Florida Renewable Energy Potential Assessment

Full Report

Draft

Prepared for

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Content of Report

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Purpose
The purpose of this study is to examine the technical potential for renewable energy (RE) in Florida, through 2020, and to bound potential RE adoption, under various scenarios. The intent of this study is not to provide recommendations on Renewable Portfolio Standard (RPS) targets, as a statewide Integrated Resource Planning process would need to be undertaken to understand how RE would fit in with: Florida's current and planned generation assets; current transmission infrastructure and potential future requirements; Florida's reliability requirements and future energy needs.

Navigant Consulting was retained to assess RE potential and penetration in Florida.

Project Scope

Navigant Consulting was retained by Lawrence Berkeley National Laboratory (LBNL), on behalf of the Florida Public Service Commission (FPSC), to:

Task 1: Identify RE resources 1) currently operating in Florida; and 2) that could be developed in Florida through the year 2020.

Task 2: Establish estimates of the quantity, cost, performance, and environmental characteristics of the identified RE resources that (1) are currently operating in Florida; and (2) could potentially be developed through the year 2020.

Task 3: Gather data to compare and contrast RE generation sources to traditional fossil fueled utility generation on a levelized cost of energy basis. Utility generation performance and cost data is available from the FPSC.

Task 4: Conduct a scenario analysis to examine the economic impact of various levels of renewable generation that could potentially be developed through the year 2020.

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Below are key terms used throughout this study.

Key Terms
• **Economic and Performance Characteristics:** Technology specific variables such as installed cost, O&M costs, efficiency, etc. that will influence a technology's economic competitiveness. • **Technical Potential:** For a given technology, the technical potential represents all the capacity that could feasibly developed, independent of economics through the scope of this study, which is 2020. The technical potential accounts for resource availability, land availability, competing resources or space uses, and technology readiness/commercialization level. • **Scenario:** A set of assumptions about how key drivers will unfold in the future. • **Levelized Cost of Electricity:** The revenue, per unit of energy, required to recoup a plant's initial investment, cover annual costs, and provide equity investors their expected rate of return. Navigant Consulting will report LCOE's with incentives and RECs factored in. • **Simple Payback:** The time required to recover the cost of an investment. For this study, simple payback period is the time required to recover the cost of an investment in a customer sited PV system. • **Technology Adoption:** The amount of a given technology actually installed and operated.

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Navigant Consulting used the following approach to assess potential RE adoption in Florida.

Project Approach

- **Step 1:** Define what technologies will and will not be covered by this study.
- **Step 2:** Compile economic and performance characteristics for each covered technology, along with Florida's current installed base of each covered technology.
- **Step 3:** Assess each technology's technical potential in Florida through 2020.
- **Step 4:** Develop scenarios to within which to project renewable energy adoption.
- **Step 5:** Develop inputs for each scenario
- **Step 6:** Assess each technology's competitiveness over time, in each scenario.
  - For customer sited PV, competitiveness is assessed using simple payback period for the investment in a PV system. A payback acceptance curve is then used to project what portion of a market would be willing to adopt a technology at a given simple payback.
  - For all other technologies, the renewable energy (RE) technology's Levelized Cost of Electricity (LCOE) was compared to that of the traditional technology it would most likely compete against.
  - Each scenario was run with and without RECS included to look at the impact of a RPS.
- **Step 7:** Use technology adoption curves to project at what rate a technology will be adopted over time. Adoption is assumed to commence when the RE technology's LCOE is less than that of the competing traditional technology's LCOE.
- **Step 8:** Using characteristics from Step 2, calculate renewable energy generation for each year, along with the resulting REC costs.

This study focused on the technologies shown below.

Resource	Subset	Notes
Solar	Photovoltaics (PV)	Study covers rooftop residential, rooftop commercial and ground mounted applications
Solar	Concentrating Solar Power (CSP)	Study focused on integrated solar combined cycle applications in which a parabolic trough system provides heating to the steam cycle of a combined cycle plant
Solar	Solar Water Heating	Study only covers systems greater than 2 MW in size. Less than 2 MW is being covered by a separate study in support of the Florida Energy Efficiency and Conservation Act.
Wind	Onshore	Study only looked at Class 2 and above resources.
Wind	Offshore	Study only looked at Class 4 and above resources.
Biomass	Solid Biomass	Study examines a broad range of feedstocks and conversion technologies, including municipal solid waste.
Biomass	Landfill Gas	
Biomass	Anaerobic Digester Gas	
Waste Heat	N/A	Study focuses on waste heat resulting from sulfuric acid conversion processes.
Ocean	Wave Energy	
Ocean	Ocean Current	
Ocean	Thermal Energy Conversion	
Ocean	Tidal Energy	

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For each technology with a technical potential in 2020, Navigant Consulting populated the template below.

	Technology XYX Economic Assumptions for Given Year of Installation (2008$)		
	2009	2015	2020
Plant Nameplate Capacity (MW)			
Project Life (yrs)			
Development Time (yrs)			
Total installed Capital Cost ($/kW)[1]			
Fixed O&M ($/kW-yr)[2]			
Non-Fuel Variable O&M ($/MWh)			
Fuel/Energy Cost ($/MWh)			
Summer Peak (kW)			
Winter Peak (kW)			
Availability (%)			
Net Capacity Factor (%)			
HHV Efficiency (%)			
Water Usage (gal/kWh)			
Hg (lb/kWh)			
CO2 (lb/kWh)			
NOx (lb/kWh)			
SO2 (lb/kWh)			

Notes:

1. The installed cost calculated in Step 2 does not include land costs. Land costs were covered in Step 6.

2. The O&M costs presented in Step 2 do not include insurance, property tax, or land lease costs (if applicable). Those costs are discussed in Step 6.

Solid biomass leads Florida's installed capacity base for renewable energy.

Florida's Current Renewable Energy Installed Base [MW][1]	
Solar – PV[2]	1.8
Solar – Water Heating > 2 MW_{th}	0
Solar – CSP	0
Wind – Onshore	0
Wind – Offshore	0
Biomass – Solid Biomass	1,091
Municipal Solid Waste	520
Agricultural By Products	191
Wood/Wood Products Industry	380
Biomass – Land Fill Gas	55
Biomass – Anaerobic Digester Gas	0
Waste Heat	370
Ocean Current	0
Hydro	55.7
Total	***1,573.5***

Notes:

1. Not all of these facilities sell power to the grid or wholesale market. Several of these facilities internally consume any energy generated.

2. Installed base is 1.82 MW_{AC}, or 2.17 MW_{DC}, assuming a 0.84 DC to AC de-rating.

Solar technologies have the largest renewable energy technical potential in Florida.

Technology	Focus of This Study	Methodology	Technical Potential by 2020 [MW]	Technical Potential by 2020 [GWh][2,3]
PV	Residential rooftop, commercial rooftop, and ground mounted systems	For rooftop systems, used state level building data, PV access factors, and system characteristics to calculate technical potential. For ground mounted systems, conducted a GIS analysis and screened out land area not suitable for PV.	Rooftop: 52,000[1] Ground Mounted: 37,000[1]	156,000 – 173,000
CSP	CSP hybridized with the steam cycle of a fossil fuel plant	Worked with utilities and public databases to identify the number power plants that could accept a CSP hybrid.	380[1]	600 - 760
Solar Water Heating	Systems greater than 2 MW in size	Identified the number of buildings within Florida that might have a > 2 MW water heating load.	1,136[1]	1,700 - 2000

Notes:

- Technical potential, for capacity, units are as follows: PV and CSP – MW_{AC} (alternating current), and Solar Water Heating – MW_{th} (thermal).
- A range is presented because solar resource varies across the state.
- Technical potential, for generation, units are as follows: PV and CSP – GWh_{AC} (alternating current), Solar Water Heating – GWh_{th} (thermal)

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Offshore wind has a large technical potential. A high resolution wind map is needed to confirm the potential onshore Class 2 wind.

Technology	Focus of This Study	Methodology	Technical Potential by 2020 [MW]	Technical Potential by 2020 [GWh]
Onshore	Coastal wind	For areas within 300 meters of the coast identified by a previous report as having the potential for utility-scale Class 2 wind[1], conducted a GIS analysis to screen out land use types not suitable for wind development, and applied a wind farm density factor to available land.	1,266[1]	1,995[1]
Offshore	Wind projects that could be installed in water <60 meters in depth	Conducted a GIS assessment to screen down NREL data on Florida offshore wind potential based on shipping lanes, local opposition to projects within sight of shore, marine sanctuaries, and coral reefs.	48,662	154,573

Notes:

1. The analysis assumes the areas identified in the Florida Wind Initiative: Wind Powering America: Project Report, which was completed by AdvanTek on November 18, 2005, contain Class 2 wind. To date, there are no high resolution wind maps that are publicly available. A high resolution wind mapping study is needed to confirm the availability of this resource.

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Florida has a wide variety of biomass resources.

Florida Solid Biomass Technical Potential (excludes biomass and waste currently used for energy production)					
Biomass Resource		**Quantities (dry tons/yr)**	**MWh/yr (25-40% efficiency)**	**MW (85% cap. factor)**	**Comments (See main text for details)**
Biomass already collected or generated onsite	Mill residues	2,000	2,345 – 3,751	0.3 – 0.5	• Unused portion only (<1% of total produced)
	Municipal solid waste	15 – 26 million (wet tons)	9,907,000 – 16,930,000	1,330-2,273	• Range based on different solid waste generation assumptions for 2020 timeframe • 650 kWh/ton net output assumed
	Animal waste	440,000 – 840,000 (wet tons)	257,000 – 673,000	34 - 90	• Poultry litter & horse manure only
	WWTP residuals	134,000 – 791,000	90,000 – 793,000	12 - 107	• 20-30% net electrical efficiency
Biomass available but not currently collected	Logging residues	2.3 million	2,635,000 – 4,216,000	354 - 566	• All existing residues from logging operations left in the forest, as reported by the US Forest Service
	Agricultural residues	0.4 – 3.6 million	410,000 – 5,904,000	55 - 793	• Range based on existing estimates for Florida
Biomass Potentially Available	Net change in "growing stock" volume	3.0 million	3,755,000 – 6,008,,000	733 – 1173	• "Net change" in merchantable timber volume in all growing stock trees >5-inch diameter. • Based on 2006 data; likely to decrease in the future
	Net change in "non-growing stock" volume	1.1 million	1,425,000 – 2,280,000	191 – 306	• "Net change" in volume in all non-growing stock trees >5-inch diameter. Based on 2005 data.
	Intensive pine silviculture	3.5 million	4,411,000 – 7,057,000	592 – 948	• Assumes intensification of management on 500,000 acres of existing planted pine forest (10%) due to market or other incentives
	Energy crops on reclaimed phosphate mined land	1.2 – 5.2 million	1,586,000 – 10,729,000	213 – 1,441	• Low acreage: 123,000 acres of clay settling areas • High acreage: 325,000 acres total reclaimed land
	Energy crops on existing farmland	14.4 – 22.4 million	18,196,000 – 45,071,000	2,444 – 6,053	• 1.3 million acres by 2020 (14% of total farmland)
	Forest Understory and other forest biomass	Insufficient data			• Several million tons/yr may be available, but more analysis required to determine sustainable quantities
	Algae	Insufficient data			• High yields possible, but more analysis required • Non-lipid faction could be used for electricity
Total		**41.8 – 68.7 million[1]**	**42,673,000 – 99,666,000**	**5,960-13,750**	

1. Total includes both dry quantities and as collected quantities, where dry tons estimates were not available, mainly for municipal solid waste.

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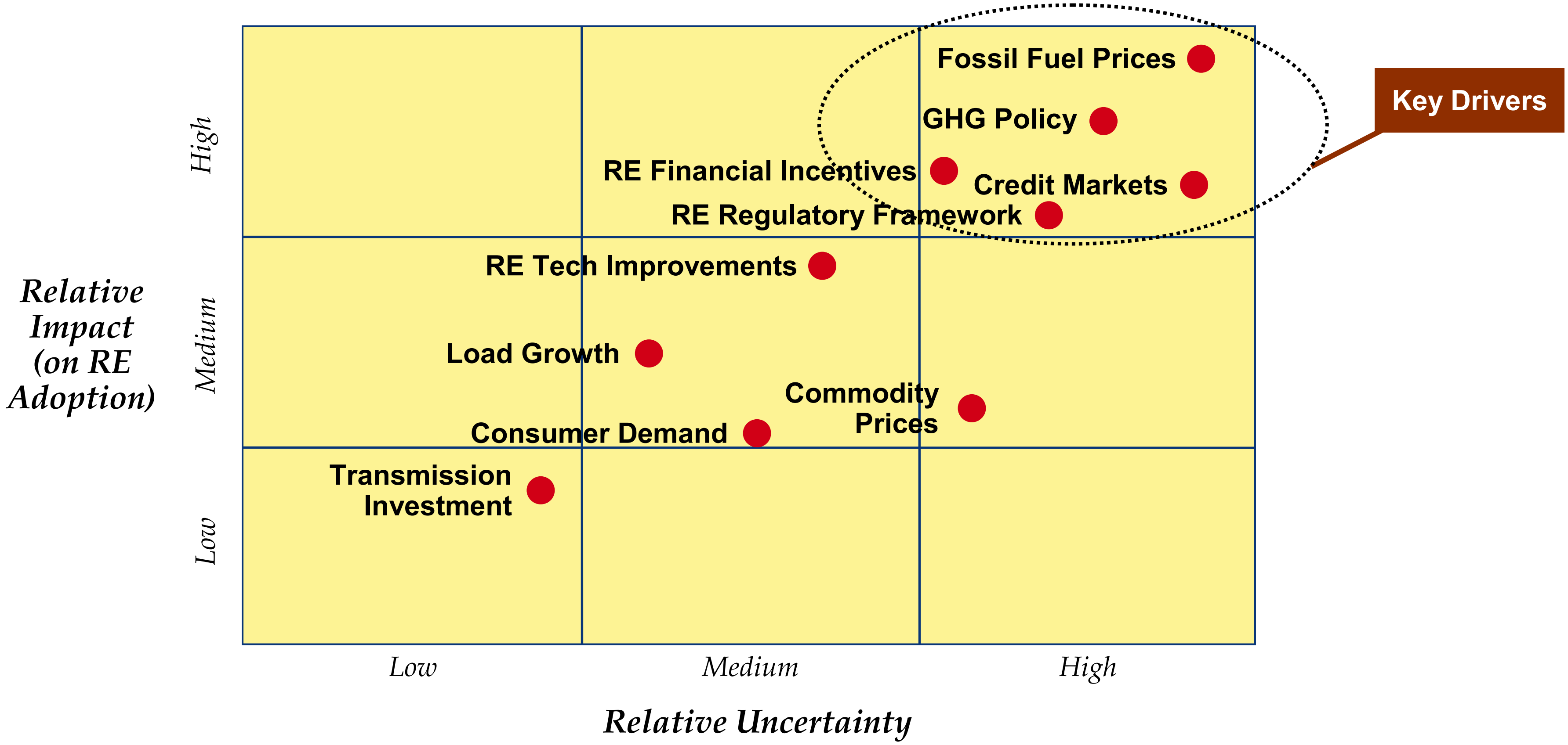
Navigant Consulting also reviewed biomass LFG, biomass ADG, waste heat and ocean resources.

Resource	Focus of This Study	Methodology	Technical Potential by 2020 [MW]	Technical Potential by 2020 [GWh][2,3]
Biomass - Land Fill Gas	Potential new landfill gas sites	Used state data and EPA data on potential landfill gas sites	110	740
Biomass - Anaerobic Digester Gas	Farm waste and waste water treatment facilities	Used several federal and state data sources to develop a technical potential	35	245
Waste Heat	Waste heat from sulfuric acid conversion processes	Worked with trade group to develop technical potential	140	1,000
Ocean	Ocean current it is likely the only ocean technology that will likely have a technical potential by 2020.	Worked with Florida Atlantic University to develop a technical potential	750	156,000 – 173,000

Scenarios were developed around drivers with the highest potential impacts on RE adoption and most uncertainty.

Navigant Consulting's Ranking of Scenario Drivers



Note: The positioning of these drivers is a qualitative assessment of their relative impact on RE adoption and the relative uncertainty surrounding the driver's future value based on Navigant Consulting's professional judgment. This analysis only applies to the period of this study 2008-2020.

Navigant Consulting developed three scenarios by varying inputs related to each key driver.

Input	Variable	Unfavorable for RE Scenario	Mid Favorable for RE Scenario	Favorable for RE Scenario
GHG Policy	CO_2 Pricing ($/ton)	$0 initially, scaling to $10 by 2020	$1 initially, scaling to $30 by 2020	$2 initially, scaling to $50 by 2020
Credit Markets	Cost of Debt	See Next Slide		
	Cost of Equity			
	Availability of Debt			
Fossil Fuel Costs	Natural Gas Prices ($/MMBtu)	Utilities' Low Case: $5-$6	Utilities' Mid Case: ~$8-$9	Utilities' High Case: $11-$14
	Coal Prices ($/MMBtu)	Utilities' Low Case: $1.5-$2.5	Utilities' Mid Case: ~$2-$3	Utilities' High Case: $2.5-$3.5
RE Financial Incentives	Federal ITC	Expires 12/31/2016	Expires 12/31/2018	Expires 12/31/2020
	Federal PTC	Expires 12/31/2009	Expires 12/31/2014	Expires 12/31/2020
	State Solar Rebate Program	Expires 2009, $5M/Year Cap	Expires 2015, $5M/Year Cap	Expires 2020, $10M/Year Cap
	State Sales Tax Exemption	For this study, only applies to solar and the solar exemption does not expire.		
	State Property Tax Exemption	Only for on-site renewables and legislation does not expire at this time.		
	State PTC	Expires in 2010, $5M Cap	Expires in 2015, $5M Cap	Expires in 2020, $10M Cap
RE Regulatory Framework	REC Spending Cap	1% of utilities' annual retail revenue	2% of utilities' annual retail revenue	5% of utilities' annual retail revenue

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Navigant Consulting used separate financing assumptions depending on a technology's commercial status.

Input	Technology Development Stage	Unfavorable for RE Scenario	Mid Favorable for RE Scenario	Favorable for RE Scenario
Cost of Debt	Established	8%	7%	6%
	Mid-Term	8.5%	7.5%	6.5%
	Future	9%	8%	7%
Cost of Equity	Established	12%	10%	8%
	Mid-Term	14%	12%	10%
	Future	16%	14%	12%
Availability of Debt (% debt financing)	Established	50%	65%	80%
	Mid-Term	50%	60%	70%
	Future	50%	55%	60%

Technology Development Stages

- **Established:** PV, Solar Water Heating, Onshore Wind, Biomass Direct Combustion, Waste to Energy, Landfill Gas to Energy, Farm Manure Anaerobic Digester, Waste Treatment Plant Fuel to Energy, Waste Heat, Repowering (with Biomass)
- **Mid-Term:** CSP, Offshore Wind, Biomass Co-firing
- **Future:** Biomass Integrated Gasification Combined Cycle, Ocean Current

Navigant Consulting also varied key inputs not directly related to the scenarios, but inputs that would be impacted by the scenario chosen.

Input	Variable	Unfavorable for RE Scenario	Mid Favorable for RE Scenario	Favorable for RE Scenario
Biomass Availability	Resource Potential	Low end of Resource Potential Range	Middle of Resource Potential Range	High End of Resource Range
Biomass Cost	Selling Price ($/Dry ton)	$40	$50	$60
Municipal Solid Waste Tipping Fee	Tipping Fee ($/ton)	$30	$50	$70
Technology Adoption Curves	Technology Saturation Times	Long Time Horizon	Mid Time Horizon	Short Time Horizon

Navigant Consulting used two different metrics to assess RE competitiveness – simple payback and LCOE.

Levelized Cost of Electricity (LCOE)

- For all technologies, except customer sited PV, Navigant Consulting compared the LCOE of a RE technology to that of the traditional technology it would likely compete against and assumed adoption commenced when the RE technology's LCOE became less than the competing traditional technology's LCOE.
- Navigant Consulting compared RE LCOEs to the following technologies:
  - Natural Gas Combined Cycle
  - Natural Gas Combustion Turbine
  - Coal Steam Cycle
  - Nuclear
  - Grid Supplied Electricity (to compete against customer cited Anaerobic Digester Gas technologies)
  - An 80% efficient natural gas fired water heater (to compete against solar water heating systems)

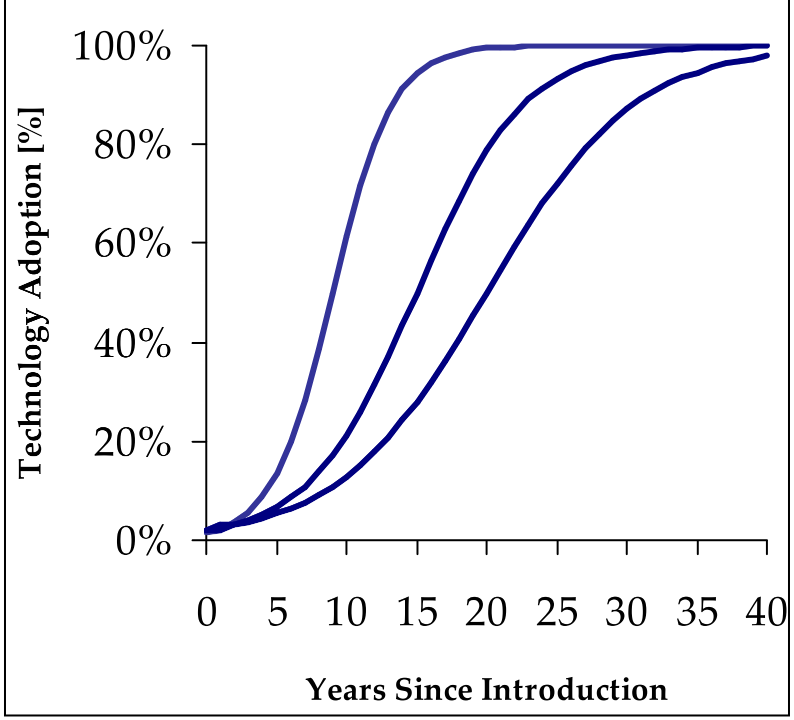
Simple Payback

- Through several prior studies, Navigant Consulting has found that simple payback is the most valid metric to look at PV adoption.
- Navigant Consulting has developed a PV Market Penetration model to project PV adoption.
- The model calculates simple payback taking into account installed costs, PV output, building load profiles, incentives, etc.
- The model then uses a payback acceptance curve to calculate what % of the market will adopt a technology at a given simple payback period.

When the RE technologies had favorable LCOEs, their adoption was estimated using a family of technology adoption curves.

- Technology adoption curves (sometimes called S-curves) are well established tools for estimating diffusion or penetration of technologies into the market.
- A technology adoption curve provides the rate of adoption of technologies, as a function of the technology's characteristics and market conditions.
  - — For this study, Navigant Consulting focused on:
    - Level of past development
    - Technology risk
    - Complexity or barriers in the technology's market
- Navigant Consulting had gathered market data on the adoption of technologies over the past 120 years and fit the data using Fisher-Pry curves[1].
- The Fisher-Pry technology substitution model predicts market adoption rate for an existing market of known size.
- For purposes of this analysis, initial introduction is assumed to occur in the first year the technology is economic in Florida.
  - — For technologies already installed in Florida, Navigant Consulting used the year of first installation.

Technology Adoption Curves Used in This Study



Source: Navigant Consulting, November 2008 as taken from Fisher, J.C. and R.H. Pry, A Simple Substitution Model of Technological Change, *Technological Forecasting and Social Change*, Vol 3, Pages 75 – 99, 1971 .

Notes:
1. Refer to the appendix for more information on Fisher-Pry curves.

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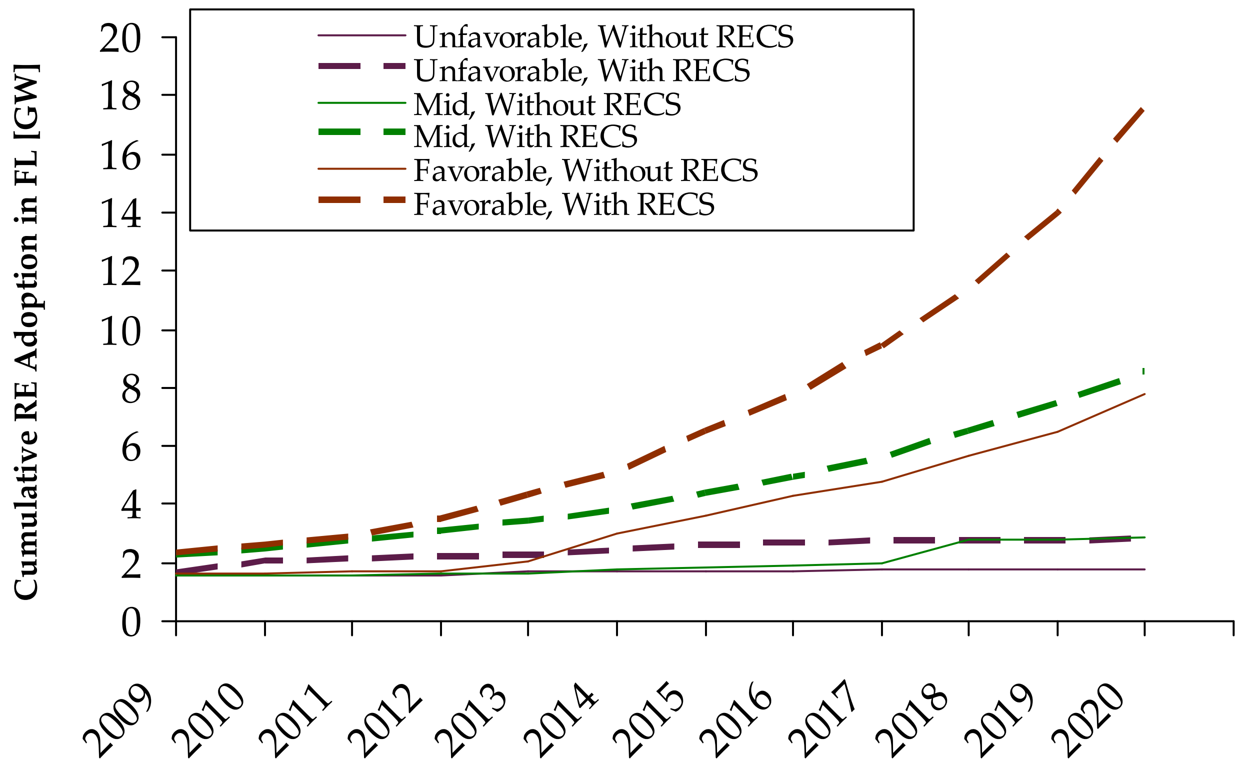
Between 1.8 and 18 GW of RE capacity could be installed in Florida by 2020, depending on the scenario used.

Potential Cumulative RE Nameplate Capacity[1,2] in Florida [GW]



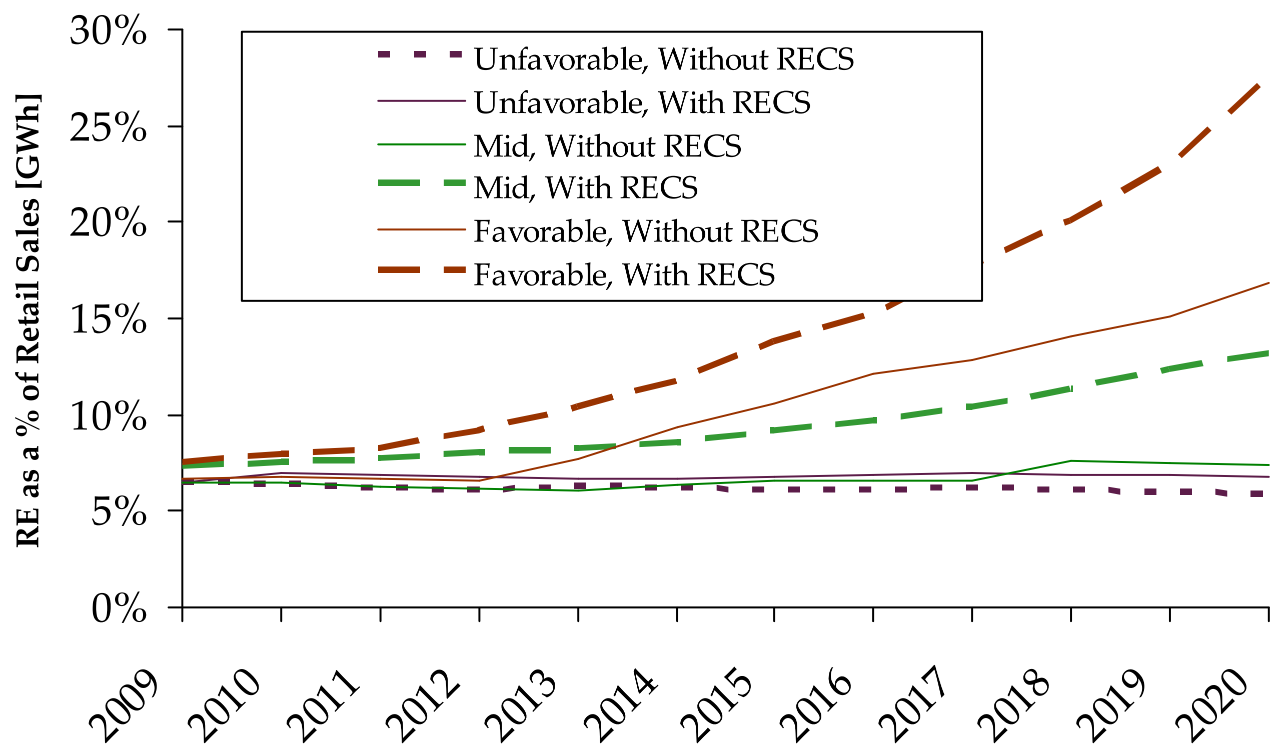
Notes:

1. Refer to the appendix for details on adoption levels by technology.
2. Results include currently installed capacity and assumes all current installations qualify for RECS.

Source: Navigant Consulting analysis, November 2008

RE could be between 6% and 27% of the IOU's retail sales by 2020, depending on the scenario assumed.

RE as a Percentage of IOU Retail Sales[1] [%]



Notes:

1. IOU retail sales projections provided by the FPSC staff.

Source: Navigant Consulting analysis, November 2008

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An RPS would encourage more RE adoption in Florida.

	Annual Costs and Benefits of a Florida RPS – Unfavorable for RE Scenario											
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
REC Expenditures [$M/Year]	191	194	198	201	204	208	211	215	219	222	226	188
Extra Renewable Energy Generation as a Result of RECs[2] [GWh]	71	1,069	1,158	1,290	733	996	1,371	1,590	1,723	1,805	1,909	1,994

	Annual Costs and Benefits of a Florida RPS – Mid Favorable for RE Scenario											
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
REC Expenditures [$M/Year]	96	297	342	364	354	380	378	378	383	381	389	392
Extra Renewable Energy Generation as a Result of RECs[2] [GWh]	1,438	1,861	2,445	3,354	4,008	4,051	5,076	6,226	7,882	8,037	10,388	12,713

	Annual Costs and Benefits of a Florida RPS –Favorable for RE Scenario											
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
REC Expenditures [$M/Year]	475	414	480	571	684	685	804	927	1,004	1,022	1,092	1,068
Extra Renewable Energy Generation as a Result of RECs[2] [GWh]	1,445	1,936	2,804	4,873	5,197	4,620	6,436	6,261	10,120	12,538	17,162	23,465

Notes:

1. Refer to the full body of this report for average REC selling price in each scenario.
2. This represents the difference, in each scenario, between the RE adoption with and without RECs.

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Key results from the Navigant Consulting analysis are discussed below.

Key Results of Analysis

- Wind technologies are only competitive in Florida with an RPS structured per the FPSC staff's draft (25% target for solar and wind with 75% of REC expenditures going to wind and solar).
- Waste heat, repowering with biomass, co-firing with biomass, anaerobic digester gas facilities (installed in a waste water treatment plant), and landfill gas are competitive by 2020 in all cases.
- With the exception of the Unfavorable for RE Scenario Without RECs, ground mounted PV is competitive in all Scenarios, by 2020.
- The impact of RECs on non-wind and non-solar technologies is very small because, per the FPSC staff's draft legislation, Class II REC expenditures are capped at 25% of the annual REC expenditure cap.
  - Almost all of Florida's existing RE installed base in Class II renewables and if these facilities qualify for RECs, as they do per the draft legislation, the demand for new Class II RECs will be low.
- This analysis was completed before the parallel analysis in support of FEECA, so adoption projections for solar water heating systems less than 2 MW were not available.
  - Thus, this analysis does not include the potential MWh's available from these systems.

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