from www.amyhrf.org- Education Section. Significant under-utilized generating capacity is revealed by comparing actual annual kWh(e) output achieved compared with "Summer rate capability" (Peak rate). Systemic supply side inefficiencies exist when there is no way to store electricity generated in times of off peak or lower seasonal demand. These "losses" could be recovered by adopting Renewable Electrolysis (RE).

In RE, electrical energy is captured and stored as compressed hydrogen gas released by electrolysis, which can be re–converted into electricity using fuel cells to meet up-turns in demand as base load. When complemented progressively by new renewable energy sources – wind or solar photo voltaic arrays – RE would enable GHG intensive plants to be phased out. Also modular RE units could be sited near substations serving population centers. Decentralizing capacity in this way would make it more difficult to disrupt supplies by Cyber attacks and create many more manufacturing, installation and maintenance jobs in the process. Recent reports of hacks into the US power grid are thought by some to be preparatory to larger disruptions.

Renewable Electrolysis.
This Foundation is indebted for the co-operation of the DOE - NREL and particularly to Darlene Steward et. al. and NREL/PR-560-47547 from proceedings of the HTAC meeting February 11, 2010. (Note that 1kg H_2 is equivalent energy to 1gal gasoline. The Florida location is not suited to the competitive Pumped Hydro or Compressed Air Energy Storage technologies.)

Note: Some of the manufacturers approached in regard to larger static fuel cells have their business models tuned to using natural gas as their energy source, which is perfectly reasonable in view of the availability of natural gas in the market place. Their process requires natural gas to be reformed into hydrogen and then the hydrogen is the energy source for the fuel cell, as opposed to electrolyzing separation of hydrogen from water. One manufacturer offers a 1MW PEM hydrogen fuel cell at a cost of about $4million.

Hydrogen technologies are reviewed in Technical Report NREL/TP-560-46267, September 2009 by Darlene Steward et al - Click here to read Darlene . Essentially, hydrogen energy electrolysis and storage offers an opportunity to harness supply side generation capacity which is not used in the absence of storage. Efficiencies suffer where plants are forced to ramp down to accommodate both seasonal and daily cyclical reduced demands. When complemented by progressive expansion of clean energy generation by wind or solar PV arrays a transition from GHG intensive fossil fuels to clean technologies can be made.

For example, based upon 2008 data, the scope for supply side increases in efficiencies from the four coal fired plants of the Crystal River Energy Complex (CREC) has a potential for 29.56% or 683 MW(e) equivalent, rising to more than 800 MW(e) including the current nuclear facility. Today's achievable Round Trip energy efficiencies (H_2 hydrolysis through fuel cell) are estimated to be between 40% and 47%. Another significant issue is the ability to site PV arrays with Renewable Electrolysis close to a substation near to a conurbation center, say Orlando or The Villages already connected to the CREC.

RE would facilitate higher supply side efficiencies, at significantly lower costs, in an environmentally preferable manner, and be beneficial instead of harmful to human health than, say, adding nuclear generating capacity. A smoother transition to an altogether cleaner strategy nation-wide could result and create jobs so urgently needed both in manufacture and installation and maintenance.

A Renewable Electrolysis Scenario.

An "Renewable Electrolysis" scenario is described avoiding much of the negative environmental consequences which does not appear to have been addressed in the draft NUREG-1941 DEIS. Time and wealth consumed with PEF LNP proposition could be applied to bring on stream increased power capacity in a radically shorter time scale, for significantly less cost, creating local employment opportunities so urgently needed and avoiding degradation of highly valued natural resources. Earlier elimination of GHG and methyl mercury emissions from earlier closure and decommissioning of the dirty coal-fired units at the CREC would be a landmark achievement for PEF.

An Example

For example, the hydrogen plant postulated below could be accommodated in some seven cubic meters of space. PV arrays could be brought on stream as described below (as similar installations have already been provided elsewhere in Florida), together with hydrogen plant providing for base load supply, both of which could be progressively expanded over time, taking advantage of cost reductions as technologies mature:

- solar energy PV arrays and inverters could be installed on the LNP site to serve prescient increases in demand,
- hydrogen electrolysis and storage plant could create an off-grid local energy reserve. The energy resource for the hydrogen plant could be derived from off-peak grid supplies in times of lower demand enabling more efficient operating schedules of existing plants, complemented by yield from solar energy arrays on site.
- future disabling events to the CREC nuclear facility could be recovered more expediently using the reserve,
- a simple energy arbitrage scenario is postulated for the hydrogen plant consisting of an initial 300 MWh nominal storage capacity that is charged during off-peak hours (18 hours per day on weekdays and all day on weekends) and discharged at a rate of 50 MWh for 6 peak hours on weekdays. Process water would be electrolyzed to produce hydrogen, for storage as compressed hydrogen gas in above ground steel tanks for use in polymer electrolyte membrane (PEM) fuel cells. Some estimated time and cost parameters are suggested (excluding any benefit from possible federal subsidies):

    1. acquire land bank for expansion of PV system or wetland s mitigation, say, 5,000 acres @ c. $100million, bringing total acreage to 10,000 acres [say, 1 year],
    2. PV indirect costs (engineer, procure,construct) @ $11million [over say, 2.5 years],
    3. build initial 10MW (AC) PV array on 60 acres @ $40million direct cost (incl. inverters c. $4million),
    4. initial PV total cost $151million - excluding land prepn. [elapsed time, say, 3 years],
    5. Hydrogen plant (Electrolyzer, Hydrogen storage, Fuel cells) consisting of, 50 electrolyzer units to yield 52,300 kg/day H_2 (run in of-peak hours only) Process water Cooling system Transformer, Thyristor, Electrolyzer Unit, Lye Tank, Feed Water Demineralizer, Hydrogen Scrubber, Gas Holder, 2 Compressor Units to 30 bar (435 psi), Deoxidizer, Twin Tower Dryer.
    6. Estimated net present (2011) cost of H2 plant @ $225million.

Note: Using hydrogen for energy storage provides unique opportunities for later integration between the transportation and power sectors. Producing a small amount of excess hydrogen (five 280-kg tanker-truck loads or 1,400 kg per day) reduces the overall levelized cost of energy for this scenario by about 6% compared with the purely energy arbitrage scenario.

Fuel Cells. A fuel cell is an electrochemical device that combines hydrogen and oxygen to produce electricity, with water and heat as its by-product. As long as fuel is supplied, the fuel cell will continue to generate power. Since the conversion of the fuel to energy takes place via an electrochemical process without combustion (electrolysis), the process is clean, quiet and efficient – two to three times more efficient than fossil fuel burning.

No other energy generation technology offers the combination of benefits that fuel cells do. In addition to low or zero emissions and fuel portability, benefits include high efficiency and reliability, multi-fuel capability, citing flexibility, durability, scalability and ease of maintenance. Fuel cells operate silently, so they reduce noise pollution as well as air pollution and the waste heat from a fuel cell can be used to provide hot water or space heating for a home or business.

There are many uses for fuel cells – all of the major automakers are working to commercialize a fuel cell car. Fuel cells are powering buses, boats, trains, planes, scooters, forklifts, even bicycles. There are fuel cell-powered vending machines, vacuum cleaners and highway road signs. Miniature fuel cells for cellular phones, laptop computers and portable electronics are on their way to market. Hospitals, credit card centers, police stations, and banks are all using fuel cells to provide power to their facilities. Waste water treatment plants and landfills are using fuel cells to convert the methane gas they produce into electricity. Telecommunications companies are installing fuel cells at cell phone, radio and 911 towers.

Hydrogen is potentially the most abundant and inexhaustible energy source available. However it cannot be harvested or mined or pumped from the ground. To isolate it as the energy carrier that it is, one has to break the bonds to other elements to which it is attached in nature. Unlike electricity which does not "keep", whereas, hydrogen can be stored or moved from place to place for use for work as a compressed gas, or as a super chilled liquid or in suspension with metal hydrides. Hydrogen is the basis of all hydrocarbon fuels we depend upon today.

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