Maximizing Environmental and Economic Benefits at the Same Time: Exploring Emission Control Strategies in Florida's Electric Utility Industry

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The past three decades have experienced rapid growth in demand for electricity to serve our growing energy intensive Florida information age economy. The five largest utilities experiencing the bulk of the demand for electricity are presented in Figure 1. The growth in Florida's winter peak demand for electric generation capacity is expected to almost double in just nineteen years from 26,869 MW in 1990 to 52,277 MW in 2009 (Figure 2). Rural and Residential, and Commercial energy use comprises the majority of electricity consumption for the state (Figure 3). Annual 1998 electric sales in Florida topped 187.3 billion kilowatt-hours (kWh) with total electricity revenues of $12.82 billion up almost 27% from $10.1 billion only ten years earlier (Figure 4). While the growth in generation and sales have been brisk over the past two decades, the advent of new technologies and their associated increases in energy generation efficiency (up from 29% in 1980 to 33% in 2000) and reliability and have resulted in the actual drop in the average real price of average 1,000 Kwh retail monthly consumer by 38%[1] over that time (Figure 5).

Florida uses quite a different fuel mix when compared to the fuel mix nationwide. For Florida, 25 percent of the total comes from electricity, 60 percent from oil, and 10 percent from natural gas. However, for the United States, the fuel mix utilization is 15 percent from electricity, 50 percent from oil, and a much greater 28 percent from natural gas (Figure 6). Florida has limited access to natural gas and thus, relies more heavily on oil and electricity. Concerning electricity generation, Florida uses 80 percent fossil (majority is coal), and almost 20 percent nuclear. However, nationwide, 66 percent used fossil (majority is coal), more than 20 percent nuclear, and hydro-electricity comprised 11 percent (Figure 7).

The historical trend of electric grid efficiency in the U.S. and Florida, defined as the conversion rate of primary energy to electricity, has gained ground from 1950 to the present (ranging from 21 percent to approximately 33 percent at present) (Figure 8). This is due to the current stock of power plants (2/3 were built before 1970) being gradually retired and replaced with more efficient technologies. However, when comparing the trend (from 1950 to current) of the overall rate of energy efficiency in the U.S. and Florida, with only electricity generating efficiency, the efficiency rate for electricity generation has experienced a considerably slower rate of growth (Figure 9).

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[1] James Dean, Public Service Commission, June, 2001.

The continued growth of reliable electric power available at a stable price is one of the key corner stones to strength, competitiveness and productivity of the Florida economy in this new century. The Florida's electric industry is responsible for $1.31 Billion in wages and salary distribution, 24,500 in employment and $9.80 Billion in output and indirectly is the underpinning for every other major and minor economic sectors (including the growing high tech centers) across the state (REMI, industry tables).

ECONOMIC IMPACT OF PLANT EMISSIONS ON HEALTH CARE AND ENVIRONMENTAL QUALITY

Concomitant with this growth in electric energy demand is the associated growth in air and water pollution, land use disruptions and other environmental complications and associated human and environmental damages each new power plant and their associated transmission lines bring. For example, nitrogen oxide (NO_x) emissions from electricity generation grew 28% from 1988 levels to 373,000 tons per year. While sulfur dioxide (SO_2) emissions remained relatively stable at 710,000 tons in 1998, carbon dioxide (CO_2) emissions rose 54 percent from 1988 levels to 133 million tons. These new emissions are added to the cumulative impacts from the discharges of existing power plants and other human pollution generating activities in both Florida and in the United States.

Figure 1. Florida's Largest Utilities.

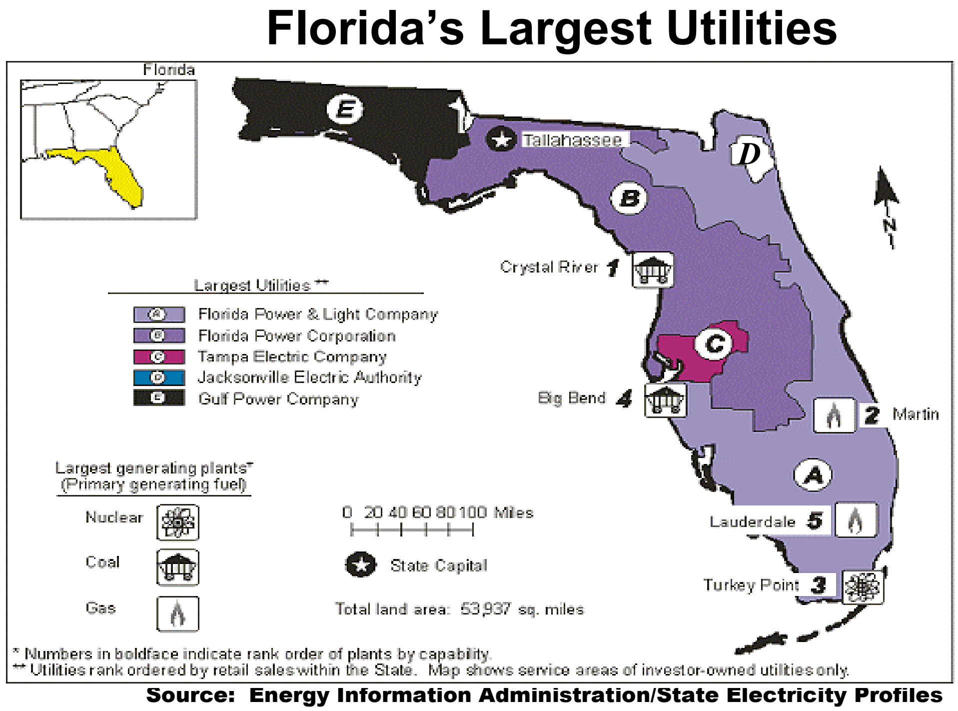


Figure 2. Florida Summer and Winter Peak Electricity Demand by Year (1999).

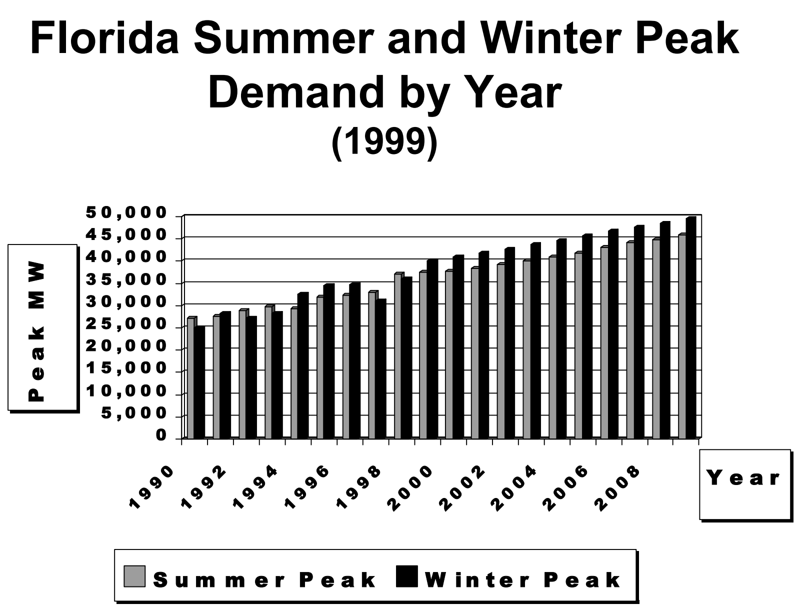


Figure 3. Florida Energy Use by Customer Type (1999).

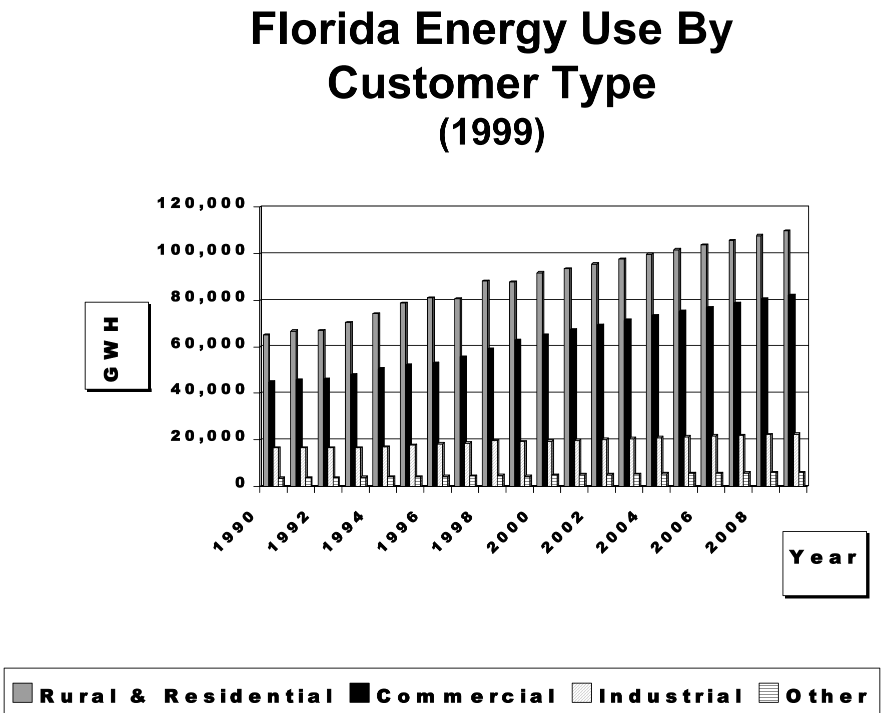


Figure 4. Florida Revenue from Sales to Consumers by Sector (Thousands 1999 $).

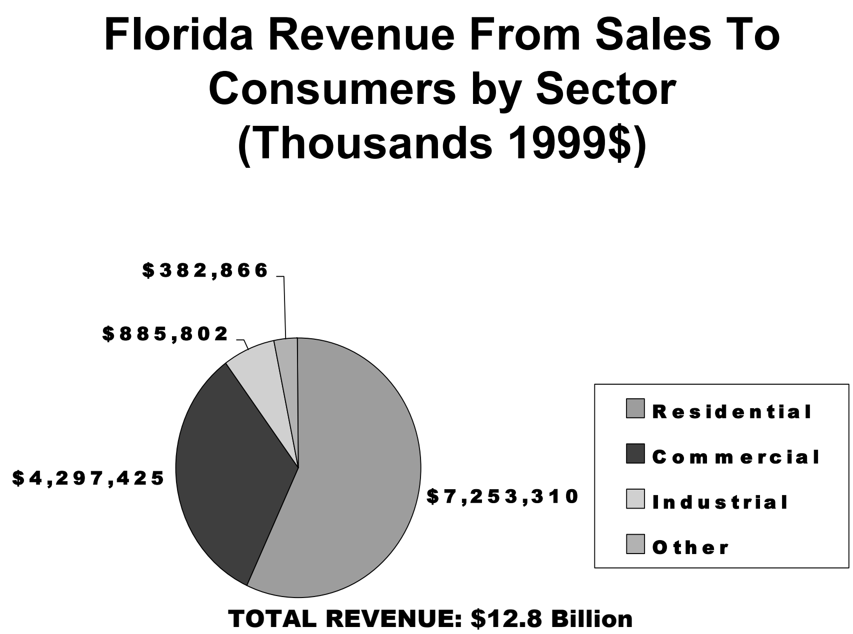


Figure 5. Electricity Prices in Florida $/1000 Kwh (1978 - 2000).

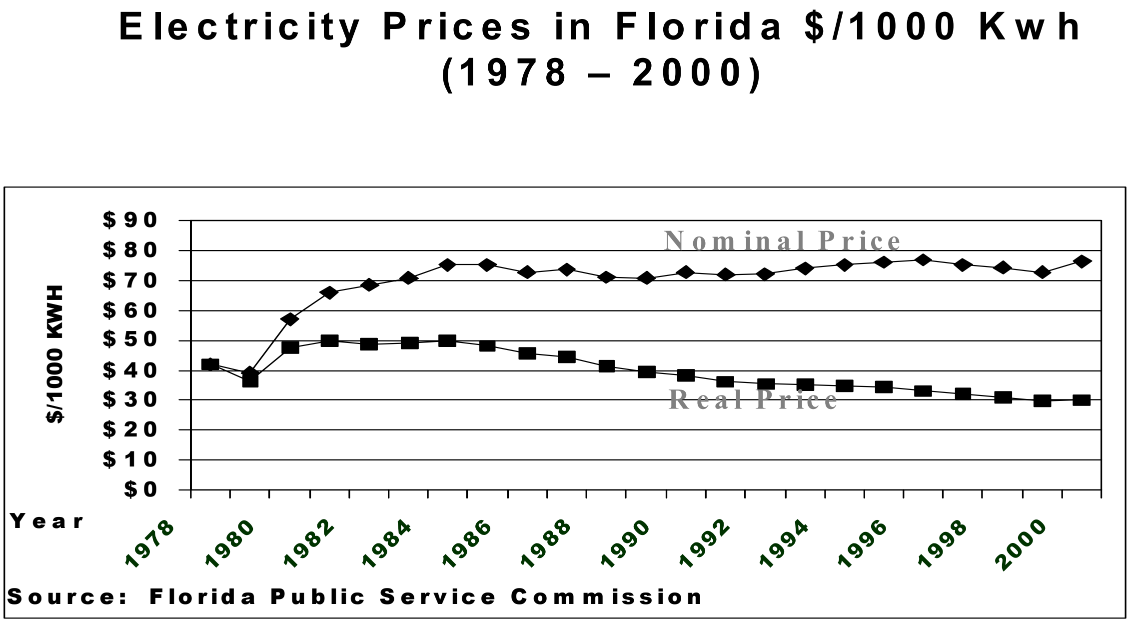


Figure 6. Fuel Mix Use in U.S. and Florida.

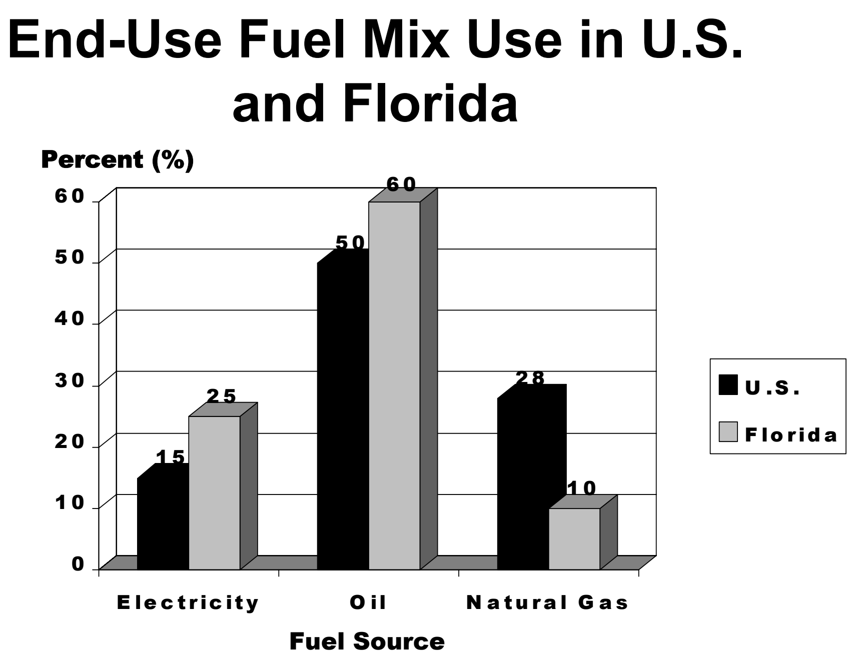


Figure 7. Electricity Generation in U.S. and Florida.

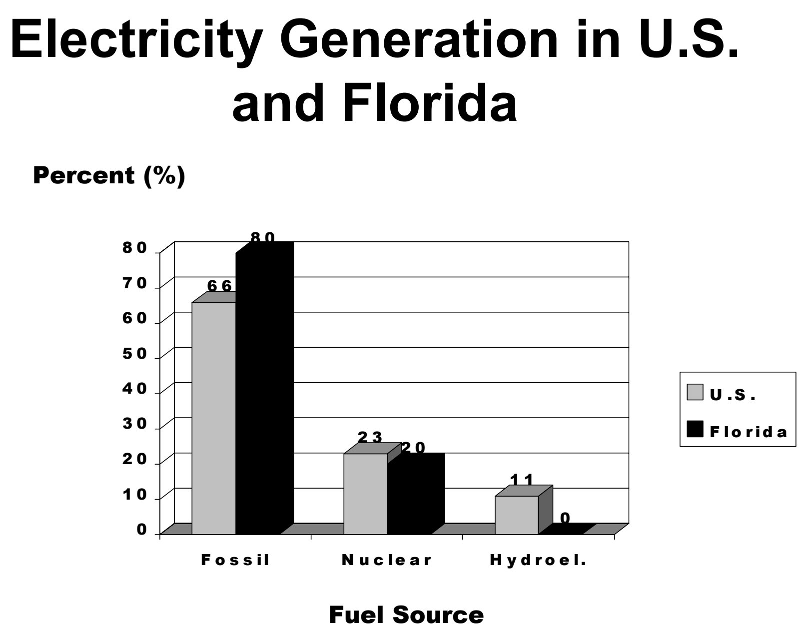


Figure 8. Historical Trend in U.S. and Florida Electric Grid Efficiency.

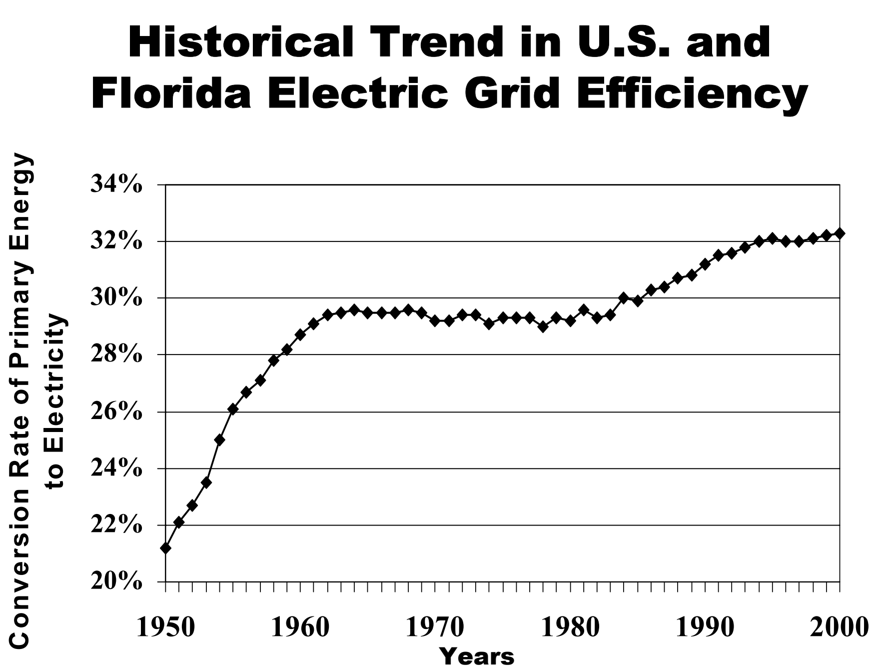
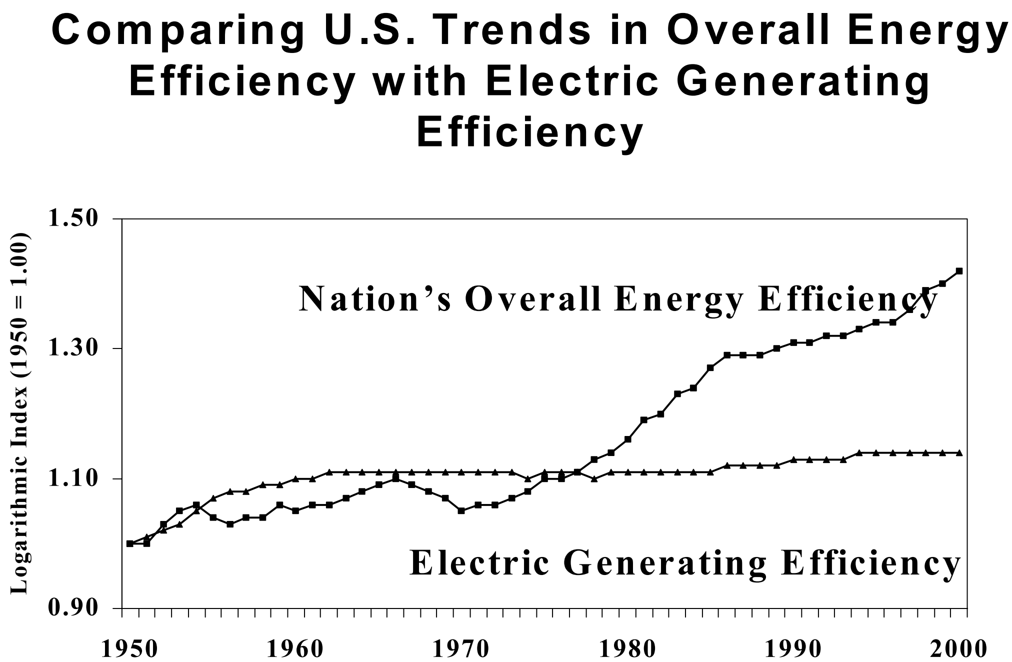


Figure 9. Historical Trend in U.S. and Florida Electric Grid Efficiency.



As but one recent example of studies on the impact of pollutants on human health, a Harvard analysis estimated human morbidity and mortality consequences of fine particulate matter ($PM_{2.5}$) emitted from existing coal-fired power plants on the residents of nine Midwest states. The conclusions are significant and the study estimates annually 300 premature deaths, 2,000 respiratory emergency room visits, 10,000 asthma attacks and 400,000 incidents of daily upper respiratory symptoms caused by these plants (Harvard Center for Risk Assessment, 2001).[2] In a separate EPA assessment of the benefits of existing Clean Air Act requirements, analysts found that Floridians now enjoy annual health care benefits of about $4.2 billion as a result of lower levels of pollution since 1990. As we will see later in the paper, even larger benefits may be available through greater levels of emission reductions (EPA, 2000).

The majority of air emissions come from the nation's older power plants, especially the older coal-fired units that are the core of the nation's electricity system. While new power plants do increase net air pollution emissions into the atmosphere, these new power plants operate with higher efficiencies, cleaner fuels and more stringent emission abatement technologies than older plants. The new plants therefore do not discharge as much pollution into the atmosphere per kWh as older less efficient plants permitted prior to 1980 (and often with lower operating costs). The previously cited Harvard study, for instance, estimated that "pre-1980 coal-fired power plants contribute about half of all electricity generation in the US while producing nearly all the sulfur dioxide (SO_2) and Nitrogen Oxides (NO_x) emissions from the entire national power industry."[3] By comparison in Florida over 75% of NO_x and 82% of SO_2 emissions came from plants that were grand fathered under New Source Review permitting standards because they were permitted or constructed prior to the effective dates in federal and state New Source Review laws.[4]

While these older higher polluting plants often produce electricity at considerably lower prices because higher sulfur coal and oil is considerably less expensive than higher grade lower sulfur fuels. This cost differential often places these facilities at a distinct competitive advantage relative to newer facilities. Economic analysis indicates that these older plants are not internalizing the true social costs of their production (in the form of

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[2] As one interesting comparison, the Center's website notes that air pollution causes between 60,000 and 70,000 premature deaths annually in the United States compared to annual traffic fatalities of 44,000 deaths annually.

[3] This constitutes about two-thirds of the SO_2 and one-quarter of the NOx emissions from all sources, nationwide.

[4] In order to determine whether a facility had a unit that was considered grand fathered for the purpose of this analysis, an initial operation date cut-off of 1975 was used. This is similar to the methodology utilized in Texas. Under New Source Performance Standard regulations, the first applicable regulation (40CFR60, Subpart D) applies to those units that commenced construction after August 17, 1971. Due to the vintage of those units, a 3-4 years construction period was assumed and a corresponding year of 1975 was used as a general cutoff date for commercial operation. Commercial operation dates for facilities are available from permit files located at the Florida Department of Environmental Protection, Division of Air Resources Management.

higher emissions related levels of human and environmental degradation) and "exporting" these true costs to environment.

This puts these facilities at a competitively subsidized position in the growing world of electric utility deregulation and is increasingly viewed as unacceptable. A growing number of proposals would require these older power plants to meet the same standards required of new facilities. President Bush recently stated that mandatory reductions of SO_2, NOx and mercury are being planned at the federal levels and similar legislation has also been introduced in Congress to achieve this goal. Also as of February 2001, four states – Massachusetts, Connecticut, New Hampshire and Texas – had proposed regulations to achieve this goal[5].

While there is decided interest in reducing air pollutants, there are appropriate concerns about the impact such reductions may have on the overall economy. A number of studies have attempted to assess the macroeconomic employment and productivity benefits from cost-effective emission reductions in the United States. One analysis indicated that if emission reductions were achieved through improved efficiency gains, this could result in a net increase in the US gross domestic product (GDP) and employment[6]

The driver behind these positive results is the assumption of accelerated penetration of existing but underutilized technologies that provide cost-effective reductions in energy use. Since pollution is so closely related to energy consumption, efficiency gains both save money and also lower a variety of air pollutants as well as carbon dioxide emissions (a greenhouse gas thought to contribute to problems associates with significant climate change.) As the Energy 20/20 Commission and the Florida Governor and Legislature examine electric utility deregulation options it will be important to evaluate both the equity of the "level playing field" for all stakeholders as well as the macroeconomic benefits and costs of deregulation. The latter point is one that we explore in the remainder of the paper. To complete that review, we first review the potential implications of emission reductions in Florida based upon plans already adopted in the states of Texas and Florida. We then develop a modeling framework to illustrate the potential gains and/or losses from a hypothetical reduction using two different emission control strategies.

FLORIDA SPECIFIC RESULTS FROM EMISSIONS SIMULATIONS

Texas and Massachusetts are among the states that have begun to implement strategies that seek further reductions in air pollutants. In this section we review DEP analysis that examines what impact and potential costs either strategy might have on Florida's current emission levels.

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[5] Levy, Jonathan, Spengler, J., Health Benefits of Emissions Reductions from Older Power Plants. Risks in Perspective, April, 2001, www.hcra.harvard.edu.

[6] Laitner, Skip, S. Bernow, and J. Decicco. 1998. Employment and Other Macroeconomic Benefits of an Innovation –led Climate Strategy for the United States. Energy Policy, Vol. 26 No. 5 pp 425-432.

Results of modeling the Texas Approach in Florida[7]

The Texas approach specifically targets emissions at plants grand fathered under New Source Review permitting programs. In Florida, there are 18 plants that have at least one unit that would fall under this category.[8] However, three unique plans for emission improvements were planned at various grand fathered units, as matters that were unrelated to the attendant analysis. These improvements were for two repowerings at FPL plants, two TECO plant improvements related to a Department of Environmental Protection Consent Agreement with TECO, and EPA-specified reductions for Phase II NOX reductions at certain targeted generating units. This analysis assumes that these specific improvements will be made and that corresponding emission improvements can be applied towards each IOU's requirement to reduce emissions. It is noteworthy that within this assumption, such improvements were considered to be creditable *only* to the utility bearing the cost of the planned improvement.[9]

Applying the Texas approach, to get a 25 percent decrease in SO_2, grand fathered IOU facilities in Florida would have to reduce SO_2 emissions from 511,029 tons per year ("TPY") to 386,272 TPY, a decrease 127,757 TPY. As a result of the already planned reductions, total SO2 emissions in the state at grand fathered facilities will actually be reduced to 319,702 TPY. Clearly, the planned reductions for TECO and FPL fully meet (and exceed) the SO_2 reductions required by the Texas approach.

However, since these "planned reductions" are assumed to be creditable only to the specific IOU, further reductions for FPC and Gulf are yet required. Under this analysis, FPC would have to reduce SO_2 by 28,265 TPY, at an estimated capital cost of $118 million, and Gulf would have to reduce SO_2 by 25,720 TPY, at an estimated capital cost of $109 million.[10]

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[7] Though Texas uses a 1997 baseline, a 1999 baseline was used to come up with Florida's emissions estimates as it represented the most current available data from the FERC Form 1 and EPA Acid Rain Scorecard databases at the (website).

[8] However, three of those plants, FPL's Port Everglades, Riviera, and Turkey Point plants were upgraded during the last 15 years for reductions in NO_x emissions. Accordingly, these plants were excluded from the review with respect to NO_x emissions only.

[9] In order to calculate what emissions would be in Florida under the Texas approach, and come up with cost estimates, several additional assumptions had to be made. Because the Texas approach lets companies trade allowances, an assumption was made for each IOU in Florida as to the likely changes they would make based on a least cost methodology. For example, one company may be able to reduce emissions at one plant enough to trade off allowances to the rest of their fleet to meet the limits. Key in this assumption was the above premise that planned improvements would be credited only to the utility bearing the cost of the improvements. Furthermore, in order to determine costs, assumptions were made as to the type of technology companies would install based on available data on pollution control technology and associated costs. It was assumed that the cheapest control method that would bring the company into compliance with the hypothetical limits would be applied.

[10] All cost data for both the Texas and Massachusetts analysis were calculated utilizing the data sources found in EPA (1998, 2000b) and Synapse Energy Economics (2000).

For NO_x, grand fathered IOU facilities in Florida would have to reduce emissions by 50 percent, from 147,480 TPY to 73,740 TPY. As a result of already planned reductions, NOx emissions will decrease to 75,164 TPY. Again, the planned reductions for TECO and FPL fully meet (and exceed) the NOx reductions required by the Texas approach. However, since these planned reductions are assumed to be creditable only to the specific IOU, further reductions for FPC and Gulf are yet required. Under this analysis, FPC would have to reduce NOx by 11,936 TPY, at an estimated capital cost of $108M, and Gulf would have to reduce NOx by 9,004 TPY, at an estimated capital cost of $62M.

Results of modeling the Massachusetts approach in Florida[11]

As a result of the applicability section of the Massachusetts rule, when applied to Florida, 16 facilities would be impacted. For SO_2, total emissions in the state from the IOU's after already planned reductions are 423,099 TPY. In order to meet the requirements of the rule, these 16 facilities would have to reduce their total SO_2 emissions by an additional 291,386 TPY.[12] This would come from SO_2 reductions of 137,689 TPY from FPC at an estimated capital cost of $775 million; 62,226 TPY from FPL at an estimated capital cost of $557 million; 89,955 TPY from Gulf at an estimated capital cost of $300 million; and 1,516 TPY from TECO at an estimated capital cost of $48 million.[13]

For NOx, total emissions in the state from the IOU's after already planned reductions are 152,777 TPY. In order to meet the requirements of the rule, these 16 facilities would have to reduce their total NOx emissions by an additional 77,994 TPY. This would come from NOx reductions from FPC of 33,721 TPY at an estimated capital cost of $333 million; 29,052 TPY from FPL at an estimated capital cost of $229 million; 14,538 TPY from Gulf at an estimated capital cost of $112 million; and 683 TPY from TECO at an estimated capital cost of $18 million.

[11] When applying the Massachusetts model to Florida's IOU's, a 1999 baseline was again used to come up with Florida's emissions estimates as it represents the most current available data. Additionally, as in the Texas model, already planned reductions have been incorporated into the analysis. And for consistency with the Texas model, as well as other reasons, the CO_2 and Mercury portions of the Massachusetts rule were not modeled.

[12] Since there is a two-tiered approach for SO_2 in the Massachusetts rule, the later, more stringent limits were used in this analysis.

[13] Due to the large number of affected facilities in the Massachusetts scenario, an analysis of every affected facility was not conducted. Accordingly, the cost estimates for FPC, Gulf, and FPL are based upon those IOU's achieving approximately 97%, 95%, and 85% of the required reductions, respectively.

Summary Chart of Results

The table that follows summarizes the results of the Texas and Massachusetts plans as they might impact Florida emissions and cost of reducing those emissions through conventional control or "end-of-pipe" technologies.

Table 1. Summary of State Emission Reductions and Costs

Expected Result	Texas	Mass	Differential
NOx Reductions (TPY)	20,940	77,994	57,054
SO2 reductions (TPY)	53,985	291,426	237,441
Capital Outlay (million dollars)	$397	$2,373	$1,976
Fixed O & M (million dollars/yr)	$30	$185	$155
Variable O & M (million dollars/yr)	$21	$101	$80

ESTIMATING THE IMPACT OF A 50 PERCENT REDUCTION IN ELECTRICITY SECTOR SO_2 AND NO_X EMISSIONS ON THE FLORIDA ECONOMY

As one contribution to the evaluation of costs and benefits driven by electric utility restructuring, this paper examines the potential economic impact on Florida of a hypothetical 50 percent reduction in electricity sector sulfur dioxide (SO_2) and nitrogen oxide (NO_x) emissions from 1998 levels. The purpose of this investigation is a heuristic inquiry rather than to recommend either a particular level of reductions or a given strategy to achieve such reductions. It is for that reason that we have selected a hypothetical reduction rather than attempt to assess the impacts of any particular emissions reduction target. At the same time, the analysis undertaken in this exercise illustrates a pattern of net costs and benefits associated with a Florida emissions reduction strategy.

We begin with a background discussion of the direct costs and benefits associated with two different approaches to reaching the emission reductions. The first scenario relies on control technologies to achieve the 50 percent reduction. The second relies on a combination of energy efficiency technologies and clean energy supply technologies such as combined heat and power systems, as well as more conventional control technologies. Next, we describe the Florida REMI (Regional Economic Models, Inc.) model, a statewide macroeconomic analytical tool used to obtain order-of-magnitude estimates of the macroeconomic impacts of the emission reduction scenarios. For purpose of comparison of modeling results using the REMI model, we also examined the impact of a

10 percent increase or price shock in Florida's electricity prices, and the impact of an introduction of high temperature superconductivity (HTS) technologies to the Florida economy (included as Appendix A and B). We then go on to describe the impacts of the resulting simulations. We finally review other similar studies to compare our heuristic inquiry with other similar exercises found in the literature, and end with concluding remarks.

Estimating the Costs and Benefits of Emission Reduction Scenarios

The two scenarios provided in this analysis are intended to *simulate* the potential economic implications of achieving a full 50 percent reduction in both SO_2 and NO_x following a multi-pollutant strategy such as that proposed by the President and currently under consideration by a number of bills filed in Congress.

They differ from the DEP emission reduction scenarios in several important ways. First, as previously noted, we evaluate a 50 percent reduction from the 1998 Florida electric sector emissions of SO_2 and NO_x air pollutants. This implies a total reduction of 542,000 tons. Including planned emission reductions as well as incremental reductions under the Texas and Massachusetts approaches, the DEP analysis implies total reductions of 349,000 and 644,000 total reductions for the Texas or Massachusetts scenarios, respectively. Hence, the reductions described here fall in between the two DEP scenarios. The target of a 50 percent reduction is based on a broader EPA level of review and following the pattern of a number of bills introduced in the U.S. Congress that would reduce emissions by as much as 75 percent below current levels.[14] Moreover, the reductions in this analysis apply to all Florida electric generation facilities and NOT just to the few existing grand fathered facilities evaluated in the DEP emission reduction scenarios. Each case assumes achievement of this 50 percent reduction but with different control strategies and associated costs.

The first Control Case Model looks only at the economic costs and impacts of implementing a set of end-of-pipe emission reduction scenarios that retrofit existing power plants with fluidized gas desulfurization, wet and dry scrubbers and so forth. The second Efficiency Case scenario assumes a series of supply and demand efficiency technology retrofits (that achieve approximately 30 percent of the reductions) with end-of-pipe emission reduction technologies achieving the balance of the emission reductions. Clearly the Efficiency Case involves higher capital and labor-intensive initial investment, but the resulting long term reduction in energy demand and associated emissions are likely to have higher payoffs in the future.

We begin with a brief review of the cost assumptions associated with a 50 percent emission reduction for the two scenarios evaluated in this paper. This involves three steps. First, we established a baseline against which we compare the alternative emission

[14] EPA (2000a), for instance, reviews the impact of proposed Senate Legislation, S 172 that would, among other things, halve SO_2 emissions and reduce NO_x emissions by 60 percent below current requirements. Other bills such as the Clean Power Act, introduced earlier this year in the Senate call for a roughly 75 percent reduction in both SO_2 and NO_x emissions.

reduction scenarios. This includes a review of the current level of electricity generation in Florida and the SO_2 and NO_x emissions associated with current generation. Second, we apply a methodology to estimate the cost of control technologies associated with a 50 percent reduction in those emissions. Third, we then estimate the associate costs of investments in more efficient generation and use of electricity as well as the costs of any remaining controls necessary to reduce emissions by 50 percent.

1998 Florida Electricity Generation and Emission Levels

In 1998 Florida households and businesses consumed an estimated 187 billion kilowatt-hours (kWh) of electricity to support the overall economic activity in the state. Total expenditures are estimated at $12.82 billion for an average cost of $0.0684 per kWh. At the same time, data from the Energy Information Administration (2001) indicates total electricity sector emissions of 710,000 tons for SO_2 and 373,000 tons for NO_x. To achieve a 50 percent reduction these pollutants implies, therefore, a reduction to 355,000 tons of SO_2 emissions and 186,500 tons of NO_x emissions.

Estimated Costs of Emissions Control Technologies

The Florida Department of Environmental Protection (Halpin, et al, 2001) provides a reasonable set of estimates for the cost of emission controls associated with two different levels of reduction based upon the application of Texas and Massachusetts power plant emission strategies. To determine how the cost estimates in that analysis might be used in this paper, we apply the cost estimates found in the DEP working paper to a unique quadratic response curve.[15] The curves must pass through the origin because, by construction, if there are no changes in emissions there are no changes in control costs. The results of this approach are displayed in Table 2 together with the estimates found in the DEP working paper.

Table 2. Cost Estimates of Emission Reduction Controls

Combined SO_2 and NO_x Reductions	Capital Costs (millions)	O&M Costs (millions)
Texas Strategy of 75,000 tons[(a)]	$397	$51
Massachusetts Strategy of 397,000 tons[(a)]	$2,373	$286
50% Reduction Strategy of 542,000 tons[(b)]	$3,800	$450

Notes: (a) estimates taken from DEP working paper; and (b) estimate derived from quadratic equation described in the text.

As shown in Table 2, the implications of a 50 percent reduction in emissions imply a capital cost of $3.8 billion together with an annual operating and maintenance cost of

[15] The unique quadratic passing through the three points (0,0), (x_1, y_1), and (x_2, y_2) is given by the equation

$$y = \left[\frac{y_1 x_2 - y_2 x_1}{x_1^2 x_2 - x_2^2 x_1}\right] x^2 + \left[\frac{x_1^2 y_2 - x_2^2 y_1}{x_1^2 x_2 - x_2^2 x_1}\right] x$$

$450 million. This becomes the basis for generating the economic impacts in the first scenario. It should be noted that the 50 percent reduction scenario requires starting from a ground zero approach, i.e., all newer technologies would be purchased at the beginning of the forecast period.

Combining Efficiency Investments and Control Costs

To provide an alternative comparison, the second scenario assumes a set of energy efficiency investments that lower electricity demand by 30 percent. By definition, this will reduce air pollutants by the same amount (542,000 tons), assuming an average rate of emissions displaced by the efficiency improvements. In that case, efficiency improvements reduce combined SO_2 and NO_x emissions by 327,000 tons. We then assume that Florida will achieve the remaining emission reductions of 215,000 tons through conventional emission controls.

Drawing from a number of engineering-economic studies, we assume a 5-year payback on efficiency technologies implies a $19.2 billion capital cost.[16] Applying the quadratic formula as before implies emission control costs of $1.3 billion together with an annual O&M cost of $156 million. While the costs are clearly higher in this scenario, both household and business consumers will reduce their combined electricity bills by about $3.5 billion on an annual basis. However, we assume that the capital expenditures for both efficiency investments and control costs are spread over a five-year period beginning in 1997. Moreover, we assume the utility costs of the control technologies, also beginning to be installed in 1997, are amortized at 12 percent over 20 years while efficiency investments are amortized at 12 percent over five years (with consumers and businesses borrowing 75 percent of the total investment costs). Based on these assumptions, the 2001 spending patterns for both the emissions control case and the efficiency case scenario are described next.

Changes in Scenario Expenditure Patterns

Tables 3a, 3b, and 3c, below, illustrate how these cost assumptions affect changes in spending and technology investment for each of the years in the analytical period 2001 through 2020. In this case, however, the data are provided only for the years 2001, 2010, and 2020.

Table 3a. 2001Changes in Final Demand by Emission Control Scenario ($MM)

Cost Category	Base Case	Control Case	Efficiency Case
Utility Revenues	12,800	13,752	9,287
Technology Investments	0	760	4,100
Interest Payments	0	440	1,063
Net Residential Costs	0	495	618
Net Commercial Costs	0	343	428
Net Industrial Costs	0	114	143

[16] For a review of such studies and their implied investment costs and energy bill savings, see Alliance to Save Energy, et al, 1997; Bernow, et al., 1998, 1999; Interlaboratory Working Group, 1997, 2000; and Nadel, et al, 2001 (forthcoming).

Table 3b. 2010 Changes in Final Demand by Emission Control Scenario ($MM)			
Cost Category	**Base Case**	**Control Case**	**Efficiency Case**
Utility Revenues	12,052	13,005	8,764
Technology Investments	0	0	0
Interest Payments	0	295	101
Net Residential Costs	0	495	-1,710
Net Commercial Costs	0	343	-1,184
Net Industrial Costs	0	114	-395

Table 3c. 2020 Changes in Final Demand by Emission Control Scenario ($MM)			
Cost Category	**Base Case**	**Control Case**	**Efficiency Case**
Utility Revenues	11,348	11,798	8,100
Technology Investments	0	0	0
Interest Payments	0	0	0
Net Residential Costs	0	234	-1,689
Net Commercial Costs	0	162	-1,169
Net Industrial Costs	0	54	-390

Background on the Florida REMI Model

In order to obtain estimates of the different types of macroeconomic effects of the emission reduction scenarios on the Florida economy, we mapped in the various spending changes shown in the Table 3 series into a well-established analytical tool known as the REMI model.

The REMI model, as Bolton (1985) states in his review of econometric models, "is a world apart in complexity, reliance on interindustry linkages, and modeling philosophy" from other econometric models. Conceptually, the model consists of five basic blocks: (1) output, (2) labor and capital demands, (3) population and labor supply, (4) wages, prices, and profits, and (5) market shares. All of these blocks have been calibrated to the Florida economy using state specific data. The detailed structure of the REMI model requires an extensive amount of data. By translating each of the emission reduction scenarios into changes in sector spending over the full time horizon of the analysis (2001 through 2021), REMI then establishes a new set of economic outputs. These can then be compared to a business-as-usual forecast to determine net changes on Gross Regional Product (GRP) and employment. The results of the two emissions scenarios are described next.

Results of the REMI Analysis

The policy variable categories that were selected for mapping the two Florida emissions models — the Control and the Efficiency scenarios — into the REMI model included:

TABLE 4: REMI INPUTS FOR CONTROL AND EFFICIENCY TECHNOLOGY MODEL ANALYSIS

COST	POLICY VARIABLE CATEGORIES	DETAIL SELECTION
Electrical Utilities Sales (In State)	Output Block→Industry Output→Sales Public Utilities	Sales Share (Electrical Utilities)
Annual Fuel Cost to Commercial and Industrial	Wage, Price and Profit Block→Electricity Fuel Costs (Share)	Commercial and Industrial
Prices (housing and consumer)	Wage, Price and Profit Block→Prices (housing and consumer)→household operation	Equivalent dollar amount
Technology Investments	Output Block→Detailed Production Durables Equipment Spending→Other Equipment Spending	Engines and Turbines Mining and Oilfield Electrical Transmission and Delivery
Interest Payments	Output Block Block→Detailed Industry Block→Finance, Insurance and Real Estate→Credit and Finance Sales	Non-Depository

Once the costs were entered and the analysis had been run, REMI provided numerous economic impacts including effects on the population as well as the economy. The results were expressed in fixed 1992 dollars. To update the results to a 2001 base year, the dollars were inflated using a REMI-generated Consumer Price Index. Tables 5a and 5b show the results for each of the two modeling scenarios. As displayed here, the results represent the economic impacts on employment, gross regional product and real disposable income. The employment results are expressed in terms of thousands of jobs. Gross Regional Product (GRP) and real disposable income results are expressed in terms of billions of dollars.

TABLE 5a: Results of Model 1 Using Only Control Technologies

Year	Employment (Thous)	GRP (Bil 2001$)	Real Disp Income (Bil 2001$)
2001	25.09	1.49	(0.05)
2002	20.93	1.30	(0.11)
2003	17.25	1.13	(0.17)
2004	14.07	0.97	(0.24)
2005	11.25	0.83	(0.30)
2006	8.79	0.70	(0.36)
2007	6.56	0.58	(0.42)
2008	4.64	0.47	(0.47)
2009	2.82	0.37	(0.53)
2010	1.41	0.29	(0.58)
2011	0.06	0.21	(0.62)
2012	(1.24)	0.13	(0.67)
2013	(2.50)	0.06	(0.71)
2014	(3.80)	(0.02)	(0.76)
2015	(5.09)	(0.11)	(0.81)
2016	(6.24)	(0.18)	(0.86)
2017	(7.05)	(0.24)	(0.90)
2018	(7.45)	(0.28)	(0.93)
2019	(7.52)	(0.29)	(0.95)
2020	(7.23)	(0.28)	(0.95)
2021	(6.78)	(0.26)	(0.96)

TABLE 5b: Control Plus Efficiency Technologies (Using a 50% Reduction Strategy):

Year	Employment (Thous)	GRP (Bil 2001$)	Real Disp Income (Bil 2001$)
2001	(18.50)	(3.63)	(0.44)
2002	(15.56)	(3.24)	0.15
2003	(7.72)	(2.61)	0.89
2004	5.38	(1.69)	1.79
2005	23.95	(0.45)	2.89
2006	27.98	(0.04)	3.08
2007	31.12	0.32	3.26
2008	33.63	0.63	3.42
2009	35.26	0.87	3.56
2010	35.61	1.03	3.64
2011	35.67	1.15	3.71
2012	35.36	1.25	3.76
2013	34.82	1.32	3.80
2014	34.18	1.37	3.82
2015	33.40	1.41	3.84
2016	32.40	1.41	3.87
2017	31.58	1.41	3.91
2018	30.79	1.41	3.93
2019	30.06	1.40	3.95
2020	29.42	1.40	3.97
2021	29.15	1.43	3.99

Thus, for the State of Florida, the emission control scenario (Table 5a) would result in an increase of employment of 25,090 jobs for 2001. Employment would continue to decline through the forecasted years, ending with a final decline of 6,778 jobs in 2021. For the efficiency emissions scenario (model 2), employment would initially decrease by 18,500 in 2001. This is because of the considerably higher level of investment in the first year of $4.1 billion in supply and demand conservation investments that temporarily would divert revenues from other sectors. However, after 2003, the employment stimulus from this scenario turns and stays positive and ultimately drives the economy and earnings into positive territory as well with employment reaching a net of 29,150 new jobs by 2021.

GRP for the control model would be show initial increases over the first few years with an increase of approximately $1.83 billion for 2001, but decline throughout the forecasted period, and conclude with a decline of $0.26 billion in 2021 (see Table 5a). Likewise the real disposable income for the control emissions model would experience initial declines of $0.05 billion in 2001 and decline to $0.95 billion by 2021.

By comparison the Efficiency Plus Control Technologies case (Table 5b) starts out with initial GRP declines of $3.63 billion for 2001 but after 2006 turns positive and yields a $1.43 billion increase by 2021. Real disposable income also starts out with a modest decline of $0.44 billion in 2001 and concludes after 2001 with a significant and positive contribution to the Florida economy with income rising thereafter and concluding at $3.99 by 2021.

It should be noted that the 50 percent reduction strategy (of 542,000 combined tons of SO_2 and NO_x emissions) represents much greater capital, and operating and maintenance costs than the current Massachusetts strategy. The efficiency case also incorporated a 30 percent energy demand reduction (or $3.5 billion less in annual utility revenues). This results in a substantial increase in consumer disposable spending that will, in turn, significantly stimulate the economy in a positive way.

Clearly the Efficiency Plus Control Technologies used to reduce emissions by 50 percent generates more positive impact to the Florida economy than the implementation of the Emissions Control strategy alone. At the same time, neither scenario incorporates the benefits to the Florida economy that results from additional environmental or socio-economic enhancements. As described in the section that follows, these could provide a further significant boost to the economy for both the Emissions Control and Efficiency-Led reduction strategies.

CHANGES IN ENVIRONMENTAL BENEFITS

There are significant health and environmental benefits associated with reductions in air pollutant emissions (U.S. EPA Analysis, 2000). These have been reasonably quantified into economic benefits using a variety of statistical techniques. While this analysis estimates the potential economic benefits to Florida from a 50 percent reduction in combined SO_2 and NO_x emissions, we did not attempt to include such estimates in the analysis supported by the REMI model at this time. Based on an estimated 50 percent reduction in SO_2 and a 60 percent reduction in NO_x emissions beyond the national requirements of Title IV of the Clean Air Act Amendments, the EPA analysis determined that health benefits to Florida would be about $5.6 billion by the year 2010 (in 2001$). Calibrating the EPA study to the Florida scenarios described above, we estimate the associated health benefits would approach $4.8 billion (again in 2001$) on an annual basis. This value reflects reduced cases of mortality, respiratory ailments, and lost worker days. However, it does not include improvements in visibility and reduced crop or material damages brought about by acidic deposition. Moreover, these benefits have not been reflected in the REMI analysis described above. To that extent, then, the benefit estimates tend to understate the full returns to the Florida economy.

COMPARISON WITH OTHER STUDIES

DeCanio (1997) notes that because of the many inefficiencies within the economy, economic activity and environmental benefits do not necessarily represent trade-offs. As expressed in a national study (Laitner, et al, 1998), an innovation-led efficiency strategy could simultaneously increase the nation's energy efficiency (thereby reducing air pollutants) while increasing both employment and GDP. In their analysis, the authors found that GDP would increase by 0.03 percent in 2010 with energy use decreasing by about 15 percent. Cleaner energy supply technologies decreased carbon emissions, for example, by a total of nearly 26 percent. In a more recent review, Hanson and Laitner (2000) showed that an investment-led strategy could strengthen GDP increase by 0.5 percent while, at the same time, reducing carbon and other emissions.

Closer to home, a study conducted by the Tellus Institute (Bernow, et al,1999) evaluating the impact of climate change policies on Florida's economy found the net economic benefits to be positive. These included employment, wage and salary earnings, and Gross State Product (GSP). The emissions reduction scenario described in the Florida study included investments in both energy efficient technologies and clean energy technologies. The analysts found that GSP increased by 0.1 percent, a figure consistent with net benefits on the national level. At the same time, trial runs using the REMI model (in Appendixes A and B) indicate that a price shock would reduce economic benefits (Appendix A) while a scenario emphasizing the use of advanced cost effective generation, transmission and end-use technologies could actually increase net economic benefits. Hence, the emission reduction scenarios described in this paper, together with a number of complementary studies underscore the point that environmental quality supported by a cost-effective technology-led policy can lead to a net positive economic gain.

REFERENCES

Alliance to Save Energy, American Council for an Energy-Efficient Economy, Natural Resources Defense Council, Tellus Institute, and Union of Concerned Scientists, *Energy Innovations*, Washington, DC: American Council for an Energy-Efficiency Economy, 1997.

Bernow, Stephen, Karlynn Cory, William Dougherty, Max Duckworth, Sivan Kartha, Michael Ruth, and Marshal Goldberg, 1998. *America's Global Warming Solutions*, Boston, MA: Tellus Institute-Stockholm Environment Institute.

Bernow, Stephen, Karlynn Cory, William Dougherty, Max Duckworth, Sivan Kartha, Michael Ruth, and Marshal Goldberg, 1999. *The Impacts in Florida of a U.S. Climate Change Strategy*, Boston, MA: Tellus Institute.

Bolton, Roger. "Regional Econometric Models." *Journal of Regional Science* 25 (1985): 495-520.

DeCanio, Stephen J., 1997. "Economic Modeling and the False Tradeoff Between Environmental Protection and Economic Growth," *Contemporary Economic Policy*, Vol. 15 (October): 10-27.

Energy Information Administration, 2001. "State Electricity Profiles 2000 — Florida," Washington, DC: U.S. Department of Energy, as downloaded from http://www.eia.doe.gov/cneaf/electricity/st_profiles/florida/fl.html, July 31, 2001.

Halpin, Michael P., Stephen Adams, and Scott A. Goodland, 2001. "The Texas and Massachusetts Power Plant Emissions Strategies and Theoretical Applications in Florida," Tallahassee, FL: Florida Department of Environmental Protection.

Hanson, Donald A. and John A. "Skip" Laitner, 2000. "An Economic Growth Model with Investment, Energy Savings, and CO2 Reductions," presented to Salt Lake City meetings of the Air & Waste Management Association, June 18-22.

Interlaboratory Working Group, 1997. *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy Technologies by 2010 and Beyond*, (Berkeley, CA: Lawrence Berkeley National Laboratory and Oak Ridge, TN: Oak Ridge National laboratory), LBNL-40533 and ORNL-444, September (URL address: http://www.ornl.gov/ORNL/Energy_Eff/CON444).

Interlaboratory Working Group on Energy-Efficient and Low-Carbon Technologies [CEF], 2000. *Scenarios for a Clean Energy Future*, prepared for Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, November (URL address: http://www.ornl.gov/ORNL/Energy_Eff/CEF.htm).

Harvard Center for Risk Analysis, "Health Benefits of Emissions Reductions from Older Power Plants", Jonathan Levy, and J. Spengler, *Risks in Perspective*, April, 2001, www.hcra.harvard.edu.

Krause, Florentin, Stephen DeCanio, and Paul Baer, 2001. *Cutting Carbon Emissions at a Profit: Opportunities for the U.S.,* El Cerrito, CA: International Project for Sustainable Energy Paths.

Laitner, Skip, Stephen Bernow, and John DeCicco, 1998. Employment and Other Macroeconomic Benefits of an Innovation-Led Climate Strategy for the United States, *Energy Policy*, Volume 26, No. 5, pp 425-433.

Nadel, Stephen, and , 2001. *Energy Efficiency Policies for a Strong America*, Washington, DC: American Council for an Energy Efficient Economy, July (forthcoming).

Synapse Energy Economics, Inc. "Use Of Selective Catalytic Reduction For Control Of NO_X Emissions From Power Plants In The U.S." February 2000a

US EPA. “Analyzing Power Generation Under The CAAA”, Appendix K, “Pollution Control Costs.” March 1998

U.S. Environmental Protection Agency, *Analysis of the Acid Deposition and Ozone Act*, Office of Air and Radiation, Clean Air Markets Division, Washington, DC, July 2000.

US EPA. “Controlling SO_2 Emissions: An Analysis of Technologies.” EPA Document EPA/600/SR-00/093. November 2000b

OVERVIEW OF THE FLORIDA TRANSMISSION LINE GRID ENVIRONMENTAL IMPACTS AND CONCERNS AND FUTURE PROSPECTS FOR MITIGATING THESE IMPACTS

Overview of the Florida Transmission Line Grid

Table 6 provides a profile of the total number of miles of transmission lines total land, other (improvements) and total transmission line costs reported for all the utilities in Florida reported on FERC Form 1 each year over the 1995 to 2000 time frame. Note all

TABLE 6

SUMMARY OF FLORIDA TRANSMISSION LINE LINEAR MILES

Year	Transmissio Line	Auxillar Line	# Circuits	Land Cost	Cost	Total Line
1995	12,27	653	1,62	$ 274,619,39	$ 1,644,883,0	$ 1,919,502,4
1996	12,34	688	1,65	$ 306,541,33	$ 1,740,869,0	$ 2,047,410,3
1997	12,41	995	1,69	$ 311,610,55	$ 1,766,209,7	$ 2,077,820,3
1998	12,42	951	1,65	$ 314,597,16	$ 1,795,397,7	$ 2,109,994,9
1999	12,53	956	1,69	$ 318,488,08	$ 1,844,284,0	$ 2,162,772,1
2000	12,68	955	1,71	$ 328,831,57	$ 1,891,377,9	$ 2,220,209,5
2010	13,30	(Estimate) (DEP,				$ 2,363,692,4

*SOURCE: FERC Form 1, pgs. 422-423

costs reported on these forms and used throughout this analysis are book value fully depreciated cost estimates. They provide only a fraction of full market value of these transmission line and land assets and may be five (or many more) times more valuable in a true market place. These data are provided only as points of reference for policy consideration and not intended as a full asset value evaluation.

The last line of Table 6 and Figure 10 also provide a forecast of the projected number of

Figure 10

new circuit line miles of needed new transmission lines that are projected to be added through 2010. Table 6 also includes a projection of and total cost while Figure 11 and Tables 6 and 7 provide estimates of total new acreage required to accommodate these new lines. According to DEP estimates each linear mile of transmission line on average requires 11 acres of dedicated land. According to these FERC data in 2000 Florida was host to 13,636 linear miles of transmission and auxiliary lines of all voltages. Given these estimates this means that the state of Florida has dedicated 149,993 acres of land for direct transmission line use across the state.

The future ten-year projections suggest the state transmission lines will need to expand by an additional 538 miles for just the 230 and 500 kV line needs. These expansions are estimated to consume an additional 6,797 acres of land across the state to accommodate these new increases alone (see Table 6 and Figures 10 and 11 and Map 4). Indirect impacts of transmission line disruption such as visual aesthetic and recreational impacts, disruption of wetlands and risks of water quality contamination and wildlife disruption and other potential effects extend far beyond these acres and effect many times this acreage across the state.

The forecast level of need is drawn from the 2000 Ten Year Site Plan and provided by staff of the Department of Environmental Protection. The detailed break out of number of projected new miles planned by voltage and company are provided in Table 7. A generalized profile of the current and projected future 230 and 500 kv

Figure 11

voltages Florida transmission line alignments are provided in Maps 1 through 5 with Map 5 providing an overview of planned expansion of just the future needs.

Table 7

Estimated Number of Circuit Miles and Acreages Which Will Be Affected For 230 And 500 kV Transmission Lines To Be Built In The 2000 - 2009 Timeframe

Utility	Beginning Point	End Point	Com-mercial In-Service Year	Nominal Design Voltage	Circuit Miles	Avg. ROW width in feet[1]	Acres
FPL	Dade	Levee	2000	230	5	105	64
FPL	Aventura	Greynolds	2000	230	2	105	25
FPL	Broward	Yamato	2000	230	3	105	38
FPL	Broward	Ranch	2000	230	9	105	115
FPL	Flagami	Turkey	2000	230	2	105	25
FPL	Sanford	Volusia	2000	230	3	105	38
FPL	Calusa	Ft. Myers	2000	230	2	105	25
FPL	Ft. Myers	Orange	2000	230	3	105	38
FPC	Lake	Intercession City #	2000	230	10	105	127
FPL	Ft.Myers	Orange	2000	230	3	105	38
FPC	Rio Pinar	Stanton#2	2000	230	3	105	38
OUC	Stanton	Rio Pinar	2000	230	6	105	76
JEA	Duval	Steelbald	2001	230	4	105	51
JEA	Steelbald	Brandy Branch Ckt	2001	230	4	105	51
JEA	Duval	Brandy Branch Ckt	2001	230	3	105	38
JEA	Duval	Brandy Branch Ckt	2001	230	3	105	38
JEA	BrandyBranc	Normandy Ckt	2001	230	9	105	115
JEA	Brandy	Normandy Ckt	2001	230	9	105	145
FPL	Broward	Corbett	2001	230	2	105	25
FPL	Greynolds	Laudania	2001	230	7	105	89
FPL	Poinsett	Sanford	2001	230	45	105	573
FPL	Poinsett	Sanford	2001	230	45	105	573
FMP / KUA	Cane	Intercession	2001	230	4	105	51
LAK	Eaton	Crews	2001	230	10	105	127
JEA	Center	Forrest	2001	230	5	105	64
JEA	Forrest	Greenland	2001	230	8	105	102
JEA	Center	Northside	2001	230	11	105	140
TEC	South Gibsonton	Gannon	2002	230	1	105	13
TEC	SR 60	River	2002	230	1	105	13
FPC	Taylor	Holopaw	2002	230	1	105	13
FPC[4]	Barcola	Pebbledal	2003	230	1	105	0
FPC	Hines Energy Complex	Barcola	2003	230	3	105	15
JEA	Cecil Field	Cecil Commerce	2003	230	7	105	89

Table 7, continued							
Utility	Beginning Point	End Point	Commercial In-service Year	Nominal Design Voltage	Circuit Miles	Avg. Row Width in Feet	Acres
JEA	Cecil Field	Cecil Commerce S.	2003	230	7	105	89
JEA	East Jax	Nocatee	2003	230	4	105	51
JEA	Nocatee	East Jax	2003	230	4	105	51
JEA	Firestone	Jax Heights	2003	230	3	105	15
JEA	Jax Heights	Firestone	2003	230	3	105	15
FPL	Broward	Corbett	2003	230	11	105	140
TEC	Gannon	Juneau	2003	230	15	105	191
TEC	Juneau	Ohio	2003	230	5	105	64
TEC[4]	Pebbledale	Barcola	2003	230	3	105	0
JEA	Center Park	Greenland	2003	230	19	105	242
TEC	Dale Mabry	Juneau	2004	230	11	105	140
JEA	Center Park	S. Kernan	2004	230	0	105	0
JEA	S. Kernan	Greenland	2004	230	0	105	0
FPC	Lake Bryan	Windermere #2	2005	230	10	105	127
FPC	Hines Energy	Westlake Wales #1	2005	230	21	105	267
JEA	Sjrpp	Patillo	2005	230	2	105	25
JEA	Patillo	Normandy	2005	230	2	105	25
FPL	Yulee	Oneil	2005	230	7	105	89
TEC	Gannon	Davis	2005	230	15	105	191
TEC	Polk	Lithia	2006	230	22	105	280
FPC	Perry	Drifton	2007	230	35	105	445
FPC	Intercession City	West Lake Wales #2	2007	230	30	105	382
TEC	Lithia	Wheeler	2007	230	11	105	140
TEC	Lithia	Davis	2008	230	14	105	178
FPC	Hines Energy Complex	West Lake Wales #2	2009	230	21	105	267
FPC	Intercession City	Gifford	2009	230	10	105	127
FPC	Gifford	Avalon	2009	230	10	105	127
TEC	Chapman	Davis	2009	230	9	105	145
					Acres Needed[2,3,4,5]	TOTAL	6,796

1. Averages Calculated from Table B, below. Sources for the numbers are certified transmission line applications.

2. Not all amount of a ROW may need to be newly cleared, depending on collocation with other features or circuits.

3. Acreage calculated as follows: (miles in length) times (average feet ROW width for that size line) divided by 43,560 [size of an acre in square feet].

4. This line is a rebuild of an existing circuit.

5. Source for Right of Way width averages (derived from Certification Applications)

transmission lines are by their very nature direct and indirect large users of land across Florida and future needs will dictate considerable expansion of the existing linear corridors across each region of the state. Disruptions of wetlands, and other incompatible land uses make the placement of needed transmission lines both very expensive, complicated and often very contentious. These factors tend to delay construction of new expansions and result in long time delays in implementation of needed new infrastructure. According to experts that testified before our Environmental Technical Advisory Committee, emerging super conducting technologies and the prospect of distributed generation hold out the potential promise of significantly minimizing a number of these potential disruptive land use and environmental disruptions 2020 time frame of our analysis. The super conducting technologies may very well even help reduce the magnitude of ***existing*** transmission lines as they are refurbished, rebuilt and ultimately upgraded[17].

The Prospects of Super Conducting Technologies

An example of the prospects of this technology is taken directly from testimony that was provided to Congress this summer by a group of experts in the field[18] reported in the Federal Register. A summary of that testimony provided by our TAC member, Dr. Skip Laitner, EPA Economist follows.

The Environmental and Energy Study Institute[19] heard from industry leaders and the U.S. Department of Energy[20] about the latest developments in electric power applications of high-temperature superconductivity (HTS), and how public-private partnerships are helping to move these new technologies toward the commercial marketplace. High-temperature superconductivity technologies are critical to solving transmission bottlenecks, system gridlock, and power reliability. As Congress debates energy policy and solutions to the nation's energy challenges, this briefing outlines HTS power applications, their costs and benefits, and the potential for HTS in solving existing energy sector problems.

Superconductivity is the ability of certain materials to conduct electrical current with no resistance and extremely low losses. Advocates of superconductivity claim that once implemented in our nation's electricity infrastructure, HTS power applications will generate and transmit electricity in a clean and highly reliable manner, with the potential to create an electric superhighway without bottlenecks or system gridlock. Proponents believe this power technology will conserve energy dramatically, help protect the environment and save tremendous amounts of money due to reduced energy losses.

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[17] See for example the testimony and presentation of Eric Snitgen, VP., American Superconductors, Inc., July, 2001, before the 2020 Environmental Technical Advisory Committee

[18] Superconductivity: A Breakthrough in Electrical Technology Enhancing Power Capacity, Increasing Energy Efficiency, and Protecting the Environment, Friday, August 3, 2001, 2168 Rayburn House Office Building

[19] For more information, please contact Beth Bleil of EESI at 202-662-1885 or bbleil@eesi.org.

[20] Superconductivity: A Breakthrough in Electrical Technology Enhancing Power Capacity, Increasing Energy Efficiency, and Protecting the Environment, 10:00 - 12:00 a.m., Friday, August 3, 2001
2168 Rayburn House Office Building

Over seven percent of energy generated is lost in transmission due to heat losses and inefficiency, and superconductivity could reduce this loss by 50 percent. Industry sources project that once available in the market, the cost of super conducting power applications will drop dramatically and realize cost savings within 2-4 years.

HTS power applications include cables, transformers, motors, generators, and other power technologies. HTS power cables can carry three to five times more power than conventional cables while using the same amount of space. In addition, HTS cables can be used underground in areas where more power is needed but space for additional lines is not available. HTS power transformers are more efficient, smaller, lighter, and do not require cooling oil, which eliminates fire and environmental hazards and allows them to operate almost anywhere. When compared to conventional motors, HTS motors are smaller, lighter and 50 percent more efficient, as well as being lower in life cycle costs. According to Rockwell Automation, HTS motors could save more than $300 million annually from efficiency savings and environmental emissions could be reduced significantly (42,000 tons of SO_2, 25,000 tons of NO_x, and 8,000,000 tons of CO_2).

The Superconductivity Partnership Initiative (SPI) is a cost-shared, collaborative effort of private industry and the federal government. A number of pilot projects, led by teams of industry and national laboratory representatives, have been field-tested at various locations in the United States, and these projects have demonstrated the enormous potential of high-temperature superconductivity. The expert panel, which will discuss their HTS projects and involvement with SPI, includes:

- Robert Dixon, Deputy Assistant Secretary, Office of Power Technologies, U.S. Department of Energy

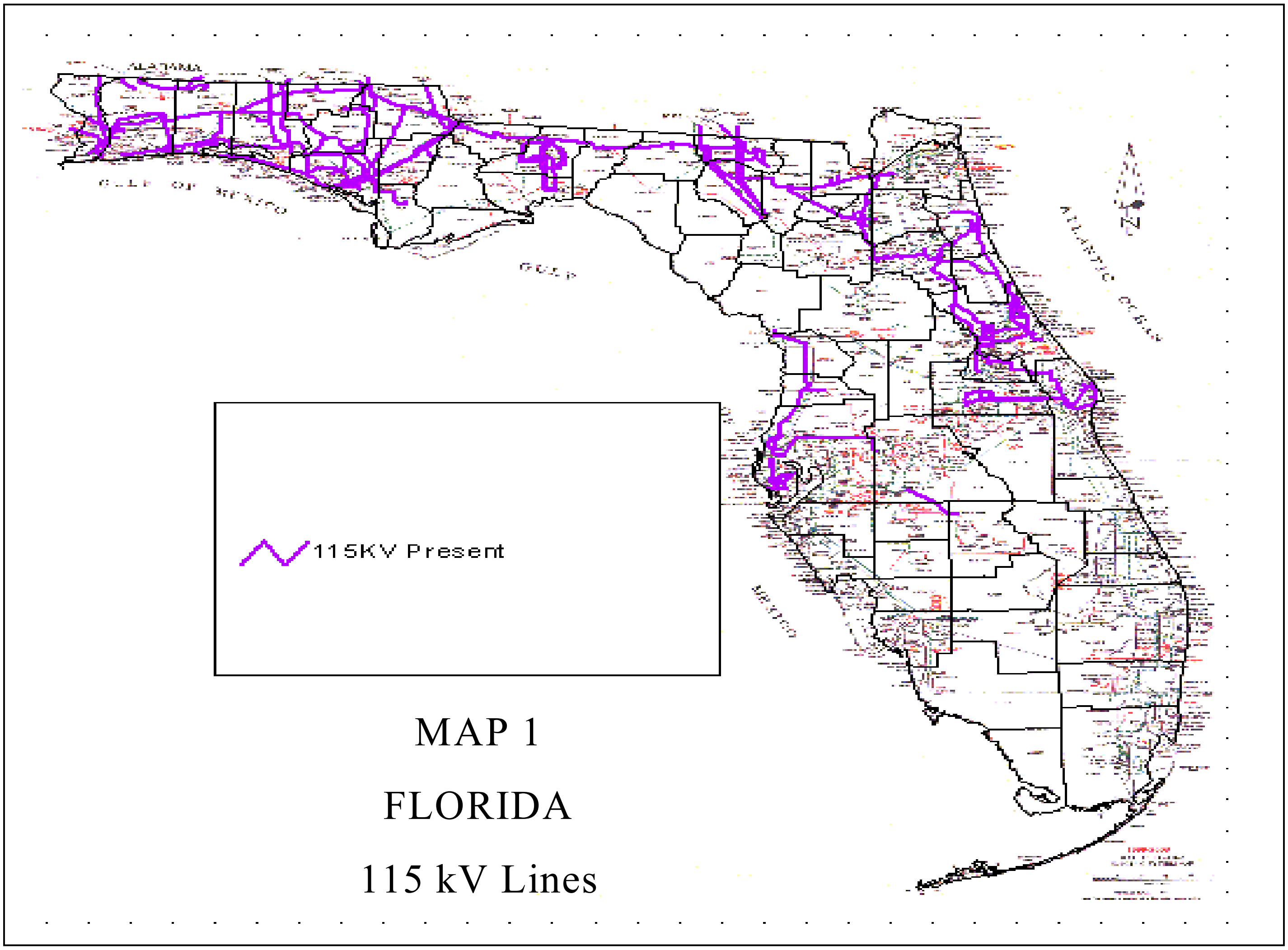
- David Lindsay, Development Engineer, Southwire Company. The Southwire Company became the world's first company to provide electricity utilizing high-temperature superconductivity for an industrial use. They installed three 100-foot HTS power cables in February 2000, which provide power to two of Southwire's plants and its machinery division. Headquartered in Carrollton, Georgia and with annual sales of $1.7 billion, Southwire Company is one of the world's leading wire and cable manufacturers.

- Jon E. Jipping, Principal Engineer, Power Delivery Planning, Detroit Edison. Detroit Edison will ribbon-cut a project this fall, in which three HTS power cables will be installed at their Frisbie Substation, one of the oldest locations on the Detroit Edison system. The HTS cables weigh about 1,000 pounds and will replace nine conventional copper cables, which weigh about 20,000 pounds. Detroit Edison is the nation's seventh-largest electric utility, and serves more than 2 million customers in Southeastern Michigan.

- Shirish Mehta, Vice President of Technology and Development, Waukesha Electric Systems. Waukesha Electric Systems is constructing an HTS power transformer, which will be installed on the Wisconsin Electric Power utility grid next year. Waukesha Electric Systems is a leading producer of medium and large-size power transformers, and is based in Waukesha, Wisconsin, with power-transformer-manufacturing plants in Waukesha, Wisconsin; Goldsboro, North Carolina; and Milpitas, California.

- David Driscoll, Research Manager of the Super conducting Motor Lab, Rockwell Automation. Rockwell Automation has demonstrated a 200 horsepower(hp) HTS motor and a 1,000 hp HTS motor and is working to develop a 5,000hp HTS motor. Rockwell Automation, a $4.3 billion company headquartered in Milwaukee, Wisconsin, employs approximately 25,000 people at more than 450 locations in more than 80 countries, and is a world-leading provider of industrial automation power, control and information solutions. The Super conducting Motor Lab for Rockwell Automation is in Euclid, Ohio.

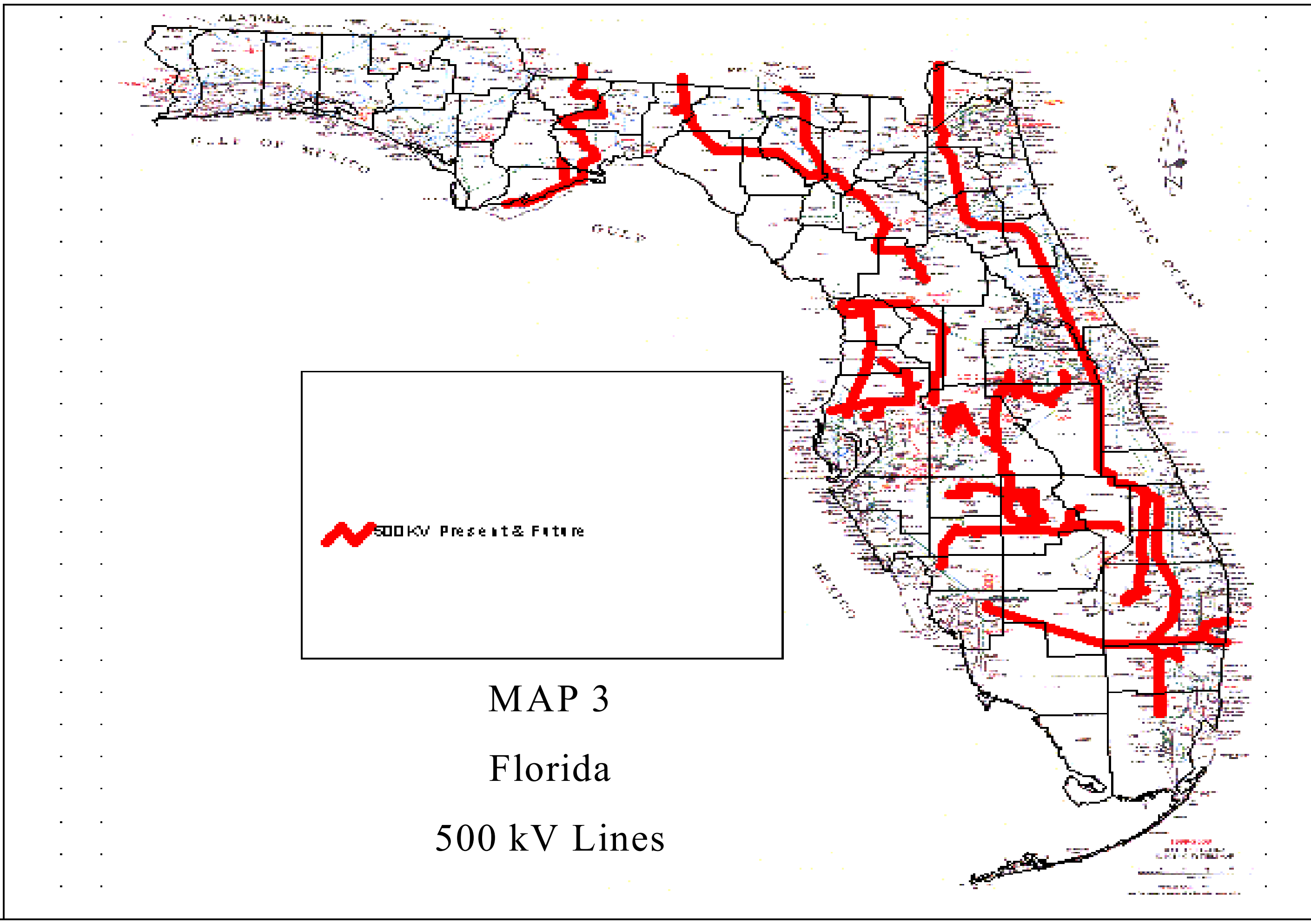
John Howe, Vice President, Electric Industry Affairs, American Superconductor. American Superconductor recently demonstrated a 5,000 horsepower HTS motor and is a partner with Detroit Edison's HTS cable project. American Superconductor, founded in 1987 and headquartered in Westborough, Massachusetts, is a leader in developing technologies and manufacturing products utilizing superconductor wire and solid-state power electronic switches for electric power applications, such as power cables, motors and generators.



MAP 1

FLORIDA

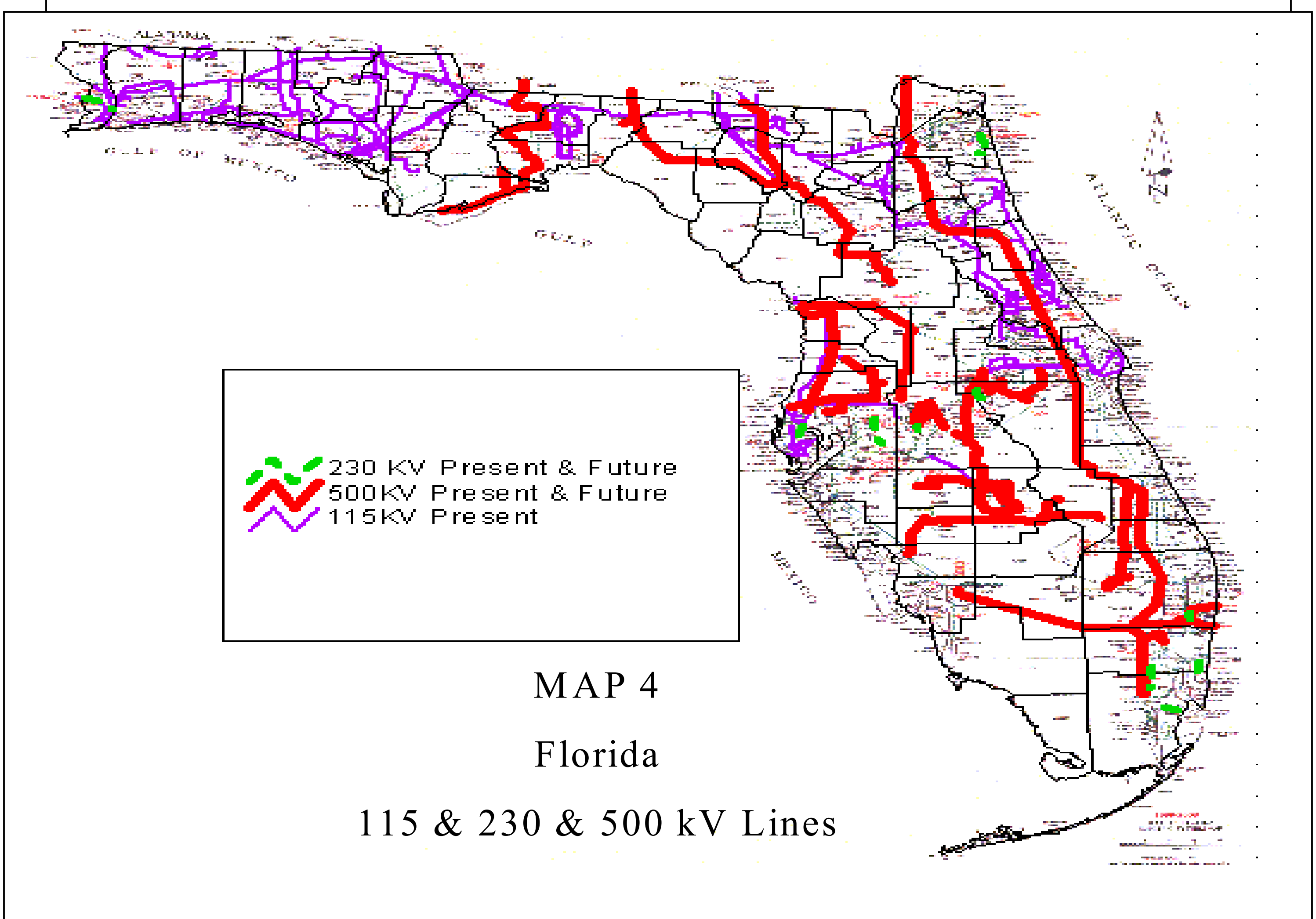
115 kV Lines



MAP 3

Florida

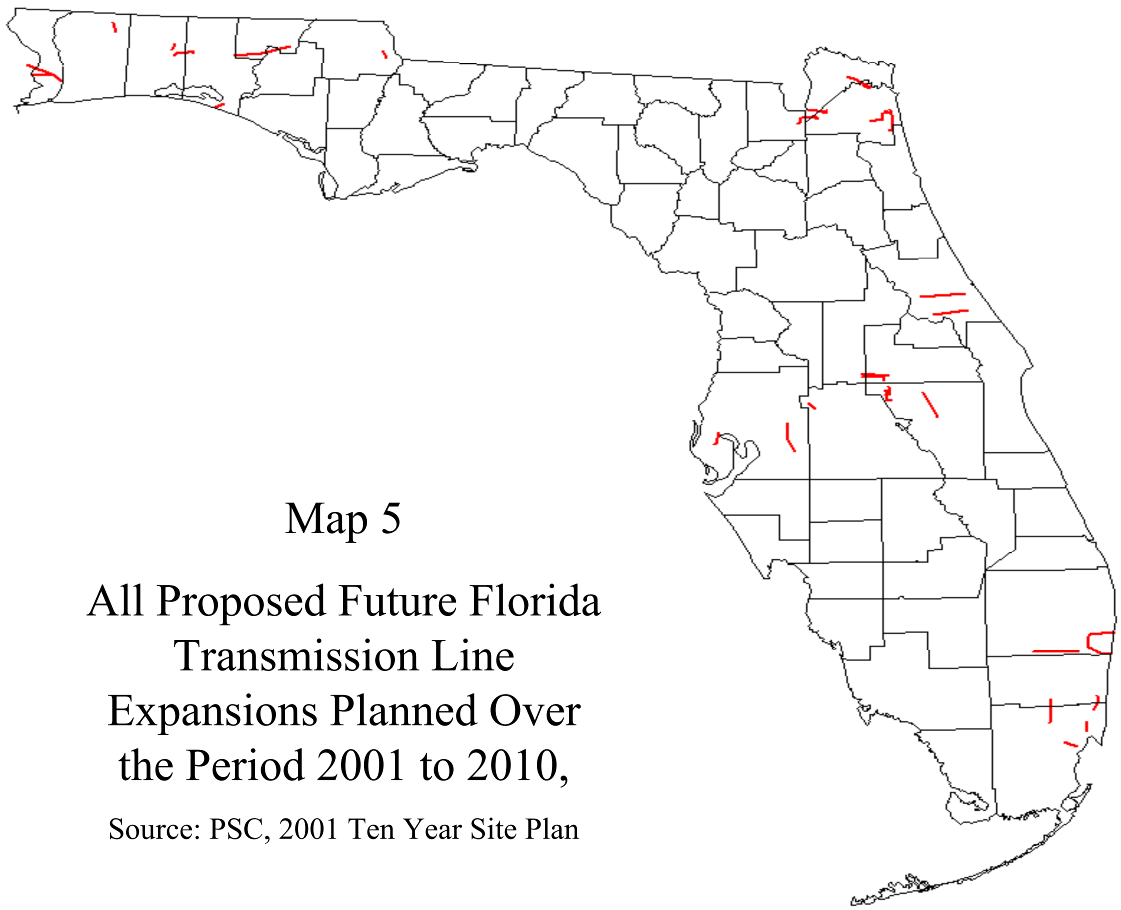
500 kV Lines



MAP 4

Florida

115 & 230 & 500 kV Lines



Map 5

All Proposed Future Florida Transmission Line Expansions Planned Over the Period 2001 to 2010,

Source: PSC, 2001 Ten Year Site Plan

Appendix A

INTRODUCTION TO THE REMI MODEL

The REMI model, as Bolton (1985) states in his review of econometric models, "is a world apart in complexity, reliance on interindustry linkages, and modeling philosophy" from other econometric models. The REMI model is more than an econometric model, though. It may better be described as an eclectic model that links an input-output model to an econometric model. If the econometric responses are suppressed, the model collapses to an input-output model. The econometric specifications are derived from economic theories that are-generally neoclassical in nature. The notion of regional equilibrium is central to the model's long-term portrait of regional economic growth.

Conceptually, the model consists of five basic blocks: (1) output, (2) labor and capital demands, (3) population and labor supply, (4) wages, prices, and profits, and (5) market shares.

The output block contains the input-output component of the model. Final demands drive the output block. Production uses factor inputs, labor, capital and fuel, and intermediate inputs. Coefficients of the production functions are based on national input-output tables produced by the Bureau of Labor Statistics. Intermediate inputs are used in fixed proportions. Factor input use is governed by Cobb-Douglas functions in Block 2. The relative factor intensities respond to changes in relative factor costs (i.e., wage rate changes, cost-of-capital changes, and changes in fuel prices).

Labor supply in Block 3 responds positively to wage rates because of migration. Also, the ratio of residence- adjusted employment to the potential labor force influences migration. Place-of-work income also is adjusted for place of residence to obtain disposable income. The interaction of labor demand calculated in Block 2 and of labor supply calculated in Block 3 determines wage rates in Block 4. Migration induces government spending through additional taxes paid and consumer spending through increased wage and non-wage income. The increase in real disposable income derived from migration also stimulates residential investment. Nonresidential investment is stimulated by increased capital demand by businesses.

Wage rates affect the competitiveness of local firms relative to firms in other regions in Block 5. Regional competitiveness affects the shares of local and exports markets (market shares) that local firms capture. The proportion of the local market captured is known as the regional purchase coefficient (RPC), and the proportion of the export market is known as the interregional and international coefficient. Also, the RPC, which is a measure of self-sufficiency, increases as a region grows because of agglomeration effects.

Endogenous consumption, investment, and government expenditures plus exports are the final demands that drive the output block. The endogenous RPC gives the proportions of local expenditures satisfied by imports or local production. Solution values for the endogenous variables in the REMI model must satisfy the equations in all five blocks simultaneously.

By suppressing certain endogenous responses in the REMI model, multipliers comparable to those computed from an input-output model can be obtained. If the responses of labor intensities, labor supply, wage rates, industry RPC's, and endogenous final demands are suppressed, Type I input-output multipliers are obtained. By allowing consumption to be endogenously determined, Type II multipliers are obtained. Complete endogeneity in the REMI model produces what is referred to as Type III multipliers. This Type III multiplier differs from standard Type III input-output multipliers because of the endogeneity of export and propensity to import responses in the REMI model.

The detailed structure of the REMI model requires an extensive amount of data. The input-output component is non-survey based, using national technical coefficients. Of particular importance are data on employment, income, and output. Also, because complete regional accounts consistent with the National Income and Product Accounts are not routinely available, they must be constructed.

REMI uses three sources of employment and wage and salary data: the Bureau of Economic Analysis (BEA) employment, wage, and personal income series, ES-202 establishment employment and wage and salary data, and County Business Patterns (CBP) data published by the Bureau of the Census. The BEA data are annual averages and are reported at the two-digit level for states and at the one-digit level for counties. The ES-202 data, the foundation for the BEA data, are collected monthly in conjunction with the unemployment insurance program at the two-digit level for counties and states, and they are the foundation for the BEA data. CBP data are collected in conjunction with the Social Security program in March of each year.

Confidentiality requirements produce many suppressions in the data. Where suppressions occur, the number of establishments and the ranges of the number of employees for each establishment are supplied by CBP. REMI fills in the suppressions based on the hierarchical structure of the BEA data within regions and within industries. First, all two-digit S.I.C. industries are made consistent within the corresponding one-digit industries for each state simultaneous with all two digit industries summed to the major region two-digit totals. Second, for counties REMI uses the ES-202 data, if available, and CBP data if ES-202 data is not available. Whichever data set is selected, it is made consistent with BEA one-digit county totals and state two-digit totals.

Output measures are based on regional employment data, the BEA Gross State Product series, and national output-to-employment ratios. REMI begins by applying the national output-to-employee ratio to employment by industry. This application is adjusted by regional differences in labor intensity and total factor productivity. Regional differences in labor intensity are given by the industry production function and the unit factor costs. Total factor productivity calculations depend on industry value added in production reported in real U.S. dollars by BEA and on adjustments by REMI to the BEA numbers to reflect differences in regional production costs. The ratio of real regional value added per unit of input relative to U.S. value added per unit of input is the REMI relative total factor productivity.

REMI Ten Percent Price Shock Model Framework:

The policy variable categories that will be used are selected. The corresponding REMI sectors for the costs in this price shock model are the following:

TABLE 1: REMI INPUTS FOR TEN PERCENT PRICE SHOCK ANALYSIS

COST	POLICY VARIABLE CATEGORIES	DETAIL SELECTION
Electrical Utilities Sales (In State)	Output Block→Detailed Industry Output→Transportation and Other Public Utilities→Public Utilities	Electrical Utilities
Annual Fuel Cost to Commercial and Industrial	Wage, Price and Profit Block→Electricity Fuel Costs (Share)	Commercial and Industrial
Annual Fuel Cost to Residential	Wage, Price and Profit Block→Prices (housing and consumer)	Household Operation
Government Spending (or additional state taxes collected)	Output Block→Government Spending (amount)	State

Once these sectors have been chosen, REMI will allow you to input the costs on a year-by-year basis. Once the costs have been entered and the analysis has been run, REMI will provide numerous economic impacts including effects on the population as well as the economy. The annual fuel costs (for commercial and industrial sectors) were projected to increase ten percent throughout the forecast horizon (from 2001 to 2021). The cost of the increase in electricity prices was estimated to be ten percent of electric revenue from sales to residential customers, obtained from the Electric Sales and Revenue report, published by the Energy Information Administration (EIA), for 1999. Regarding the government spending sector, the ten percent rise in electricity prices corresponded to a 9.5 percent increase in gross receipts tax from electricity sales (given the inelastic nature of electricity demand), or for given current tax estimates; an additional $34 million in state government tax receipts. The "balanced budget" approach was selected for this price shock model, thereby reducing government spending by an additional $34 million per year.

The results were expressed in fixed 1992 dollars, thus the dollars were inflated to express them in current year 2001 dollars. From the REMI results, the PCE-Index (the equivalent REMI-generated CPI index) is 117.732 and the 1992 CPI is 98.786. The inflator to convert 1992 dollars to year 2001 dollars is:

$$(CPI\ 2000)/(CPI1992) = 117.732/98.786 = 1.191788$$

The results that are for the following categories (Table 2 and Figures 1 and 2):

TABLE 2: TEN PERCENT PRICE SHOCK ECONOMIC IMPACTS (INPUT 2001$)

Year	Employment (Thous)	GRP (Bil 2001$)	Real Disp Income (Bil 2001$)
2001	(27.74)	(1.47424)	(1.60891)
2002	(28.03)	(1.56720)	(1.68161)
2003	(28.35)	(1.65301)	(1.74955)
2004	(28.59)	(1.72928)	(1.81390)
2005	(28.79)	(1.79960)	(1.87826)
2006	(28.94)	(1.86634)	(1.94023)
2007	(29.15)	(1.93308)	(2.00340)
2008	(29.34)	(1.99386)	(2.06299)
2009	(29.57)	(2.04273)	(2.12734)
2010	(29.73)	(2.09516)	(2.18693)
2011	(29.96)	(2.14879)	(2.24652)
2012	(30.10)	(2.19527)	(2.29419)
2013	(30.24)	(2.24175)	(2.33948)
2014	(30.39)	(2.28704)	(2.38358)
2015	(30.51)	(2.33114)	(2.42410)
2016	(30.60)	(2.37166)	(2.46104)
2017	(30.69)	(2.41218)	(2.49680)
2018	(30.72)	(2.44912)	(2.52659)
2019	(30.72)	(2.48250)	(2.55281)
2020	(30.68)	(2.51348)	(2.57545)
2021	(30.62)	(2.54208)	(2.59691)

The results represent the economic impacts on employment, gross revenue product and real disposable income. The employment results are expressed in terms of thousands of jobs and GRP and real disposable income results are expressed in terms of billions of dollars.

Thus, for the State of Florida, a ten percent increase in the price of electricity across the commercial, industrial and residential sectors would result in a loss of employment of 27,740, for 2001. This corresponds to a reduction of approximately half-percent of Florida’s total current employment levels. As expected, a ten percent increase in the price of electricity would also result in a decrease in GRP and real disposable income.

References

Bolton, Roger. "Regional Econometric Models." *Journal of Regional Science* 25 (1985): 495-520.

"Regional Economic Modeling A Systematic Approach to Economic Forecasting and Policy Analysis", Treyz, I., George, University of Massachusetts at Amherst, 1993, Kluwer Academic Publishers, Third Printing 1994.

Figure 1. A Drop in Florida Employment Resulting from a Ten Percent Increase in Electricity Prices.

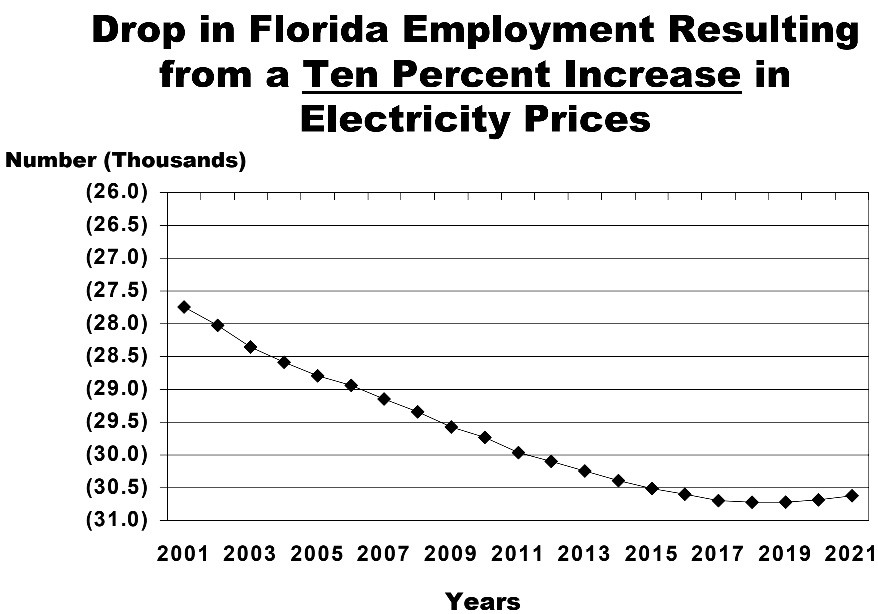
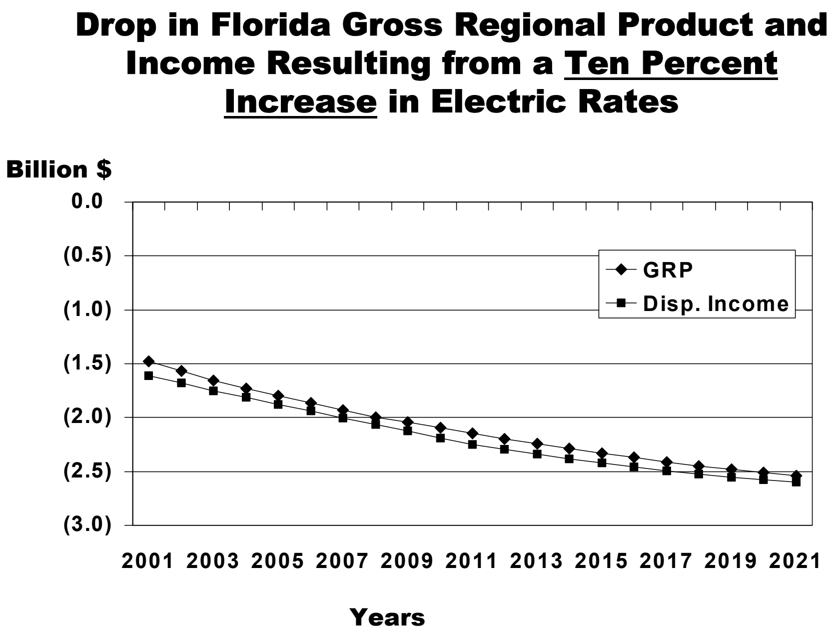


Figure 2. A Drop in Florida Gross Regional Product and Income Resulting from a Ten Percent Increase in Electric Rates.



APPENDIX B

GETTING READY FOR NEW TECHNOLOGIES: RENEWABLES AND DISTRIBUTED

Emphasizing the use of advanced cost effective generation, transmission and end-use technologies such as super conducting electric motors, and generators, transmission lines, SMES (super conducting electromagnetic storage systems) can considerably reduce electricity consumption and power plant emissions. The transition to a more efficient economy on both the demand and supply sides is about:

- Investing in new technologies
- Putting America's technological leadership to competitive advantage: and
- Developing new ways to make things, and new ways to get where we want to go, where we want to work, and where we want to play in cost and energy effective ways while minimizing environmental degradation.

One EPA study, Scenarios for a Clean Energy Future, indicates that cost effective end-use technologies alone might reduce electric consumption by almost 1,000 billion Kwh by 2020. This level of savings in the US markets alone is more than Japan now uses for its entire economy. (See http://www.ornl.gov/ORNL/Energy_Eff/CEF.htm for more details on this study).

Implementation of advanced technologies also provides a win-win-win conclusion for our economy, energy demands and environment. These new technologies provide enhancements of economic productivity and increases in power supply quality while reducing energy demand, waste generation and risk and environmental degradation. Advanced technologies introduced into the American workplace over the past several decades have actually helped reduce the demand for electricity while increasing economic productivity.

A recent Lawrence Berkeley National Laboratory indicates that the Internet and all electronic equipment only consume 1 and 3 percent respectively (see http://n4e.lbl.gov) of the overall demand for electricity. These different information and communication technologies integrated into the American workplace have already contributed to increasing opportunities for energy savings and large productivity gains in business. The benefits range from improved cost accounting and benchmarking, reduced warehousing and inventory needs, and internet-brokered sales and service.

The resulting higher environmental economic externality costs are increasingly possible to measure and evaluate in quantitative terms. Development of advanced computer based environmental-economic modeling techniques is increasingly helping us to evaluate and understand the potential tradeoffs alternative policy decisions we face in deploying these technologies. For example, the following analysis uses the REMI macro economic modeling tool to evaluate the economic impact of implementing advanced super conducting technologies in Florida and the economic stimulus these technologies may have on the state's economy.

REMI High Technology Superconductivity (HTS) Model Framework

HTS technology is beginning to make inroads in the electric utilities industry with several national electric utilities serving as pilot projects for implementation of HTS equipment technologies. By definition, superconductivity is the property of a material to conduct unusually large quantities of electrical current with virtually no resistance. The low temperature conductivity (LTS) technologies were expensive to cool to the required temperature of liquid helium (4K). Currently, however, the new HTS technology requires approximately 25 times less energy than the LTS to cool to the temperature of liquid nitrogen (77K). The benefits of HTS, when compared to LTS technologies, are tremendous in terms of cost savings: helium costs about $5.00/liter whereas liquid nitrogen costs $0.10/liter.

Few economic studies have been performed regarding HTS technology in the electrical utilities industry. One recently completed study, by L.R. Lawrence and Craig Cox, and funded by the Office of Energy Efficiency and Renewable Energy, examined the currently available HTS products and benefits. The authors attempted to quantify HTS annual benefits, to 2020, by examining five classes of HTS electrical equipment (electric motors, transformers, generators, underground cable, and fault current limiters), and projecting market entry dates and total annual savings, among other variables.

The projected entry dates where the HTS is expected to capture 50% of the potential market are as follows:

Equipment	**Motors**	**Transformers**	**Generators**	**Underground Cable**
50% of market (Year)	2016	2015	2021	2013

Two scenarios were developed for predicting benefits for the HTS equipment. The first case was based on electrical generation and equipment market growth averaging 2.5% per year through 2020. This number was chosen based on historic figures from 1990 – 1998 and the assumption that a strong economy will continue this kind of growth. The second case followed present Energy Information Administration (EIA) projections of 1.4% growth, with somewhat more conservative results. Benefits calculated are determined by the value of electricity saved that would otherwise by wasted. Operational benefits were not quantified.[1]

Using REMI, two scenarios were developed that simulated the Lawrence study benefits applied to the State of Florida. One model simulated the 2.54% growth rate and the other model represented the 1.4% growth rate in demand for the electrical industry. The models were initially created, based on REMI's national simulation model, because the Lawrence study pertained to HTS national results. Subsequently, the REMI regional (Florida) simulation model was run, using the base underlying national model. The 2.5% and 1.4% growth rates were adjusted accordingly to account for the built-in REMI national model's electric industry growth rate. Additional assumptions used for both REMI models included for HTS technologies: a decrease in the price of electricity of 0.9%/year in the commercial and industrial sectors (from the Lawrence study), and a decrease in household consumer expenditure price index of 0.03% (household savings/household consumption). The HTS technologies are assumed to save the U.S $18.24 Billion per year in presently envisioned equipment (10% market penetration is assumed within the first five years, and 50% market penetration is assumed after five years. These assumptions are incorporated into the $18.24 Billion annual benefits).

The policy variable categories that were selected for the national model included:

TABLE 3: REMI INPUTS FOR HTS ANALYSIS

COST	POLICY VARIABLE CATEGORIES	DETAIL SELECTION
Electrical Utilities Sales (In State)	Output Block→Industry Output→Sales Public Utilities	Sales Share (Electrical Utilities)
Annual Fuel Cost to Commercial and Industrial	Wage, Price and Profit Block→Electricity Fuel Costs (Share)	Commercial and Industrial
Prices (housing and consumer)	Wage, Price and Profit Block→Prices (housing and consumer) CEPI	All personal household consumption expenditures

Once the costs were entered and the analysis had been run, REMI provided numerous economic impacts including effects on the population as well as the economy.

The results were expressed in fixed 1992 dollars, thus the dollars were inflated to express them in current year 2001 dollars. From the REMI results, the PCE-Index (the equivalent REMI-generated CPI index) is 117.732 and the 1992 CPI is 98.786. The inflator to convert 1992 dollars to year 2001 dollars is:

$$(CPI\ 2000)/(CPI1992) = 117.732 / 98.786 = 1.191788$$

The results that are for the following categories: (Tables 4 and 5; Figures 3 through 5)

TABLE 4: HTS Technologies (2.54% Growth Rate)

Year	Employment (Thous)	GRP (Bil 2001$)	Real Disp Income (Bil 2001$)
2001	9.889	0.573287	0.313544
2002	3.664	0.217700	0.146321
2003	0.701	0.033528	0.076225
2004	0.775	0.037150	0.086593
2005	0.797	0.036283	0.095536
2006	0.800	0.035226	0.101011
2007	0.782	0.032590	0.104634
2008	0.764	0.028421	0.108078
2009	0.754	0.026093	0.111486
2010	0.750	0.023848	0.113339
2011	0.753	0.021746	0.115477
2012	0.750	0.018563	0.118589
2013	0.753	0.016307	0.119836
2014	0.762	0.014644	0.121023
2015	0.764	0.012613	0.121023
2016	0.766	0.010221	0.120905
2017	0.770	0.006669	0.123755
2018	0.776	0.004422	0.123755
2019	0.787	0.002609	0.124111
2020	0.791	0.000145	0.123518
2021	0.792	(0.00261)	0.122850

TABLE 5: HTS Technologies (1.4% Growth Rate)

Year	Employment (Thous)	GRP (Bil 2001$)	Real Disp Income (Bil 2001$)
2001	8.557	0.47974	0.29887
2002	3.549	0.19965	0.15877
2003	0.720	0.02941	0.08279
2004	0.767	0.03148	0.09089
2005	0.781	0.03123	0.09683
2006	0.779	0.02952	0.10144
2007	0.769	0.02607	0.10619
2008	0.747	0.02292	0.10771
2009	0.744	0.02059	0.11054
2010	0.741	0.01828	0.11231
2011	0.746	0.01646	0.11417
2012	0.748	0.01458	0.11537
2013	0.754	0.01248	0.11638
2014	0.758	0.01037	0.11699
2015	0.764	0.00849	0.11728
2016	0.764	0.00442	0.11967
2017	0.773	0.00247	0.12014
2018	0.781	0.00044	0.12038
2019	0.789	(0.00152)	0.12038
2020	0.793	(0.00442)	0.11967
2021	0.797	(0.00704)	0.11919

The results represent the economic impacts on employment, gross revenue product and real disposable income. The employment results are expressed in terms of thousands of jobs, and GRP and real disposable income results are expressed in terms of billions of dollars. One can expect that an increase in energy demand result in an increase in sales (revenues), which would result in an increase in employment and intermediate inputs.

Thus, for the State of Florida, HTS technologies (with an electrical demand growth rate of 2.54%) across the commercial, industrial and residential sectors would result in an initial increase of employment of 9,889, for 2001. Employment would continue to decrease through the forecasted years, ending with about an additional thousand employed in 2021. For the next model (with an electrical demand growth rate of 1.4%) additional employment would amount to 8,557 jobs for 2001.

GRP for both models for the State of Florida would be approximately $500 million for 2001, and decline significantly throughout the forecasted period. Likewise, the real disposable income for both models would be approximately $300 million for 2001, and decline incrementally throughout the forecasted period.

Figure 3. Growth in Florida Net Employment with Introduction of Super Conducting (HTS) Technologies.

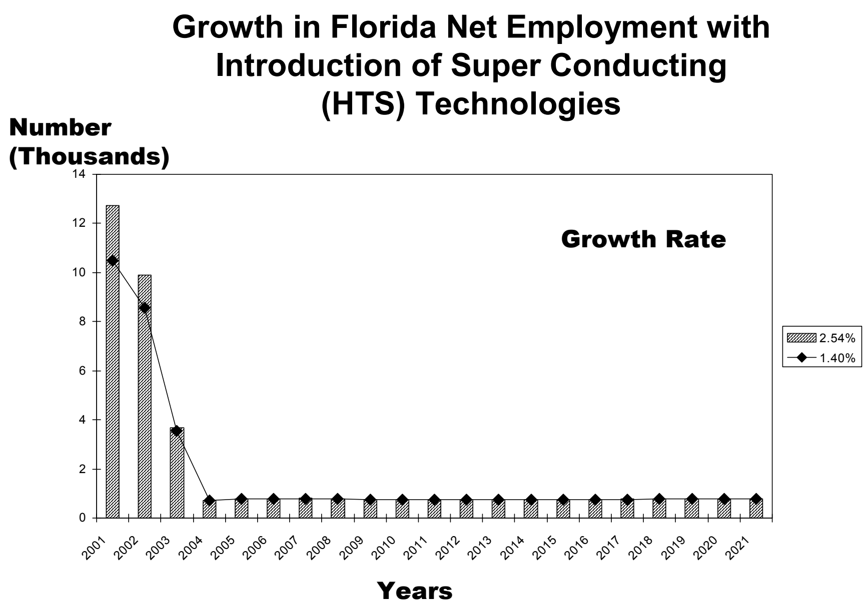


Figure 4. Growth in Florida Gross Regional Product with Introduction of Super Conducting (HTS) Technologies.

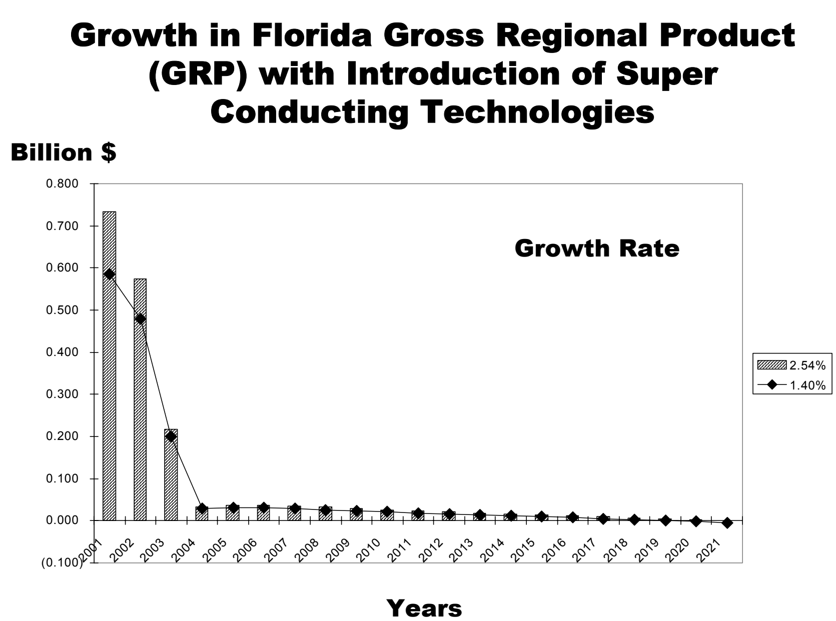
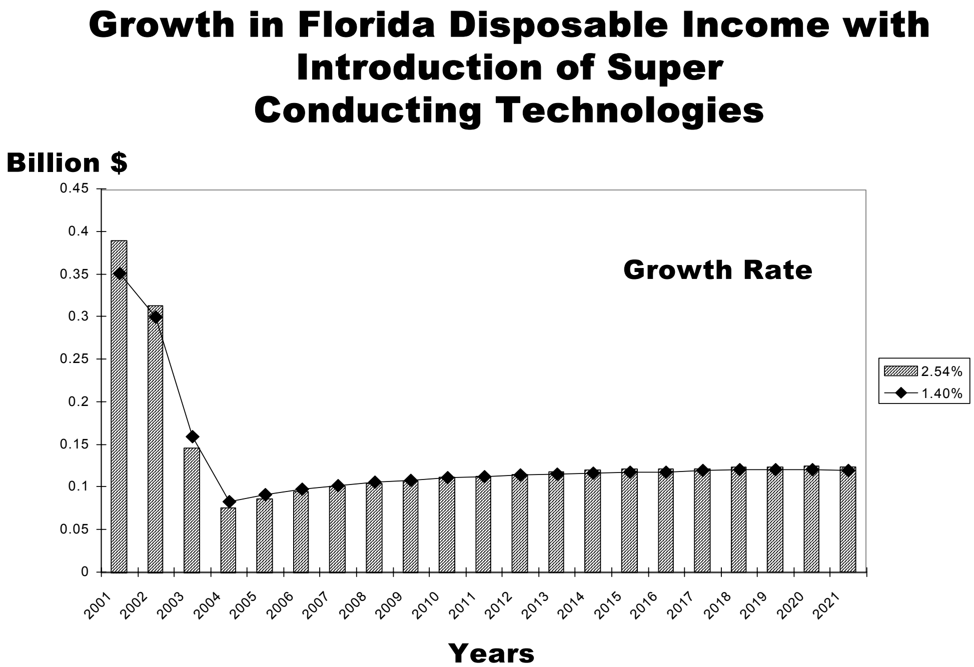


Figure 5. Growth in Florida Disposable Income with Introduction of Super Conducting (HTS) Technologies.



It is evident that HTS technologies serve to provide significant future benefits to the State of Florida. In addition, there are considerable benefits that were not quantified for this REMI HTS analysis. The higher efficiency of electric generation, transmission, distribution, and utilization results in a lowered generated power requirement, resulting in lower greenhouse emissions to the atmosphere.