Florida Renewable Energy Potential Assessment

Full Report

Draft

Prepared for

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Content of Report

This report was prepared by Navigant Consulting, Inc.[1] under a sub-contract from Lawrence Berkeley National Laboratory (LBNL), which was funded by the Department of Energy Office of Electricity Delivery and Energy Reliability (OE). This effort was also supported by the Florida Public Service Commission (FPSC) and the Florida Governor's Energy Office (EOG). The work presented in this report represents our best efforts and judgments based on the information available at the time this report was prepared. Navigant Consulting, Inc. is not responsible for the reader's use of, or reliance upon, the report, nor any decisions based on the 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.

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.

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)			
CO_2 (lb/kWh)			
NO_x (lb/kWh)			
SO_2 (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.

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.

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

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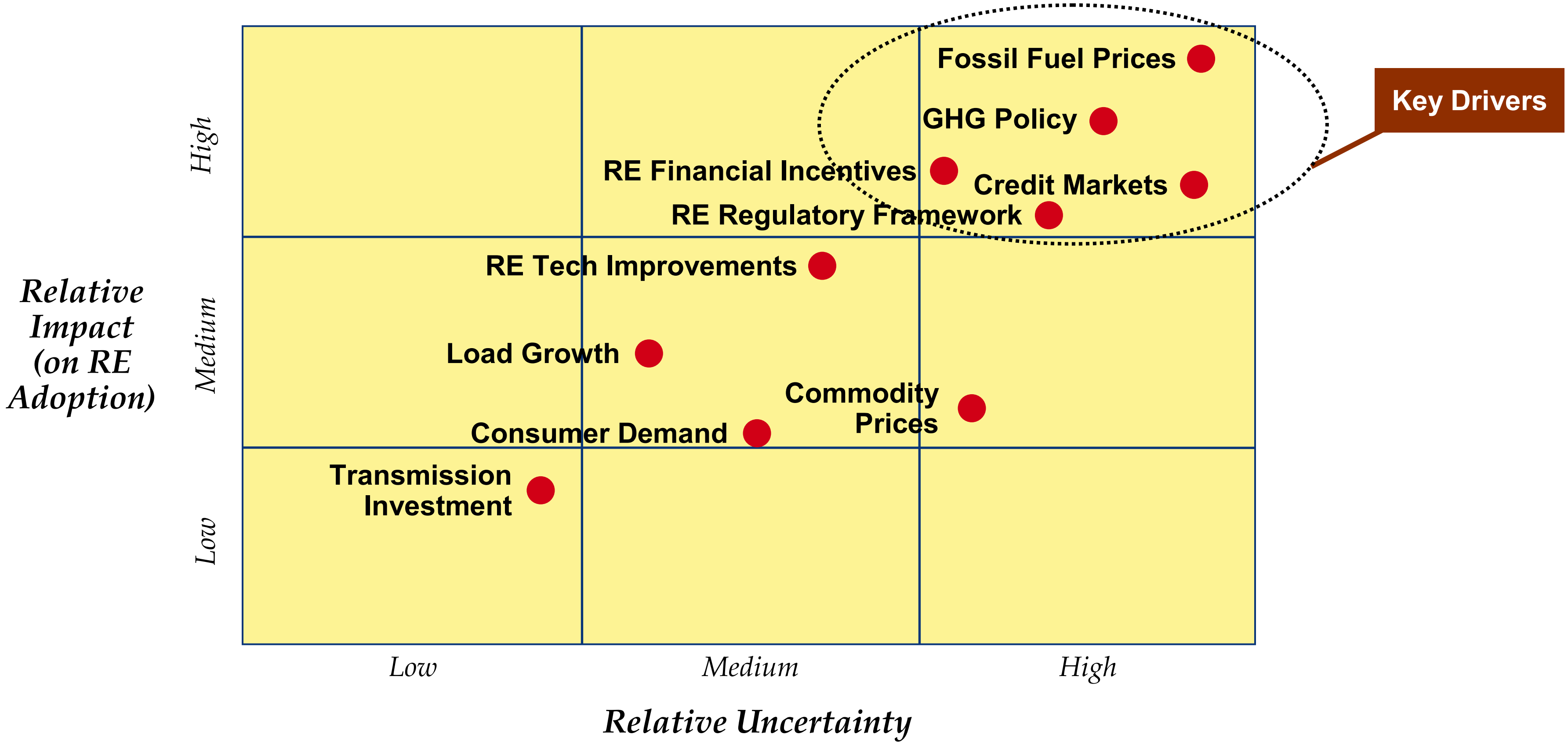
Scenarios were developed around drivers with the highest potential impacts on RE adoption and most uncertainty.

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.

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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)

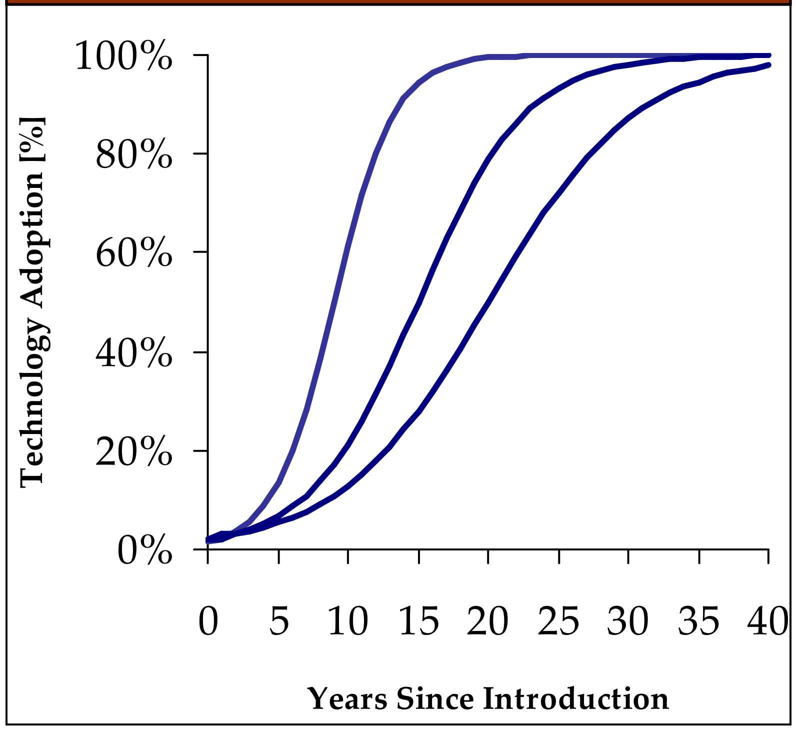
Simple Payback

- 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

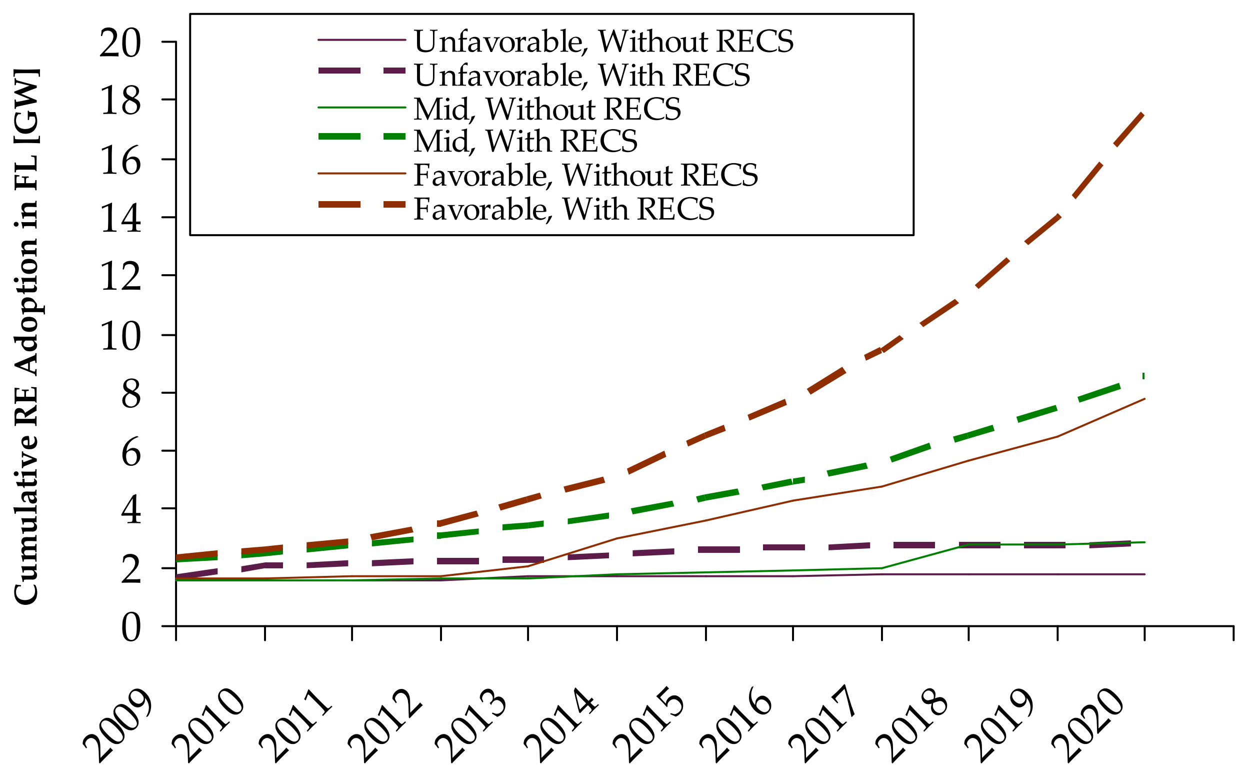


Source: Navigant Consulting, November 2008 as taken from Fisher, J.C. and R.H. Pry, A Simple Substitution Model of Technological Change, *Technological Forecasting and Social Change*, Vol 3, Pages 75 – 99, 1971 .

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

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]



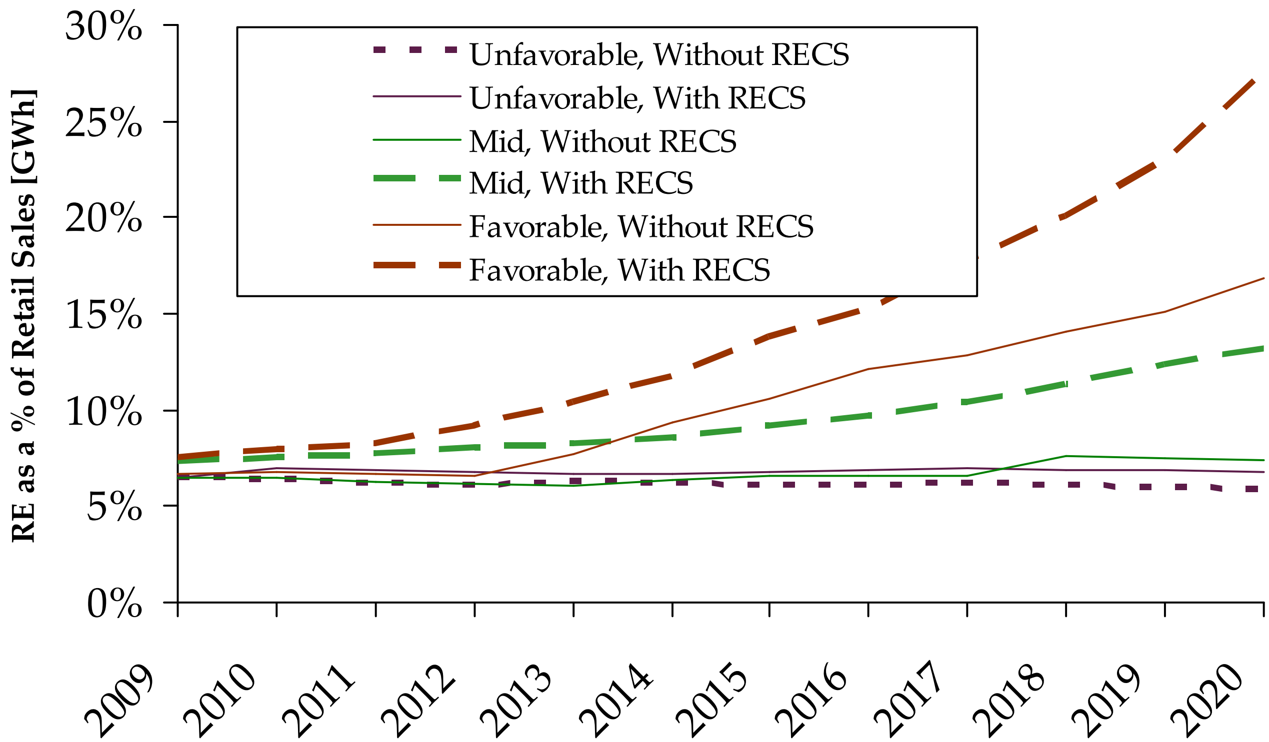
Notes:

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

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]	1,44 5	1,936	2,804	4,873	5,197	4,620	6,436	6,261	10,12 0	12,538	17,16 2	23,46 5

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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Steps 1 through 3 develop technical potential and economic & performance characteristics for each resource and technology.

Technical Potentials and Economic & Performance Characteristics

- Steps 1 through 3 develop technical potentials and economic and performance characteristics for each technology
  - Navigant Consulting defines technical potential as representing all the capacity that could feasibly developed, independent of economics and equipment supply through the scope of this study, which is 2020. The technical potential accounts for resource availability, land availability, competing resources or space uses (for non-energy related uses), and technology readiness/commercialization level.
- The following key assumptions apply to the economic and performance characteristics compiled for each technology:
  - Installed cost projections are done in $2008, thus inflation is factored out.
  - Cost projections take into account commodity cost increases, efficiency improvements, supply chain issues, and learning curve effects.
    - To project commodity costs, Navigant Consulting used an annual average commodity cost increase of 2.6% based upon the historical average commodity cost increase of "Metals and Metal Products" and "Nonmetallic Mineral Products" (which includes glass, concrete, cement, and asphalt) between 1982 and October of 2008.[1]
  - O&M costs reported in Steps 1 – 3 do not include insurance costs, property tax, or land lease costs. Those will be discussed in Step 6.
- Competing land uses by different renewable energy technologies are not addressed in Steps 1 – 3, but will be addressed in Step 7.

Notes:

1. Data taken from the U.S. Bureau of Labor and Statistics at www.bls.gov/data. Metals and Metal Products are data type WPU10 and Nonmetallic Mineral Products are data type WPS13.

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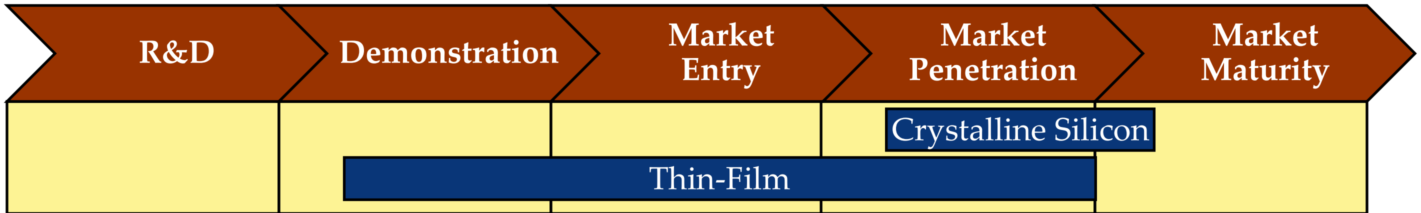
PV technologies are mature and have decades of deployment history.



Technology Definition

- For this study, photovoltaics (PV) are defined as a solid-state technology that directly converts incident solar radiation into electrical energy. The panel may be mounted on a roof or the ground.

Technology Maturity

- Crystalline Silicon based technologies have been in use for many decades, mostly in off-grid applications, but have been widely deployed in grid-connected applications for a decade.
- Thin-film technologies have been in use for several years, but do not have the deployment history of Crystalline Silicon technologies.

Market Maturity

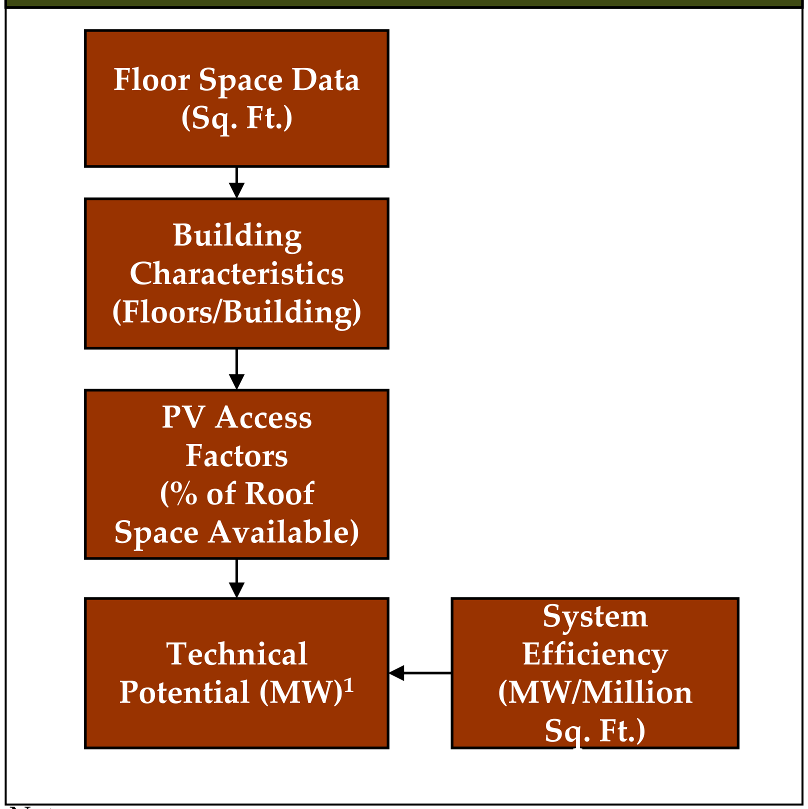
- With the establishment of European feed-in tariffs and Japanese incentives, the global PV market has been growing at 30-40% per year for several years. Growth has been furthered in the U.S. with federal tax credits.
- However, the PV industry has been slow to grow, with Florida have in an estimated installed base of ~ 2 MW[1].
- With the strong growth, the PV value chain has streamlined, major players have developed, and markets are becoming defined.

Notes:

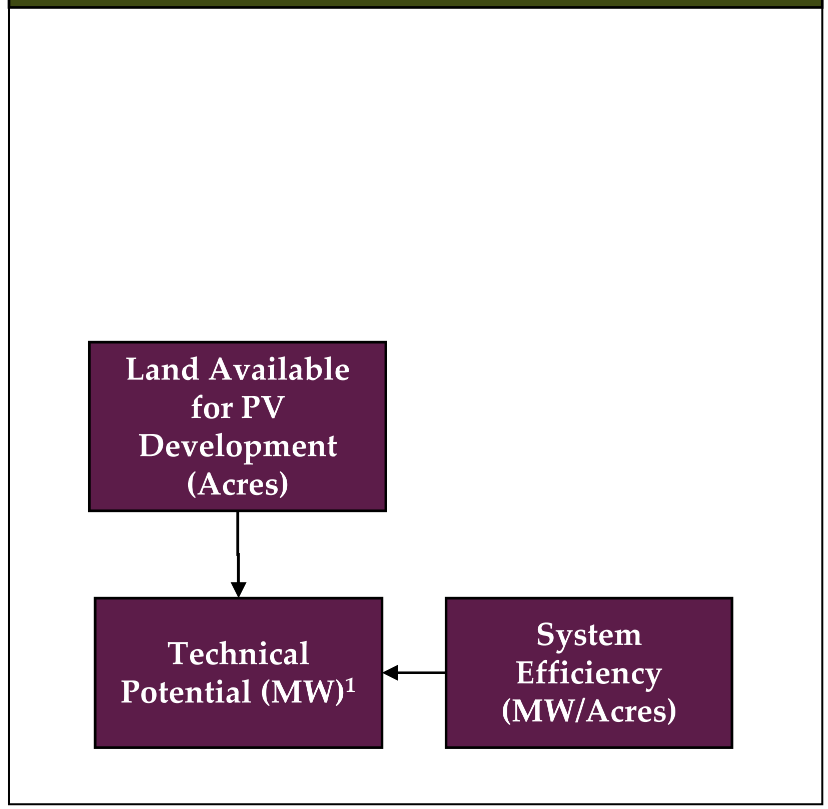
1 Installed base number calculated from state rebate information and NCI's PV Services Program. Data as of November 2008.

Navigant Consulting conducted separate analysis for rooftop and ground mounted PV systems.

Rooftop PV Methodology



Ground Mounted PV



Notes:

1. Technical potential will be presented in MW_{pAC}. Technical potential in MW_{pDC} is converted to AC using a 0.84 conversion factor. This is based upon the National Renewable Energy Laboratories Solar Advisory Model (available at https://www.nrel.gov/analysis/sam/) and assumes the following % derates: 2% for DC nameplate derating, 6% inverter loss, 2% for module mismatch, .5% for diodes, 2% for DC wiring, 1% for AC wiring, and 3% for soiling.

Navigant Consulting used floor space data from McGraw-Hill and used EIA data on building characteristics

Floor Space Data

- McGraw-Hill maintains residential and commercial floor space data
  - McGraw-Hill has data by county, but only provides state level data for public projects.
  - McGraw-Hill was able to provide floor space data for 2008, with projections to 2012, along with construction starts for the same period.
  - The data for 2008-2012 shows a growth rate of 3.5%/Yr in the residential sector and 2.7%/Yr in the commercial sector
  - However, given the recent economic downturn and its impact on commercial and residential real estate markets, Navigant Consulting reduced the aforementioned growth rates by the expected decline in the states load growth rate. Comparing the state's 10 Year Site Plan[1] (created in July of 2008), to the recent revised load growth rates projected by the Governor's Action Team on Energy and Climate Change[2] (created in September, 2008), shows an average 37% reduction in load growth projections out to 2017, thus Navigant Consulting reduced the McGraw-Hill projections by 37% to arrive at 2.2%/Year growth in residential and 1.8% growth in commercial floor
- Navigant Consulting then used data from Florida state offices to forecast floor space out to 2020
  - For the residential market, NCI used data from the Florida Office of Economic and Demographic[3] Research on population growth projections.
    - Residential floor space does not linearly correlate with population growth, as house size has been increasing over time.
    - Thus, NCI used the % change in growth rate in the 2010-2020 time frame, relative to population growth rate from 2000-2010 arrive at a 2012-2020 floor space growth rate of 1.8%/Yr.
  - For the commercial market, NCI used personal income growth rate, from the Florida Office of Economic and Demographic Research[3], as a proxy for state economic growth rate.
    - The data did not indicate any strong shifts going forward, but given recent economic events, state projections for load growth are only 1.7%/Year, so NCI used 1.7%/Year.
- To calculate the number of floors per building, NCI used Florida specific data from the U.S. Energy Information Administration's Residential Energy Consumption Survey (RECS) and Commercial Building Energy Consumption Survey (CBECS).
  - 2003 data was available from CBECS and 2005 data available from RECS.

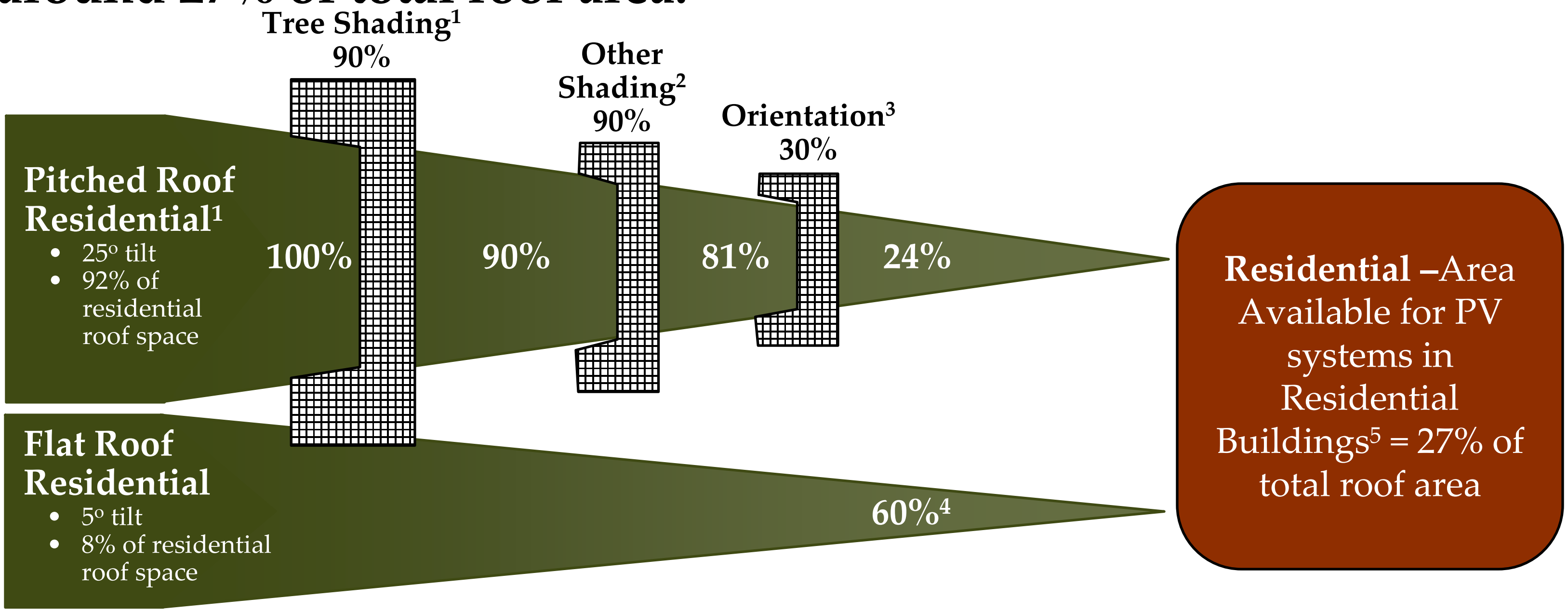
Notes:

1. Plan available at http://www.floridapsc.com/publications/pdf/electricgas/FRCC_Plan2008.PDF

2. Revised projections available at http://www.flclimatechange.us/ewebeditpro/items/O12F19874.pdf

3. Data available at http://edr.state.fl.us/conferences/fleconomic/FEEC0807_LRTABLES.pdf. Data from July 15, 2008

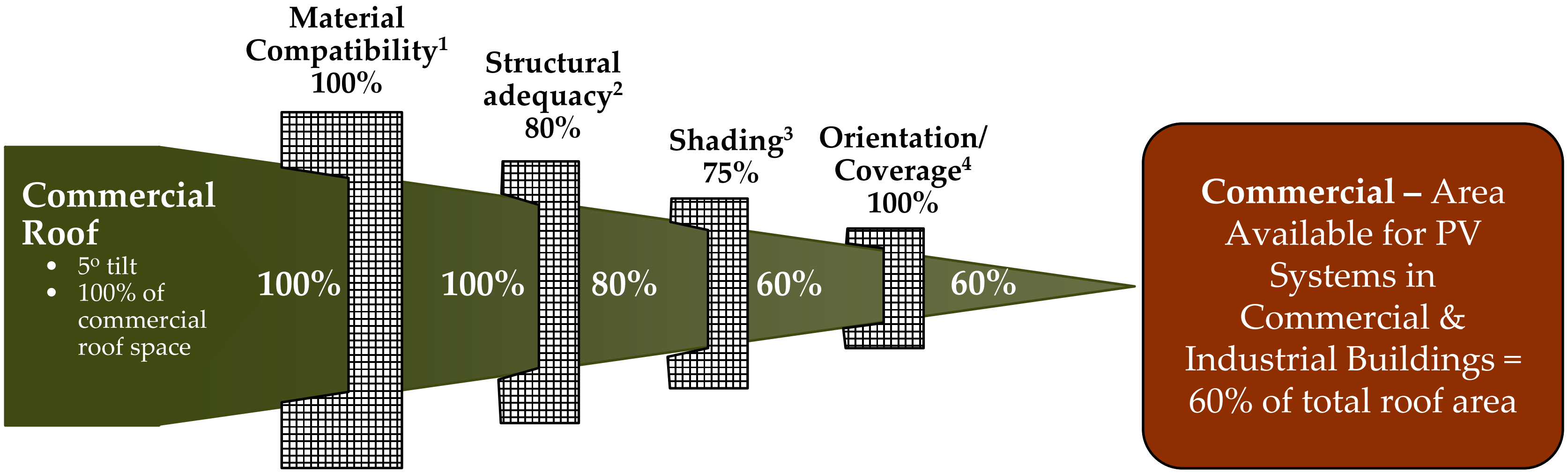
The roof space available on residential buildings for PV installations is around 27% of total roof area.



Notes:

1. Roof area available for PV is reduced due to tree shading by around 90% for single homes at 95% for townhouses. Townhouses and other residential buildings are often higher and thus there would be less shading than for a detached house. Closely packed homes in high density neighborhoods allow little room for large trees to grow and shade roofs, compared to larger homes in low density neighborhoods.
2. Other shading may be due to chimneys, vent stacks and other roof obstructions.
3. Based on assumptions made for single homes, which account for 70% of the building stock. Assume that orientations from southeast clockwise around to west are appropriate for PV installations. For gable ended roofs with one long ridge line, assume that one of the pitched surfaces will face in the proper direction for 75% of the residences. If each surface is half the roof, 38% of the roof area can accommodate PV arrays. For hip roof buildings, one of four roof area will be facing in the right direction, or 25% of the roof area. The average of 38% and 25% is around 30%, which is what is assumed as the percentage of roof area with acceptable orientation.
4. See analysis of roof area availability for flat roof buildings on following pages.
5. Assumes pitched roof accounts for 92% of total roof space, the balance 8% being flat roof space.
6. The data are based on a study conducted by Navigant Consulting staff for a major U.S. utility company and adjusted for warm climates based upon interview with Ed Kern of Irradiance, May 2006.

The roof space available in commercial buildings for PV installations is around 60% of total roof area.



Notes:

1. Roofing material is predominantly built up asphalt or EPDM, both of which are suitable for PV, and therefore there are no compatibility issues for flat roof buildings.
2. Structural adequacy is a function of roof structure (type of roof, decking and bar joists used, etc.) and building code requirements (wind loading, snow loading which increases the live load requirements). Since snow is not a design factor in Florida, it is assumed at 20% of the roofs do not have the structural integrity for a PV installation.
3. An estimated 5% of commercial building roofing space is occupied by HVAC and other structures. Small obstructions create problems with mechanical array placement while large obstructions shade areas up to 5x that of the footprint. Hence, around 25% of roof area is considered to be unavailable due to shading. In some commercial buildings such as shopping centers, rooftops tend to be geometrically more complex than in other buildings and the percentage of unavailable space may be slightly higher.
4. A 5º tilt is assumed. If a larger tilt were assumed, then more space would be required per PV panel due to panel shading issues, which would reduce the roof space available.
5. The data is based on a study conducted by Navigant Consulting for a major U.S. utility company adjusted for warm climates based upon interview with Ed Kern of Irradiance, May 2006.

System power density was calculated using module efficiency, market share of leading PV technologies and a module packing factor.

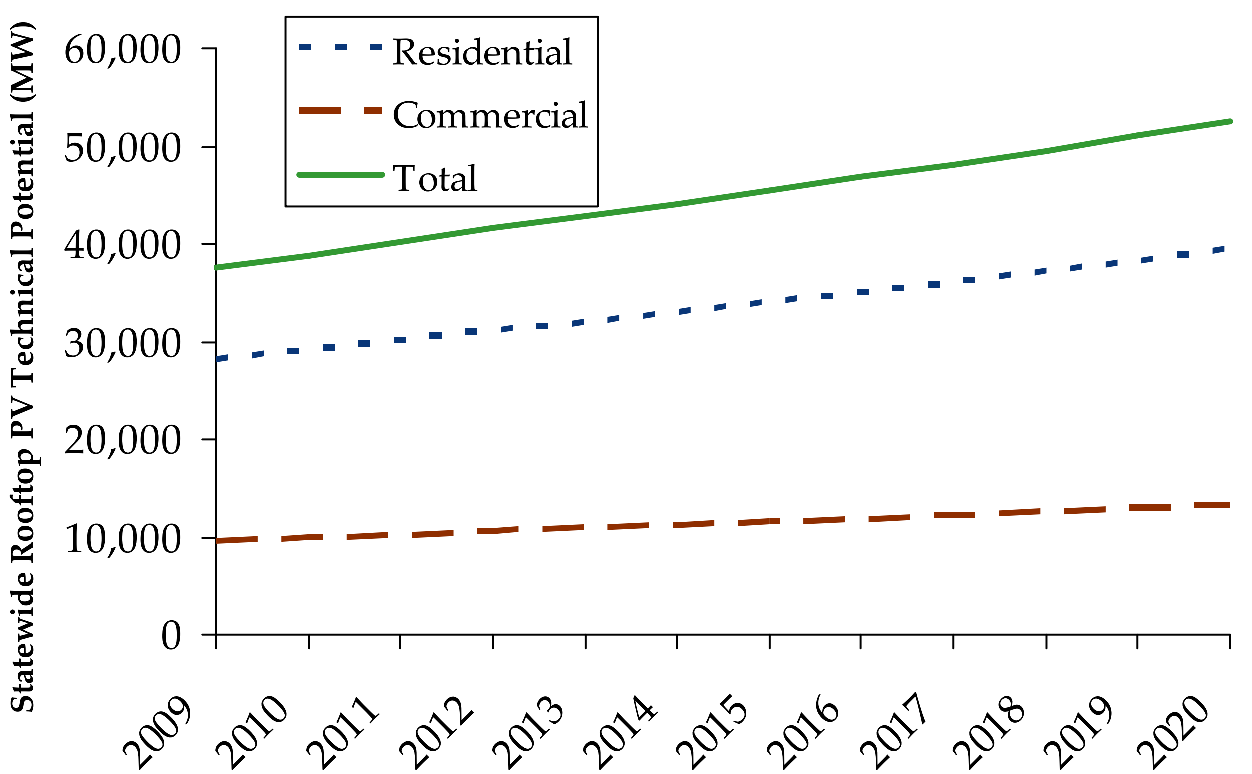
	2009/2020 Weight Averaged Module Efficiency	Module Power Density (W_{pDC}/ft^2)	Packing Factor[1]	System Power Density (MW_{pDC}/ million sq. ft.)
2009 calculation	2009 Weight Averaged Module Efficiency: 13.9%	13.0	1.25	2009 System Power Density: 10.4
2020 calculation	2020 Weight Averaged Module Efficiency: 15.7%	14.6	1.25	2020 System Power Density: 11.7

Notes:

1 This includes both residential and commercial systems. The packing factor for both systems is similar. Packing factor accounts for spacing required between modules for access, shading, etc. and accounts for area required for racking, wiring, inverters, and junction boxes.

A combination of growing roof space and improved efficiency will drive technical potential up over time, reaching a total of 52 GW by 2020.

Florida Rooftop PV Technical Potential



Depending on location in the state and system design, this will result in a technical potential of 82,000 – 90,000 GWh in generation.

NAVIGANT CONSULTING

Navigant Consulting obtained land-use data from each of FL's water management districts.

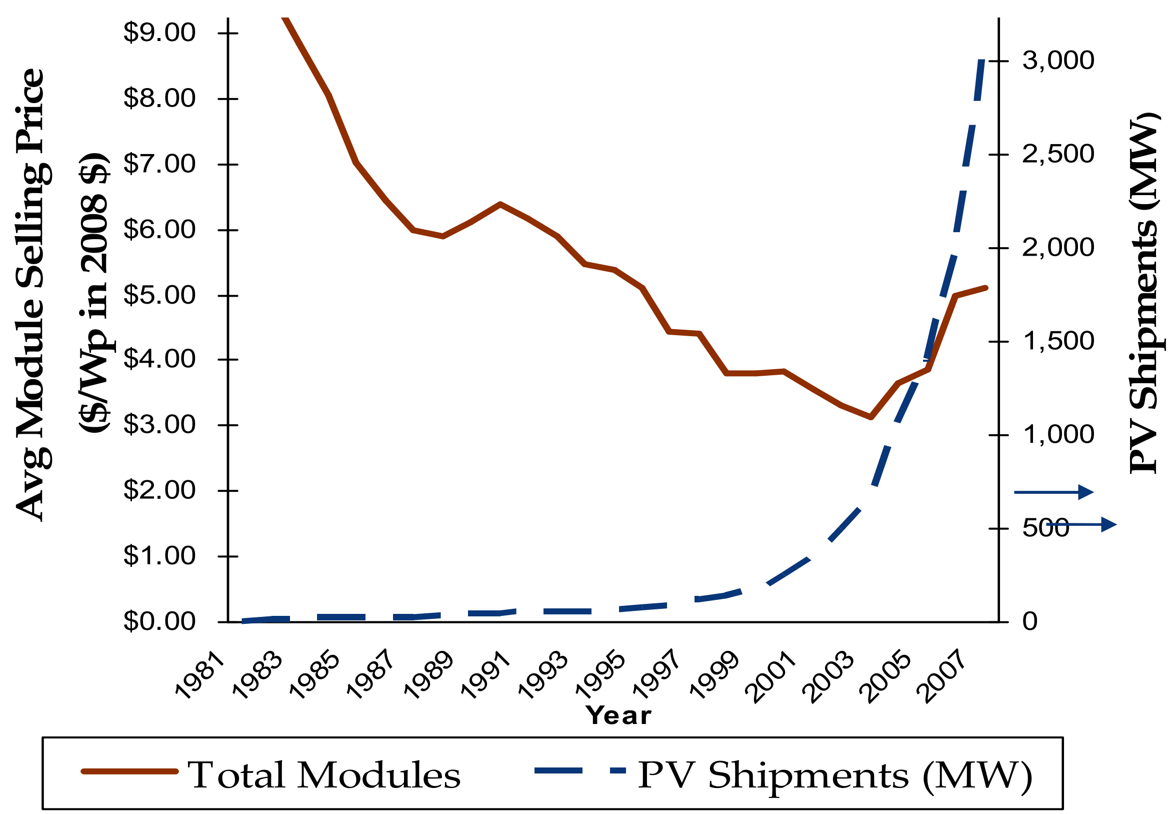
Land Use Data

- Each of FL's water management district (St. Johns, Northwest, Sewanee, South Florida, and Southwest Florida) maintains land-use GIS databases.
  - Each database divides land-use into 152 different land-use types.
  - For the land available to install ground mounted PV, Navigant Consulting used five land-use types below and screened all types of wetlands, forested land, developed lands, urban areas, recreational lands, and farm lands.
    - Abandoned mining lands
    - Open land
    - Inactive land with street pattern, but no structures
    - Other open lands – rural
    - Barren land
  - On top of this, NCI overlaid data on national parks, forests, etc., to screen out preserved areas, and historic sink hole data provided by the FL DEP.
- The resulting land available was 389,000 acres, or ~600 square miles.
  - This equates to ~1% of the state's area.
- Assuming a system power density of 10 acres/MWDC, this equates to a technical potential of **32 GW in 2009,** rising to a technical potential of **37 GW in 2020** because of the aforementioned increases in module efficiency.
- Depending on location in the state, this will results in between a technical potential of **74,000 and 83,000 GWh** of generation by 2020.

DRAFT

PV module prices have come down by 50% over the last 25 years…

Historical PV Cost Trends



Source: NCI PV Service Program, June 2008

… but have been rising recently because of a polysilicon (a key feedstock) shortage, but Navigant Consulting expects this shortage to be alleviated in the near term and a return to historic price declines.

NAVIGANT CONSULTING

A recent raw material (polysilicon) shortage has caused upward pressure on installed costs, but Navigant Consulting expects costs to fall.

	Residential PV Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Plant Nameplate Capacity (kW)[1]	4	4	4
Project Life (yrs)	25	25	25
Development Time (yrs)[2]	0.3	0.25	.2
Installed Cost ($/kW)[3]	8,100	5,900	4,900
Fixed O&M ($/kW-yr)[4]	41	24	13
Non-Fuel Variable O&M ($/kWh)	0	0	0
Fuel/Energy Cost ($/kWh)	0	0	0

Sources: Stakeholder data submitted to the Florida Public Service Commission, September 2008; Navigant Consulting, October 2008

Notes:

1 . **All data is presented in kW_{pAC}. PV systems are typically rated in kW_{pDC}, but for a proper comparison to other technologies' economics, Navigant Consulting will present economics as a function of a system's kW_{pAC} rating assuming a 84% DC to AC derate.**

2. This does not account for delays due to state rebate availability.

3. Pricing includes hurricane protection. NCI projects cost declines due to: an easing of the current polysilicon shortage, increased module efficiency, and streamlined installation/construction practices. The PV industry has been experiencing a shortage of a key feedstock (polysilicon) and that has drive costs up over the past several years. Prior to this PV costs had steadily been declining.

4. This includes two inverter replacements over the system's life.

PV performance varies across the state.

	Residential PV Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Summer Peak Output(kW)[1]	2.4	2.4	2.4
Winter Peak Output (kW)	0.8	0.8	0.8
Availability (%)	99%	99%	99%
Net Capacity Factor (%)[2,3]	18%-20%	18%-20%	18%-20%
HHV Efficiency (%)	N/A	N/A	N/A
Water Usage (gal/kWh)[4]	Negligible	Negligible	Negligible
Hg (lb/kWh)	0	0	0
CO2 (lb/kWh)	0	0	0
NOx (lb/kWh)	0	0	0
SO2 (lb/kWh)	0	0	0

Sources: Stakeholder data submitted to the Florida Public Service Commission, September 2008; Navigant Consulting, October 2008

Notes:

1 . **All data is presented in kW_{pAC}. PV systems are typically rated in kW_{pDC}, but for a proper comparison to other technologies' economics, Navigant Consulting will present economics as a function of a system's kW_{pAC} rating assuming a 84% DC to AC derate.**

2. Capacity factor varies because of location, system orientation relative to due south and technology. Thus, a range is presented.

3. In this study, PV capacity factor is defined as (kW_{hAC} Output)/(kW_{pAC} rating)

3. A minor amount of water is required for cleaning of the panels.

A raw material (polysilicon) shortage has caused upward pressure on installed costs, but Navigant Consulting expects costs to fall.

	Commercial PV Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Plant Nameplate Capacity (kW)[1]	200	200	200
Project Life (yrs)	25	25	25
Development Time (yrs)	0.5-1	0.5-1	0.5
Installed Cost ($/kW)[2,3]	7,300	5,300	4,400
Fixed O&M ($/kW-yr)[4]	34	20	15
Non-Fuel Variable O&M ($/kWh)	0	0	0
Fuel/Energy Cost ($/kWh)	0	0	0

Sources: Stakeholder data submitted to the Florida Public Service Commission, September 2008; Navigant Consulting, October 2008

Notes:

1 . **All data is presented in kW_{pAC}. PV systems are typically rated in kW_{pDC}, but for a proper comparison to other technologies' economics, Navigant Consulting will present economics as a function of a system's kW_{pAC} rating assuming a 84% DC to AC derate.**

2. Costs shown are for a 200 kW_{pAC} system. Commercial systems typically range from 10 kw to 2 MW in size, with /kW pricing decreasing with size.

3. Pricing includes hurricane protection. NCI projects cost declines due to: an easing of the current polysilicon shortage, increased module efficiency, and streamlined installation/construction practices. The PV industry has been experiencing a shortage of a key feedstock (polysilicon) and that has drive costs up over the past several years. Prior to this PV costs had steadily been declining.

4. This includes two inverter replacements over the system's life.

PV performance varies across the state.

	Commercial PV Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Summer Peak Output (kW)[1]	120	120	120
Winter Peak Output (kW)	40	40	40
Availability (%)	99%	99%	99%
Net Capacity Factor (%)[2,3,4]	17%-19%	17%-19%	17%-19%
HHV Efficiency (%)	N/A	N/A	N/A
Water Usage (gal/kWh)[5]	Negligible	Negligible	Negligible
Hg (lb/kWh)	0	0	0
CO2 (lb/kWh)	0	0	0
NOx (lb/kWh)	0	0	0
SO2 (lb/kWh)	0	0	0

Sources: Stakeholder data submitted to the Florida Public Service Commission, September 2008; Navigant Consulting, October 2008

Notes: 1 . **All data is presented in kW_{pAC}. PV systems are typically rated in kW_{pDC}, but for a proper comparison to other technologies' economics, Navigant Consulting will present economics as a function of a system's kW_{pAC} rating assuming a 84% DC to AC derate.**

2. Capacity factor varies because of location, system orientation relative to due south and technology. Thus, a range is presented.

3. Results assume a 5º module tilt.

4, In this study, PV capacity factor is defined as (kW_{hAC} Output)/(kW_{pAC} rating)

5. A minor amount of water is required for cleaning of the panels.

Economies of scale results in lower costs for ground mounted systems, relative to commercial systems, even with trackers.

	Ground Mounted, Single Axis Tracking PV Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Plant Nameplate Capacity (kW[1])	10,000	10,000	10,000
Project Life (yrs)	25	25	25
Development Time (yrs)	1	1	1
Installed Cost ($/kW)[2,3]	7,100	5,100	4,300
Fixed O&M ($/kW-yr)[4]	34	20	15
Non-Fuel Variable O&M ($/kWh)	0	0	0
Fuel/Energy Cost ($/kWh)	0	0	0

Sources: Stakeholder data submitted to the Florida Public Service Commission, September 2008; Navigant Consulting, October 2008

Notes:

1 . **All data is presented in kW_{pAC}. PV systems are typically rated in kW_{pDC}, but for a proper comparison to other technologies' economics, Navigant Consulting will present economics as a function of a system's kW_{pAC} rating assuming a 84% DC to AC derate.**

2. Costs shown are for a single-axis tracking system.

3. Pricing includes hurricane protection. NCI projects cost declines due to: an easing of the current polysilicon shortage, increased module efficiency, and streamlined installation/construction practices. The PV industry has been experiencing a shortage of a key feedstock (polysilicon) and that has drive costs up over the past several years. Prior to this PV costs had steadily been declining.

4. This includes two inverter replacements over the system's life.

PV performance varies with the state's solar resource.

	Ground Mounted, Single Axis Tracking PV Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Summer Peak Output (kW)[1]	6,000	6,000	6,000
Winter Peak Output (kW)	2,000	2,000	2,000
Availability (%)	99%	99%	99%
Net Capacity Factor (%)[2,3,4]	23%-26%	23%-26%	24%-27%
HHV Efficiency (%)	N/A	N/A	N/A
Water Usage (gal/kWh)[5]	Negligible	Negligible	Negligible
Hg (lb/kWh)	0	0	0
CO2 (lb/kWh)	0	0	0
NOx (lb/kWh)	0	0	0
SO2 (lb/kWh)	0	0	0

Sources: Stakeholder data submitted to the Florida Public Service Commission, September 2008; Navigant Consulting, October 2008

Notes: 1 . **All data is presented in kW_{pAC}. PV systems are typically rated in kW_{pDC}, but for a proper comparison to other technologies' economics, Navigant Consulting will present economics as a function of a system's kW_{pAC} rating assuming a 84% DC to AC derate.**

2. Capacity factor varies because of location, system orientation relative to due south and technology. Thus, a range is presented.

3. Results assume a 28^{o} module tilt and single-axis tracking.

4. In this study, PV capacity factor is defined as (kW_{hAC} Output)/(kW_{pAC} rating)

5. A minor amount of water is required for cleaning of the panels.

DRAFT

NAVIGANT CONSULTING

Solar water heating technologies have been in the Florida market for several decades .

R&D	Demonstration	Market Entry	Market Penetration	Market Maturity
			Solar Water Heating	

Technology Definition

- Per NCI's statement of work, his study will focus on solar water heating systems at least 2 MW in size. Systems under 2 MW in size are being covered under another study in support of the Florida Energy Efficiency and Conservation Act.
- This study will not cover pool heating applications.

Technology Maturity

- Glazed flat plate collector technology has successfully been deployed for several decades. Evacuated tube technology is starting to reach maturity as well.
- The remaining system components are all well established technologies (e.g., storage tanks, piping, valves, etc.).
- Utility grade meters that can record system heat output in terms of kWh's are readily available.

Market Maturity

- Florida is currently the second leading state for solar water heating installations (behind Hawaii) and has several established manufacturers, distributors and installers.
- Several barriers – including poor perception due to past industry problems, lack of qualified installers, lack of customer awareness, and lack of government support – have been holding the U.S. solar water heating industry back.

Navigant Consulting obtained data on number of buildings that could use a 2 MW_{th} solar water heating system.

Solar Water Heating Technical Potential

- NCI's original plan was to collect data on the number of Florida buildings that had at least a 2 MW_{th} water heating load.
  - However, this data does not exist for the state of Florida.
- As a proxy, NCI collected data on number of buildings that could likely use a 2 MW_{th} solar water heating system:
  - Private hospitals with 65,000+ sq. ft. of floor space
  - Public hospitals with 65,000+ sq. ft. of floor space
  - College and university buildings with 65,000+ sq. ft. of floor space
  - Hotels and motels with 200,000+ sq. ft. of floor space
- NCI worked with Armasi, Inc.[1] to collect number of buildings meeting the above criteria.
- The results was 568 buildings, which at 2 MW_{th} each, results in a technical potential of **1,136 MW_{th} or 1,700 to 2,000 GWh_{th}.**
- Note that other potential applications might exist in the state (such as large scale industrial or commercial), but this time, sufficient data did not exist to quantify this potential.

Notes:

1. Armasi, Inc. uses Florida Property Appraiser real property tax data that contains land use codes, building area, parcel size, and a brief legal description for every building in the state. Armasi then queried this database based upon the above type and size criteria.

As the U.S. solar water heating market grows, Navigant Consulting projects that installed costs will decrease.

	Solar Water Heating Economic Assumptions for Given Year of Installation (2008$)		
	2008	**2015**	**2020**
Plant Capacity (kW offset)[1]	2,000	2,000	2,000
Project Life (yrs)	30	30	30
Development Time (yrs)	0.75	0.75	0.75
Installed Cost ($/kW)[2]	1,700	1,600	1,500
Fixed O&M ($/kW-yr)	14	12	10
Non-Fuel Variable O&M ($/kWh)	0	0	0
Fuel/Energy Cost ($/kWh)	0	0	0

Sources: Navigant Consulting October 2008; Stakeholder data submitted to the Florida Public Service Commission; "Economic Impacts of Extending Federal Solar Tax Credits" Navigant Consulting Inc, September 200

Notes:

1 All data is presented in thermal energy unit (i.e., kWth).

2 NCI projects system cost declines due to: learning curve impacts as the U.S. solar water heating industry grows and efficiency improvements.

Solar water heating performance varies across the state.

	Solar Water Heating Economic Assumptions[1] for Given Year of Installation (2008$)		
	2008	**2015**	**2020**
Summer Peak (kW offset)[2]	2,000	2,000	2,000
Winter Peak (kW offset)[2]	2,800	2,800	2,800
Availability (%)	99%	99%	99%
Typical Net Capacity Factor (%)	17%-20%	17%-20%	17%-20%
HHV Efficiency (%)	N/A	N/A	N/A
Water Usage (gal/kWh)[3]	Negligible	Negligible	Negligible
Hg (lb/kWh)	0	0	0
CO2 (lb/kWh)	0	0	0
NOx (lb/kWh)	0	0	0
SO2 (lb/kWh)	0	0	0

Sources: Navigant Consulting, October 2008; stakeholder data submitted to the Florida Public Service Commission

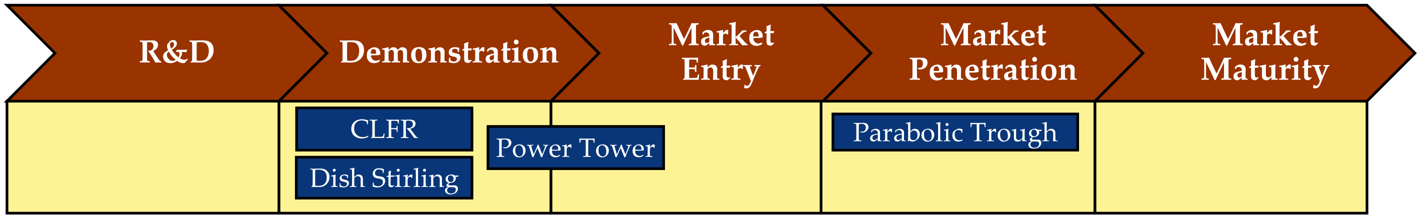
Notes:

1. All data in thermal energy units (i.e., kW_{th})

2. Winter peak is higher because more energy for water heating is used in Florida, thus there is greater potential to offset energy usage for water heating.

3. Water usage for system is negligible except for potentially a small amount used each year for cleaning.

Navigant Consulting will focus on hybrid CSP designs, given recent PPA announcements with a natural gas combined cycle hybrid.



Technology Definition

- Concentrating solar power (CSP) technologies require Direct Normal Insolation (as opposed to PV technologies which can use scattered or diffuse insolation as well). A vast majority of U.S. CSP projects are going in the desert southwest, where Direct Normal Insolation Resources are 50%-60% higher than Florida.
- Most systems in the desert southwest are currently dependent on federal tax credits to be competitive with traditional forms of generation. Given the lower resource in Florida, stand alone systems will not likely be economically competitive in the time frame of this study.
- However, a project has been announced in Florida for a hybrid CSP system in which the CSP system heats steam for a natural gas combined-cycle plant's steam cycle. Also, full (non-hybrid) CSP systems have been commercially operating in California for over 20 years. Thus, Navigant Consulting assumes this design is feasible in Florida and will focus on the technical potential of these designs.

Technology and Market Maturity

- Parabolic trough technologies have been operating in California since the mid 1980's and new plants have recently been completed in Nevada and Spain. Many more are scheduled to be built in the next decade.
- Compact linear fresnel, dish Stirling, and power tower technologies are still in the demonstration phase, but several plants of each technology are scheduled to be built in the next decade.

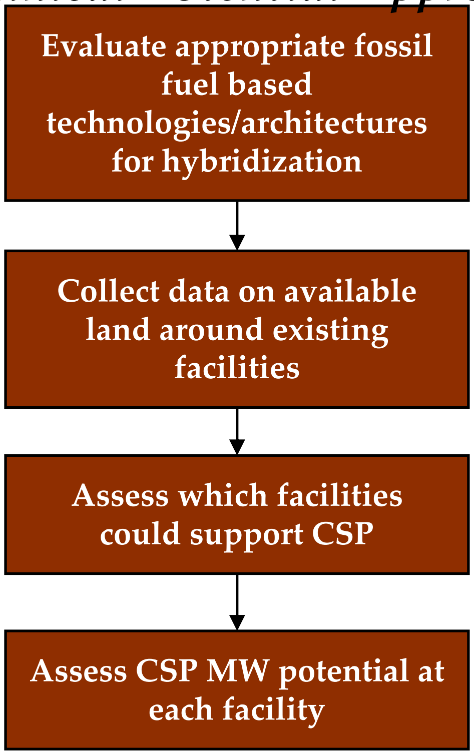
NAVIGANT CONSULTING

Navigant Consulting focused on hybrid CSP systems.

CSP Technical Potential Methodology

- NCI is focusing on hybrid CSP systems where the CSP system provides heat to the steam cycle of a fossil fuel plant.
  - CSP hybridized with natural gas combined cycle plants, called Integrated Solar Combined Cycle Systems (ISCCS) are not yet constructed, but several are scheduled to be built.
  - NCI will focus on ISCCS systems but will look into hybridization with coal plants as well, where the CSP system would preheat steam.

Technical Potential Approach



Navigant Consulting reviewed each fossil fuel architecture for compatibility with CSP.

Appropriate Technologies and Architectures for Hybridization

- NCI started by evaluating each type of fossil fuel and system architecture:
  - **Steam Cycle with Coal**: Turbines are sized assuming base load operation, thus a larger turbine would need to retrofitted into an existing plant to utilize CSP. Economically, the revenue loss of taking a plant offline specifically to retrofit a larger turbine does not outweigh the gains. However, if a plant was schedule to be offline for major work (i.e., scrubber addition), CSP could be added.
  - **Steam Cycle with Residual Fuel Oil:** These plants present a possible opportunity, but the state's 10 year plan suggests utilities will be relying less on these plants over time (going from 6.25% of the states generation to ~1% by 2017), either through retirements or reducing run time. Thus, Navigant Consulting did not look at these plants.
  - **Natural Gas Combustion Turbine:** These are not steam cycles and hybridization is not possible.
  - **Distillate Fuel Oil Combustion Turbine:** These are not steam cycles and hybridization is not possible.
  - **Natural Gas Combined Cycle:** The steam cycle portion of a combined cycle plant is a natural fit for hybridization, but to prevent aforementioned costly retrofits, candidate plants should have duct firing capabilities because those configurations will have turbines oversized relative to the plants baseline power.
- Thus, **Steam Cycle with Coal** and **Natural Gas Combined Cycle** were the only likely candidates.

Navigant Consulting arrived at a CSP technical potential of 380 MW.

CSP Technical Potential
• First, Navigant Consulting used EIA data[1] to gather data on which coal plants do and do not have scrubbers. – Any plant that did not have scrubbers did not have available land, indicating a technical potential for IOU owned coal plants of 0 MW. • Next, on behalf of Navigant Consulting, the FL PSC solicited the 4 state IOU's for data on land available around power plants for CSP installations. – The results yielded ~1,000 to ~2,900 acres potentially available for CSP. – However, the acreage was not evenly distributed by plant, and many plants did not have adequate land available for CSP installations. – Navigant followed up with each IOU to discuss which plants had duct firing and could support CSP. • NCI also queried Energy Velocity for which non-IOU own Natural Gas Combined Cycle plants in the state had duct firing. • The resulting technical potential was **380 MW or 600 to 760 GWh** (depending on the solar resource).

Notes:

1 Source is EIA form 767

NAVIGANT CONSULTING

CSP installed costs should decrease over time as the CSP industry matures.

	CSP Economic Assumptions for Given Year of Installation (2008$)[1]		
	2009	**2015**	**2020**
Plant Capacity (kW)	75,000	75,000	75,000
Project Life (yrs)	40	40	40
Development Time (yrs)	4	4	4
Installed Cost ($/kW)[2]	5,700	5,700	5,400
Fixed O&M ($/kW-yr)	80	75	70
Non-Fuel Variable O&M ($/kWh)	0	0	0
Fuel/Energy Cost ($/kWh)	0	0	0

Sources: NCI October, 2008; Stakeholder data submitted to the Florida Public Service Commission, September 2008

Notes:

1. Analysis assumes a parabolic trough system hybridized with a natural gas combined cycle system, but costing is only for the solar portion of the system.

2.

CSP performance will vary with solar resource across the state.

	CSP Economic Assumptions for Given Year of Installation (2008$)		
	2008	2015	2020
Summer Peak (kW)	75	75	75
Winter Peak (kW)	0	0	0
Availability (%)[1]	95%	95%	95%
Typical Net Capacity Factor (%)[2]	18%-23%	18%-23%	18%-23%
HHV Efficiency (%)	N/A	N/A	N/A
Water Usage (gal/kWh)[3]	Negligible	Negligible	Negligible
Hg (lb/kWh)	0	0	0
CO2 (lb/kWh)	0	0	0
NOx (lb/kWh)	0	0	0
SO2 (lb/kWh)	0	0	0

Sources: NCI October, 2008; Stakeholder data submitted to the Florida Public Service Commission, September 2008

Notes:

1. Does not account for outages at associated natural gas facility that the CSP plant is hybridized with.

2. Capacity factors vary throughout Florida.

2. Does not include water required for steam cycle as that would be accounted for in the natural gas facility's economics.

DRAFT

Onshore wind is a booming market, while offshore wind is just starting.

Technology Definition

- In the context of this analysis, wind energy refers to the use of horizontal axis wind turbines to generate energy from onshore and offshore wind regimes. The turbines range in nameplate capacity from under tens of kWs to upwards of 6 MWs, and installations range from single turbines to large farms with hundreds of turbines.

Technology Maturity

- Onshore wind turbine technology has matured considerably over the last decade as market demand has grown explosively. Average turbine nameplate capacity, tower height, and blade length have all grown steadily.
- While offshore wind turbines have been installed in Europe, the technology is less mature than that of onshore wind. Manufacturers are working on larger turbines with innovative foundations and less maintenance requirements. At 45 meters in sea depth, the Beatrice Demonstration Windfarm, is the deepest installation to date[1]. Deep sea (>60 meter in depth) technologies are still in R&D and developers, researchers, and regulators indicate they will not be commercially ready by 2020.

Market Maturity

- The onshore wind market in the United States has entered market maturity. In 2007, the United States. was the largest country wind market in the world[2], and wind was the second largest source of new generation capacity in the country for the third consecutive year.[3]
- The global offshore wind market is transitioning from market entry to market penetration. Although there are active U.S. projects, no installations have occurred to date primarily due to regulatory and social barriers. Some barriers may be addressed when the Minerals Management Service (MMS) issues its final rulemaking in late 2008.

Sources: 1.) Eaton, Susan R., Innovative Idea Could Expand North Sea Winds Fuel Production, AAPG Explorer, February 2008. 2.) BTM Consult ApS. International Wind Energy Development: World Market Update 2007. March 2008. 3.) U.S. Department of Energy, Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2007, May 2008.

There are no existing wind farms in the state of Florida. The only projects to date have been distributed installations of small turbines.

Current Wind Installations in Florida

- Although there have been discussions of some larger wind projects (see the subsequent slide) there are no existing installations.
- Projects in the state to date have been distributed installations of individual small wind turbines. For example Bergey WindPower Co., the primary manufacturer of turbines of 10 kW or below in size has sold units in the state.[1]

Source: 1.) http://www.bergey.com/About_BWC.htm. Accessed October 8, 2008.

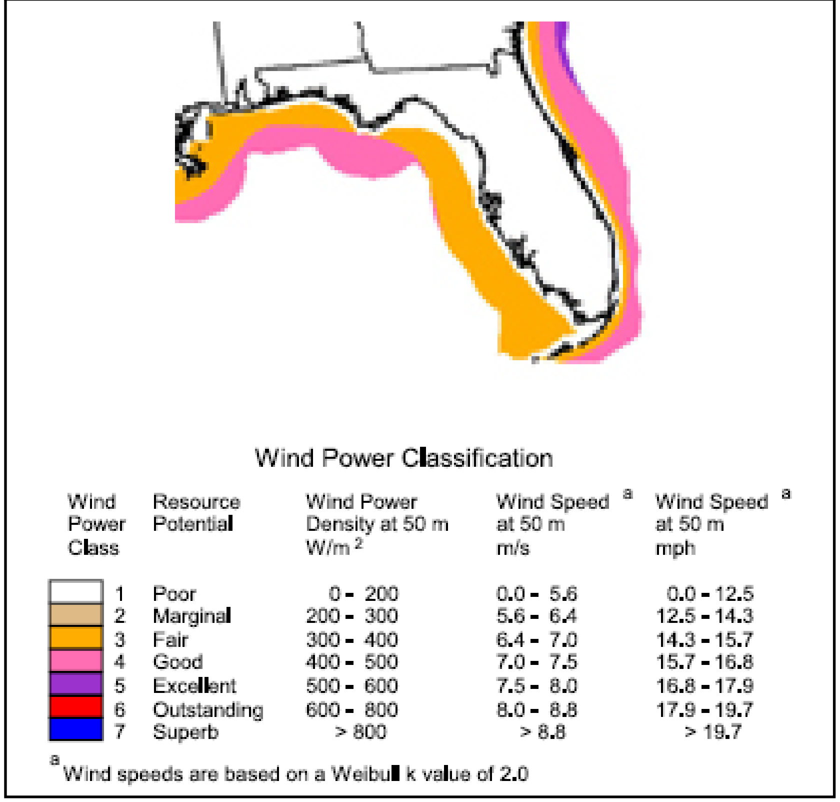
The onshore wind resource in Florida is limited.

FL Onshore Wind Resource

- Based on currently available wind mapping, the Florida onshore wind resource is limited.
  - To date, no Class 3 regimes, which are generally the minimum for economically viable wind farms, have been identified.[1,2]
  - Most of the state has Class 1 wind, but there are indications that some Class 2 wind pockets may be found along the coast and on a small inland ridgeline.[3] To date, a state-wide high resolution mapping exercise has not been undertaken to identify the potential of these sites.

Source: 1.) 20% Wind Energy by 2030. U.S. Department of Energy. June 2008. 2.) Proprietary Global Energy Concepts study of the southeast performed for Navigant Consulting, November 2007 3.) Florida Wind Initiative: Wind Powering America: Project Report. Completed by AdvanTek. November 18, 2005.

Map of FL Onshore Wind Resource



Note: The map above is part of a national map produced by NREL. It shows all class one wind onshore.

Source: National Renewable Energy Laboratory (NREL) http://www.windpoweringamerica.gov/pdfs/wind_maps/us_windmap.pdf, Accessed November 24, 2008.

Utility-scale onshore wind technical potential consists of 1,252 MW of Class 2 winds along the coastline.

Florida Onshore Wind Technical Potential

Steps Taken

- Several wind mapping exercises have uncovered no Class 3 resources in the state.[1,2]
- A 2005 Florida Wind Initiative report identified potential areas of Class 2 wind along the coast and a small inland ridgeline. It indicated that all utility-scale systems would need to be located within a few hundred meters of the coastline.[3] A high resolution mapping study is necessary to precisely quantify the state's Class 2 resource, but no such study is publicly available to date.
- Navigant Consulting conducted a Geographic Information System (GIS) land use analysis of the areas identified in the Florida Wind Initiative report as having the potential for Class 2 winds that could potentially support utility-scale system installations. The GIS assessment identified approximately 62,000 acres of those lands as suitable for wind development, and a technical potential was estimated based on an assumption that the lands had Class 2 wind. A WindLogics study identified one additional area with Class 2 wind, which was added to the total.[4]

Resulting Potential

- Technical Potential for Class 2 wind: **1,252 MW; 2.0 TWh**

Assumptions

- See the following slide

Source: 1.) 20% Wind Energy by 2030. Increasing Wind Energy's Contribution to U.S. Electricity Supply. U.S. Department of Energy. June 2008. 2.) Proprietary Global Energy Concepts study of the southeast performed for Navigant Consulting, November 2007. 3.) Florida Wind Initiative: Wind Powering America: Project Report. Completed by AdvanTek. November 18, 2005. 4.) Wind Results from the St. Lucie Project Site. Prepared by WindLogics for Florida Power & Light, 2008.

The onshore wind technical potential analysis has the following assumptions and notes.

Florida Onshore Wind Technical Potential (continued)

Assumptions and Notes

- The analysis assumes that Class 1 resources are not viable for wind projects and that small wind, defined here as projects using turbines less than 150 kW, will not contribute appreciably to total renewable generation in the state (e.g., in 2007, 1,292 small turbines were sold in the United States for on-grid application, but they accounted for 5.7 MW in capacity[1]).
- Based on analysis completed in the 2005 Florida Wind Initiative report, the lands analyzed for utility-scale wind suitability were those within 300m of the coastline and located within the target areas identified in the report.[2]
- Exclusions included state and federal parks, wildlife refuges, conservation habitats, urban areas, wetlands, water, airfields, areas with identified stink holes, 50% of state and federal forests, 50% of Department of Defense lands, 30% of agricultural lands, and 10% of pastures.
- Continued on next page

Source: 1.) Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2007. U.S. Department of Energy. May 2008. 2.) Florida Wind Initiative: Wind Powering America: Project Report. Completed by AdvanTek. November 18, 2005.

The onshore wind technical potential analysis has the following assumptions and notes.

Florida Onshore Wind Technical Potential (continued)
Assumptions and Notes • The assumed wind farm density was 5 MW/km^2, which is independent of turbine type or size.[1] As an example, this translates for a GE 1.5 MW turbine with a 77 meter diameter to 7.8 diameter spacing between rows and 6.5 diameter spacing within rows. • The application of this macro factor does not account for two circumstances: 1.) some parcels of available land are too small for a single turbine and 2.) single and double turbine installations require less land than installations of 3 or more turbines. A project-level siting study is necessary to determine the actual potential of any given site. • WindLogics identified one other site outside the 6 areas identified in the 2005 Florida Wind Initiative report and completed a detailed analysis of the site's wind resource. The analysis found capacity of 14 MW on Hutchinson Island.[2] A high resolution mapping exercise would be necessary to determine whether any other such areas exist in the state.

Source: 1.) 20 Percent Wind Energy Penetration in the United States: A Technical Analysis of the Energy Resource, Prepared by Black & Veatch for the American Wind Energy Association, October 2007. 2.) Wind Results from the St. Lucie Project Site. Prepared by WindLogics for Florida Power & Light, 2008.

Rising installed costs have recently hurt wind economics. Near-term stabilization followed by a gradual decline is expected.

	Onshore Wind Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Plant Capacity (MW)[1]	1.5	1.5	1.5
Project Life (yrs)	25	25	25
Development Time (yrs)	2	2	2
Capital Cost ($/kW)[2]	$2,470	$2,340	$2,300
O&M Cost ($/MWh)[3]	$17	$16	$15
Fuel/Energy Cost ($/kWh)	$0	$0	$0

Sources: Navigant Consulting Estimates 2008. Interviews with developers, manufacturers, trade associations, and regulators throughout 2008. *Renewable Energy Costs of Generation Inputs for IEPR 2007*, April 2007, prepared for CEC/PIER. *Renewable Energy: Costs, Performance and Markets – an outlook to 2015.* NCI report for CEA Technologies, June 22, 2007, NREL1: *Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2007*, May 2008. *IEEE Power and Energy Magazine*, Vol 5, Num 6, Nov/Dec 2007. 20 Percent Wind Energy Penetration in the United States, Prepared by Black and Veatch for AWEA, October 2007. Data submitted by stakeholders in 2008. Wind Results from the St. Lucie Project Site, Prepared by WindLogics for Florida Power & Light, 2008. Musial, W and S. Butterfield, Future for Offshore Wind Energy in the United States: Preprint, NREL, June 2004.

Notes:

1. The economic analysis assumes a representative project of a single 1.5 MW turbine installation.
2. Capital cost estimates are based on interviews, stakeholder data, CEA Technologies, CEC/PIER, NREL, 20 Percent Wind and Musial. Transmission costs are not included in capital costs, but interconnection costs are included. The 2009 number incorporates a 10% cost premium for installation in the east over the average cost in the United States and a 15% cost premium for coastal installations driven by higher foundation costs. The cost decline is driven by a 12% wind technology learning curve based on world cumulative wind capacity offset by a 2.6%/year assumed increase based on commodity costs (calculated based on the historical average for metallic and nonmetallic commodities).
3. O&M costs include fixed and variable O&M costs. The costs, including the decline over time, which are 1%/yr based on learning curve effects, are based on Navigant Consulting's internal analysis, interviews, stakeholder data, CEC/PIER, 20 Percent Wind, and IEEE.

Capacity factors for wind projects in Florida's Class 2 wind are low.

	Onshore Wind Economic Assumptions for Given Year of Installation (2008$)		
	2009	2015	2020
Summer Peak (MW)	Varies	Varies	Varies
Winter Peak (MW)	Varies	Varies	Varies
Availability (%)[1]	98%	98%	98%
Typical Net Capacity Factor (%)[2]	18%	19%	20%
HHV Efficiency (%)	NA	NA	NA
Water Usage (gal/kWh)	NA	NA	NA
Hg (lb/kWh)	0	0	0
CO2 (lb/kWh)	0	0	0
NOx (lb/kWh)	0	0	0
SO2 (lb/kWh)	0	0	0

Sources: Navigant Consulting Estimates 2008. Interviews with developers, manufacturers, trade associations, and regulators throughout 2008. *Renewable Energy Costs of Generation Inputs for IEPR 2007*, April 2007, prepared for CEC/PIER. *Renewable Energy: Costs, Performance and Markets – an outlook to 2015.* NCI report for CEA Technologies, June 22, 2007, NREL: *Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2007*, May 2008. Data submitted by stakeholders in 2008. Wind Results from the St. Lucie Project Site, Prepared by WindLogics for Florida Power & Light, 2008. *IEEE Power and Energy Magazine*, Vol 5, Num 6, Nov/Dec 2007

Notes:

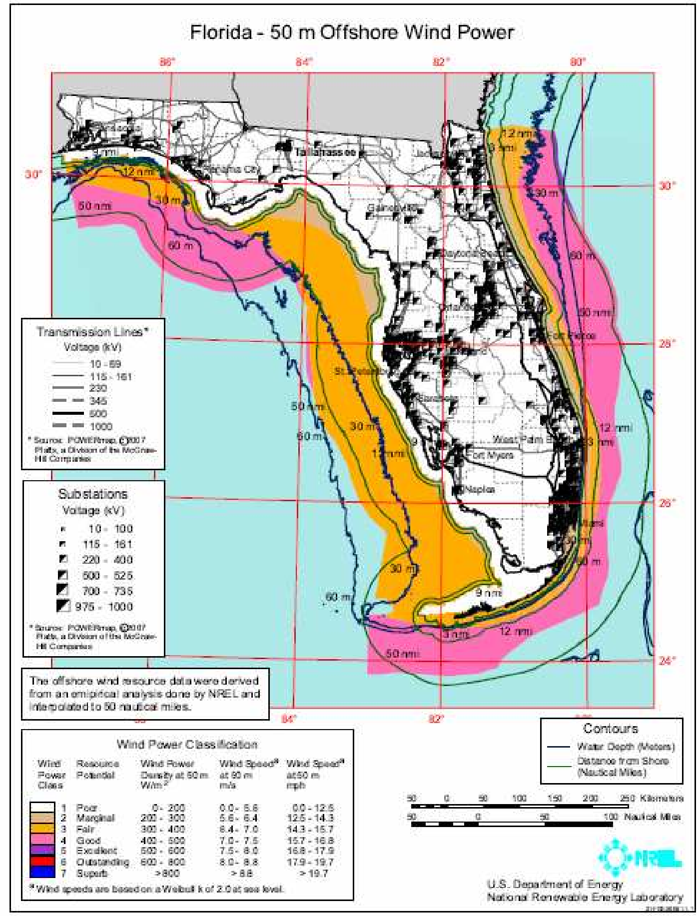
1. Availability based on interviews, IEEE, and stakeholder data.
2. Capacity factor based on interviews, stakeholder data, NREL, CEA Technologies, CEC/PIER, WindLogics. It increases over time based on increasing turbine height and improved performance.

Florida has offshore wind potential around much of its coastline.

FL Offshore Wind Resource

- Florida's offshore wind resource is larger than its onshore resource.
- Most of the resource is Class 4 wind although there is a pocket of Class 5 wind off the northwestern coast of the state.
- Due to ocean depths and the location of both coral reefs and marine sanctuaries, the most promising areas of development are likely to be along the northern sections of both coasts.

Map of FL Offshore Wind Resource



Source: National Renewable Energy Laboratory. February 2008.

Florida's offshore wind technical potential through 2020 is 49 GW.

Florida Offshore Wind Technical Potential

Steps Taken

- Data from a NREL pre-publication report[1] that is slated for release in the coming months were used to determine Florida's offshore wind potential. The report indicates that there is a resource of 40 GW in waters less than 30 meters in depth and 88 GW in waters between 30 and 60 meters in depth.[2]
- Navigant Consulting conducted a GIS assessment to estimate the technical potential. Notes are below:
  - Based on extensive interviews with developers, researchers and regulators, it was assumed that deep sea (>60 meter in depth) wind technologies will not be available commercially until after 2020.
  - Class 4 winds are required to make offshore wind projects viable.
  - Exclusions based on NREL recommendations were applied to the Class 4 and 5 winds that are available within 60 meters in order to estimate the technical potential. These exclusions account for shipping lanes, local opposition to projects within sight of shore, marine sanctuaries, and coral reefs. These exclusions are 100% within 3 nautical miles of the coast and 60% beyond that distance except in areas with coral reefs in which case an 80% exclusion was used.[2]
  - Hurricane patterns were not a screening criteria. Rather than eliminating potential sites, these patterns increase the risk premium associated with a project (see Step 6 of the report for the incorporation of the premium into insurance costs for projects).

Resulting Potential

- Technical potential: **Class 5: 2.5 GW, 9.1 TWh; Class 4: 46.1 GW, 145.4 TWh.**

Sources: 1.) NREL Pre-publication report. Data taken from table A-1, which was received from NREL's Walt Musial via facsimile on October 21, 2008. 2.) Florida Offshore Wind Resource Potential (MW) by State, Region, Wind Power Class, Water Depth, and Distance from Shore, NREL, February 2008.

Note: A Department of Defense (DOD) marine testing grounds, which stretches from the Alabama border to Tampa Bay, was considered available area because of past development in the area and the location of the wind resource. Actually availability will vary on a project by project basis depending on negotiations with DOD.

Offshore wind installed costs have also risen over the past few years.

	Offshore Wind Economic Assumptions for Given Year of Installation (2008$)		
	2009[1]	**2015**	**2020**
Plant Capacity (MW)	NA	300	300
Project Life (yrs)	NA	25	25
Development Time (yrs)[2]	NA	5	5
Capital Cost ($/kW)[3]	NA	$4,620	$4,330
Fixed O&M ($/kW-yr)[4]	NA	$21	$21
Non-Fuel Variable O&M ($/MWh)[4]	NA	$25	$22
Fuel/Energy Cost ($/kWh)	NA	$0	$0

Sources: Navigant Consulting Estimates 2008. Interviews with developers, manufacturers, trade associations, and regulators throughout 2008. 20% Wind Energy by 2030. Increasing Wind Energy's Contribution to U.S. Electricity Supply. U.S. Department of Energy. June 2008. Musial, W and S. Butterfield, Future for Offshore Wind Energy in the United States: Preprint, NREL, June 2004.

Notes:

1. No data is provided in 2009 because it is not expected that construction of offshore wind plants could begin until 2010 since MMS is not expected to finalize its rulemaking on permitting until early 2009.
2. Construction time is based on interviews and stakeholder data.
3. Capital costs are based on interviews and stakeholder data, and Musial. Transmission costs are not included in capital costs, but interconnection costs are included. The cost decline is driven by a 12% offshore wind technology learning curve based on world cumulative offshore wind capacity offset by a 2.6%/year assumed increase based on commodity costs (calculated based on the historical average for metallic and nonmetallic commodities).
4. Fixed and non-fuel O&M costs are based on interviews, Navigant Consulting's internal analysis, and the 20% Wind report. The decline over time in the non-fuel variable O&M, which is 1%/yr are based on learning curve effects.

The offshore resource results in higher capacity factors relative to onshore wind.

	Offshore Wind Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Summer Peak (MW)	NA	Varies	Varies
Winter Peak (MW)	NA	Varies	Varies
Availability (%)[1]	NA	96%	97%
Typical Net Capacity Factor (Class 4/5) (%)[2]	NA	36%/41%	38%/43%
HHV Efficiency (%)	NA	NA	NA
Water Usage (gal/kWh)	NA	0	0
Hg (lb/kWh)	NA	0	0
CO2 (lb/kWh)	NA	0	0
NOx (lb/kWh)	NA	0	0
SO2 (lb/kWh)	NA	0	0

Sources: Navigant Consulting Estimates 2008. Interviews with developers, manufacturers, trade associations, and regulators throughout 2008. 20% Wind Energy by 2030. Increasing Wind Energy's Contribution to U.S. Electricity Supply. U.S. Department of Energy. June 2008. *IEEE Power and Energy Magazine*, Vol 5, Num 6, Nov/Dec 2007. U.S. Department of the Interior, Minerals Management Services (MMS), Cape Wind Energy Project Draft EIS, January 2008, 2.) Proprietary Global Energy Concepts study of the southeast performed for Navigant Consulting, November 2007.

Notes:

1. Availability based on IEEE. It is assumed that the lower end of the range given for onshore wind applies to offshore wind since offshore wind is a newer technology. It is assumed that the availability will improve over time as the technology matures.
2. Capacity factors based on interviews, stakeholder data, MMS, Global Energy Concepts, and 20% Wind report. It increases over time based on increasing turbine height and improved performance.

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The Florida Statutes include a broad definition of biomass for power generation that is not technology specific.

Resource & Technology Definition

- Florida Statutes 366.91(2)(a) "Biomass" means a power source that is comprised of, but not limited to, combustible residues or gases from forest-products manufacturing, agricultural and orchard crops, waste products from livestock and poultry operations and food processing, urban wood waste, municipal solid waste, municipal liquid waste treatment operations, and landfill gas.

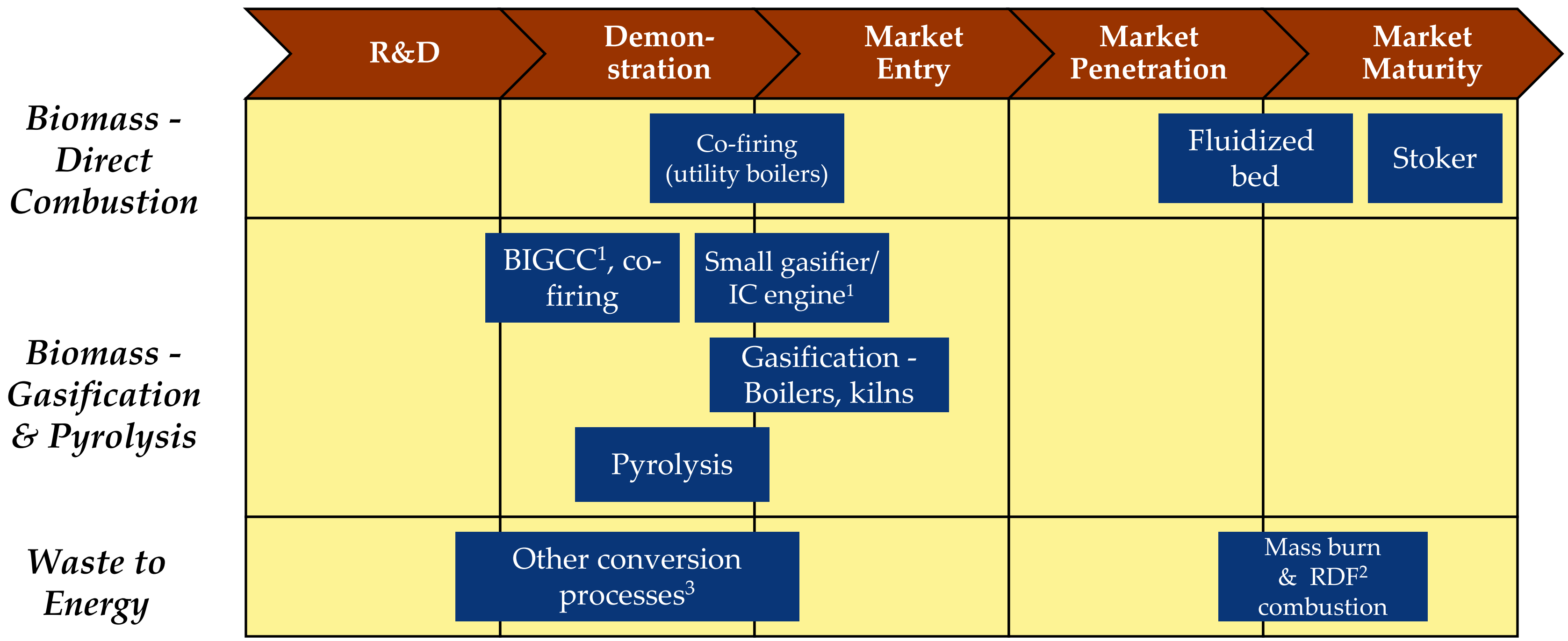
Technology Maturity

- Biomass combustion is mature and widely deployed technology, mainly for cogeneration but also for stand-alone power generation.
- Biomass gasification is relatively well developed but lacks significant commercial deployment for power generation
- Direct co-firing of biomass with coal in utility boilers is technologically mature but not widely deployed
- There have been three recent announcements in GA, HI and WI regarding repowering of older coal units to fire 100% biomass, one using gasification.
- Waste to energy based on combustion is mature, and there are various other thermal conversion technologies in development, including conventional gasification, plasma gasification, and pyrolysis.

Market Maturity

- The FL forest products and sugarcane industries make extensive use of biomass CHP today, with a combined capacity of about 550MW.
- Markets for onsite use of biomass residues is generally mature but there is the potential for repowering with gasification
- There is less use of biomass for stand-alone power generation
- Co-firing has historically been limited by economic and regulatory factors (e.g., risk of New Source Review, fly ash specifications).
- About 11% of FL's municipal solid waste is incinerated at 11 WTE plants, which generate ~520 MW.

Biomass power generation includes multiple technology platforms at varying levels of technology and market maturity



1. BIGCC = Biomass integrated gasification combined cycle.
2. RDF = Refuse derived fuel.
3. Includes RDF gasification, plasma gasification, and pyrolysis.

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The following solid biomass feedstock types are covered by the technical potential analysis.

Logging Residues	Unused portion of trees cut or killed as a result of roundwood product harvest on timberland (e.g., tops, limbs, aboveground stumps), and left in the forest.
Mill Residues*	Residues produced at forest product mills, including bark, sawdust, wood chips and black liquor. Most of these residues are currently used by the mills for energy or other purposes.
Other forest biomass	The net change (growth) in forest biomass volume; Timberland removals, other than roundwood, including fuel treatments (for forest fire risk), small diameter trees, rough and rotten trees, or other removals that have no market within the forest products industry; Other removals unrelated to roundwood harvest such as trees harvested in land clearings.
Agricultural Residues	The portions of extractable plant material remaining after crop harvest, such as corn stover and wheat straw. Can also include residues available at food processing plants (e.g., rice hulls, peanut shells), and animals wastes.
Urban Biomass Residues*	Includes urban wood (shipping pallets, construction and demolition debris, utility right of way clearings, and tree trimmings) and municipal solid waste
Energy Crops	Dedicated energy crops (e.g., switchgrass, eucalyptus, energy cane). These crops would compete for land used for traditional crops, but they can also be cultivated on more marginal land that is not suitable for conventional crops (e.g., pasture, reclaimed mining land).

* Main sources of solid biomass for power generation today.

Based on Energy Velocity[1] about 191 MW of agricultural by-product capacity (all using sugarcane bagasse) is installed in Florida.

	Existing Agricultural By-products Installations in Florida			
Agricultural by-products Unit	**Owner**	**Nameplate Capacity (MW)**	**Technology**	**In-Service Year**
Clewiston Sugar House	United States Sugar Corp	3.1	Steam Turbine	1981
Clewiston Sugar House	United States Sugar Corp	6.0	Steam Turbine	1983
Clewiston Sugar House	United States Sugar Corp	21.6	Steam Turbine	1997
Clewiston Sugar House	United States Sugar Corp	20.0	Steam Turbine	2006
Okeelanta Cogeneration	New Hope Power Partnership	74.9	Steam Turbine	1996
Okeelanta Cogeneration	New Hope Power Partnership	65.0	Steam Turbine	2006

1. Energy Velocity is a database provided by Ventyx Inc. For more information, visit http://www1.ventyx.com/velocity/vs-overview.asp

Based on Energy Velocity about 380 MW of wood & wood waste capacity is installed in Florida.

	Existing Wood/Wood Waste Installations in Florida			
Wood/Wood Waste Unit	**Owner**	**Nameplate Capacity (MW)**	**Technology**	**In-Service Year**
Buckeye Florida LP*	Buckeye Florida LP	8.2	Steam Turbine	1953
Buckeye Florida LP*	Buckeye Florida LP	14.8	Steam Turbine	1956
Buckeye Florida LP*	Buckeye Florida LP	11	Steam Turbine	1964
Buckeye Florida LP*	Buckeye Florida LP	10.4	Steam Turbine	1965
Georgia Pacific	Florida Power & Light Co	N/A	Steam Turbine	1983
Jefferson Power LLC	K & M Energy Inc	7.5	Steam Turbine	1990
Palatka*	Georgia Pacific Corp	9.7	Steam Turbine	1956
Palatka*	Georgia Pacific Corp	47.8	Steam Turbine	1965
Palatka*	Georgia Pacific Corp	32	Steam Turbine	1993
Jefferson Smurfit Corp (FL)*	Smurfit-Stone Container Corp	44	Steam Turbine	1988
Panama City Mill	Smurfit-Stone Container Corp	20	Steam Turbine	1956
Panama City Mill*	Smurfit-Stone Container Corp	4	Steam Turbine	1930
Panama City Mill*	Smurfit-Stone Container Corp	10	Steam Turbine	1949
Pensacola Florida*	International Paper Co	39.6	Steam Turbine	1981
Pensacola Florida*	International Paper Co	43.2	Steam Turbine	1981
Rayonier Fernandina Mill*	Rayonier, Inc	20	Steam Turbine	1950
Ridge (FL)	Ridge Generating Station LP	45.5	Steam Turbine	1994
Telogia Power	Telogia Power LLC	14	Steam Turbine	1986

* Spent pulping liquors, including black liquor, red liquor and sulfite liquor.

Based on Energy Velocity nearly 520 MW of waste to energy capacity is installed in Florida.

	Existing Waste-to-Energy Installations in Florida			
Waste-to-Energy Unit	**Owner**	**Nameplate Capacity (MW)**	**Technology**	**In-Service Year**
Bay Resource Management Center	Bay County Board County Commission	13.6	Steam Turbine	1987
Hillsborough County Resource Recovery	Hillsborough (County Of)	29	Steam Turbine	1987
Lake County	Covanta Lake Inc	15.5	Steam Turbine	1990
Lee County Solid Waste Energy (unit 1)	Lee County Board Commissioners	39	Steam Turbine	1994
Lee County Solid Waste Energy (unit 2)	Lee County Board Commissioners	20	Steam Turbine	2007
McKay Bay	Tampa (City of)	22.1	Steam Turbine	1985
Miami Dade County Resources (unit 1)	Metro Dade County	38.5	Steam Turbine	1981
Miami Dade County Resources (unit 2)	Metro Dade County	38.5	Steam Turbine	1981
North Broward	Wheelabrator Environmental System	67.6	Steam Turbine	1991
North County Regional Resource Recovery	Solid Waste Authority of Palm Beach	62.3	Steam Turbine	1989
Pasco County Solid Waste Resource Recovery	Pasco (County Of)	31.2	Steam Turbine	1991
Pinellas County Resource Recovery	Pinellas County Utilities	50.5	Steam Turbine	1983
Pinellas County Resource Recovery	Pinellas County Utilities	26	Steam Turbine	1986
South Broward	Wheelabrator Environmental System	66	Steam Turbine	1991

The biomass power technical potential resource analysis has two basic steps.

1 Assess solid biomass quantities available on a sustainable basis[1]

- Expressed in dry tons/year of feedstock that can be sustainably collected from various sources, including energy crops.
- Develop range estimates based on existing literature & data sources, and from information from FL stakeholders.
- Estimates generally are based on "recoverable quantities", which closely approximately technical potential.

2 Estimate capacity (MW) and generation (MWh/yr) potential

- Convert tons/yr to MMBtu/yr
- Apply range of conversion efficiencies based on current and future technology
  - 25% for direct combustion of biomass[2]
  - 40% for biomass integrated gasification combined cycle[2]
  - 650 kWh/ton for waste to energy (net output)
  - Assume 85% annual capacity factor

1. This assessment considers biomass resources in Florida only and does not include the potential for biomass to be sources from neighboring states or that some Florida biomass may be exported to neighboring states.
2. These efficiencies are indicative and used to bracket the technical potential for comparison to other renewable energy options. For the economic analysis, specific technology characteristics will be used in combination with the technical potential estimates.

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Every 1 million dry tons of biomass can support ~150-250 MW, and every 1 million tons of municipal waste (as collected) can support ~90 MW.

Woody Biomass[1]

- 1 dry ton ≅ 16 MMBtu[2]
- 25% efficiency = 13,648 Btu/kWh (direct combustion)[3]
- 40% efficiency = 8,530 Btu/kWh (integrated gasification combined cycle)[3]
- 1 dry ton can therefore produce 1.2-1.9 MWh
- At an annual capacity factor of 85%, 1 MW requires between 3,970-6,350 dry tons/yr
- **Thus, for every 1 million dry tons, 157-252 MW of capacity is possible**

Municipal Solid Waste

- Current state of the art in waste-to-energy
- 650 kWh/ton MSW (net)
- At an annual capacity factor of 85%, 1 MW requires between 11,455 tons/yr of MSW
- **Thus, for every 1 million tons MSW, 87 MW of capacity is possible**
- In the future, values could potentially be higher by applying different conversion technologies, including gasification.

1. These calculations would be similar for other biomass types, such as perennial grasses being considered for energy crops
2. This energy content value is illustrative. Different values have been used for different biomass types in the resource assessment. Typical moisture content for "green" (wet) biomass is 30-50%.
3. These efficiencies are indicative and used to bracket the technical potential for comparison to other renewable energy options. For the economic analysis, specific technology characteristics will be used in combination with the technical potential estimates.

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Biomass and waste resources can be segmented into three categories, based on availability.

1 — Already collected or generated onsite

- Forest products mill residues
- Municipal solid waste (including urban tree trimmings and yard trash)
- Animal wastes (poultry litter, horse manure)[1]
- Certain agricultural residues (e.g., orchard trimmings), food processing wastes
- Wastewater treatment plant residuals (biosolids)

2 — Available but not collected

- Logging residues
- Certain agricultural residues (e.g., corn stover, wheat straw – anything typically left on the field after harvest)

3 — Potentially available

- Additional net woody biomass forest growth from existing timberland
- Conversion of some existing timberland to energy plantations
- Dedicated energy crops on degraded land from phosphate mining[2]
- Dedicated energy crops on existing agricultural land[2]
- Forest understory biomass and other non-traditional biomass from timberland
- Algae grown for energy purposes (non-lipid fraction can be used for electricity generation

1. Other animal wastes are considered in the section on anaerobic digestion.
2. It is possible that other land could also be converted to energy crop production, but these are considered more likely. Note that most existing farmland is classified as pasture, rangeland and woodland. Only about 20% of Florida farmland is harvested for crops.

A summary of the solid biomass resource potential is below.

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.

NAVIGANT CONSULTING

Biomass power may eventually compete with advanced biofuels for feedstock, but there may also be synergies.

Potential Challenges from Advanced Biofuels Production

- So-called "second generation" biofuels technologies (e.g., cellulosic ethanol, Fischer-Tropsch fuels) use the same feedstocks as biomass power generation.
- Conventional biofuels plants, such as corn-ethanol plants, may choose to use biomass combined heat and power (CHP) instead of natural gas and purchased power, which will also increase demand for solid biomass fuels.
- In an analysis by the Governor's Action Team on Energy and Climate Change, it was assumed that by 2020, there would be a demand for 5 million dry tons/yr of biomass for biofuels production of about 500 million gallons/yr.[1]

Potential Synergies with Advanced Biofuels Production

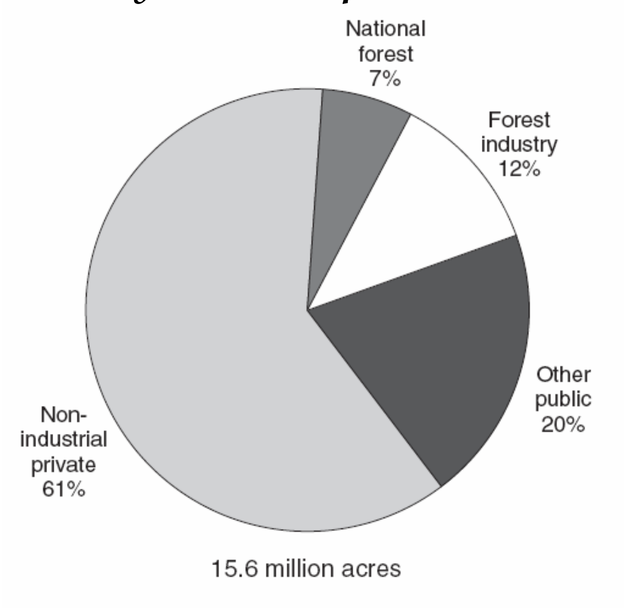
- Integrated biorefineries, built around 2nd generation biofuels conversion technologies, will almost certainly have a biomass CHP component, fueled by the onsite biomass residues generated by the biofuels production process.
  - The increased use of biomass CHP is therefore a natural outcome of deploying 2nd generation biofuels and may also include power for export, depending on the plant configuration.
- Existing forest product mills could be converted into integrated biorefineries to produce power and fuels for export, in addition to traditional products.[2]
- The degree to which this onsite generation qualifies for the RPS will depend on the final rules for RPS implementation.

1. See http://www.flclimatechange.us/documents.cfm, Chapter 6 and Appendix D.
2. For example, see: Larson, E.D., Consonni, S., Katofsky, R.E., Iisa, K., and Frederick, J.W. (2006), *A Cost-Benefit Assessment of Gasification-Based Biorefining in the Kraft Pulp and Paper Industry*, final report, and Larson, E.D., Consonni, S., and Katofsky, R.E. (2003), "*A Cost-Benefit Assessment of Biomass Gasification Power Generation in the Pulp and Paper Industry*," final report, Princeton Environmental Institute, Princeton, NJ (Downloadable from www.princeton.edu/~energy).

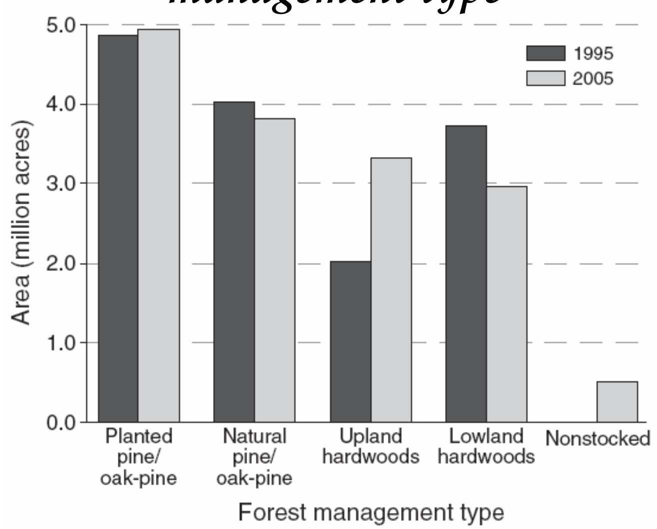
DRAFT

Florida has approximately 15.6 million acres of timberland, mostly in the north. A large fraction is planted pine/oak-pine.

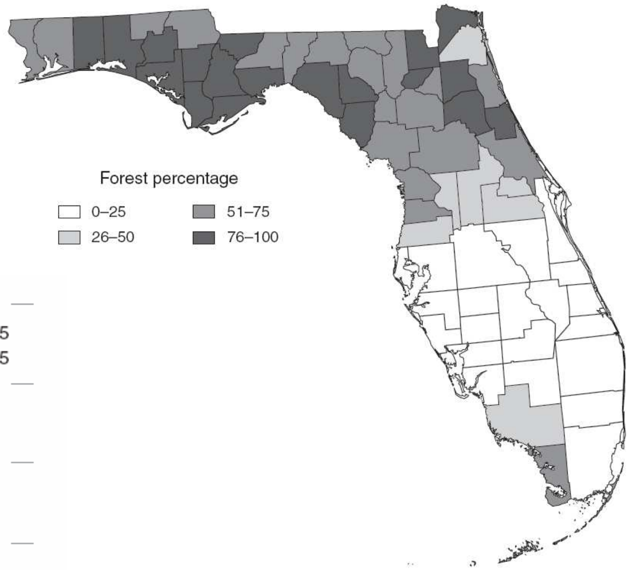
Florida's Area of timberland by ownership class (2005)



Florida's area of timberland by forest management type



Florida's counties by forest cover percentage (2005)



Source: Mark J. Brown, *Florida's Forests – 2005 Update,* U.S. Forest Service, Southern Research Station, July 2007.

NAVIGANT CONSULTING

Florida's forests offer the potential for large amounts of biomass, but more intensive resource exploitation needs careful consideration.

- Florida's timberland is currently producing net positive growth of merchantable timber of about 3 million dry tons/yr, but there is a high likelihood this will change within the next few years, driven mainly by reduced reforestation rates since 1988.
  - Current acreage being harvested exceeds the acreage that was planted since about the year 2000, so that in 5-10 years, net growth, all else equal, could become negative.
- In addition to growing stock trees[1], there is other forest biomass that is less well quantified, but that could provide significant quantities.
- Florida's timberland is predominantly managed to provide feedstock for the forest products industry, and any change in management of that land needs to consider the impacts on the industry.
- There are currently several large biomass power projects in development, one large biomass pellet plant in operation and also interest in producing biofuels from lignocellulosic biomass.
  - These projects are targeting, at least initially, primarily woody biomass forest resources.
- Given that biomass is locally sourced (typically within 50-100 miles) for each plant, every project requires a careful assessment of biomass availability and the sustainability of that supply.
- Not all timberland is privately held[2], and accessing biomass on public lands may be restricted and therefore reduce the technical potential relative to NCI's estimates.
- A study addressing the economic impact of financial incentives to energy producers who use woody biomass as fuel, addressing effects on wood supply and prices, impacts to current markets and forest sustainability was mandated by the Florida Legislature in HB 7135. This study is getting underway and will be conducted by the Florida Division of Forestry together with the University of Florida researchers.

1. "Growing stock trees" represents the majority of woody biomass in Florida's timberland. It is defined as trees of commercial species that have, currently or potentially, wood that is merchantable to the forest products industry. It excludes rough or rotten live trees, and non-commercial species of trees.
2. The technical potential estimated here will be adjusted in the market penetration analysis to account for factors that may limit access.

It is estimated that greater than 99% of forest product mill residues are already used, primarily for energy production and fiber.

Mill residues: Bark, fine wood residue and course wood residue generated at forest products mills.

Florida Forest Products Mill Residues – 2005 (dry tons/yr)[1]	
Used	2,511,000
Unused	2,000

MMBtu/yr[2]	32,000	
Electricity Potential		
	25% efficiency	**40% efficiency**
MWh/yr	2,345	3,751
MW[3]	0.31	0.50

1. U.S. Forest Service, Southern Research Station , Timber Product Output (TPO) Reports - 2005. Accessed online at http://srsfia2.fs.fed.us/php/tpo2/tpo2.php . Note that 2005 is the most recent year for which data are available.
2. Assuming 8,000 Btu/lb (dry).
3. For an annual capacity factor of 85%.

Logging residues are estimated at approximately 2.3 million dry tons for 2006. Not all of this will be practical to recover.

Logging residues: Unused portion of trees cut or killed as a result of roundwood product harvest on timberland (e.g., tops, limbs, aboveground stumps), and left in the forest.

Florida Forest Logging Residues – 2005[1]	
Wet tons/yr[2]	4,580,000
Dry tons/yr[3]	2,290,000

MMBtu/yr[4]	35,966,148	
Electricity Potential		
	25% efficiency	40% efficiency
MWh/yr	2,635,000	4,216,000
MW[5]	354	566

1. U.S. Forest Service, Southern Research Station , Timber Product Output (TPO) Reports - 2005. Accessed online at http://srsfia2.fs.fed.us/php/tpo2/tpo2.php . Note that 2005 is the most recent year for which data are available.
2. Converted from cubic feet assuming 69.6 lb/cuft for softwoods and 75.2 lb/cuft for hardwoods, as provided by the US Forest Service to Jarek Nowak of the FL Division of Forestry.
3. Assuming 50% moisture
4. Assuming 7,800 Btu/lb (dry) for softwood s and 8,000 Btu/lb (dry) for hardwoods.
5. For an annual capacity factor of 85%.

Note: Some individual values rounded for presentation purposes.

FL's merchantable volume of growing stock trees[1] has accumulated biomass at a rate of about 3 million dry tons/yr from 2003-2006.

Growing stock net annual change: Increase or decrease in merchantable volume of growing stock trees[1] of at least 5-inch diameter, breast height (d.b.h.). Equal to *gross growth* minus *mortality* minus *removals*.

Florida Forest Average Net Annual change in growing stock volume – 2006[2]	
Wet tons/yr[3]	5,945,000
Dry tons/yr[4]	2,973,000

MMBtu/yr[5]	51,245,000	
Electricity Potential		
	25% efficiency	40% efficiency
MWh/yr	5,458,000	8,732,000
MW[6]	733	1,173

1. The volume of "growing stock trees" represents the merchantable wood contained in commercial species of trees of at least 5-inch d.b.h. It excludes non-merchantable portions of growing stock trees, rough or rotten live trees, trees smaller than 5-inch d.b.h., and non-commercial species of trees.
2. U.S Forest Service, *Forest Inventory Analysis* online database. Analysis conducted by NCI in consultation with the FL Division of Forestry. The values shown in the 2006 data actually represent the average for 2003-2006.
3. Converted from cubic feet assuming 69.6 lb/cuft for softwoods and 75.2 lb/cuft for hardwoods, as provided by the US Forest Service to Jarek Nowak of the FL Division of Forestry.
4. Assuming 50% moisture
5. Assuming 8,600 Btu/lb (dry) for softwood s and 8,800 Btu/lb (dry) for hardwoods.
6. For an annual capacity factor of 85%.

Note: Some individual values rounded for presentation purposes.

Net forest growth in growing stock trees[1] is likely to decline in the future, driven mainly by a decrease in plantings.

Factors that would decrease future net forest growth

- Decreased forest growth rates
  - The rate of tree planting (reforestation) peaked in 1988 at about 300,000 acres/yr, and recently has been as low as 100,000 acres/yr, which is below the current rate of harvesting.
  - Assuming a 20-year rotation age, these trees are now beginning to be harvested
  - All else equal, future net forest growth will begin to decrease in the very near future
- Relative to the 2006 US Forest Service data, there has been increased demand for bioenergy from forest biomass in Florida
  - The Green Circle pellet plant in Jackson county: approximately 1 million wet tons/yr
  - International Paper in Contonment, FL, terminated the import of hardwood and will be purchasing pine from FL,AL and GA: approximately 1 million wet tons/yr total, FL amount not known, but may be 50% of the total.

Factors that would increase future net forest growth

- Decrease in demand for merchantable timber due to further contraction of the traditional forest products industry (e.g., mill closures)
- Increased use of more intensive silviculture on existing timberland would increase growth rates of growing stock trees.
- If bioenergy producers are able to access non-growing stock biomass, this could mitigate competition for growing stock volumes.

1. The volume of "growing stock trees" represents the merchantable wood contained in commercial species of trees of at least 5-inch d.b.h. It excludes non-merchantable portions of growing stock trees, rough or rotten live trees, growing stock trees smaller than 5-inch d.b.h, and non-commercial species of trees of all sizes.

There is other forest biomass that could be available for energy, but it is not well quantified.

- Existing timberland has historically been managed to meet the needs of the forest products industry, not the energy industry.
- The USFS tree volume statistics are primarily for size classes of 5-inch d.b.h. and larger, and focus on the merchantable volume of the tree.
  - This does not provide a complete picture of forest biomass as it relates to energy use.
- Other potential forest biomass that is in addition to net change in growing-stock volume and logging residue includes:
  - Diseased, rotten or rough trees of commercial species
  - Non-commercial species
  - Small diameter trees (less that 5-inch d.b.h.), e.g., pre-commercial thinnings
  - The forest understory (e.g., shrubs)
- These biomass sources could be significant but are not well quantified
- If efforts were made to utilize these resources, there would need to an effort to understand and address environmental, sustainability and ecosystem issues
  - E.g., habitat preservation, ecosystem health, and impact on seedling growth of more intensive forest removals, including the understory.
  - The wildland-urban interface could be areas where could target understory for forest fire prevention.

Non-growing stock trees[1] are one potential source of additional forest biomass. About 1 million dry tons of net growth is currently available.

Non-growing stock net annual change: Annual change in the volume of non-growing stock trees[1] of at least 5-inch d.b.h. Equal to *gross growth* minus *mortality* minus *removals*.

Florida Forest Average Net Annual change in non-growing stock volume – 2005[2]	
Wet tons/yr[3]	2,225,000
Dry tons/yr[4]	1,112,000

MMBtu/yr[4]	19,446,000	
Electricity Potential		
	25% efficiency	**40% efficiency**
MWh/yr	1,425,000	2,280,000
MW[5]	191	306

1. Includes rough or rotten live trees of commercial species and all non-commercial species of trees.
2. No estimate was available for 2006 from the U.S Forest Service, *Forest Inventory Analysis* online database. These estimates are made from the data contained in Mark J. Brown, *Florida's Forests – 2005 Update,* U.S. Forest Service, Southern Research Station, July 2007. However, data for other categories were similar between the 2005 and 2006 data, suggesting that this value is also similar for 2006.
3. Estimated by comparing the net annual change in "live trees" and "growing stock trees". The volume of live trees includes sound wood in the central stem in all live trees of at least 5.0 inches d.b.h. from a 1-foot stump to a minimum 4.0-inch top d.o.b . Live trees include both commercial and non-commercial species. This estimate does not include the other volume of these trees, such as tops and limbs.
4. Assuming 8,600 Btu/lb (dry) for softwood s and 8,800 Btu/lb (dry) for hardwoods.
5. For an annual capacity factor of 85%.

Note: Some individual values rounded for presentation purposes.

Converting a portion of Florida's forests to intensive silviculture could yield additional quantities of biomass for energy.

- While speculative as to the extent and timing of implementation, it is possible to apply more intensive management practices to existing forests to increase biomass yields, particularly, if the right incentives are in place for landowners.
- As an example, there is approximately 5 million acres of planted pine forest in Florida.
  - Some of this land could be managed more intensively to maximize biomass productivity.
  - Alternatively, some of this land could be converted to short-rotation woody crops specifically designed for energy production.
- For analysis purposes, NCI has assumed that 10% of this land could be converted to intensive silviculture, yielding 7 dry tons/acre-yr.
  - This amount is representative of what might reasonably be developed in the next few years.
  - Note that a <u>new stand</u> of pine managed in this way, established in 2010 would not yield substantial biomass until about 2022.

	Additive Effects of Modern Day Intensive Pine Silviculture[1]		
	Cubic feet/acre at harvest	Wet tons/acre at harvest	Wet tons/ acre-yr
Natural stand	1,429	50.7	2.8
Planting	857	30.4	1.7
Site prep	572	20.3	1.1
Fertilization	1,286	45.7	2.5
Weed control	929	33.0	1.8
Tree improvement	1,072	38.1	2.1
Biotech/Clonal	1,072	38.1	2.1
TOTAL	**7,217**	**256.3**	**14.2**
Rotation Age (yrs)	18		

1. Jarek Nowak, Donald Rockwood, Eric Jokela and Gary Peter, "Woody Biomass Feedstocks for Bioenergy in Florida", *Farm-to-Fuel Summit*, Orlando, FL, 31 July 2008.

Converting a portion of Florida's forests to intensive silviculture could yield additional quantities of biomass for energy. (continued)

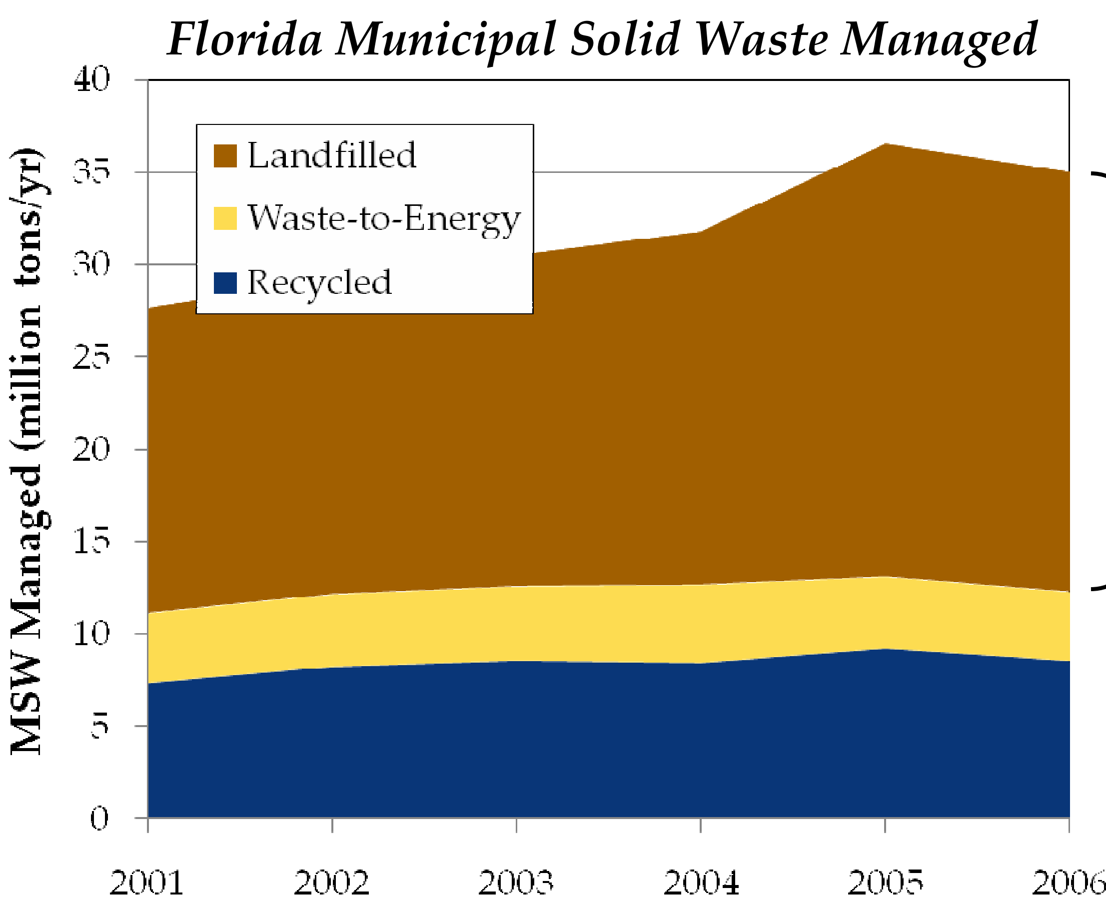
Intensive Pine Silviculture[1]	
Acres assumed[2]	500,000
Yield (dry tons/acre-yr)[1]	7
Technical potential (dry tons/yr)	3,500,000

MMBtu/yr[3]	60,200,000	
Electricity Potential		
	25% efficiency	40% efficiency
MWh/yr	4,411,000	7,057,000
MW[4]	592	948

1. See preceding slide for details.
2. 10% of current acres in planted pine timberland, or about 3.2% of all timberland.
3. Assuming 8,600 Btu/lb (dry)
4. For an annual capacity factor of 85%.

Note: Some individual values rounded for presentation purposes.

The portion of MSW currently landfilled represents the technical potential for additional WTE capacity. It has been growing.



2006 Statistics (million tons)
22.7 landfilled
\- 0.9 WTE ash landfilled
21.8 available for WTE

2001-2006 Compounded Annual Growth Rate	
Landfilled	6.6%
WTE[1]	-0.2%
Recycled	3.1%
Total MSW	**4.8%**

Source: Florida Department of Environmental Protection, *2006 Solid Waste Annual Report* (http://www.dep.state.fl.us/waste/categories/recycling/SWreportdata/06_data.htm).

Notes: 1. A negative growth rate of WTE is not indicative of future WTE growth, and future WTE technical potential is not based on that figure.

The future technical potential for WTE in Florida will depend in part on future trends in waste management.

- MSW generation in Florida grew at nearly 5%/ per year from 2001-2006, and landfilling growth rates were even higher.
  - Will this trend continue?
- Possible factors affecting MSW generation and landfilling rates in the future include:
  - Slowing population growth
  - Greater emphasis on recycling, composting, waste minimization and waste prevention
- The 2008 Florida Energy Bill (House Bill 7135) established a new statewide recycling goal of 75% to be achieved by the year 2020.
  - According to the Florida DEP, Renewable Energy is included in this goal, which currently includes MSW. Therefore, MSW consumed in waste-to-energy plants will count towards the recycling goal.
- To help bracket the technical potential, NCI developed four difference cases for future MSW management (see next slide). These cases assume:
  - Two different annual growth rates in total MSW generation: 2.5% and 1% per year
  - Two different recycling rates
    - 1/2 of the 75% recycling goal is met by recycling
    - 2/3 of the 75% recycling goal is met by recycling
  - In each case, the <u>incremental</u> technical potential for WTE is the remainder being landfilled above the baseline WTE already in place.

Between 16-47 million tons of MSW could be available for incremental WTE capacity by 2020.

Description / Tons/year	2006 Actual MSW disposition	Possible future MSW generation rates in 2020 based on different assumptions			
		2.5% growth & 37.5% recycling	1% growth & 37.5% recycling	2.5% growth & 50% recycling	1% growth & 50% recycling
	FL DEP data from 2006 Annual Report	Assuming 2.5% annual growth in total MSW and that half of the 2020 recycling goal of 75% is met with non-WTE recycling	Assuming 1% annual growth in total MSW and that half of the 2020 recycling goal of 75% is met with non-WTE recycling	Assuming 2.5% annual growth in total MSW and that 2/3 of the 2020 recycling goal of 75% is met with non-WTE recycling	Assuming 1% annual growth in total MSW and that 2/3 of the 2020 recycling goal of 75% is met with non-WTE recycling
Recycled	8,567,930	18,565,951	15,103,664	24,754,601	20,138,219
Landfilled[1]	**22,741,259**	**27,025,641**	**21,255,163**	**20,836,991**	**16,220,608**
WTE[2]	3,729,820	3,917,610	3,917,610	3,917,610	3,917,610
Total	35,039,009	49,509,202	40,276,437	67,781,110	40,276,437

1. Includes the ash from existing WTE plants
2. In all 2020 cases, WTE consumption of MSW is set to the 2001-2006 average to serve as a baseline. The amount landfilled in each scenario therefore represents the incremental technical market potential for WTE.

Between 1,300 and 2,300 MW of incremental WTE capacity is technically possible if all landfilled MSW is used for WTE in 2020.

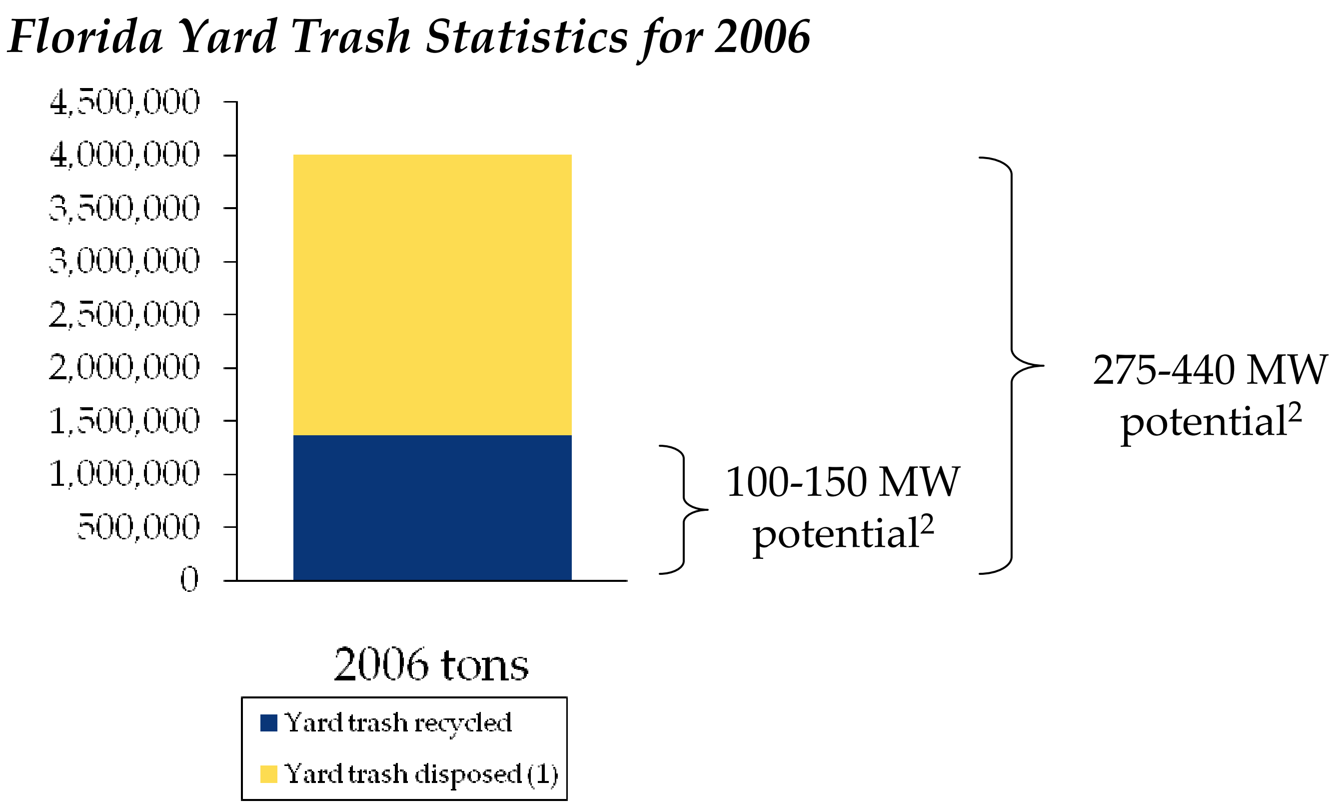
	Estimate of incremental WTE technical potential in Florida in 2020			
	2.5% growth & 37.5% recycling	**1% growth & 37.5% recycling**	**2.5% growth & 50% recycling**	**1% growth & 50% recycling**
Tons/yr[1]	26,046,000	20,276,000	19,858,000	15,241,000
MMBtu/yr[2]	305,522,000	237,835,000	232,930,000	178,779,000
MWh/yr[3]	16,930,000	13,179,000	12,907,000	9,907,000
MW[4]	2,274	1,770	1,733	1,330
% of WTE technical potential needed to meet 75% recycling goal	56%	55%	43%	40%

1. From previous slide, this is the amount landfilled, rounded to nearest thousand tons/yr and reduced by the amount of ash disposal from existing WTE facilities, assuming this is 25% of what is combusted in those facilities.
2. Based on a heat content of 11.73 MMBtu/ton (DOE, EIA, *Methodology for Allocating Municipal Solid Waste to Biogenic and Non-Biogenic Energy*, May 2007.
3. Based on a net generation rate of 650 kWh/ton.
4. At an annual capacity factor of 85%.

Note: Some individual values rounded for presentation purposes.

Based on assumptions here about future MSW generation and recycling rates, about 40-55% of the WTE technical potential would be needed to meet the 75% recycling goal by 2020.

Yard trash represents approximately 11% of current total MSW generation. Only about 25% of it is currently recycled.

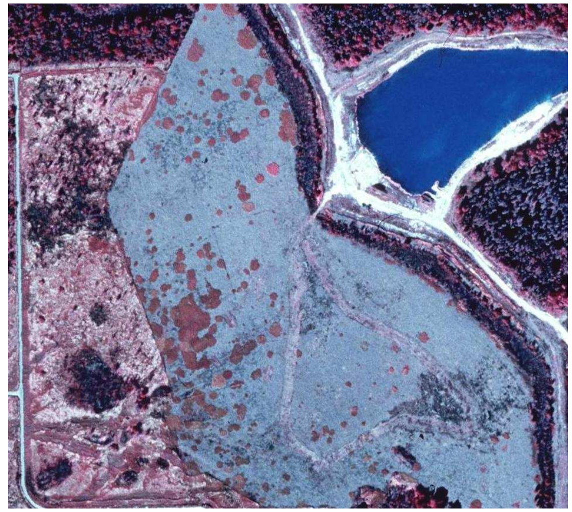


1. This is the difference between the reported data on yard trash produced and recycled.
2. These estimated are made using similar assumptions as for other biomass resources, and are for illustrative purposes. If yard trash currently disposed of is further separated and used for energy generation, this would reduce the potential for waste-to-energy shown previously.

Source: Florida Department of Environmental Protection, *2006 Solid Waste Annual Report* (http://www.dep.state.fl.us/waste/categories/recycling/SWreportdata/06_data.htm).

Degraded mining land presents a good opportunity to establish energy plantations on land with little other value.

- There are about 125,000 acres of clay settling areas (CSAs) and a total of about 325,000 acres of reclaimed phosphate mined land in central Florida
- This land has minimal value for other uses
- With proper site preparation and crop management practices, trials with several energy crop species have shown very promising results, with varieties of Eucalyptus achieving yields of 20-32 green tons/acre-yr, or about 10-16 dry tons/acre-yr.[1]



Before

Harvest @ 3.5 years

1. *Commercial Tree Crops for Phosphate Mined Lands, Final Report, 2001-2005*; D. L. Rockwood, D. R. Carter, and J. A. Stricker, Principal Investigators, UNIVERSITY OF FLORIDA, May 2008.

Degraded mining land presents a good opportunity to establish energy plantations, with 1.2-5.2 million dry tons/yr of potential.

Short-Rotation Woody Energy Crops on reclaimed phosphate mining land[1]	
Acres assumed[2]	123,000-325,000
Yield (dry tons/acre-yr)[3]	10-16
Technical potential (dry tons/yr)	1,230,000 – 5,200,000

MMBtu/yr[3]	21,548,000 – 91,520,000	
Electricity Potential		
	25% efficiency	**40% efficiency**
MWh/yr	1,586,000-6,706,000	2,538,000-10,729,000
MW[4]	213-901	341-1,441

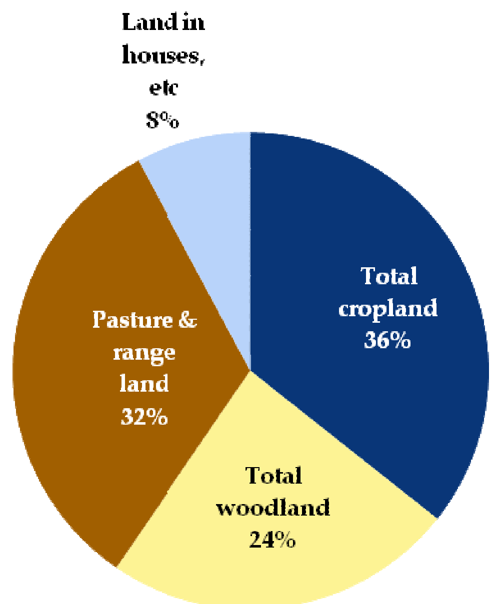
1. Data derived from *Commercial Tree Crops for Phosphate Mined Lands, Final Report, 2001-2005*; D. L. Rockwood, D. R. Carter, and J. A. Stricker, Principal Investigators, UNIVERSITY OF FLORIDA, May 2008.
2. Low end is clay settling areas only. Upper end is all reclaimed phosphate mining land in central Florida.
3. Assuming 50% moisture as harvested and 8,800 Btu/lb (dry) for Eucalyptus.
4. For an annual capacity factor of 85%.

Note: Some individual values rounded for presentation purposes.

Energy crops could also be established on a portion of Florida's 10 million acres of farmland.

- There are about 10 million acres of land classified as farmland in Florida, with about 70% of this classified as rangeland, pasture and woodland.
  - In 2007, approximately 1.9 million acres was harvested for crops, including citrus, sugarcane, hay, grains, peanuts, vegetables, melons, and berries
  - About another 1 million acres of cropland was used for pasture or grazing
  - About 6 million acres is pasture, rangeland, and woodland
- Most of this land would likely be highly productive for energy crops.
- With the right market conditions and incentives, farmers could begin to se some of this land to establish perennial energy crops
  - Fast growing trees, such as Eucalyptus
  - Grasses, including elephant grass, energy cane, miscanthus and switchgrass
  - Converting 1-2%/yr would result in over 1 million acres of energy crops by 2020.
  - The exact amount and timing of energy crop establishment is uncertain, but this rate of establishment appears feasible.
- Energy crops generally do not require irrigation, and so should not put additional burdens on water requirements for farming.

Florida land in farms, 2002 census (10.4 million acres)



Notes:
- Cropland include land harvested and land used for pasture and grazing
- Woodland includes land used for pasture

Sources: "Florida Agricultural Facts" (http://www.nass.usda.gov/Statistics_by_State/Florida/Publications/Annual_Statistical_Bulletin/fasd08p.htm); US Department of Agriculture, 2002 Census of Agriculture for Florida, June 2004.

Converting less than 15% of existing farmland to energy crop production could provide 14-22 million dry tons/yr of biomass.

Perennial Energy Crops on Existing Florida Farmland	
Acres assumed by 2020[1]	1,318,000
Woody crop yield (dry tons/acre-yr)[2]	10-16
Grasses/energy cane yield (dry tons/acre-yr)[3]	12-18
Technical potential (dry tons/yr)[4]	14,458,000-22,367,000

MMBtu/yr[5]	248,333,000-384,455,000	
Electricity Potential		
	25% efficiency	40% efficiency
MWh/yr	18,196,000-28,169,000	29,113,000-45,071,000
MW[6]	2,444-3,783	3,910-6,053

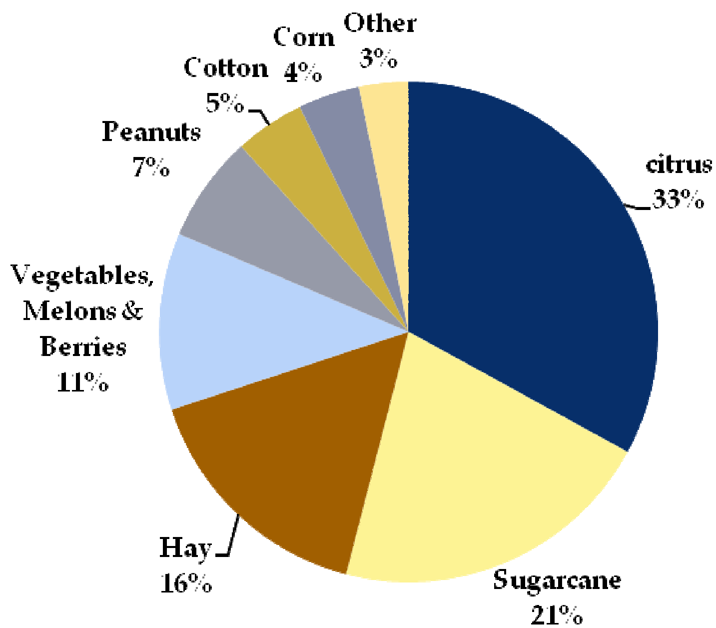
1. Based on NCI assumptions of percentages converted to energy crops for different farmland categories. Represents approximately 190,000 acres of cropland harvested (10%), 41,000 acres of conservation reserve program (CRP) land (50%) and 1.1 million acres of pasture, rangeland , woodland, and cropland used for pasture and grazing (15%). In total this is approximately 13% of total land in farms.
2. Jarek Nowak, Donald Rockwood, Eric Jokela and Gary Peter, "Woody Biomass Feedstocks for Bioenergy in Florida", *Farm-to-Fuel Summit,* Orlando, FL, 31 July 2008.
3. Lynn Sollenberger and Zane Helsel, University of Florida/IFAS and Rutgers University, Cellulosic Feedstocks for Bioenergy in Florida: Perennial Grasses, *Farm-to-Fuel Summit*, Orlando, FL, 31 July 2008.
4. NCI made assumptions about which crop type would be planted on different types of land.
5. Assuming 50% moisture as harvested, 8,800 Btu/lb (dry) for Eucalyptus and 8,400 Btu/lb (dry) for perennial grasses/energy cane.
6. For an annual capacity factor of 85%.

Note: Some individual values rounded for presentation purposes.

Crop residues represent a modest resource in Florida, especially compared to other states with large cereal crops.

- Crop residues represent the recoverable fraction of plants following harvest
  - E.g., wheat straw, corn stover, orchard trimmings.
- In states with large cereal crops, like Iowa, this resource is substantial.
- In Florida, the main sources of suitable crop residues would be orchard trimmings and sugarcane field residues, although the former is not well categorized
- A 2005 NREL GIS analysis[1] estimated that Florida has 3.6 million dry tons/year of agricultural crop residues, primarily sugarcane field residues.
- An alternative estimate was provided by Dr. Mary Duryea[2] from the University of Florida IFAS, for vegetable & fruit waste
  - (500,000 acres) * (0.8 dry tons/acre-yr) = 400,000 dry tons/yr

Florida cropland harvested, 2007
(total = 1.9 million acres)[3]



1. A. Milbrandt , *A Geographic Perspective on the Current Biomass Resource Availability in the United States*, Technical Report, National Renewable Energy Laboratory, NREL/TP-560-39181, December 2005.
2. Mary Duryea, *Bioenergy at UF/IFAS*,, presentation to the Agriculture, Forestry, & Waste Management Technical Work Group of the Governor's Action Team on Energy and Climate Change.
3. Sources: "Florida Agricultural Facts" (http://www.nass.usda.gov/Statistics_by_State/Florida/Publications/Annual_Statistical_Bulletin/fasd08p.htm); US Department of Agriculture, 2002 Census of Agriculture for Florida, June 2004. "Other" includes the 2002 census data for non-citrus fruits & nuts, which was not available for 2007..

Crop residues represent a modest resource in Florida, up to about 3.6 million dry tons.

Florida Agricultural Crop Residues	
Technical potential (dry tons/yr)[1]	400,000-3,600,000

MMBtu/yr[2]	5,600,000 – 50,364,000	
Electricity Potential		
	25% efficiency	**40% efficiency**
MWh/yr	410,000-3,690,000	656,000-5,904,000
MW[3]	55-496	88-793

1. Range based on: (i) A. Milbrandt , *A Geographic Perspective on the Current Biomass Resource Availability in the United States*, Technical Report, National Renewable Energy Laboratory, NREL/TP-560-39181, December 2005, and (ii) Mary Duryea, *Bioenergy at UF/IFAS*,, presentation to the Agriculture, Forestry, & Waste Management Technical Work Group of the Governor's Action Team on Energy and Climate Change.
2. Assuming 7,000 Btu/lb (dry)
3. For an annual capacity factor of 85%.

Note: Some individual values rounded for presentation purposes.

Poultry litter and horse manure are the primary solid biomass resources from animal wastes in Florida.

Poultry Litter

- Unlike dairy waste, poultry litter is fairly dry, as it contains a large amount of bedding, and can be transported by truck.
- In 2007:
  - There were approximately 11 million egg layers in inventory
  - Approximately 73 million broilers were raised
- There are only a few thousand turkeys raised in Florida each year.
- An estimated 300,000 tons of poultry litter was produced.[2]

Horse Manure & Stall Waste[3]

- Florida is home to a large number of thoroughbred and breeding farms, concentrated in Ocala/Marion County, with about 35,000 thoroughbred horses.
- It is estimated that these horses along with those on other farms generated >550,000 tons/yr of manure & stall waste, with 300,000 currently managed via land application, and 100,000 composted on farms.
- The Florida Thoroughbred Breeders' & Owners' Association and MaxWest Environmental Systems are planning a project to gasify ~100,000 tpy to generate approximately 7MW.

1. Estimates based on: "Florida Agricultural Facts" (http://www.nass.usda.gov/Statistics_by_State/Florida/Publications/Annual_Statistical_Bulletin/fasd08p.htm); US Department of Agriculture, 2002 Census of Agriculture for Florida, June 2004. "
2. Based on generation rates reported in *Availability Of Poultry Manure As A Potential Bio-fuel Feedstock For Energy Production*, Joseph R.V. Flora, Ph.D., P.E. and Cyrus Riahi-Nezhad, Department of Civil and Environmental Engineering, University of South Carolina, August 2006.
3. Media Kit provided by the Florida Thoroughbred Breeders' & Owners' Association and MaxWest Environmental Systems.

Solid animal wastes are a limited resource in Florida.

Florida Poultry Litter and Horse Manure	
Technical potential (tons/yr)[1]	440,000-840,000

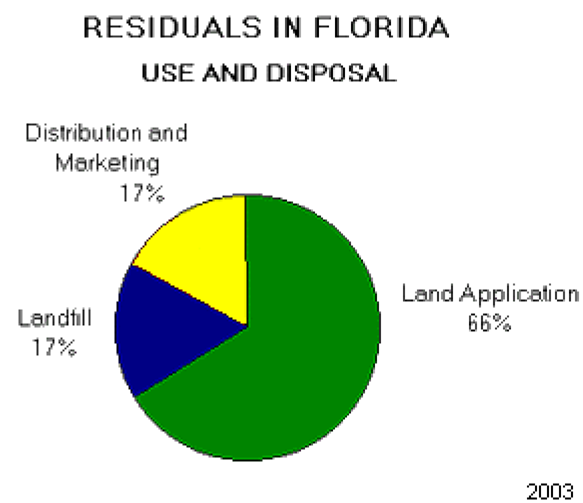
MMBtu/yr[2]	3,503,000 – 5,743,000	
Electricity Potential		
	25% efficiency	**40% efficiency**
MWh/yr	257,000 - 421,000	411,000 – 673,000
MW[3]	34 - 57	55 - 90

1. Estimated based on: "Florida Agricultural Facts" (http://www.nass.usda.gov/Statistics_by_State/Florida/Publications/Annual_Statistical_Bulletin/fasd08p.htm); US Department of Agriculture, 2002 Census of Agriculture for Florida, June 2004. "; *Availability Of Poultry Manure As A Potential Bio-fuel Feedstock For Energy Production*, Joseph R.V. Flora, Ph.D., P.E. and Cyrus Riahi-Nezhad, Department of Civil and Environmental Engineering, University of South Carolina, August 2006; Media Kit provided by the Florida Thoroughbred Breeders' & Owners' Association and MaxWest Environmental Systems.
2. Assuming 4,600 Btu/lb (wet) for poultry litter and 2,800 Btu/lb (wet) for horse manure.
3. For an annual capacity factor of 85%.

Note: Some individual values rounded for presentation purposes.

Florida's existing wastewater treatment plants produce an estimated 800,000 dry tons/yr of residuals.

- Most (83%) of residuals in Florida are :
  - Marketed as Class AA residuals (either distributed in bulk or bagged for sale at retail garden centers
  - Directly land applied as Class A or B residuals
- The remainder (17%) is currently disposed of in landfills.
- The FL DEP reported that in 2007 134,523 dry tons of Class AA residuals were produced
  - At 17% of the total, this implies total production of almost 800,000 dry tons/yr
- At a minimum, the amount available for energy conversion would be the 17% currently landfilled (~135,000 dry tons)
- Residuals are still high in moisture unless dried, which has implications for overall conversion efficiency.



Source: Florida Department of Environmental Protection (http://www.dep.state.fl.us/water/wastewater/dom/reshome.htm)

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WWTP residuals represent a small opportunity in Florida.

Florida Wastewater Treatment Plant Residuals	
Technical potential (dry tons/yr)[1]	134,000 – 791,000

MMBtu/yr[2]	1,534,000 – 9,021,000	
Electricity Potential[3]		
	20% efficiency	**30% efficiency**
MWh/yr	90,000 – 529,000	135,000 – 793,000
MW[4]	12 – 71	18 - 107

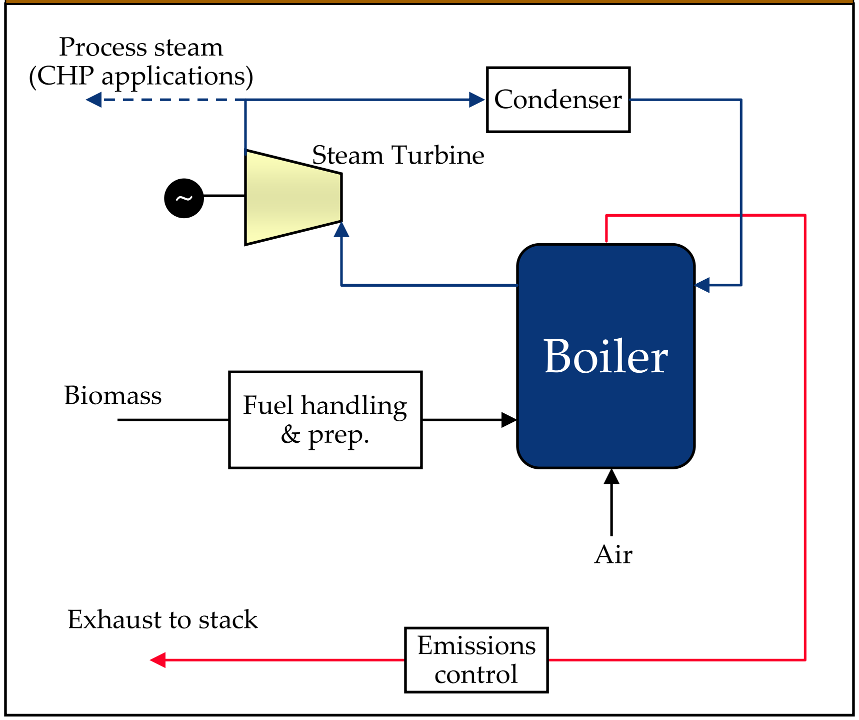
1. NCI estimate based on FL DEP data (http://www.dep.state.fl.us/water/wastewater/dom/reshome.htm). Low end represents fraction currently landfilled. High end represents total residuals production.
2. Assuming 9,500 Btu/lb of volatile solids (VS) and a VS fraction of 60% (*Energy Considerations with Thermal Processing of Biosolids*, Peter Burrowes and Tim Bauer CH2M HILL Canada Limited).
3. Lower efficiencies are assumed here than for other resources given the high moisture content of WWTP residuals.
4. For an annual capacity factor of 85%.

Note: Some individual values rounded for presentation purposes.

Direct combustion uses the same Rankine cycle technology as coal plants, only at a smaller scale.

- Both fluidized-bed boilers and stoker boilers are mature technologies.
  - Historically, stoker boilers have been the most commonly used technology, but fluidized bed combustors are becoming the systems of choice for biomass fuels due to good fuel flexibility and good emissions characteristics
- Compared to a stoker boiler a fluidized-bed boiler:
  - Achieves a higher carbon burn-out
  - Ensures more fuel flexibility due to the good mixing that occurs in the fluidized bed.
  - The relatively low combustion temperature ensures reduced NOx emissions, and the CFB process allows for the addition of certain minerals into the bed to control SOx emissions.
- Emissions controls, such as an electrostatic precipitator (ESP) or baghouse for particulates, and some form of NOx control, such as ammonia injection or staged combustion, are standard on new plants today to meet typical emissions requirements.

Biomass Power Plant (Rankine cycle)



Source: Navigant Consulting, Inc.

Biomass capital costs have risen considerably in the last 2-3 years. Future costs will be heavily influenced by commodity prices.

	Biomass Greenfield Direct Combustion Economic Assumptions for Given Year of Installation (2008$)		
	2009	2015	2020
Plant Capacity (MW)[1]	100	100	100
Project Life (yrs)	25+	25+	25+
Development Time (yrs)	3-5	3-5	3-5
Total installed Capital Cost ($/kW)[2]	$4,000	$4,200	$4,400
Fixed O&M ($/kW-yr)[3]	$125	$117	$111
Non-Fuel Variable O&M ($/MWh)[4]	$2.50	$2.50	$2.50
Fuel/Energy Cost ($/MWh)[5]	$31-46	$30-45	$29-43

Sources: Navigant Consulting estimates 2008; stakeholder data submitted to the Florida Public Service Commission, September 2008. Reviewed with biomass project developers.

1. Size will vary based on the tradeoff between fuel price and availability. Projects proposed for FL range from about 35MW to over 200 MW, with several 100 MW projects recently announced in FL and elsewhere in the Southeast.
2. Total Installed Costs can vary widely depending on several factors, including site conditions, local permitting requirements, grid interconnection, and civil works. Assumed to decline by ~1% per year, reflecting moderating commodity prices and maturity of technology, but they rise overall because of commodity price increases.
3. O&M costs are based on interviews with industry, review of literature and FL PSC stakeholder provided data. Assumed to decline 1% per year.
4. Variable O&M consists of consumables and ash disposal. All other O&M is included in the fixed component.
5. Biomass prices in FL expected to range from $40-60/dry ton, delivered, or about $2.25-3.75/MMBtu, depending on energy content. Values given here based on 8,800 Btu/lb (dry), and the efficiencies provided on the following page.

Biomass combustion has high availability and good environmental performance. Efficiency is limited by project size and fuel moisture content.

	Biomass Greenfield Direct Combustion Economic Assumptions for Given Year of Installation (2008$)		
	2009	2015	2020
Summer Peak (MW)	100	100	100
Winter Peak (MW)	100	100	100
Availability (%)[1]	90%	90%	90%
Typical Net Annual Capacity Factor (%)	85%	85%	85%
HHV Efficiency (%)	25%	26%	27%
Water Usage (gal/kWh)[2]	0.6-0.8	0.6-0.8	0.6-0.8
Hg (lb/MWh)	Minimal	Minimal	Minimal
CO_2 (lb/MWh)[3]	0	0	0
NOx (lb/MWh)[4]	1.36	1.31	1.26
SO_2 (lb/MWh)[5]	0.88	0.85	0.82

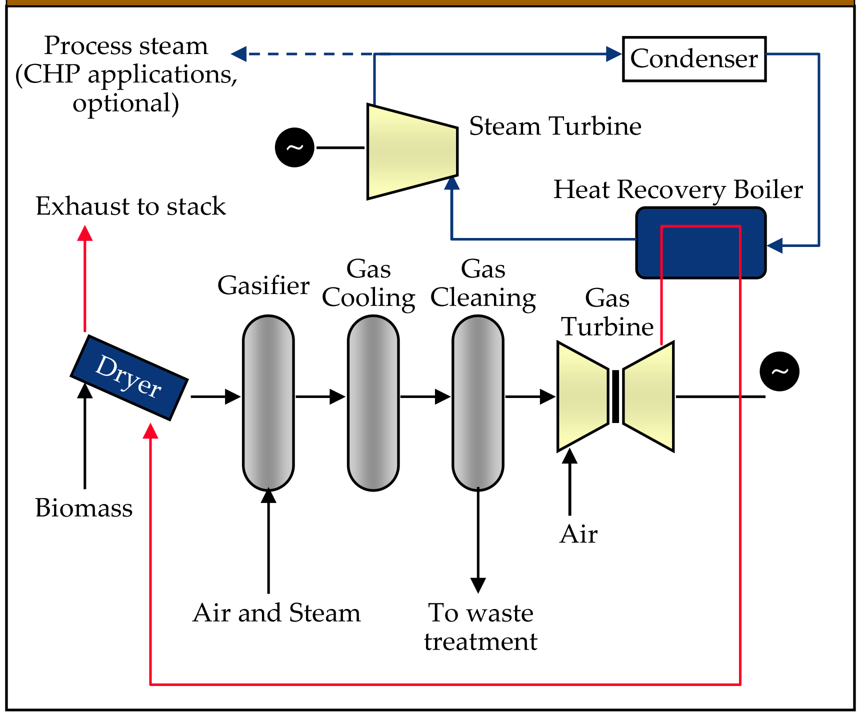
Sources: Navigant Consulting estimates 2008; stakeholder data submitted to the Florida Public Service Commission, September 2008. Reviewed with biomass project developers.

1. Scheduled outage based on approximately 2 weeks/year. This includes a major turbine/generator overhaul every six years lasting one month, 5-7 days of annual for cleaning, tube repairs, etc and 2 days for inspections. 6% forced outage based on interviews.
2. Assumes use of a wet cooling tower for the condenser and 1% steam losses, assuming approximately 10,700 pph steam per MW.
3. For analysis purposes, biomass assumed to be carbon neutral.
4. Based on an emissions rate of 0.1 lb/MMBtu. This would require NOx controls such as ammonia injection , staged combustion or NSCR.
5. For a wood sulfur content of 0.03% by weight, dry basis, 5% of sulfur retained in ash.

Biomass integrated gasification combined cycle technology (BIGCC) offers the prospect of high conversion efficiency and low emissions.

- The use of a gas turbine and steam turbine (a combined cycle), coupled with heat integration from the gasifier, offers the potential for efficiencies about 50% higher than for direct combustion.
- The syngas is a mixture of mainly H_2, CO, CO_2, CH_4, N_2, and other hydrocarbons.
  - At a minimum, the syngas must be cleaned of particulates, alkali compounds and tars to make it suitable for combustion in a gas turbine.
- BIGCC systems are inherently low polluting when compared to biomass combustion
  - The syngas must be clean enough so as not to damage the gas turbine
  - Because combustion occurs in the gas turbine, emissions of NOx, CO and hydrocarbons are comparable to those of a natural gas-fired GTCC
- Smaller gasifiers can be coupled to internal combustion engines instead of gas turbines.

Biomass Integrated Gasification Combined Cycle (BIGCC)



Source: Navigant Consulting, Inc.

NAVIGANT CONSULTING

Early BIGCC plants are expected to be expensive, but costs should fall due to learning, if the technology is successfully deployed.

	Biomass IGCC Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Plant Capacity (MW)[1]	50	145	150
Project Life (yrs)	25+	25+	25+
Development Time (yrs)	3-5	3-5	3-5
Total installed Capital Cost ($/kW)[2]	$6,500	$4,700	$4,500
Fixed O&M ($/kW-yr)[3]	$125	$109	$98
Non-Fuel Variable O&M ($/MWh)[4]	$2.50	$2.50	$2.50
Fuel/Energy Cost ($/MWh)[5]	$24-36	$20-31	$19-29

Sources: Navigant Consulting estimates 2008; stakeholder data submitted to the Florida Public Service Commission, September 2008.

1. Size will vary based on the tradeoff between fuel price and availability. For 2008, size is representative of a first of a kind plant. For 2015 and 2020 Sizes reflect use of similar quantities of biomass to a 100MW plant based on direct combustion.
2. Total Installed Costs can vary widely depending on several factors, including local permitting requirements, grid interconnection, civil works. Key assumptions include: Total installed costs on a $/kW basis decline by ~5% per year through 2015 and then at 3% through 2020.
3. Fixed O&M costs are assumed to be the same as for direct combustion but decline at 2% per year due to learning.
4. Variable O&M consists of consumables and ash disposal. All other O&M is included in the fixed component. Assumed to be the same as for the direct combustion plant.
5. Biomass prices in FL expected to range from $40-60/dry ton, delivered, or about $2.25-3.75/MMBtu, depending on energy content. Values given here based on 8,800 Btu/lb (dry), and the efficiencies provided on the following page.

Note: these cost and performance characteristics should be considered more speculative than for other technologies, as there is very limited experience with BIGCC. The major components of BIGCC plants , such as gasification, gas, cleanup, and gas turbines operating on low-medium Btu gas have each been relatively well demonstrated, but have not yet been integrated in a commercial plant at the scale envisioned.

BIGCC should provide superior environmental performance and higher efficiency than direct combustion.

	Biomass IGCC Economic Assumptions for Given Year of Installation (2008$)		
	2009	2015	2020
Summer Peak (MW)	130	145	150
Winter Peak (MW)	130	145	150
Availability (%)[1]	80%	90%	90%
Typical Net Annual Capacity Factor (%)[2]	70%	85%	85%
HHV Efficiency (%)	32%	38%	40%
Water Usage (gal/kWh)[3]	0.4-0.6	0.4-0.6	0.4-0.6
Hg (lb/MWh)	Minimal	Minimal	Minimal
CO_2 (lb/MWh)[4]	0	0	0
NO_x (lb/MWh)[5]	1.07	0.90	0.85
SO_2 (lb/MWh)[6]	0.69	0.58	0.55

Sources: Navigant Consulting estimates 2008; stakeholder data submitted to the Florida Public Service Commission, September 2008. Reviewed with biomass project developers.

1. Early availability expected to be lower due to technology maturity. Long term, scheduled outage based on approximately 2 weeks/year. This includes a major turbine/generator overhaul every six years lasting one month, 5-7 days of annual for cleaning, repairs, etc and 2 days for inspections. 6% forced outage based on interviews.
2. Early units expected to have lower annual capacity factors due to lower availability.
3. Assumed to be approximately 25% lower than for the direct combustion plant.
4. For analysis purposes, biomass assumed to be carbon neutral.
5. Based on an emissions rate of 0.1 lb/MMBtu, the same as for direct combustion.
6. For a wood sulfur content of 0.03% by weight, dry basis, 5% of sulfur retained in ash.

Biomass can be co-fired with coal at rates of up to 15% (heating value basis) in existing boilers, after making necessary modifications.

- Although co-firing is relatively routine in industrial multi-fuel boilers, most utility coal boilers were not designed to co-fire biomass.
- The two types of direct fire options are blended feed and separate feed. The choice depends on the boiler type and the amount of co-firing.
  - For pulverized coal boilers (the most common type), blended feed systems can be used up to about 2% biomass (by energy content)
  - For values of 2-15% biomass, a separate biomass feed system must be used and other modifications may be needed. Each application must be evaluated on a case-by-case basis.
- Gasified biomass (syngas) can also be fed into a coal boiler. This would require fewer boiler modifications, but have higher capital costs than direct co-firing, and is not evaluated here.
- A key challenge is that each co-firing opportunity must be evaluated on a case-by-case basis to address unit-specific technical and economic feasibility.
- The emissions impacts of co-firing will vary but generally, since biomass has less sulfur than coal, co-firing results in lower SO_2 emission. Also, in plants without NOx controls, it is generally accepted that co-firing should reduce NOx formation.
- Another option to evaluate on a case-by-case basis is the repowering of selected coal units, as was recently announced by Southern Company for it Plant Mitchell in Georgia.
  - There are several existing coal units in Florida for which this may be an option.
- The potential loss of fly ash sales, due to the current ASTM specification, has historically been an important reason why co-firing has not been more widely deployed.

Where feasible, biomass co-firing with coal offers the potential for attractive economics.

	Biomass Co-firing with Coal Economic Assumptions for Given Year of Installation (2008$)
	2009-2020
Plant Capacity (MW)[1]	50
Project Life (yrs)	25 (will depend on coal plant remaining life)
Development Time (yrs)	2-4
Total installed Capital Cost ($/kW)[2]	$300
Fixed O&M ($/kW-yr)[3]	$12
Non-Fuel Variable O&M ($/MWh)[4]	$6
Fuel/Energy Cost ($/MWh)[5]	$26-39 (biomass purchases) / $(2)-11 (net of coal savings)

Sources: Navigant Consulting estimates 2008, based on DOE/EPRI Technology Characterizations, and US DOE/EIA data.

1. Based on an average coal unit size in FL of 350MW and 15% co-firing (Btu basis).
2. Capital cost will be highly site specific. This is an indicative value.
3. This is the incremental O&M cost for the biomass handling and feed system. Assumes 4 additional FTEs to operate the biomass fuel yard and feed equipment @ $70K/yr, plus 2% of installed capital in maintenance.
4. This is the assumed ongoing non-fuel O&M cost of the coal plant.
5. Biomass prices in FL expected to range from $40-60/dry ton, delivered, or about $2.25-3.75/MMBtu, depending on energy content. Values given here based on 8,800 Btu/lb (dry), and the efficiencies provided on the following page. First range is the direct cost of biomass purchases. Second range is the net cost after subtracting avoided coal purchases, assuming a coal price of $2.75/MMBtu, which is close to the average for 2008. Does not include any revenue loss from fly ash sales, which may be an issue for some plants.

Note: unlike other biomass technologies, co-firing technical feasibility and costs are highly site specific and will depend on, among other things, biomass availability near the coal plant, boiler type, and the emissions control equipment installed at the coal plant. NCI has not conducted any site specific assessment of co-firing potential, but rather has developed broad estimates of technical potential.

Repowered coal facilities are expected to have similar performance to greenfield facilities.

	Biomass Co-firing with Coal Economic Assumptions for Given Year of Installation (2008$)
	2009-2020
Summer Peak (MW)	50
Winter Peak (MW)	50
Availability (%)[1]	90%
Typical Net Annual Capacity Factor (%)	85%
HHV Efficiency (%)[2]	30%
Water Usage (gal/kWh)	See note 3
Hg (lb/MWh)	minimal
CO2 (lb/MWh)[5]	-2,123
NOx (lb/MWh)[6]	-5.6
SO2 (lb/MWh)[7]	-28.5

Sources: Navigant Consulting estimates 2008, based on DOE/EPRI Technology Characterizations, and US DOE/EIA data.

1. Scheduled outage based on approximately 2 weeks/year, or 4%, and a 6% forced outage rate.
2. Based on a coal plant efficiency of 33% and a 10% degradation applied to the biomass portion .
3. Existing water usage at the plant is expected to be minimally impacted, but could increase slightly due to a degradation in heat rate – thus requiring more cooling water per MWh of output.
4. Biomass contains virtually no Hg. Total plant Hg should be reduced by displacing some coal with biomass.
5. Avoided coal CO2 emissions assuming a coal carbon content of 56 lb/MMBtu and 10,063 Btu/lb .
6. NOx benefits can vary. Figures shown assume baseline NOx emissions of 5.14 lb/MWh and a 1% reduction in NOx emissions for every 1% co-firing.
7. Assumes coal with 1.5% wt% sulfur , no FGD, and 5% of sulfur retained in the ash. Biomass assumed to be 0.03% sulfur by weight (dry basis).

Where possible, repowering coal plants to biomass plants offers lower capital costs than greenfield with comparable overall performance.

	Biomass Repowering Direct Combustion Economic Assumptions for Given Year of Installation (2008$)		
	2009	2015	2020
Plant Capacity (MW)[1]	100	100	100
Project Life (yrs)	25+	25+	25+
Development Time (yrs)	3-5	3-5	3-5
Total installed Capital Cost ($/kW)[2]	$1,400	$1,500	$1,650
Fixed O&M ($/kW-yr)[3]	$125	$117	$111
Non-Fuel Variable O&M ($/MWh)[3]	$2.50	$2.50	$2.50
Fuel/Energy Cost ($/kWh)[4]	$31-46	$31-46	$31-46

Sources: Navigant Consulting estimates 2008.

1. This is the same as for the greenfield direct combustion plant, and also close to the average unit size of existing coal plants in FL under 150 MW in size.
2. Total Installed Costs will vary widely. Figures quoted are estimated based on Georgia Power's proposed repowering of Plant Mitchell. Unit 3. See *Georgia Power Company's Application for the Certification of the Conversion of Plant Mitchell Unit 3 into a Biomass Facility*, Georgia Public Service Commission Docket 28158-U. Costs rise over time here because of rising commodity costs.
3. O&M costs are assumed to be the same as for the greenfield direct combustion plant.
4. Biomass prices in FL expected to range from $40-60/dry ton, delivered, or about $2.25-3.75/MMBtu, depending on energy content. Values given here based on 8,800 Btu/lb (dry), and the efficiencies provided on the following page.

Repowered coal facilities are expected to have similar performance to greenfield facilities.

	Biomass Repowering Direct Combustion Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Summer Peak (MW)	100	100	100
Winter Peak (MW)	100	100	100
Availability (%)[1]	90%	90%	90%
Typical Net Annual Capacity Factor (%)	85%	85%	85%
HHV Efficiency (%)	25%	25%	25%
Water Usage (gal/kWh)[2]	0.6-0.8	0.6-0.8	0.6-0.8
Hg (lb/MWh)	Minimal	Minimal	Minimal
CO2 (lb/MWh)[3.6]	0 / -2,123	0 / -2,123	0 / -2,123
NOx (lb/MWh)[4.6]	1.36 / -3.77	1.36 / -3.77	1.36 / -3.77
SO2 (lb/MWh)[5,6]	0.88 / -28.4	0.88 / -28.4	0.88 / -28.4

Sources: Navigant Consulting estimates 2008.

1. Scheduled outage based on approximately 2 weeks/year. This includes a major turbine/generator overhaul every six years lasting one month, 5-7 days of annual for cleaning, tube repairs, etc and 2 days for inspections. 6% forced outage based on interviews.
2. Assumes use of a wet cooling tower for the condenser and 1% steam losses, assuming approximately 10,700 pph steam per MW.
3. For analysis purposes, biomass assumed to be carbon neutral.
4. Based on an emissions rate of 0.1 lb/MMBtu. This would require NOx controls such as ammonia injection , staged combustion or NSCR.
5. Assumes coal with 1.5% wt% sulfur , no FGD, and 5% of sulfur retained in the ash. Biomass assumed to be 0.03% sulfur by weight (dry basis).
6. Values on the left are direct emissions of the repowered plant. Values on the right are net reductions considering retirement of the coal capacity making the same assumptions about the baseline coal plant as for co-firing.

Waste to Energy capital costs are high, in part due to extensive emissions control requirements.

	Waste to Energy Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Plant Capacity (MW)	50	50	50
Project Life (yrs)	25+	25+	25+
Development Time (yrs)	5-7	5-7	5-7
Total installed Capital Cost ($/kW)[1]	$6,000-9,000	$6,000-9,000	$6,000-9,000
Fixed O&M ($/kW-yr)[2] / **Non-Fuel Variable O&M ($/MWh)[2]**	$70/MWh	$70/MWh	$70/MWh
Tipping Fee Revenue ($/MWh)[3]	$46.2-107.7	$46.2-107.7	$46.2-107.7

Sources: Navigant Consulting estimates 2008; stakeholder data submitted to the Florida Public Service Commission, September 2008. Reviewed with WTE industry consultants.

1. Total Installed Costs can vary widely depending on several factors, including project scale, local permitting requirements, and grid interconnection costs. Low end would be representative of a plant expansion, whereas the high end would be representative of a greenfield facility. This total installed cost is consistent with a range of $150,000-250,000/ton of daily capacity.
2. Based on published data and industry estimates, total O&M is estimated at $43/ton MSW, or $70/MWh, based on 650 kWh (net)/ton.
3. Range is based on tipping fees of $30-70/ton, which is an NCI estimate based on historical data, desk research and discussion with industry representatives. Using a WTE conversion efficiency of 650 kWh/ton (net) yields a range of $46.2-107.7/MWh.

WTE performance is not that different from solid biomass. Efficiency is lower due to poorer fuel properties and internal power needs.

	Waste to Energy Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Summer Peak (MW)	50	50	50
Winter Peak (MW)	50	50	50
Availability (%)[1]	90%	90%	90%
Typical Net Annual Capacity Factor (%)	85%	85%	85%
HHV Efficiency (%)[2]	650 kWh/ton	650 kWh/ton	650 kWh/ton
Water Usage (gal/kWh)[3]	0.5 – 1.5	0.5 – 1.5	0.5 – 1.5
Hg (lb/MWh)[3]	0.0003	0.0003	0.0003
CO2 (lb/MWh)[4]	0	0	0
NOx (lb/MWh)[3]	2.7	2.7	2.7
SO2 (lb/MWh)[3]	0.03	0.03	0.03

Sources: Navigant Consulting estimates 2008; stakeholder data submitted to the Florida Public Service Commission, September 2008. Reviewed with WTE industry representatives and consultants.

1. Scheduled outage based on approximately 2 weeks/year. This includes a major turbine/generator overhaul every six years lasting one month, 5-7 days of annual for cleaning, tube repairs, etc and 2 days for inspections. 6% forced outage based on interviews.
2. Corresponds to an implied efficiency of 19% based on a heat content of 11.73 MMBtu/ton (DOE, EIA, *Methodology for Allocating Municipal Solid Waste to Biogenic and Non-Biogenic Energy*, May 2007. No natural gas fuel is included in this figure, as natural gas is typically only used during startup.
3. Provided by FL stakeholders to the FL PSC.
4. For analysis purposes, biomass portion of WTE assumed to be carbon neutral, consistent with other biomass options. The non-biomass portion of WTE (e.g., plastics) will have CO2 emissions.

Internal combustion (IC) engines are most commonly used in landfill gas to energy applications.

R&D	Demonstration	Market Entry	Market Penetration	Market Maturity
			Market	Technology

Resource/ Technology Definition

- Landfill gas (LFG) is the naturally occurring biogas produced through anaerobic digestion at landfill sites.
- A landfill gas to energy (LFGTE) project utilizes the biogas produced by decomposing organic waste in landfills to power an electricity generator.

Technology Maturity

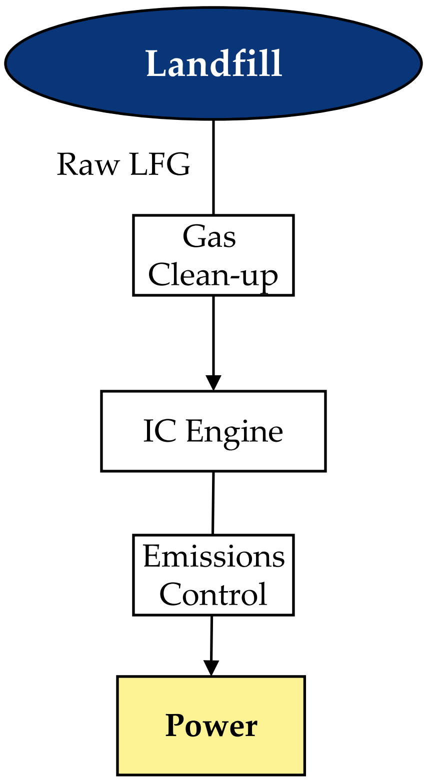
- LFGTE technologies are fully developed, though efficiency and emissions improvements are expected.
- IC engines are most commonly used, but gas turbines, steam turbines, microturbines and fuel cells have all found application with landfill gas/biogas.

Market Maturity

- The market for LFGTE is mature, but substantial potential exists in Florida as population and GDP growth drive waste generation.
- According to the EPA, as of December 2007, 445 LFG energy projects were operational in the US and about 535 landfill sites had been identified as attractive investment opportunities.

The majority of Florida's LFG conversion projects use electricity-generating reciprocating (IC) engines.

Schematic of the Technology



Description

- Since most applications use an IC engine, the diagram shown here assume a power-only internal combustion engine (no heat capture / CHP).
- Microturbine and fuel cell technologies tend to be used at smaller landfills and in niche markets.
- IC engines are more forgiving than gas turbines of the typically poor fuel quality that comes from a landfill.
- Costs can vary significantly based on the size of the application and the amount of front-end gas clean-up and tail-end emission clean-up. Cost estimates going forward will assume both front-end gas clean-up and tail-end emission clean-up due to the increasing stringency of air emission regulations.

Nine landfills with a total of 55 MW of LFGTE capacity are installed in Florida today.

	Current LFGTE FL Installations[1]			
Landfill	**Landfill Owner/Project Developer**	**Capacity (MW)**	**Technology**	**Date Installed**
Orange County SLF	Orange County/DTE Biomass Energy	16.3	Steam Turbine	1998
Central Disposal SLF	Waste Management, Inc./Bio Energy Partners	11.3	Combined Cycle	2000
Osceola Road Solid Waste Mgmt Facility	Seminole County/Landfill Energy Systems	9.6	Recip Engine	2007
Brevard County Central Disposal Facility	Brevard County/Landfill Energy Systems	6.2	Recip Engine	2008
Springhill Regional LF	Waste Management Inc.	4.8	Recip Engine	2006
Tomoka Farms Rd. LF	Volusia County/Fortistar Methane Group	3.6	Recip Engine	1998
SW Alachua SLF	Gainesville Regional Utilities	2.4	Recip Engine	2003
North LF	City of Jacksonville	0.5	Steam Turbine	1999
Girvin Road LF	City of Jacksonville	0.4	Recip Engine	1997

Notes:
1. Based on Energy Velocity Database and the Environmental Protection Agency's (EPA) Landfill Methane Outreach Program (LMOP) database, 2008 and input from industry stakeholders.

Navigant Consulting used the EPA's Landfill Methane Outreach Program (LMOP) database as the primary LFG data source.

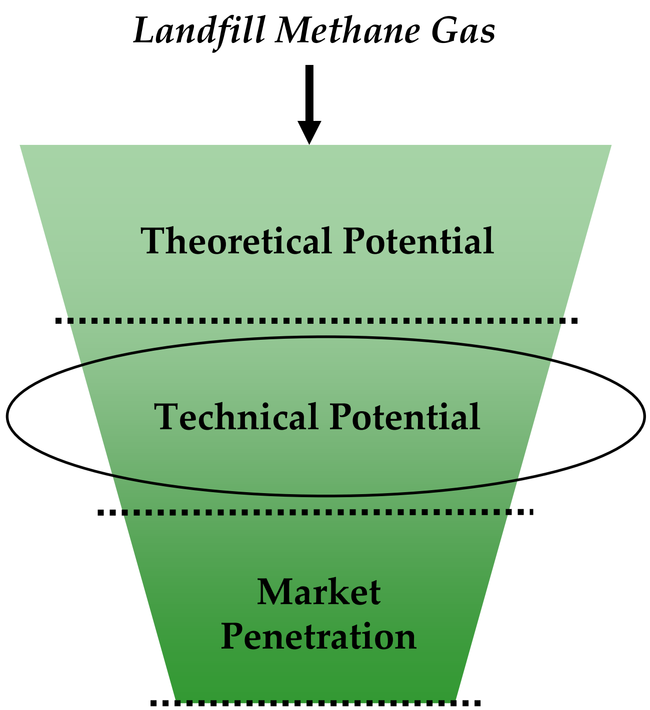
Sources:

- The LMOP's goal is to promote the use of landfill gas as a source of renewable energy and means of preventing methane emissions. The Project's public database provides state-by-state data on existing and potential LFGTE sites.[1]
  - LMOP has identified "Candidate" landfill sites where a LFGTE project is technically viable based on the following criteria: "is accepting waste or has been closed for five years or less and has at least one million tons of waste and does not have an operational or under construction project; or is designated based on actual interest or planning."
- NCI used the Florida's department of environmental protection (DEP) database of active landfills, the "WasteMap Florida" database, and Energy Velocity to cross-check data from LMOP. [2,3]
- Finally, potential facilities and future utility planning data submitted to NCI from the PSC was cross-checked against NCI's final technical potential estimates.

Notes:

1. Source: US Environmental Protection Agency. *Landfill Methane Outreach Program.* http://www.epa.gov/lmop/proj/
2. Source: Table 1C: Florida Active Landfill Facilities – Class I,II,III
3. Source: WasteMap Florida: A Leon County Project. Managed by the Southern Waste Information eXchange, Inc. http://www.wastemap.org/

Navigant Consulting identified 20 potential LFGTE sites in Florida.



Landfill Gas Technical Potential

- The technical potential is based on the sites listed in the LMOP, cross-checked with data submitted to NCI from the PSC.
- EPA's criteria for "Candidate" LFGTE sites was used to define NCI's technical potential, in any given year:
  1. >1 million tons of WIP
  2. Landfill closure year ≥ 2003
  3. Known interest in LFGTE project at that site
  4. No project in place or under construction
- A total of 20 sites fit the criteria identified above and have an average of 1.5 million tons of WIP today.
- 3 LF sites are deemed "Candidate" by EPA but fail to meet either the WIP or closure year criteria above. They are excluded from the technical potential; however, developers may have had interest in projects at those sites.
- From 2008-2020, waste acceptance rates at each of the 19 landfills are assumed to remain constant, based on the historic rate, thus MW potential remains constant over the timeframe.
- The resulting technical potential for undeveloped sites is ~100 MW[1] or 740 GWh.
- NCI then verified these results with the DEP's database, "WasteMap Florida" and Energy Velocity.

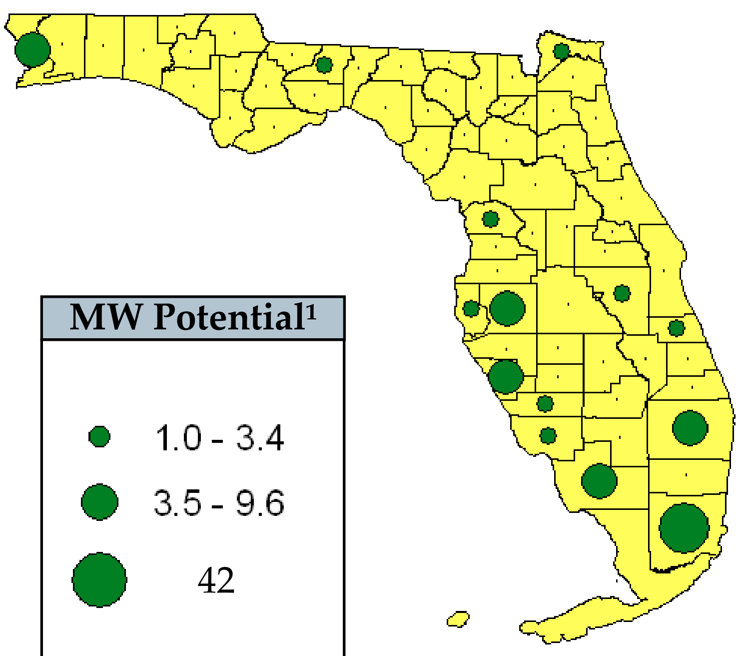
Notes:
1. 1 million tons of WIP ≈ 1 MW

Potential LFGTE sites are concentrated areas with the densest populations.

FL LFG Resource

- Potential LFGTE resources are mapped by county on the map to the right.
- The most populated counties contain the most WIP.
  - Miami-Dade county makes up almost 50% of the total 2008 state-wide capacity, at 42 million tons of WIP.
- LFG potential in the future could either rise or fall, depending on waste management practices.
  - An initiative for on-site anaerobic digestion of organic waste could take away the resource from LFG sites.
  - Improved separation of organic v. non-organic material at LF sites can improve gas quality and volume, making a LFGTE project more attractive.[2]

New County Level LFGTE Resources (2008)



Notes:
1. Aggregated by County, based on the assumption that 1 million tons of WIP ≈ 1 MW
2. Source: NCI 2008 Interview with LFGTE developer.

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LFGTE performance and capital costs are not expected to significantly change over time.

	LFGTE Economic Assumptions for Given Year of Installation (2008$)		
	2008	2015	2020
Plant Capacity (kW)[1]	2,000	2,000	2,000
Project Life (yrs)	20	20	20
Development Time (yrs)	3	3	3
Capital Cost ($/kW)[2,3]	$2,000	$2,100	$2,200
Fixed O&M ($/kW-yr)[4]	-	-	-
Non-Fuel Variable O&M ($/kWh)[4]	$0.015	$0.014	$0.013
Fuel/Energy Cost ($/kWh)[5]	$0.08	$0.08	$0.08

Sources: Navigant Consulting Estimates 2008. NCI Interviews with several project developers, Data provided from Florida stakeholders

1. Sizes vary by the scale of the landfill. The average size of future facilities using IC engines is expected to be about 2 MW.
2. Total Installed Costs for LFG vary by the stringency of local emissions standards. Emissions control may not be necessary in parts of the U.S. and Canada. Many areas have enforced stricter air emission standards, driving costs higher over the past 5 years. Costs for the electric generating equipment are expected to decline by about 1%/yr based on interviews as well as DOE/NREL projections.
3. Gas collection facilities are required to be in place for MSW facilities with design capacities over 2.75 million tons. If they need to be added, they typically cost $500/kW. Development costs and installation costs are expected to remain constant in real terms as these are driven more by labor and permitting.
4. Total annual O&M costs are implicit in the "Non-fuel variable O&M" and include only the maintenance of the generating equipment and not the maintenance of the landfill collection system, which is estimated to be about $50/kW-yr (10% of the installed cost of the gas collection system annually, or approximately $50/kW-yr).
5. Source: Data submitted to NCI from Florida Stakeholders

LFGTE performance and economics are not expected to change significantly over time.

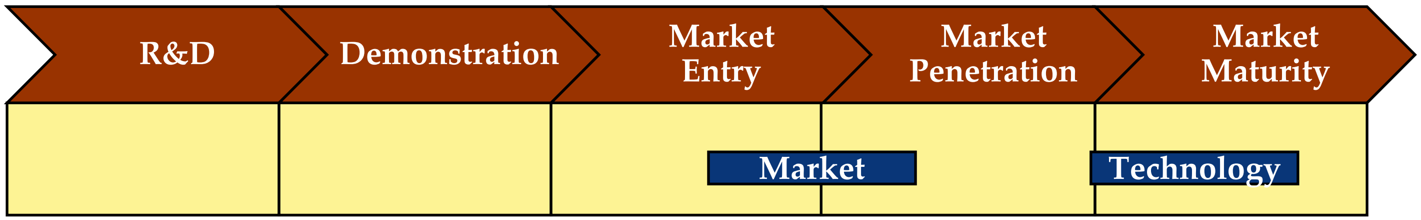
	LFGTE technology Economic Assumptions for Given Year of Installation (2008$)		
	2008	**2015**	**2020**
Summer Peak (kW)	2,000	2,000	2,000
Winter Peak (kW)	2,000	2,000	2,000
Availability (%)	90%	90%	90%
Typical Net Capacity Factor (%)[1]	85%	85%	85%
HHV Efficiency (%)	29.5%	30.5%	31.5%
Water Usage (gal/MWh)	-	-	-
Hg (lb/MWh)	-	-	-
CO2 (lb/MWh)[3]	LFGTE is assumed to be CO2 neutral		
NOx (lb/MWh)[4]	0.62	0.6	0.58
SO2 (lb/MWh)[5]	0.34	0.33	0.32

Sources: Navigant Consulting Estimates 2008. NCI Interviews. Energy Velocity.

Notes:

1. Capacity factors are based on historical data at existing plants as reported by Energy Velocity.
2. When considering the whole-fuel cycle character of biomass, carbon emissions are either zero or net negative. For LFG, depending on the baseline conditions (e.g., venting vs. flaring) adding a LFGTE plants may produce net carbon offsets that can be monetized, for example on the Chicago Climate Exchange. California's SB 1368 contains provisions recognizing the net emission, whole-fuel cycle character of Biomass.
3. NOx can vary widely. Figures shown assume 25 ppmv @15% O2 in exhaust, equivalent to approximately 0.2 g/bhp-hr. This would require after-treatment
4. Sulfur content of LFG can vary. Figures shown assume SO2 in exhaust of 10 ppmv @ 15% O2. This would require sulfur removal prior to combustion.

Internal combustion (IC) engines are most commonly used in anaerobic digester gas applications.



Resource/ Technology Definition

- This analysis will focus on waste products from “livestock operations”, “food processing” and “municipal liquid waste treatment operations” as defined in the “Biomass” definition in Florida’s Statute 366.91(2)(a).
- An anaerobic digester utilizes the natural process of anaerobic decomposition to treat waste (e.g. dairy cow manure) and produce biogas that can be used to power electricity generators.

Technology Maturity

- Anaerobic digester technologies are mature, though future costs are expected to decline as designers and manufacturers of the digesters learn and optimize the design.
- IC engines are most commonly used in anaerobic digestion power production.

Market Maturity

- At a national level, dairy and beef farms are the most typical farm-based feedstocks and are at a low level of penetration. Wastewater sludge and food processing waste are at a medium level of penetration.
- In Florida, very few anaerobic digest gas projects have been installed.

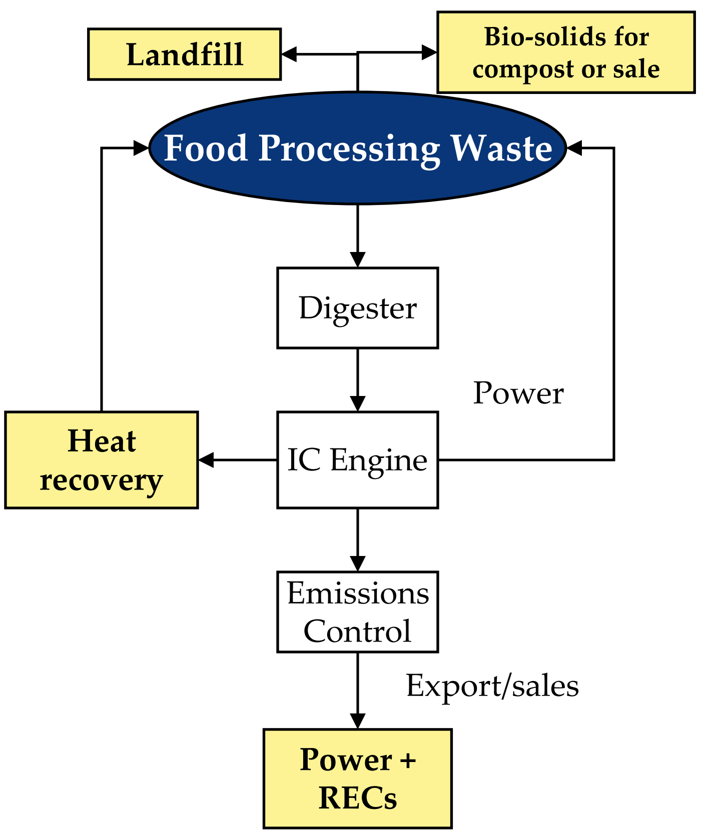
Of the range of feedstocks for anaerobic digestion, dairy farm waste is the most likely candidate for an anaerobic digestion project.

Feedstocks	Description/Caveats
Municipal Liquid Waste	• WWTP sludge, produced as by product from municipal or industrial water treatment plants • Currently in Florida, it is common practice to treat wastewater *aerobically* versus *anaerobically*, thus producing a biosolids renewable resource, <u>not</u> a biogas. • Treatment facilities are experimenting with the use of biosolids for energy applications, which may make it unattractive to convert to anaerobic digestion.[1]
Livestock Waste	Manure is the livestock waste resource for biogas production • Typically, manure is an ideal feedstock due to its high moisture content; however, given the climate in Florida, digester projects have been economically unattractive because the water content is high enough that the lagoon becomes very expensive.[2] • In Florida, dairy farms operations have been identified as the primary manure resource for anaerobic digester gas.[2]
Food Processing Waste	Organic wastes of food processing operations include: • Cheese processing: liquid whey • Vegetable Canning: vegetable skins, roots, ends. Food processing waste is most commonly sent to landfill, sent to compost, or sold to other industries. Specifically, citrus peels are sold to cattle farmers for animal feed and are used in the development of ethanol (fuel or food-grade).

Sources: 1)NCI conversations with Florida Wastewater division at FL DEP. 2) Interviews with Florida farm industry experts and digester gas project developers.

Food processing waste to biogas projects have been developed very limitedly throughout the United States thus far.

Food Processing Waste Disposal Options

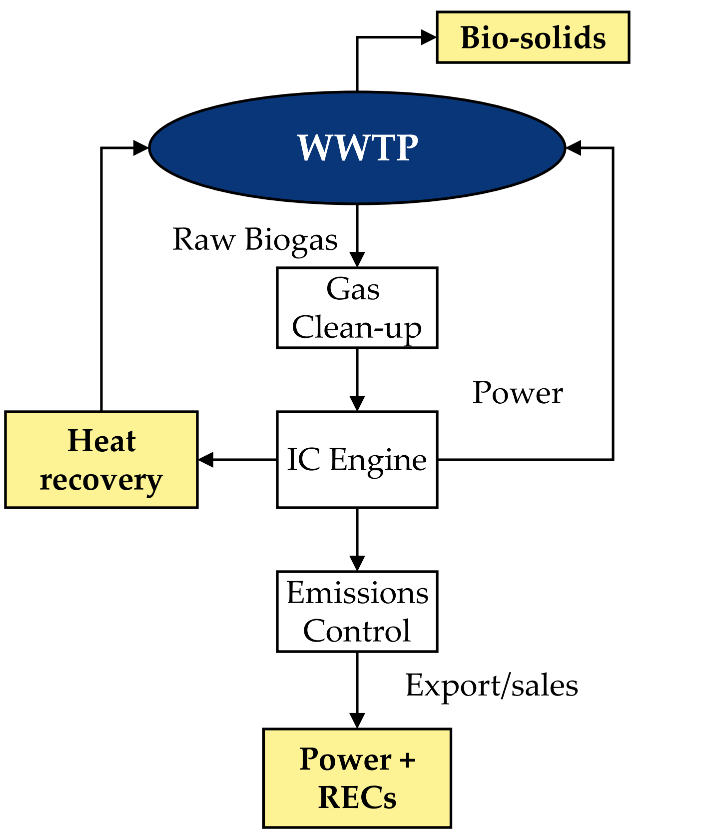


Food Processing Waste Exclusion

- Food processing waste is commonly disposed of through the following methods: landfilling, composting facility, or sale to other industries.
- Food process waste was not directly estimated by NCI for two reasons:
  1. A portion of the waste that would be harnessed for electricity is accounted for in the LFGTE and/or MSW biomass analyses.
  2. The two major agricultural products in Florida are Citrus and Sugar. The process waste of those two crops are "spoken for":
     - Citrus peels are being used for either cattle feed or ethanol production.
     - Sugar bagasse is burned for energy at sugar mills.
- Given that no total food processing industry output data is available, NCI assumes that much of the technical potential is captured in points 1 and 2 above.

A waste water treatment fuel to energy facility utilizes the biogas produced at the treatment plant to fuel an electricity generator.

Schematic of the Technology



Description

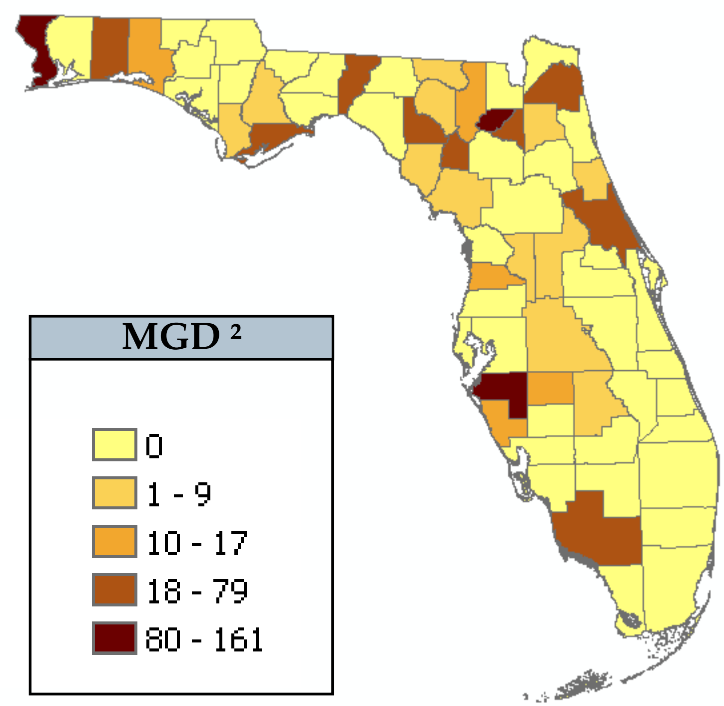
- A waste water treatment fuel to energy (WWTFTE) facility utilizes the biogas produced by decomposing organic waste in a waste water treatment facility to power an electricity generator and produce heat.
- IC engines are more forgiving of the typically poor fuel quality that comes from a waste water treatment facility.
- Costs for a WWTFTE facility are typically higher than a LFGTE due to the smaller size of the engine, and the additional costs of the heat capture / CHP.
- Cost estimates assume both front-end gas clean-up and tail-end emission clean-up due to the increasing stringency of air emission regulations.

Florida has over 200 municipally-operated domestic waste water treatment plants.

FL Municipal WWTP Resource

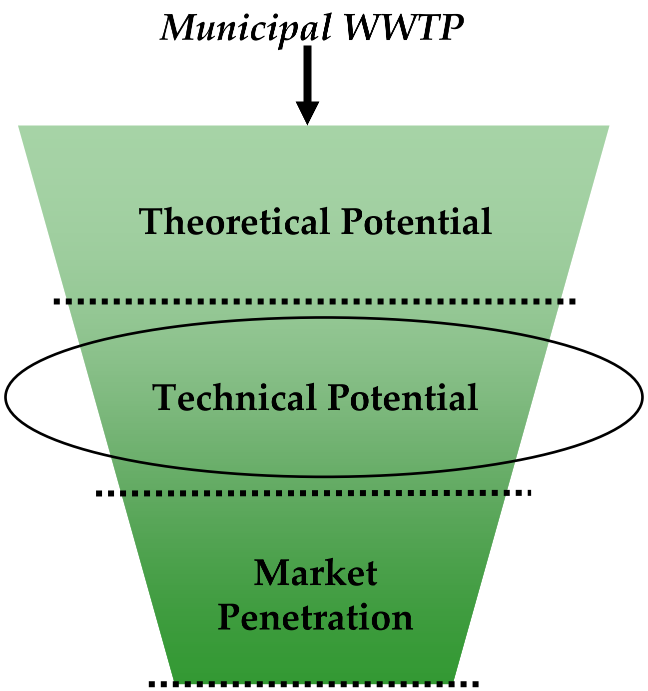
- The Florida Department of Environmental Protection (DEP) Wastewater Program provides a database of domestic wastewater treatment facilities, including the million gallons per day (mgd) treated.[1]
  - NCI considered only "municipal liquid waste treatment operations" as part of its analysis, based on the "biomass" definition in Florida Statute 366.91(2)(a)
  - Total wastewater treated (mgd) is aggregated by county and displayed to the right
- Anaerobic treatment of wastewater sludge results in the creation of methane (CH4), from which electricity is derived.
- Under NCI's technical potential approach, certain facilities will be screened out, which is described on the next slide.

County Level Million Gallons Per Day (MGD) Wastewater Treated (2008)



Sources: 1) Florida DEP Wastewater Program: Domestic Wastewater Facilities: http://www.dep.state.fl.us/water/wastewater/facinfo.htm
2) Aggregated by County, some facility data was unavailable or unrecorded in FL DEP database, and those facilities are not reflected.

There is ~20 MW and ~130 GWh of technical potential for methane gas from municipal wastewater treatment plants in Florida.



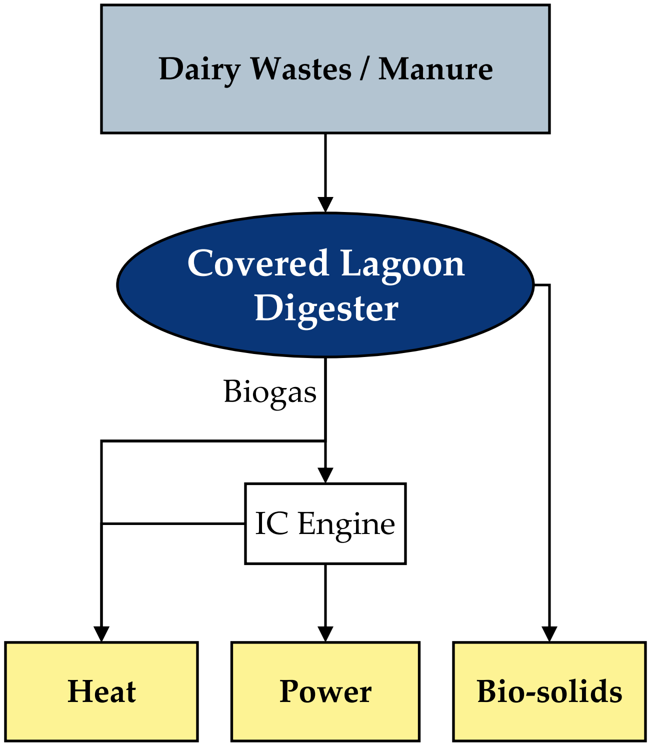
Municipal WWTP Technical Potential

- A list of municipally owned WWTP and the gallons per day treated was obtained from FL DEP.
  - Only municipal operations were included as part of the biomass definition of Florida Statute 366.91(2)(a)
- Technical potential was narrowed to those sites currently treating >3 million gallons per day (mgd), which is considered sufficient to generate enough feedstock for a digester project.[1]
- NCI used EPA's State GHG Inventory Tool – Wastewater Module to make assumptions about BOD and CH4 factors in order to calculate methane gas potential.[2]
- There are ~83 WWTP processing a total of ~1 billion gallons per day, which translates to a total technical potential of 20 MW.
- Current anaerobic digestion in place:
  - Only one municipal facility lists anaerobic digestion under its "Treatment Process Summary." This site processes 7 mgd, equivalent to ~0.5 MW, which has a minimal impact on the total technical potential.

Notes:
1. Source :US DOE EERE http://www1.eere.energy.gov/femp/newsevents/fempfocus_article.cfm/news_id=8961
2. Biochemical Oxygen Demand (BOD) is a measure of the oxygen uptake of biological organisms in water. Digestion reduced the BOD of wastewater, creating methane. NCI used the assumption from EPA's Inventory Tool: 0.6 kg CH4/kg BOD and 16.25% of BOD is treated anaerobically.
3. MW to MWh conversion assumes a net capacity factor of 85% and Higher Heating Value (HHV) of 28%

An anaerobic digester treats manure to produce biogas that can be used to produce electricity, heat, and bio-solids.

Schematic of the Technology



Description

- Small operations generally use IC engine.
- Costs can vary depending on the digester being deployed. The Covered Lagoon digester is the least expensive option.
- Other conventional digester technologies are Plug-Flow (rectangular flow-through tank, 11-13% solids), Complete Mix (large tanks, 10% solids, most expensive), and Fixed film (large tanks, short HRT vs. covered lagoon.[1]
- Other more advanced digester technologies use "multi-stage" digesters or "flow" designs with the use of "thermophilic" (high temperature) bacteria.
- In Florida, a Fixed Film or Covered Lagoon system are the most likely to be installed in the near term, given the manure management practice of flushing stalls.
- The University of Florida has the only fixed film digester running in the state.

Notes:
1. Hydraulic Retention Time (HRT) is a measure of the average length of time that a soluble compound remains in a reactor.

Livestock waste from dairy farms is analyzed based on concentrated feeding operations in Florida.

FL Dairy Livestock Waste Resource

Dairy cows are considered to be the only viable resource in Florida for anaerobic digester gas.[1]

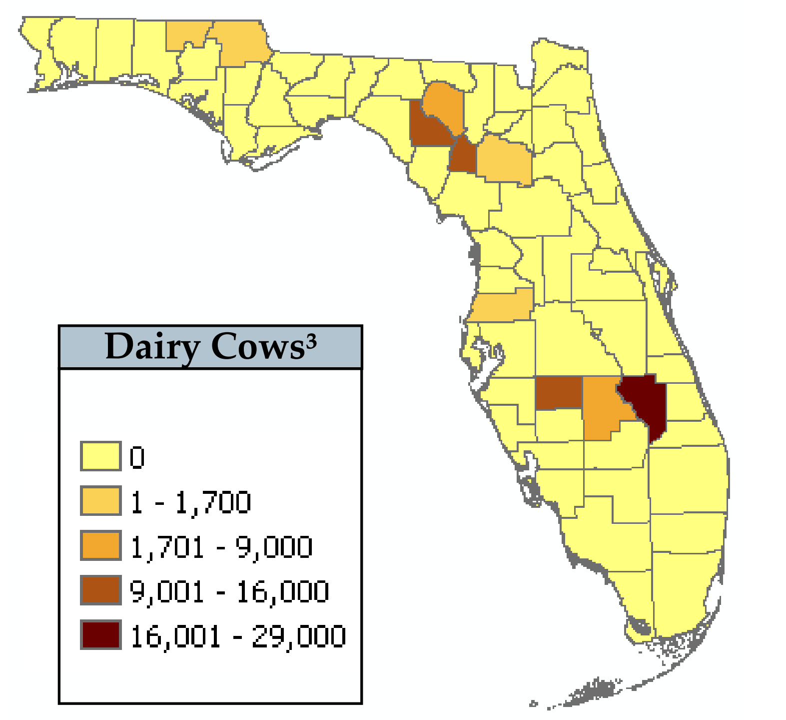
Based on USDA, NASS and Florida Field Office data, Dairy cows are concentrated in Okeechobee, Gilchrist and Hardee Counties.

34,400 dairy cows are now captured on the resource map:

- 34,100 dairy cows have been grouped into an "Other Counties" category
- 300 dairy cows have been grouped in the "Non-commercial" farm category

Additionally, some counties' dairy cow inventory were combined in published data to avoid disclosing individual operations. [2]

County Level Inventory of Dairy Cows (2008)



Notes:
1. Interviews with Florida stakeholders, including anaerobic digester gas project developers
2. Source: *Livestock, Dairy & Poultry Summary – 2007:* USDA, NASS, Florida Field Office.
3. Aggregated by County, based on 2008 Florida Milk Cows: Inventory by county, published by USDA, NASS, Florida Field Office

The technical potential for anaerobic digester gas will focus on 500+ head dairy operations in Florida.

Key Consideration for Potential

- Livestock waste resources that will support large scale digesters:
  - Swine and beef cattle farms are considered technically unattractive for anaerobic digestion opportunities in Florida[1]
  - "Potential" sites are those Florida dairy farms identified by USDA as having 500+ head. [2]
- Manure management practices:
  - The majority of dairy farms are believed to have storage ponds, which would need to be increased ~10-fold to suffice as a covered lagoon for anaerobic digestion.[3]
- Permitting process and time frame:
  - Obtaining a 5-year permit for a digester project can range from $750-$2,500, depending on the type of permit required.

Stephenville, TX, largest Renewable Natural Gas facility of its kind in the US. Will rely on the waste of ~10,000 dairy cows to produce 635,000 MMBTU/yr (~64 GWh/yr).
Source: EPA AgStar

Notes:
1. One project is currently under construction at a beef cattle farm, one of the few considered to be attractive for such an investment
2. Based on previous analysis by EPA's AgSTAR program, 500+ head farms were considered to be feasible for methane gas projects.
3. Source: NCI interviews with anaerobic digester gas and farm industry stakeholders in Florida

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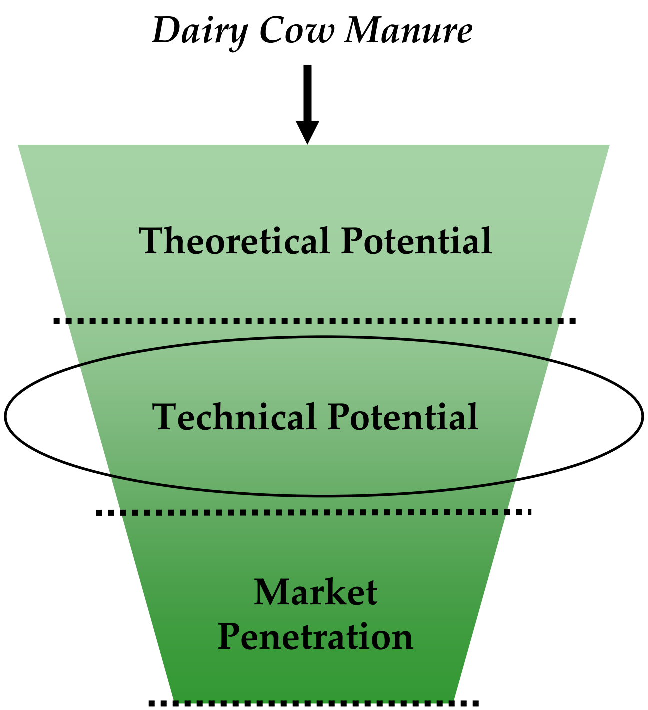
There is ~15 MW and ~95 GWh of technical potential for dairy waste power, based on the available resource and siting considerations.



Dairy Livestock Waste Technical Potential

- The technical potential is based on the number of dairy cows estimated at the 500+ category farms, as defined by the USDA.[1]
  - Of the 124,000 dairy cows in Florida, 85% reside at farms in the 500+ category, resulting in ~100,000 cows.
  - No commercial dairy anaerobic digester projects are currently installed in Florida.
- 1 cow is estimated to produce 440 m^3/year of methane, which results in a total of about 15 MW per year.[2]
- The remaining ~24,000 dairy cows in Florida are at much smaller, potentially dispersed farms. Additional potential could be realized if neighboring farms were able to cost-effectively transport waste to a central digester. The logistics and legal restrictions of transporting toxic waste is a barrier that would need to be addressed, however.

Notes:
1. Based on previous analysis by EPA's AgSTAR program, 500+ head farms were considered to be feasible for methane gas projects.
2. Source: Wilkie, Ann. *Opportunities for reducing greenhouse gas emissions through livestock waste management in Florida.* Assuming an HHV efficiency of 20%, and a net capacity factor of 75%. MW potential may be higher if HHV efficiency is assumed to be greater.

Anaerobic digesters systems for dairies are expensive because of their small scale and the need to construct the digester.

	Technology AD Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Plant Capacity (kW)[1]	250	250	250
Project Life (yrs)	10	10	10
Development Time (yrs)	0.5	0.5	0.5
Capital Cost ($/kW)[2]	$5,000	$5,200	$5,200
Fixed O&M ($/kW-yr)[3]	-	-	-
Non-Fuel Variable O&M ($/MWh)[3]	$57	$56	$55
Fuel/Energy Cost ($/kWh)	-	-	-

Sources: Navigant Consulting Estimates 2008, Cornell Manure Management Program, California Dairy Power Production Program, Wisconsin Anaerobic Digester Casebook – 2004 Update, NCI Interviews with equipment and digester manufacturers.

Notes:
1. The average installed capacity of dairy-cow digester to energy systems in the US is 250 kW and is expected to remain constant over the analysis timeframe.
2. Includes development fees, interconnection, but not interest during construction. The cost breakdown between engine/generator, digester, and other is an approximation, and is performed differently by each source.
3. Total annual O&M costs are assumed to be 3% of total capital costs, as recommended by EPA AgSTAR.

Anaerobic digesters systems for dairies are expensive because of their small scale and the need to construct the digester.

	AD technology Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Summer Peak (kW)	250	250	250
Winter Peak (kW)	250	250	250
Availability (%)	90%	90%	90%
Typical Net Capacity Factor (%) [1]	75%	75%	75%
HHV Efficiency (%)[2]	20%	21%	23%
Water Usage (gal/MWh)	-	-	-
Hg (lb/MWh)	-	-	-
CO2 (lb/MWh)[3]	AD – Dairy is assumed to be CO2 neutral		
NOx (lb/MWh)[4]	2.0	2.0	1.8
SO2 (lb/MWh)[5]	1.9	1.8	1.7

Sources: Navigant Consulting Estimates 2008, Cornell Manure Management Program, California Dairy Power Production Program, Wisconsin Anaerobic Digester Casebook – 2004 Update, NCI Interviews with equipment and digester manufacturers

Notes:

1. Capacity Factors can vary significantly by dairy and can be dependent on the owner's motivation or amount paid for an O&M service contract.
2. HHV Efficiency is based on the feedstock to electricity. Feedstock to methane is typically 60% to 70% efficient and the IC engine ~30%.
3. When considering the whole-fuel cycle character of biomass, carbon emissions are either zero or net negative. California's SB 1368 contains provisions recognizing the net emission, whole-fuel cycle character of Biomass.
4. NOx can vary widely. Figures shown assume 75 ppmv @15% O_2 in exhaust, equivalent to approximately 0.7 g/bhp-hr. This is consistent with the use of a lean-burn engine.
5. Sulfur content can vary. Figures shown assume SO2 in exhaust of 50 ppmv @ 15% O_2. This would require sulfur removal prior to combustion.

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Waste Water Treatment Fuel to Energy (WWTFTE) performance and economics are similar to LFGTE.

	Waste Water Treatment Fuel to Energy: Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Plant Capacity (kW)	500	500	500
Project Life (yrs)	20	20	20
Development Time (yrs)	2	2	2
Total Installed Cost ($/kW)[1]	$2,650	$2,800	$2,800
Fixed O&M ($/kW-yr)[2]	$22	$20	$20
Variable O&M ($/kWh)[2]	$0.018	$0.017	$0.016
Fuel/Energy Cost ($/kWh)	-	-	-

Sources: Navigant Consulting Estimates 2008. NCI cost estimates 2002-2006, NCI Interviews; Energy Velocity; "Gas-fired Distributed Energy Resource Technology Characterizations", DOE/NREL/GTI, October 2003.

Notes:

1. Costs for a WWTFTE facility are typically higher than a LFGTE due to the smaller size of the engine, and the additional costs of the heat capture / CHP. The O&M cost does not include the O&M for the digester. There are limited sources for historical costs of WWTFTE systems. The estimates are based on historical NCI estimates and interviews. NCI also confirmed the difference in capital costs due to CHP and size with DOE/NREL estimates. Since 2007, developers have estimated a 10-15% increase in installed cost.
2. Historical O&M costs are based on historical costs at existing facilities as obtained from Energy Velocity as well as interviews with industry. O&M costs are higher for the WWTFTE than the LFGTE due to the decreased scale.

Waste Water Treatment Fuel to Energy (WWTFTE) performance and economics are similar to LFGTE. (continued)

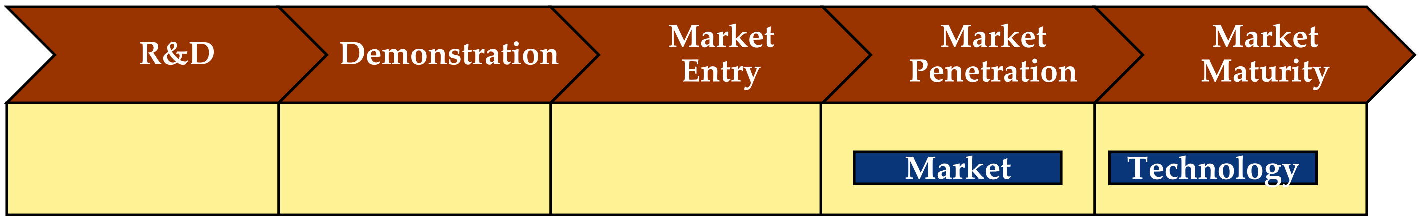
	Waste Water Treatment Fuel to Energy: Performance Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Summer Peak (kW)	500	500	500
Winter Peak (kW)	500	500	500
Availability (%)	90%	90%	90%
Typical Net Capacity Factor (%)[1]	85%	85%	85%
HHV Efficiency (%)	28.5%	29.5%	32.0%
Water Usage (gal/MWh)	n/a	n/a	n/a
Hg (lb/MWh)	-	-	-
CO2 (lb/MWh)[2]	WWTFTE is assumed to be CO2 neutral		
NOx (lb/MWh)[3]	0.68	0.66	0.61
SOx (lb/MWh)[4]	0.38	0.37	0.34

Sources: Navigant Consulting Estimates 2008. NCI Interviews; Energy Velocity;

Notes:

1. Capacity factors are based on historical data at existing plants as reported by Energy Velocity.
2. When considering the whole-fuel cycle character of biomass, carbon emissions are either zero or net negative. California's SB 1368 contains provisions recognizing the net emission, whole-fuel cycle character of Biomass.
3. NOx can vary widely. Figures shown assume 25 ppmv @15% O2 in exhaust, equivalent to approximately 0.23 g/bhp-hr. This would require after-treatment.
4. Sulfur content of WWTP can vary. Figures shown assume SO2 in exhaust of 10 ppmv @ 15% O2. This would require sulfur removal prior to combustion.

A steam turbine generator is the most commonly used technology to convert waste heat into electricity.



Resource/ Technology Definition

- Waste Heat is a by-product of machine-driven processes. Waste heat can be used for a variety of purposes, depending on the source and temperature. It can be used for thermal processes, turned into electricity or a combination of the two (cogeneration). It can also be used for cooling purposes.
- This study will focus on the MW electricity-potential from waste heat at sulfuric acid conversion processes, as stated in Title XXVII 366.91(2)(d).

Technology Maturity

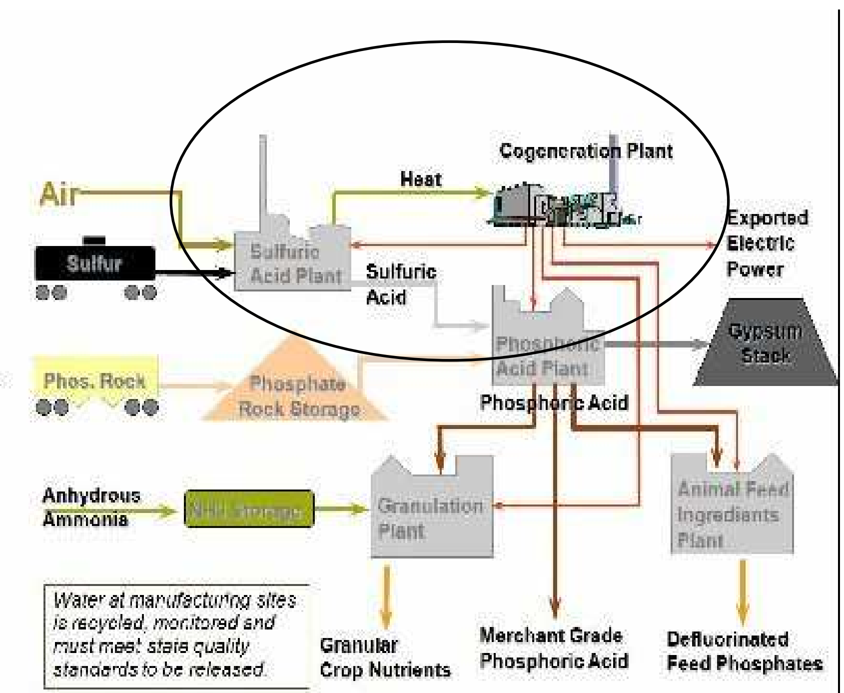
- Waste heat conversion technologies are fully developed, though the concept of "turn-key" cogeneration technologies are evolving.
- In the Florida sulfuric acid manufacturing process, conventional steam-turbine generators are widely used to capture waste heat and will be the only technology analyzed for this resource.

Market Maturity

- The market for waste heat to electricity is still growing. Rising energy cost, among other factors, have improved the economics of heat recovery systems has and led to a more widespread adoption of the concept.
- In Florida, the estimated penetration of waste heat recovery in the sulfuric acid production process for phosphate-based fertilizers is 73%.

A sulfuric acid plant generates a significant amount of high temperature heat as part of the manufacturing process.

Schematic of the Technology[1]



Description

- Sulfuric acid manufacturing is an integral part to the Phosphate fertilizer industry in Florida.
- Creating sulfuric acid is a highly exothermic process, which creates the opportunity to capture the waste heat as steam for conversion to electricity
- A steam-turbine generator is the most widely employed generator for this application, and costs presented will reflect that technology.

Notes:

1. Source: Florida Industrial Cogeneration Association

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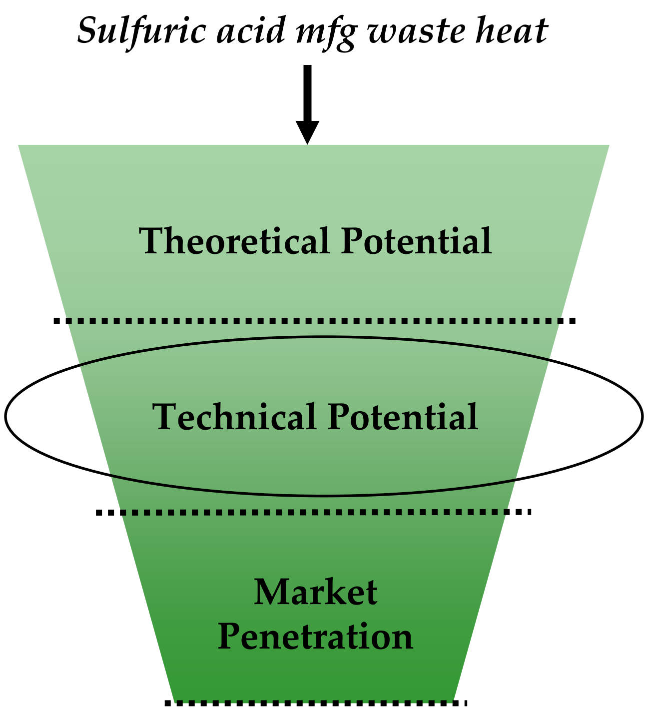
Roughly 75% of Florida's waste heat potential has been developed to-date at sulfuric acid manufacturing operations.

Current FL Waste Heat Installations

- A total of 20 sulfuric acid manufacturing operations currently exist in Florida, all of which are believed to be part of the Phosphate fertilizer industry.[1]
- A total of 370 MW, producing ~2 TWh, of waste heat to electricity is currently installed.[2]
- The average system size is 30MW, though units currently installed range from 8 MW to ~60 MW.[2]
- Existing Capacity and Generation can vary due to factors such as:
  1. Oversizing of the turbine generator (for the potential of future expansion)[2]
  2. Facility production and demand throughout the year (driving waste heat generation)[2]

Notes:
1. Source: NCI communication with a representative of Florida Industrial Cogeneration Association
2. Source: Renewable Energy From Waste Heat – Data Response of Florida Industrial Cogeneration Association. FPSC docket No. 080503

Navigant Consulting relied upon the survey of the industry plants to determine the technical potential for waste heat to electricity.



Waste Heat Technical Potential

- The technical potential is estimated based on an industry survey taken by the Florida Industrial Cogeneration Association
- Technical potential estimates were given to NCI based on what is possible at each of the 20 plants, without overhauling existing infrastructure to potentially increase the MW potential.
  - According to the Industrial Cogeneration Association, no plants have future plans for such upgrades, thus 140 MW is set at the technical potential out to 2020.
- A total of 370 MW-worth of existing projects exist at 20 sulfuric acid manufacturing plants in Florida.[1]
- The remaining technical potential with in those 20 facilities is estimated to be a total of 140 MW, or 1 TWh. [1]
  - Projects are estimated to be installed in increments of 8 MW, on average, and ~55GWh each.

Sources: 1) Renewable Energy From Waste Heat – Data Response of Florida Industrial Cogeneration Association. FPSC docket No. 080503

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A steam-turbine generator for waste heat conversion is an attractive investment with minor annual costs after installation.

	Waste Heat Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Plant Capacity (kW)	8,000	8,000	8,000
Project Life (yrs)	30	30	30
Development Time (yrs)	2	2	2
Capital Cost ($/kW)	$3,750	$4,100	$4,400
Fixed O&M ($/kW-yr)	$40	$40	$40
Non-Fuel Variable O&M ($/MWh)	$0.10	$0.10	$0.10
Fuel/Energy Cost ($/kWh)	-	-	-

Sources: 1) Renewable Energy From Waste Heat – Data Response of Florida Industrial Cogeneration Association. FPSC docket No. 080503

A steam-turbine generator has a high availability and capacity factor .

	Waste Heat Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Summer Peak (kW)[1]	8,000	8,000	8,000
Winter Peak (kW) [1]	8,000	8,000	8,000
Availability (%) [1]	95%	95%	95%
Typical Net Capacity Factor (%) [1]	80%	80%	80%
HHV Efficiency (%)	n/a	n/a	n/a
Water Usage (gal/kWh)	-	-	-
Hg (lb/kWh)	-	-	-
CO2 (lb/kWh)	-	-	-
NOx (lb/kWh)	-	-	-
SO2 (lb/kWh)	-	-	-

Sources: 1) Renewable Energy From Waste Heat – Data Response of Florida Industrial Cogeneration Association. FPSC docket No. 080503

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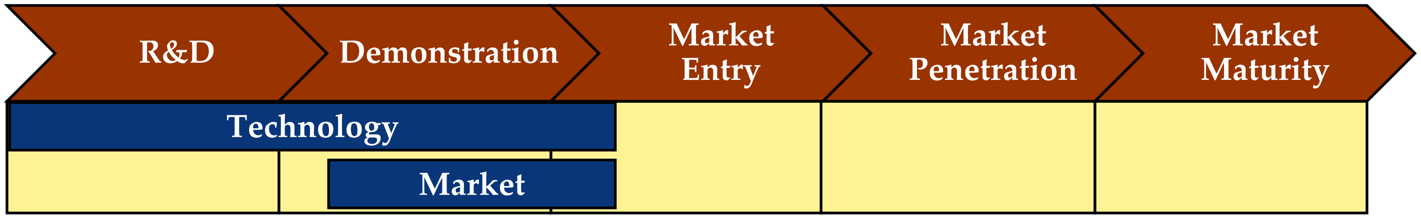
Certain wave technologies have reached the market entry stage.



Technology Definition

- For the purposes of this project, the definition of wave energy technologies will include both onshore and offshore wave power systems. The wave energy technologies are described in more detail on the following slides.

Technology Maturity

- Though most wave technologies remain in the R&D stage, a handful of companies (5 to 10) have completed the development stage and are at or near the commercial demonstration phase. A few companies are prepared to develop commercial projects.

Market Maturity

- The first commercial sale was announced in 2005 and some additional commercial orders have been secured in Scotland, Portugal, and Australia. Commercial projects in CA, HI, and OR are seeking preliminary FERC permits. One commercial project in WA has been issued a license to move forward. No commercial or pilot wave projects exist or are seeking permitting in FL.
- Due to technology risk, FERC has ruled that all ocean power projects first be developed as pilots and operate for five years.

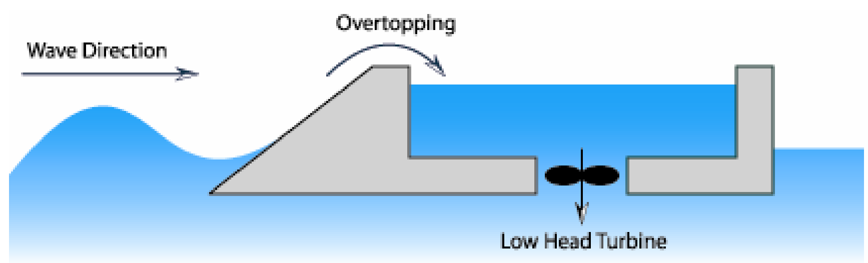
Onshore and offshore wave power systems use the breaking and bobbing motion of waves, respectively, to generate electricity.

Wave Energy Technologies	
Onshore Systems	**Offshore Systems**
Oscillating Water Column: Consists of a partially submerged concrete or steel structure with an opening to the sea below the waterline. It encloses a column of air above a column of water. As waves enter the air column, they cause the water column to rise, compressing and pressurizing the air column. As a result of the fluctuating air pressure, air is repeatedly drawn through the turbine. **Tapchan/overtopping:** Consists of a tapered channel which feeds into a reservoir constructed on cliffs above sea level. The narrowing of the channel causes the waves to increase in height as they move toward the cliff face. The waves spill over the channel walls into a reservoir and the water is then fed through a turbine. **Pendulor Device:** A rectangular box is open to the sea at one end. A flap is hinged over the opening and the action of the waves causes the flap to swing back and forth, powering a hydraulic pump and a generator.	Offshore systems are typically situated in water more than 130 feet deep. **Pump:** Submerged or floating, offshore pump systems use the bobbing motion of waves to power a pump that generates electricity **Hose:** Hoses are connected to floats that ride the waves. The rise and fall of the float stretches and relaxes the hose, which pressurizes the water, thereby rotating a turbine. **Turbine Vessel/overtopping:** Seagoing vessels can also capture the energy of offshore waves. These floating platforms create electricity by funneling waves through internal turbines and then back into the sea.

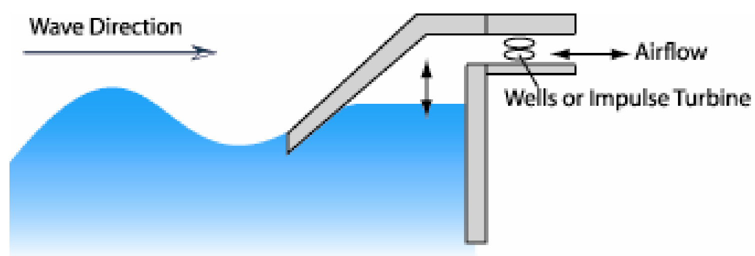
Note: Some of these technologies are depicted on the following slide.

Wave energy conversion devices convert wave motion to electricity.

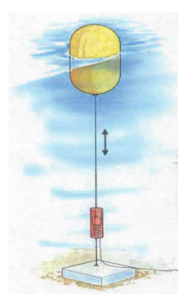
Tapchan/ Overtopping

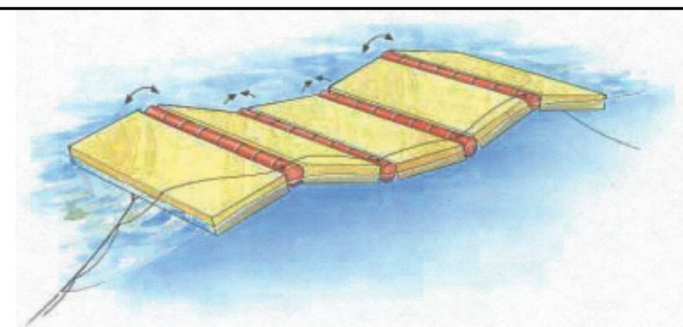


Oscillating Water Column



Buoyant Moored Device (Pump or Hose)





Sources: EPRI

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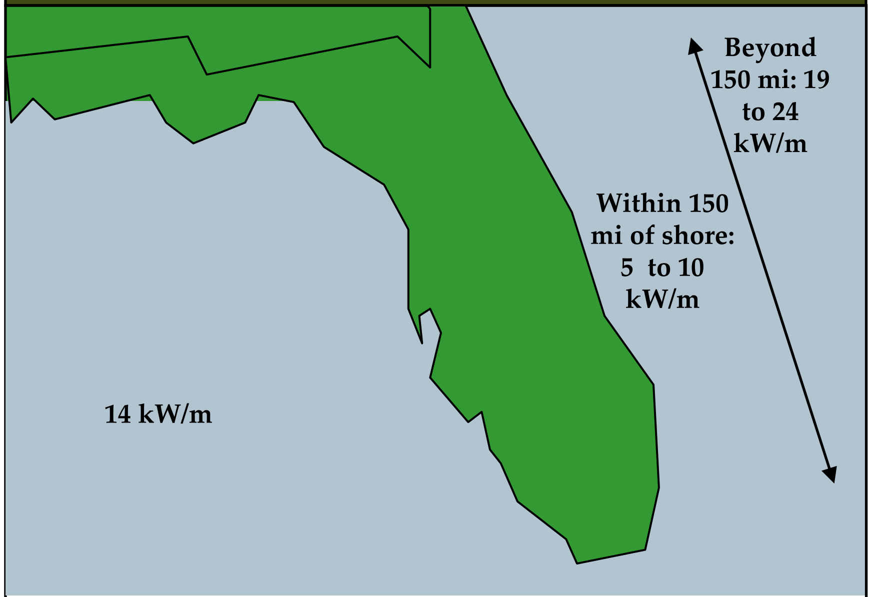
Florida's wave resource is modest, but is relatively more significant off the east coast of the state.

FL Wave Energy Resource

- Florida's wave resource is shown at the right.
- On the Atlantic side, average annual wave potential of 19 to 24 kW/m exists far from shore. An appx. 5 – 8 kW/m wave potential exists within ~150 miles from shore.[1,2]
- The wave resource is strongest on the state's Atlantic coast. The west coast of the state is sheltered, resulting in a weaker wave resource.
- On a global scale, average energy potential per meter of wave crest ranges from 0 to roughly 100 kW/m.

Map of FL Wave Resource[1,2]



Wave energy is measured in kW/m of wave crest.

Sources:

1. World Energy Council. *2004 Survey of Energy Sources*. CEC, *Summary of PIER-Funded Wave Energy Research*, March 2008.
2. National Buoy Data Center wave height and wave period data

Florida's wave potential, due to the low power of the waves and technology considerations, is not currently a developable resource.

Wave Energy Technical Potential by 2020
Based on discussions with industry developers and EPRI Ocean Energy Leader, Roger Bedard, Florida's wave energy potential is not currently a developable resource. • On the Atlantic coast, the higher end of the wave energy potential 19 - 24 kW/m is found over 150 miles off the north coast. The lower wave energy resource 5 – 10 kW/m • Wave technologies are not currently optimized for such a low energy resource as is found within the 150 mile reach of Florida's shore, and it is unlikely that this level of resource will see any development before 2020 • Development of the potential may be possible beyond the 2020 time frame, as technologies become optimized to capture such low-energy waves, costs decline due to production capacity and learning curves, and as the world's primary wave sites become developed.[a]

Notes:

a. If the wave resource could eventually be developed, it could potentially support a few hundred megawatts installed capacity.

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Ocean current technology demonstration may begin during 2009, with full scale prototypes being tested by 2011.

Technology Definition

- For the purposes of this project, ocean current technologies will be defined as technologies which use the flow of water due to ocean currents to generate electricity.

Technology Maturity

- Ocean current technology is in the R&D stage, with demonstration projects planned for the 2009 – 2011 time frame to test the operational capabilities of turbine designs, as well as environmental impacts. The first commercial systems could potentially be installed during the 2013 – 2015 timeframe at the earliest, given a supportive regulatory environment.
- Some additional research has been under way since 2000, when three companies received small business innovation research (SBIR) awards from the U.S. Department of Energy to explore ocean-current power generators.

Market Maturity

- Due to technology risk, FERC requires that ocean power projects be developed first as pilots and operate as long as five years. FERC has issued ~30 preliminary permits (mostly in-stream) since 2005.
- Ocean Renewable Power Company has obtained six Preliminary Permits from FERC for ocean current energy sites in the Gulf Stream.

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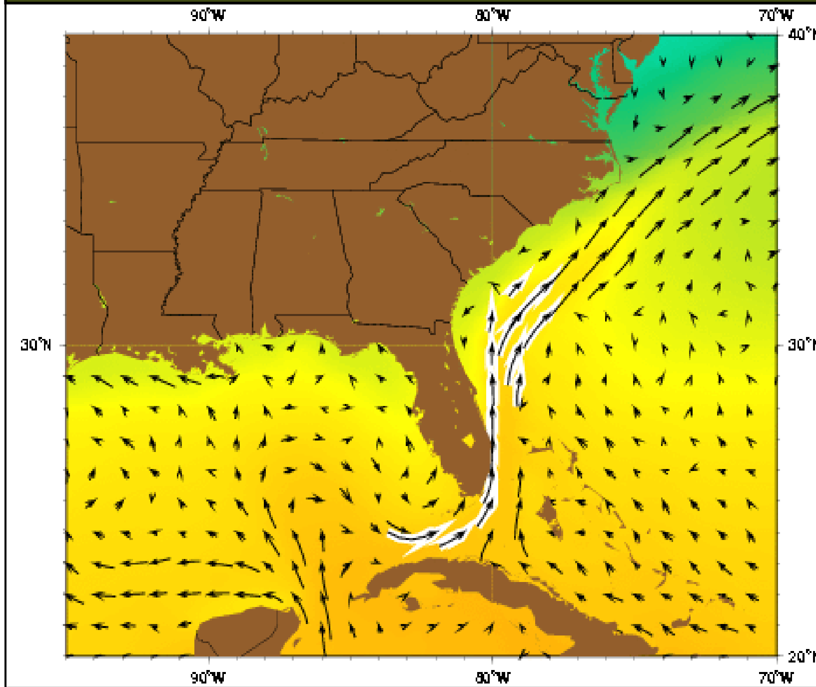
The Gulf Stream contains Florida's ocean current resource, which travels past the southern tip of the state and up the east coast.

FL Ocean Current Resource

- The Florida Current has an average velocity of 3 knots (5.5 km/hr),[2] and represents a significant source of energy.
- It contours the coast of Florida beginning at the state's southern tip near Miami, and following the coast past Jacksonville.
- This region has a steep continental shelf with the core of the current located about 15 miles off shore before it meanders from the coast. It re-attaches to the coast in North Carolina.[1,2,3,4]
- Offshore Ft. Lauderdale and West Palm Beach are two regions that are considered prime development sites

Map of FL Ocean Current Resource [5]



Sources:

1. Communication with President & CEO, Ocean Renewable Power Company.
2. University of DE, Offshore Wind Power - Final Project, *Wind and ocean power resources off the Florida coast, USA*, Spring 2005. Developer interviews, resource maps.
3. Florida Atlantic University Center for Ocean Energy Technology. Phone communication.
4. MMS Renewable Energy and Alternate Use Program, Technology White Paper on Ocean Current Energy Potential on the U.S. Outer Continental Shelf, May 2006
5. The Florida Current, MGSVA Seasonal Plots. http://oceancurrents.rsmas.miami.edu/atlantic/florida.html.

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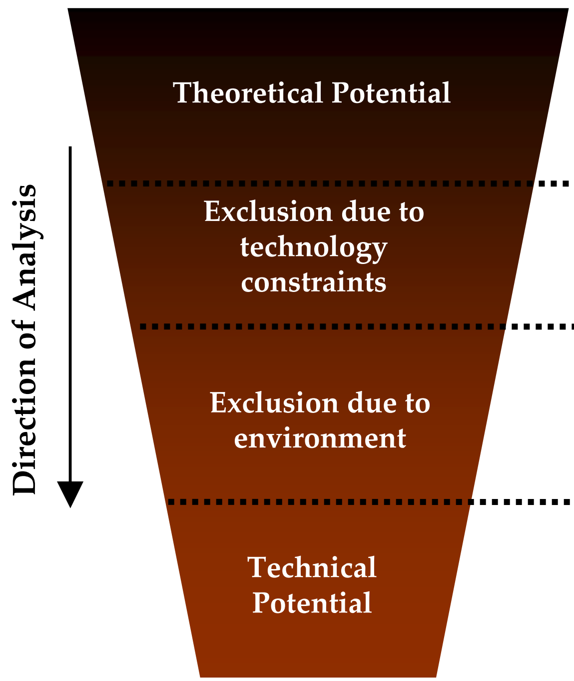
Using existing theoretical potential information, Navigant Consulting will employ a screening approach to arrive at technical potential.

Ocean Current Energy Methodology



- Theoretical potential as found in existing literature and as provided by Florida Atlantic University (FAU) ocean current energy experts. Represents total energy available for capture.
- Reduced theoretical potential with regard to available technology specifications such as capture efficiency.
- NCI will take into account input as to areas which will likely be excluded from development due to sensitive environmental habitats.
- Florida's estimated technical potential for ocean current energy development by 2020.

Theoretical installed capacity for ocean current technology ranges from 4 to 10 Gigawatts.

Ocean Current Energy Assumptions and Analysis

~25 GW[1]

↓

~4 GW- 10 GW[1,a]
The maximum theoretical installed capacity. This does not take into consideration environmental exclusion.

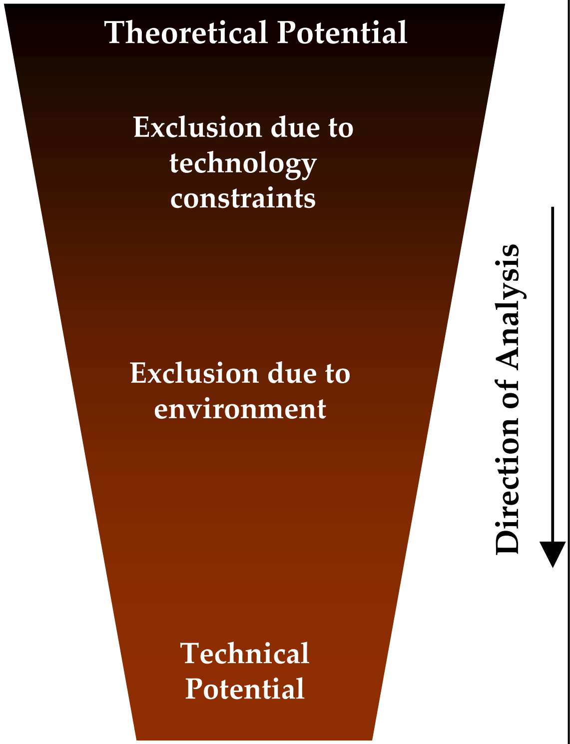
↓

Exclusion due to the environment and due to needs for technology spacing are not yet fully understood, and research still needs to be conducted in this area. However, the full technical potential will not be entirely developed by 2020. An estimate for the portion that may be developed by 2020 is provided below. [b]

↓

~500 MW to 1 GW could possibly be developed by 2020 given a supportive regulatory environment, as estimated by Florida Atlantic University ocean experts. [1,c]

Given this range, NCI will assume a technical potential of 750 MW, or 5,900 GWh, by 2020.



Sources:
1. Florida Atlantic University, Center for Ocean Technology estimates. Technical potential also based on interviews with ocean current developers.

Notes:
a. Based on capture efficiency of technology and areas excluded due to slow flow.
b. To the extent that environmentally sensitive areas exist, it is likely to be able to develop 750 MW of technical potential outside of those areas, based on discussions with Florida Atlantic University ocean energy experts. However, ocean energy environmental exclusions are an area of ongoing and future research. Therefore, there is potential for unforeseen changes to environmental exclusions as research progresses in this area.
c. Much more technical potential exists to be developed beyond 2020.

Installed costs for ocean current technology are expected to drop as the technology matures.

	Ocean Current Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Plant Capacity (kW)	-	5,000	100,000
Project Life (yrs)	-	20	20
Development Time (yrs)[1]	-	5	5
Capital Cost ($/kW) [2]	-	$8,800 – $9,600	$6,500 - $7,200
Fixed O&M ($/kW-yr) [3]	-	$200	$148
Non-Fuel Variable O&M ($/kWh)	-	Included in fixed O&M	Included in fixed O&M
Fuel/Energy Cost ($/kWh)	-	n/a	n/a

Sources: 2015 costs based on quotes from developers for 50 MW and 100 MW plants. 88% learning curve assumed based on NREL estimates for learning curve of offshore wind.

Notes:

1. Total construction time including generator fabrication lead time (~6 months), onshore assembly, and on water construction. On water construction time is only a portion of the total stated construction time. Includes approximately 2 years for permitting and regulatory matters.
2. 2015 costs include ~$7 million in transmission costs. Due to the emerging status of the technology, installed costs are have a high uncertainty. 2020 estimates are derived from a learning curve equation with the following assumptions: 2015 installed costs of $9600 and $8800 remain steady until 100 MW are installed, 88% learning curve based on NREL estimates for learning curves of offshore wind; cumulative installed capacity of 500 MW in 2020. Cost reductions assumed as a result of technology maturation, economies of scale, and streamlined permitting and construction practices.
3. 2020 estimates derived from a learning curve equation. Assumptions: 2015 O&M of $200 will remain steady until 100 MW are installed, 88% learning curve based on NREL estimates for learning curves of offshore wind; cumulative installed capacity of 500 MW in 2020.

Due to resource strength, ocean current units benefit from a high capacity factor, experiencing very little intermittency.

	Ocean Current Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Summer Capacity (kW) [1]	-	105,000	105,000
Winter Capacity (kW)	-	95,000	95,000
Availability (%) [2]	-	98%	98%
Typical Net Capacity Factor (%)	-	90%	90%
HHV Efficiency (%)	-	n/a	n/a
Water Usage (gal/kWh)	-	n/a	n/a
Hg (lb/kWh)	-	n/a	n/a
CO2 (lb/kWh)	-	n/a	n/a
NOx (lb/kWh)	-	n/a	n/a
SO2 (lb/kWh)	-	n/a	n/a

Sources: Florida Atlantic University Center for Ocean Energy Technology estimates that winter volume transport is ~10% weaker than summer volume transport. and NREL Technical Assumptions, http://www.nrel.gov/wind/coe.html

Notes:

1. Further studies need to be completed before it is clear to what extent this will have an effect on energy production. However, if there is an effect, it is unlikely that the summer/winter capacity variability will exceed +/- 5% of the nameplate capacity.
2. Availability refers to the amount of time the technology is available to generate electricity (ie. is not being serviced or repaired). Due to the turbine similarities between wind and proposed ocean current technologies, the availability of wind technology is used here as a best estimate.

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Ocean thermal energy's limited applicability has impacted its growth.

R&D	Demonstration	Market Entry	Market Penetration	Market Maturity
Technology Market				

Technology Definition

- For the purposes of this project, the definition of ocean thermal energy conversion (OTEC) technologies will include open loop, closed loop, and hybrid systems, as well as onshore and floating offshore systems. The OTEC technologies are described in more detail in the following slides.

Technology Maturity

- Small-scale OTEC pilot systems and individual system components have been tested successfully off the coast of Hawaii. No OTEC facilities are currently generating electricity.

Market Maturity

- The limited applicability of OTEC technology in the United States has constrained public R&D investments and commercial interest.
- Due to technology risk, FERC now requires that all ocean power projects be developed first as pilots and operate for as long as five years.

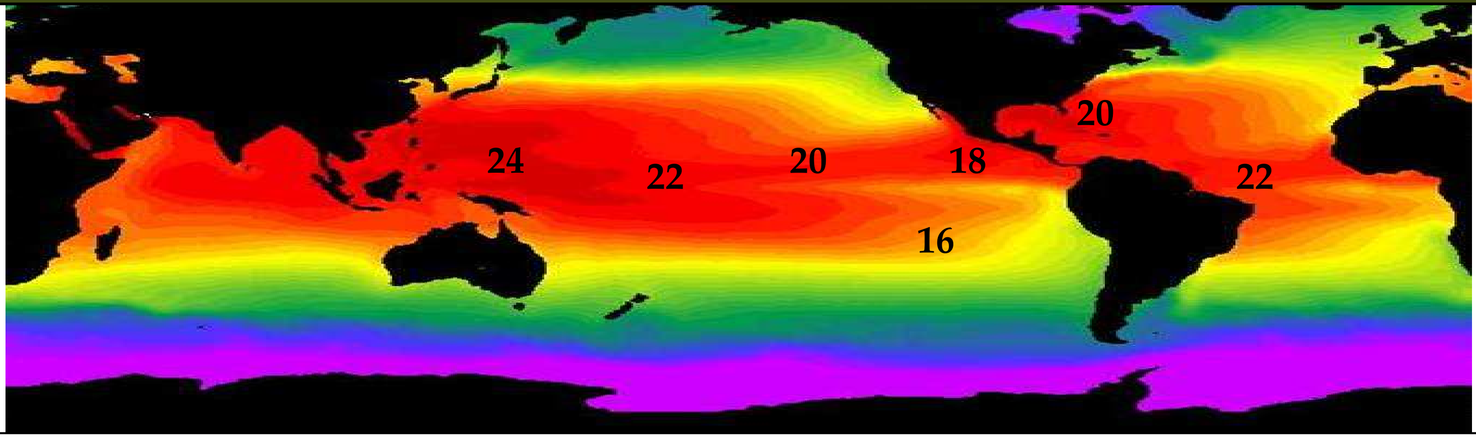
OTEC technology relies on the contrast of cold and warm water temperatures to function, and can be mounted onshore or offshore.

Ocean Thermal Energy Conversion Technologies		
Open-Cycle	**Closed-Cycle**	**Hybrid**
These systems place warm surface water in a low-pressure container, causing it to boil. The expanding steam drives a low-pressure turbine attached to an electrical generator. The steam, which has left its salt behind in the low-pressure container, is almost pure fresh water. It is condensed back into a liquid by exposure to cold temperatures from deep-ocean water.	These systems use a working fluid with a low-boiling point, such as ammonia, to rotate a turbine to generate electricity. Warm surface seawater is pumped through a heat exchanger where the working fluid is vaporized. The expanding vapor turns the turbo-generator. Cold deep-seawater—pumped through a second heat exchanger—condenses the vapor back into a liquid, which is then recycled through the system.	In a hybrid system, warm seawater enters a vacuum chamber where it is flash-evaporated into steam, similar to the open-cycle evaporation process. The steam vaporizes a low-boiling-point fluid (in a closed-cycle loop) that drives a turbine to produce electricity.

- Developers have said that, due to Florida's hurricane hazards, any OTEC development would likely take place on an offshore floating platform rather than onshore.
- These floating offshore systems will likely be closed-cycle, ranging from 20 MW to 100 MW, as close to shore as possible (~5 - 8 miles), but will be not likely be available before the year 2020.

Florida has a strong ocean thermal resource off both the Atlantic and the Gulf coasts.

World Ocean Thermal Resource (°C)



Source: Florida Atlantic University, An Overview of Ocean Energy and the COET.

FL Ocean Thermal Resource

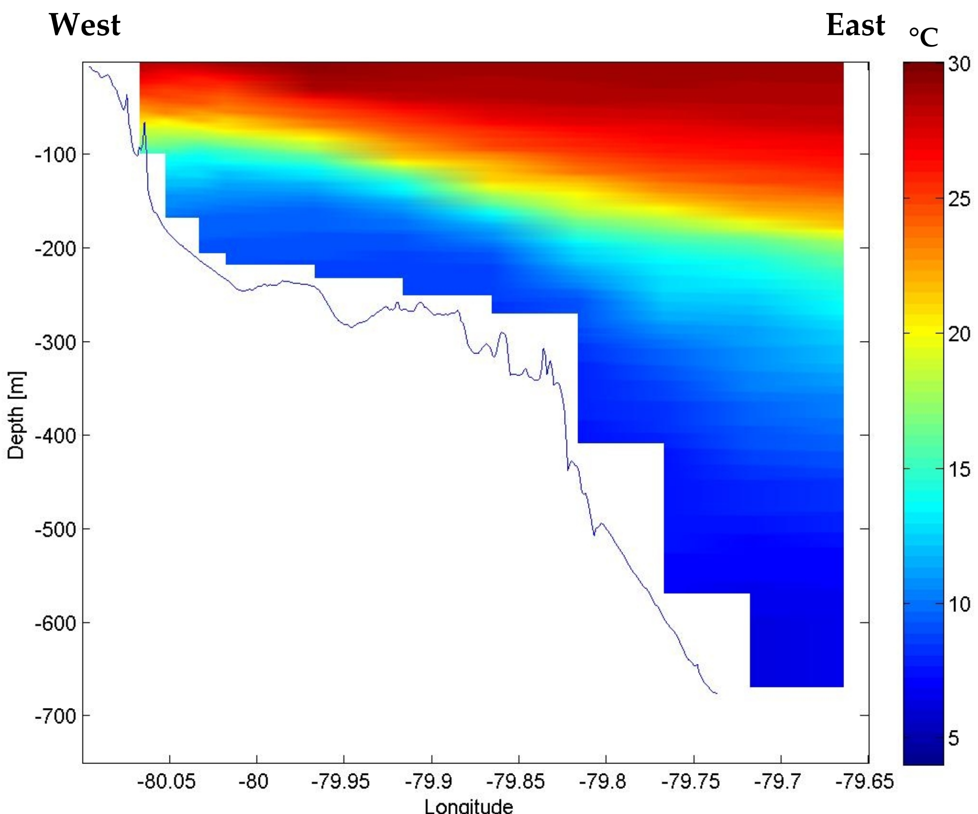
- The map above shows the temperature difference in degrees Celsius between high temperature surface water and low temperature deep water.
- A temperature difference of 20°C (36°F), is necessary for OTEC development.
- Both the Gulf and Atlantic coasts of Florida exhibit ocean temperature differences suitable for OTEC development.
- A more detailed map of Florida's resource is presented on the following slide.

Florida's ocean thermal resource is located near load centers such as Miami and Ft. Lauderdale.

FL Ocean Thermal Resource

- In the Gulf Stream, hot water is flowing northward, while cold water exists at depths shown above.
- The detail on the temperature profile off of Fort Lauderdale illustrates this resource.
- There is minimal seasonal temperature variation. During the winter, surface water temperatures may drop 2-4 degrees Fahrenheit.
- The deep coldwater resource could also provide seawater-based air conditioning for FL.

Florida's Atlantic Coast Temperature Profile[1]



Source:
1. Florida Atlantic University, Center of Excellence in Ocean Energy Technology

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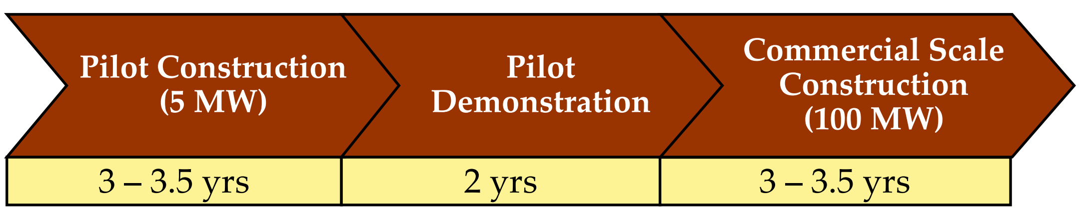
Florida's OTEC resource is strong, but based on developer interviews, it is unlikely to see any commercial plants in the state before 2020.

FL Ocean Thermal Energy Development

- **Technology readiness:** Won't see commercially-sized (100 - 200 MW) plants until ~2020. OTEC developers have said they don't expect any OTEC to happen in FL until ~2020 at the earliest or 2030 at the latest.
  - By 2013, a 20 MW working prototype could reasonably be installed, but not off of Florida. Rather, the first working prototypes will likely be installed off of islands which rely heavily on diesel as a fuel for electricity generation, and after being proven, will then be adopted elsewhere.
- **Constrained manufacturing capacity:** Shipyards that would be used to construct the floating platform for a 100 MW system are currently booked for 5 to 10 years to build oil platforms due to increased offshore exploration. Because of this, project size and economics will be limited to smaller, working prototypes until 2013 to 2018.

OTEC Construction Timeline

- Even in the fastest development scenario, if a 5 MW pilot technology were to be installed in 2011, and there were no delays in permitting or need for further refinement of the technology, (which is highly unlikely), FL still wouldn't see a commercial scale plant beginning to generate electricity until between 2019 and 2020.



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In-stream tidal may be able to gain a foothold in the market by 2010 given a supportive regulatory environment.

Technology Definition

- For the purposes of this project, tidal technologies will be defined as technologies which use the flow of water due to tidal changes to generate electricity. The tidal technologies are described in more detail in the following slides.

Technology Maturity

- Traditional tidal technology has reached commercial market entry in some areas of the world, but has not been implemented in the United States.
- In-stream tidal power is still in the design/piloting stages. Recent and current demonstration projects are testing the operational capabilities of turbine designs, as well as environmental impacts. Companies are refining their designs and preparing for large-scale deployment. One major area of uncertainty is O&M, and performance and lifetime have yet to be proven.

Market Maturity

- Due to technology risk, FERC requires that ocean power projects be developed first as pilots and operate for five years at most. FERC has issued ~30 preliminary tidal permits throughout the US (mostly in-stream) since 2005.
- Traditional tidal technology requires a difference of ~16 feet between high and low tide, limiting the worldwide and U.S. potential for development to ~40 sites.

Tidal devices are designed to use kinetic energy from the flow of water across or through the rotor to power a generator.

Tidal Current Technologies		
Traditional Tidal	**Tidal Fence**	**Tidal Turbine**
A barrage or dam is typically used to convert ocean tidal energy into electricity by forcing the water through turbines, activating a generator. Gates and turbines are installed along the dam. When the tides produce an adequate difference in the level of the water on opposite sides of the dam, the gates are opened. The water then flows through the turbines. The turbines turn an electric generator to produce electricity.	Underwater turnstiles span a channel or narrow strait. They can reach across channels between small islands or across straits between the mainland and an island. The turnstiles spin via tidal currents typical of coastal waters. Some of these currents run at 5–8 knots (5.6–9 miles per hour) and generate as much energy as winds of much higher velocity.	Turbines are arrayed underwater in rows. The turbines function best where coastal currents run at between 3.6 and 4.9 knots (4 and 5.5 mph). In currents of that speed, a 15-meter (49.2-feet) diameter tidal turbine can generate as much energy as a 60-meter (197-feet) diameter wind turbine. Ideal locations for tidal turbine farms are close to shore in water depths of 20–30 meters (65.5–98.5 feet).

Florida's tidal energy resource is not strong enough to be developed within the 2009 - 2020 timeframe.

FL Ocean Tidal Resource

- Based on information from developers who have looked into developing Tidal Current plants Florida:
  - **Traditional tidal:** Height differences between high and low tide are not great enough to support traditional tidal development.
  - **Tidal current:** Tidal current resources off the coast of Florida are not robust. Though one site in Jacksonville was preliminarily identified as a potential location for development by an ocean tidal developer, it was later rejected due to lack of a strong resource.
  - There are locations with good tidal resources between the Gulf of Mexico and the Florida Straits where the Florida Keys help channel the flow between islands. However, this area would be challenging to develop given the sensitive coral and shoreline environments.
  - Discussions with developers and technology experts confirm that the state's ocean tidal energy is not a likely developable resource within the 2020 timeframe.

This study will not cover hydroelectric dams or pumped storage.

Florida Hydro Potential

- **Hydroelectric dams**
  - Florida currently has 55.7 MW of hydroelectric capacity
  - According to Idaho National Laboratory's state-level hydropower assessment, Florida has the following potential:
    - 49.3 MW of potential capacity in developed sites without power generation[1].
    - 9.9 MW of potential capacity in greenfield sites.
  - Given the relatively small potential and the likely high hurdles a developer would face in permitting due to environmental concerns, NCI will not be analyzing hydroelectric dams as part of this study.
- **Pumped storage**
  - Pumped storage is a storage technology. Any RECs associated with pumped storage would be generated when the electricity is originally created.
  - Thus, NCI will not be analyzing pumped storage as part of this study.

Notes

1. The site has some type of developed impoundment or diversion structure, but no developed hydropower generating capability.

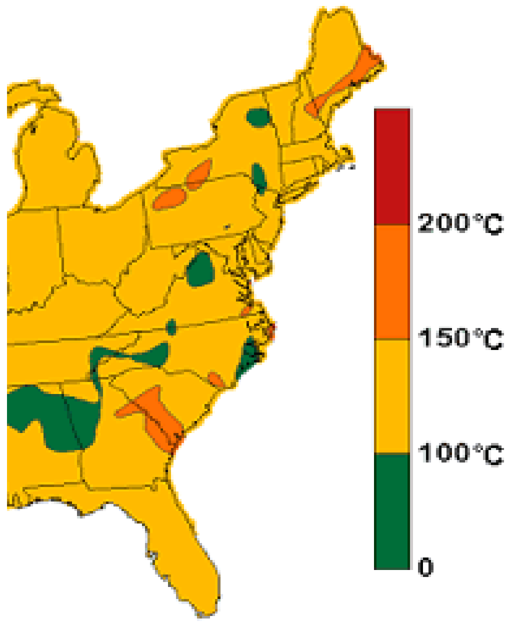
This study will not cover geothermal electric power.

Florida Geothermal Potential

- A geothermal resource of 150 °C (~300 °F) is needed for geothermal electric plants to be feasible.
- Florida does not have resources at this level. Thus, this study will not analyze geothermal resource potential.
- This study will not analyze geothermal heat pumps, as those a demand reduction technology, rather than a supply technology.

Eastern U.S. Geothermal Resource

Resource Potential at a Depth of 6 km.



Source: U.S Department of Energy's Geothermal Technologies Program.

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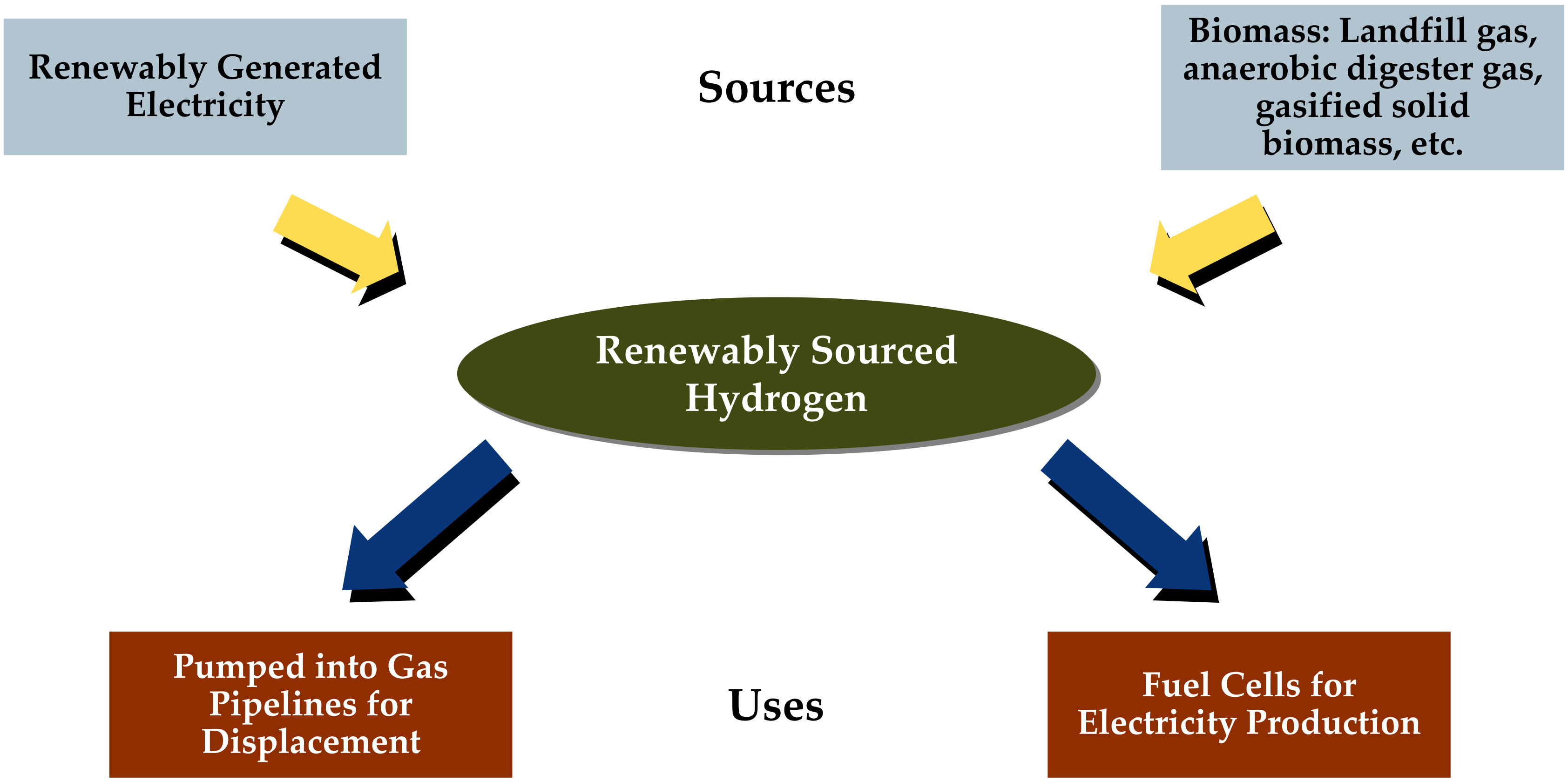
Hydrogen differs from the other RE resources in that it is a derivative resource. Only hydrogen from renewable sources was considered.



Notes: The analysis was limited to hydrogen from renewable sources based on the definition of hydrogen provided in Title XXVII, Section 366.91 of the 2008 Florida Statutes. This analysis assumes that the use of hydrogen as a transportation fuel and as a component of industrial processes (e.g., hydrogen used for desulphurization in refineries) would not qualify under the state RPS. As a result, these uses are not depicted in the diagram above.

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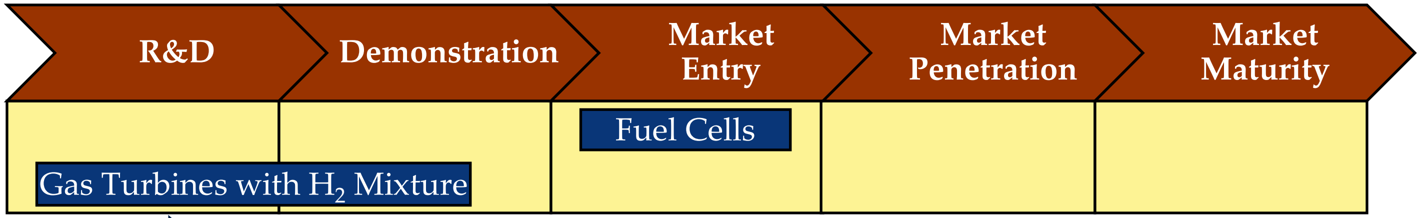
Hydrogen technologies have limited market penetration to date.



Technology Definition

- Technologies that can produce electrical, mechanical, or thermal energy from hydrogen include fuel cells and natural gas turbines, which can combust a mix including natural gas and a small portion hydrogen.

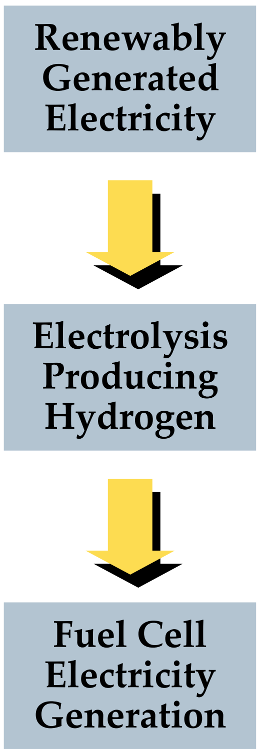
Technology Maturity

- There are four principal types of fuel cells being developed for commercial markets: proton exchange membrane (PEM), phosphoric acid (PAFC), molten carbonate (MCFC), and solid oxide (SOFC). While they have been around for some time, their primary challenges continue to be costs and efficiency losses (from a complete system perspective that considers losses from hydrogen production plus the fuel cell).
- Natural gas turbines are an established technology, but their usage to date for combustion of a mix of gas and hydrogen has been limited. R&D indicates that mixtures containing upwards of 10% hydrogen has the potential to work in some existing gas turbines, and there is experience in the combustion of syngas, which can contain 30% hydrogen, from coal/biomass gasification. The technical challenges to development include preventing hydrogen leakage (due to its small molecular size), avoiding hydrogen-induced metal embrittlement, and ensuring burner tips can handle hydrogen's combustion profile.

Market Maturity

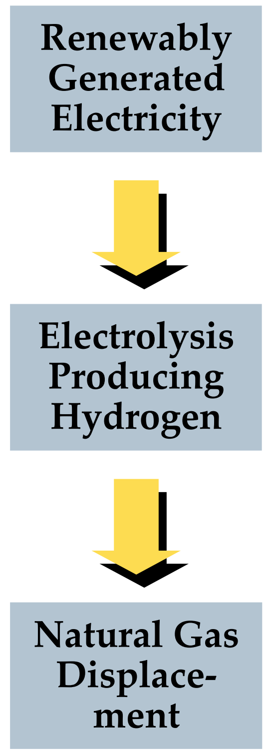
- The use of fuel cells for stationary power generation is an established technology, but widespread penetration has not happened due primarily to high system costs.
- The use of hydrogen mix in gas turbines has been discussed but remains largely unimplemented to date.

Hydrogen from renewable electricity provides other benefits, but it does not serve as an additional RE resource.



Approach for Fuel Cell Usage of H_2 from RE Electricity

- Typical commercial electrolyzers achieve 56 to 73% efficiency[1] while fuel cells range in efficiency from 40 to 60%[2,3,4,5]. The resulting combined process efficiency reaches a max of just over 40%.
- The potential for fuel cells is therefore a subset of total RE generation. Rather than serving as an additional RE resource, the primary benefit of fuel cells is that systems coupled with hydrogen storage can serve as a RE storage technology.
- Navigant Consulting will note hydrogen fuel cells as a storage technology for RE resources in the final report, particularly intermittent resources with offpeak production, rather than modeling it as an additional RE resource.



Approach for Gas Displacement with H_2 from RE Electricity

- Typical commercial electrolyzers achieve 56 to 73% efficiency[1] and hydrogen has a lower energy density when compared to natural gas (320 Btu/ft^3 vs. 1,000 Btu/ft^3)[6,7].
- The potential for hydrogen is therefore a subset of total electricity generated from RE resources. The benefit of displacing natural gas with hydrogen is as a NO_x emission reduction technique rather than as an additional RE resource.
- Navigant Consulting will note this benefit in the appendix of the final report, rather than modeling this use of hydrogen as an additional RE resource.

Sources: 1.) Kroposki, et al., "Electrolysis: Information and Opportunities for Electric Power Utilities". DOE/NREL. September 2006. 2.) *2008 Energy Technology Perspectives*, International Energy Agency, 2008. 3.) http://www.energy.ca.gov/distgen/equipment/fuel_cells/performance.html, 4.) "Gas-fired Distributed Energy Resource Technology Characterizations", DOE/NREL/GTI, October 2003. 5.) NCI Interviews with fuel cell manufacturers. 6.) Higher heating value for natural gas from http://www.nrel.gov/docs/fy01osti/27637.pdf. 7.)Higher heating value for hydrogen from Petchers, Neil, *Combined Heating, Cooling & Power Handbook: Technologies & Applications : an Integrated Approach to Energy Resource Optimization*, The Fairmont Press, Inc. 2002.

Again, hydrogen from biomass provides other benefits but are not additional RE resources.

Approach for Fuel Cell Usage of H_2 from Biomass

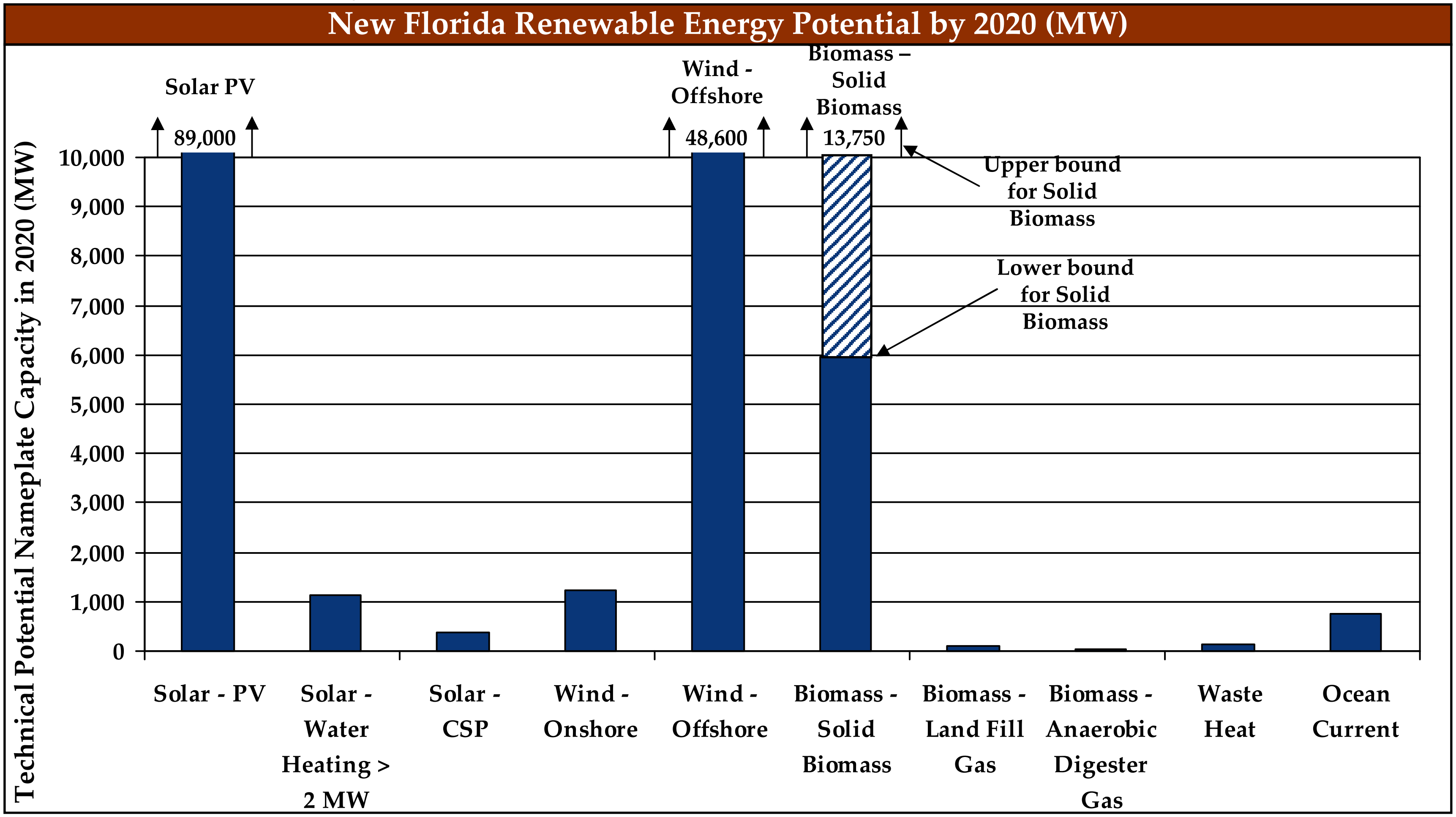
- Depending on the type of biomass, different steps are required to produce hydrogen, but they generally involve syngas production and purification followed by steam reforming. Steam reforming is 65% to 75% efficient[1] while fuel cell efficiencies range from 40 to 60%.[2,3,,4,5] Purification processes further reduce system efficiency. Driven by the complications of the process (the purification step is challenging) and costs, this will a niche application in the future.
- Another possible arrangement is direct use of syngas in high temperature fuel cells, which when used with heat capture and reuse can have high efficiencies. This technology has been in R&D for years. Since this a straight use of only biomass, this arrangement will be noted in the final report as a potential future biomass application.

Approach for Gas Displacement with H_2 from Biomass

- Depending on the type of biomass, different steps are required to produce hydrogen, but they generally involve syngas production and purification followed by steam reforming. Steam reforming is 65% to 75% efficient,[1] purification further reduces total system efficiency, and hydrogen has a lower energy density compared to both the syngas from which it is made and natural gas.
- Since the energy value of hydrogen is lower than that of syngas, the value of this process would be NO_x emission reduction technique rather than serving as an additional RE resource.
- Navigant Consulting will note this benefit in the appendix of the final report, rather than modeling this hydrogen use as an additional RE resource.

Sources: 1.) http://www.getenergysmart.org/Files/HydrogenEducation/6HydrogenProductionSteamMethaneReforming.pdf. 2.) *2008 Energy Technology Perspectives*, International Energy Agency, 2008. 3.) http://www.energy.ca.gov/distgen/equipment/fuel_cells/performance.html, 4.) "Gas-fired Distributed Energy Resource Technology Characterizations", DOE/NREL/GTI, October 2003., 5.) NCI Interviews with fuel cell manufacturers.

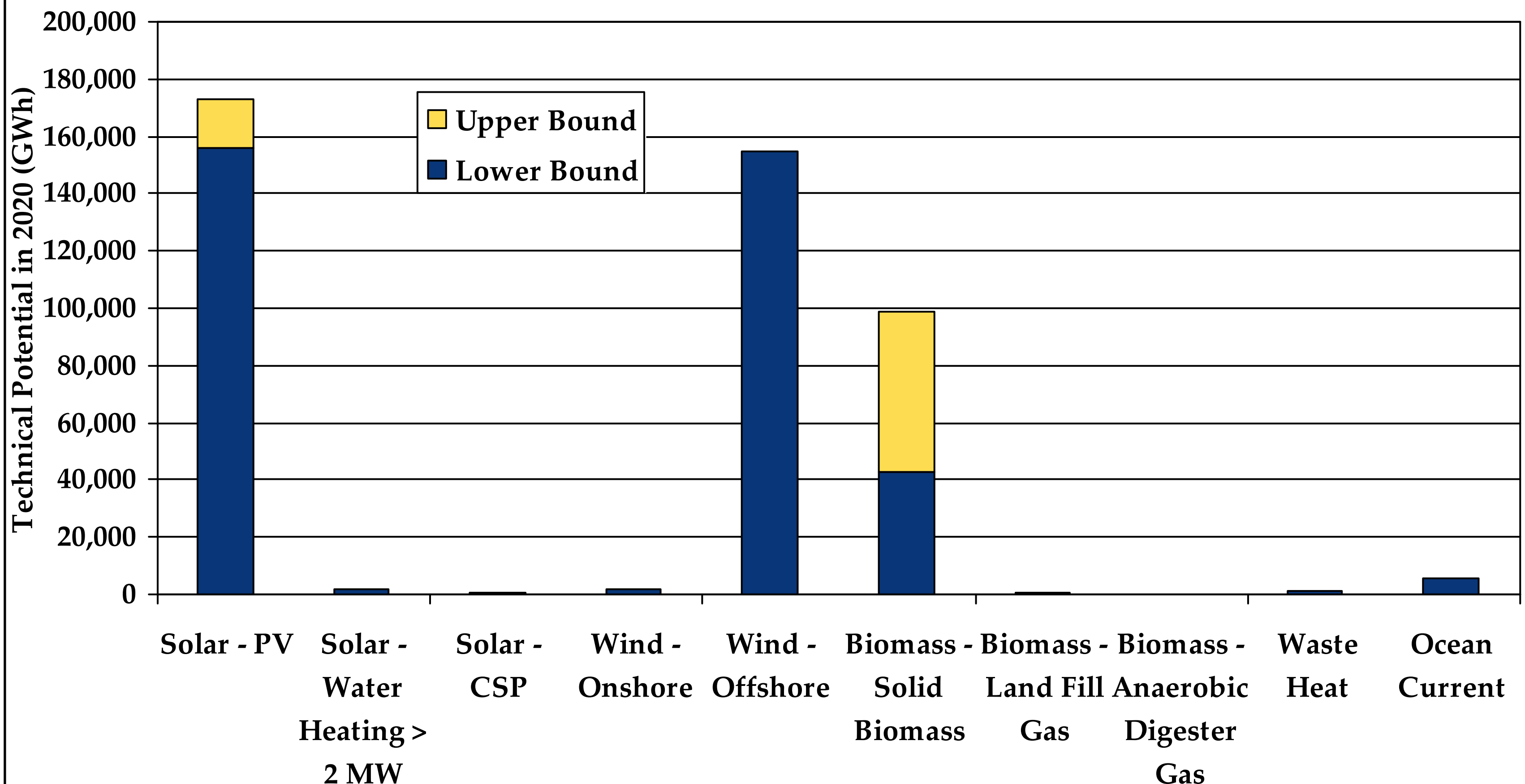
PV, solid biomass and offshore wind provide most of Florida's renewable energy technical potential.



Note: A range for biomass is presented given the efficiency range of conversion technologies. Solar Water Heating is presented in megawatts thermal. Technical potential as shown here does not account for competing land uses between technologies, but competing land uses was accounted for in Step 7.

PV, solid biomass and offshore wind provide most of Florida's renewable energy technical potential.

New Florida Renewable Energy Potential by 2020 (GWh)



Note: A range for some technologies is given either because of resource level variations across the state or variations in conversion technology. Solar water heating results in GW_{th}.

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The table below summarizes technical potential, in nameplate capacity, over time.

	Technical Potential in Nameplate Capacity [GW]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass – ADG	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Biomass - LFG	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Biomass - Solid	3.4-5.0	3.5 - 5.5	3.7 - 6.0	4.1 – 7.9	4.2 - 8.4	4.4 – 8.9	4.5 - 9.4	4.7 – 9.9	4.9 - 10.4	5.0 – 10.9	5.2 – 11.4	5.9 – 13.8
Ocean - Current	0	0	0	0	0	0	0.7	0.7	0.7	0.7	0.7	0.7
Solar - CSP	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Solar – PV	70.3	72.3	73.8	75.4	76.9	78.5	80.7	82.3	83.9	85.6	87.3	89.1
Solar – Water Heating	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Waste Heat	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Wind – Offshore	0	48.6	48.6	48.6	48.6	48.6	48.6	48.6	48.6	48.6	48.6	48.6
Wind - Onshore	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Total	76 - 78	127 - 130	129 - 131	131 - 135	133 - 137	135 - 139	137 - 143	139 - 145	141 - 147	143 - 149	145 - 151	147 - 155

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Navigant Consulting, in consultation with the FPSC and EOG, developed scenarios to project RE adoption within Florida.

Scenarios

An approach to long-term planning in situations with significant uncertainty about important future events

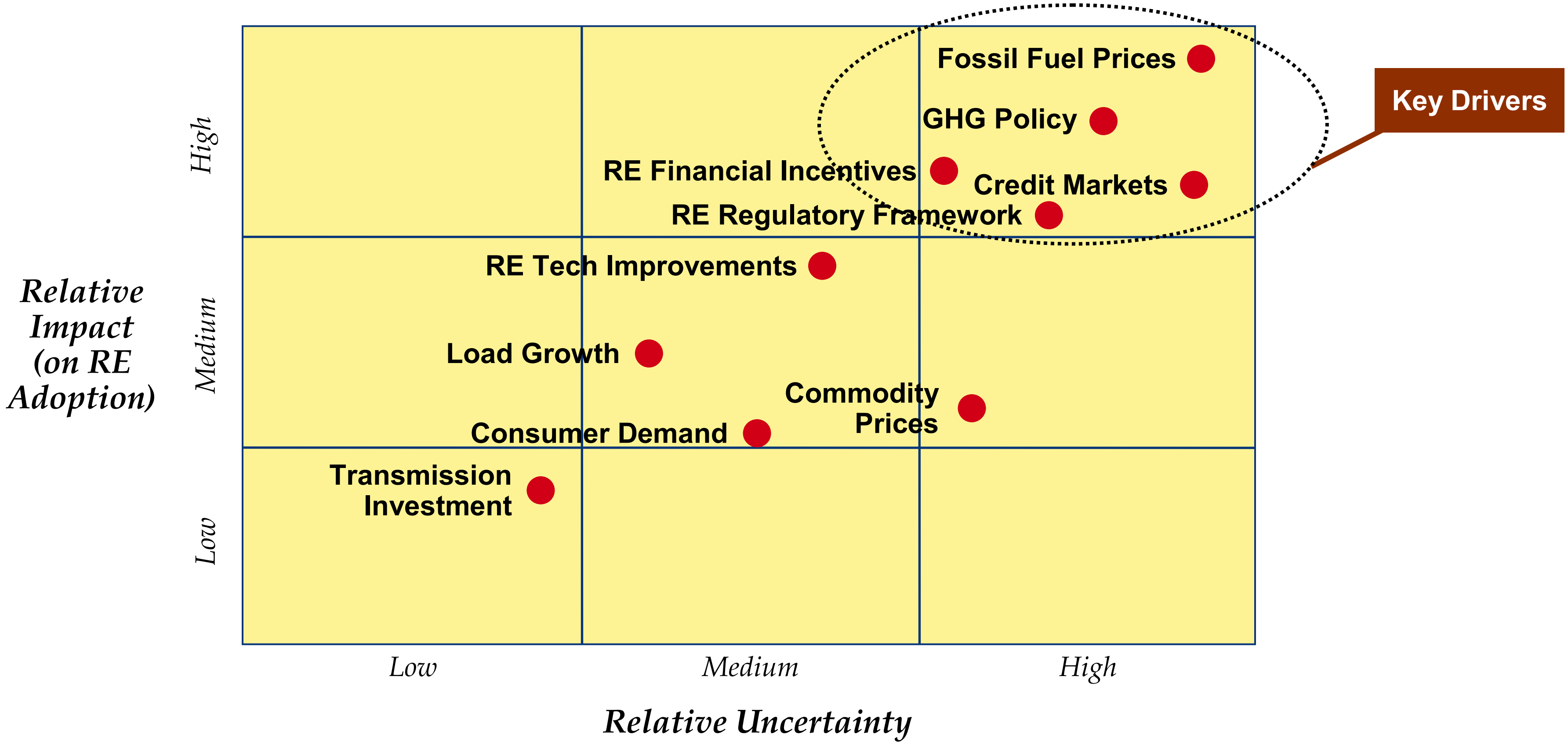
- Future scenarios developed around high impact/high uncertainty "change elements" (drivers).
  - These drivers will make the biggest difference in the amount of RE adopted in Florida, but their actual future values are the most uncertain.
  - Drivers with lower impact will not significantly influence the amount of RE adopted.
  - Drivers with lower uncertainty are easier to predict and can be taken as certain.
- Plans may be developed under alternative scenarios, then compared for similarities and differences.
- The scenarios are meant to realistically bound potential amounts of RE adoption in Florida, thus providing the FPSC, EOG, and stakeholders with guidance on potential RPS levels.
- The scenarios are not predictive.
- The scenarios can help identify key issues and explore alternatives.

Navigant Consulting identified ten key drivers that could impact Florida RE development.

Drivers	Definition and Explanation
Commodity Prices	Level of inflation in commodity prices (including steel, concrete, and oil, but not natural gas, coal or nuclear materials) will influence RE and traditional power installed costs over time.
Consumer Demand	Degree of consumer and societal demand/support for RE (e.g., through green marketing programs) and environmentally friendly energy policies can influence RE adoption.
Fossil Fuel Prices	In addition to future RE installed costs, RE technology's competitiveness with fossil fuels out into the future will drive their adoption.
GHG Policy	This driver is based on Navigant Consulting's assessment that national or regional greenhouse gas (GHG) policy is highly likely by 2020. It examines the aggressiveness of this policy, which will influence the cost of electricity generation from traditional fuels against which RE competes.
Load Growth	The rise in electricity demand, based on established rates of economic, population, and electricity consumption growth (including the impacts of efficiency and smart grid) can influence RE demand.
RE Financial Incentives	Strength of the federal and state policies providing financial incentive for RE projects will drive RE competitiveness. The focus is on select incentives: the federal production tax credit (PTC), investment tax credit (ITC), as well as the state PTC, ITC, and sales tax exemption.
RE Regulatory Framework	The scope and form of RE regulation can influence RE adoption. This driver will primarily focus on the creation of an RPS and the resulting renewable energy credit (REC) market.
RE Tech Improvements	RE technologies' installed costs change over time (driven by learning curve impacts, efficiency improvements, and technology breakthroughs), which alters their competitiveness relative to traditional generation and therefore influences adoption.
Credit Markets	The availability of and cost of debt financing will influence RE project economics.
Transmission Investment	Development, or lack, of adequate transmission capacity to allow continued growth in renewable electricity generation and delivery can impact RE adoption.

Scenarios were developed around the key drivers with the highest potential impacts 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.

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Navigant Consulting used the key drivers to create three scenarios that bound potential RE adoption.

Building the Scenarios
• Navigant Consulting created three scenarios (unfavorable, mid favorable, and favorable for RE), focusing on the five key drivers shown on the previous slide. • For each driver, Navigant Consulting chose key inputs to analyze as shown on the following slides. • Different values were selected for these inputs under each scenario.

Within each key driver, Navigant Consulting chose key inputs to analyze.

GHG Policy

- CO_2 pricing

Credit Markets

- Availability of debt
- Cost of debt
- Cost of equity

Fossil Fuel Prices

- Natural gas prices
- Coal pricing
- Note that Navigant Consulting did not look at future new residual or distillate oil fuel plants. The *2008 Regional Load and Resource Plan* does not contain new plants scheduled for construction

RE Financial Incentives

- Federal Investment Tax Credit
- Federal Production Tax Credit
- Florida State Solar Rebate
- Florida State Sales Tax Exemption
- Florida State Property Tax Exemption
- Florida State Production Tax Credit

RE Regulatory Framework

- RPS spending cap

Note: These items will then be varied to create the scenarios.

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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 $50 by 2020
Credit Markets	Cost of Debt	See Slide 20		
	Cost of Equity			
	Availability of Debt			
Fossil Fuel Costs	Natural Gas Prices ($/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

Navigant Consulting also varied key inputs not directly related to the scenarios, but 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 separate financing assumptions depending on a technology's development stage.

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

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Input	Variable	Sources/Key Assumptions
GHG Policy	CO_2 Pricing ($/ton)	Navigant Consulting assumptions based upon range of proposed legislation and selling prices in other carbon markets. The impact of carbon prices on fossil fuel generation assumes national average carbon intensity values for coal, natural gas combine cycle, and natural gas combustion turbine units. In reality, the characteristics of each plant (e.g., plant efficiency and fuel grade) will change emission levels and therefore carbon costs. The analysis assumes generators will pay for 100% of emissions, as opposed to a credit for non-emitting technologies.
Credit Markets	All Variables	Navigant Consulting assumptions based upon likely range of rates IPP's could obtain.
Fossil Fuel Costs	Natural Gas Prices ($/MMBtu)	Each IOU submitted 10 year fuel cost projections (a high, mid, and low case) as part of the state's *2008 Regional Load and Resource Plan.*
	Coal Prices ($/MMBtu)	Each IOU submitted 10 year fuel cost projections (a high, mid, and low case) as part of the state's *2008 Regional Load and Resource Plan.*
RE Financial Incentives	Federal ITC	Current legislation is set to expire 12/31/2016. Navigant Consulting looked at 2 (mid case) and 4 (attractive case) year extensions beyond that.
	Federal PTC	Current legislation is set to expire 12/31/2009. Navigant Consulting looked at 5 (mid case) and 11 (attractive case) extensions beyond that.
	State Solar Rebate Program	Navigant Consulting worked with the FPSC and Florida Governor's Energy Office to develop plausible funding scenarios.
	State Sales Tax Exemption	Interviews with the Florida Governor's Energy Office confirmed that the only technology in this study that applies to is solar, and the solar exemption does not expire.
	State Property Tax Exemption	Interviews with the Florida Governor's Energy Office confirmed that this incentive does not expire.
	State PTC	Navigant Consulting worked with the FPSC and Florida Governor's Energy Office to develop plausible funding scenarios.
RE Regulatory Framework	REC Spending Cap	The FPSC staff's draft legislation contained a 2% cap. As a sensitivity, Navigant Consulting went down to 1% and up to 5%.

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Driver	Input	Sources/Key Assumptions
Biomass Availability	Resource Potential	The resource ranges came from the *Technical Potential* portion of this study. Navigant Consulting assumes that more favorable economics will drive more planting and harvesting of biomass feedstock.
Biomass Cost	Selling Price ($/Dry ton)	Implicit in the assumption of resource availability increasing across the scenarios is that attractive economics encourage more harvesting or planting of biomass feed stocks. For harvesters or growers of feed stocks, the price they can get for their feedstock is their main driver. Thus, Navigant Consulting assumes a higher selling price as the other scenario variables become more attractive.
Municipal Solid Waste Tipping Fee	Tipping Fee ($/ton)	Inputs based upon interviews with stakeholders in Florida.
Technology Adoption Curves	Technology Saturation Times	See Step 7 of this study for a discussion of Navigant Consulting's Technology Adoption approach.

Note: The next slide delineates what incentives apply to each RE technology.

Scenario Inputs » Applicability of Incentives

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Resource and Conversion Technology	State Solar Rebate	Accelerated Depreciation	State Production Tax Credit	Federal PTC	Federal ITC	State Sales Tax Exemption	State Property Tax Exemption
Solar – PV – Ground Mounted		X			X	X	X
Solar – PV – Ground Mounted	X	X			X	X	X
Solar – PV – Ground Mounted	X	X			X	X	X
Solar – Water Heating > 2 MW_{th}	X	X			X	X	X
Solar – CSP		X			X	X	X
Wind – Onshore		X	X	X			
Wind – Offshore		X	X	X			
Biomass – Solid Biomass – Direct Combustion		X	X	X			
Biomass – Solid Biomass – Co-Firing		X					
Biomass – Solid Biomass – Repowering		X					
Biomass – Solid Biomass – Waste to Energy		X	X	X			
Biomass – Solid Biomass – BIGCC		X	X	X			
Biomass – Land Fill Gas		X	X	X			
Biomass – Anaerobic Digester Gas – Farm Waste		X					
Biomass – Anaerobic Digester Gas – WWTP		X					
Waste Heat		X					
Ocean Current		X	X	X			

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

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.
- This first part of this section discusses and presents:
  - How Navigant Consulting's LCOE model works.
  - How Navigant Consulting developed inputs for traditional technology's LCOE analysis.
  - What traditional technology each RE technology was compared against.
  - Results from the LCOE analysis in each scenario.

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.
- The second part of this section discusses the model;s architecture, data sources and the payback acceptance curve used, along with Navigant Consulting's definition of simple payback for PV.

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Navigant Consulting assessed the impacts of RECs, per the FPSC staff's draft RPS legislation

RECs
• The FPSC staff's draft RPS legislation, dated 10/2/2008, proposed two REC markets. — Class I RECs, for wind and solar technologies — Class II RECs for all other technologies defined as renewable energy by the draft legislation. • The draft RPS legislation also specified what portion of REC expenditures should go towards each Class (within the REC spending cap) — 75% of REC expenditures towards Class I RECs — 25% of REC expenditures towards Class II RECs • Navigant Consulting accounted for this structure in its analysis and also ran the analysis without RECs, to assess the impact of an RPS program on RE adoption in Florida.

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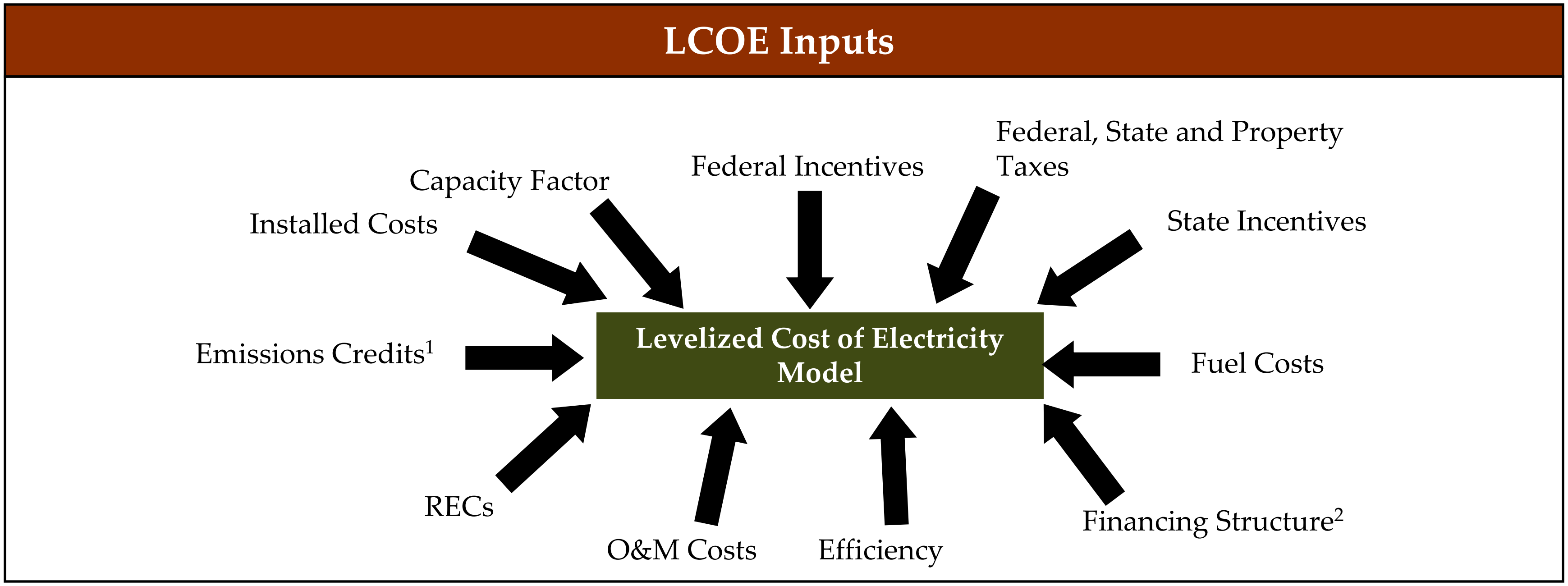
The LCOE model takes into account the following variables and their changes over time.



Navigant Consulting's LCOE model calculates a power plant's revenue required to meet equity and debt requirements and takes into account all of the variables shown above.

Note:

1. Navigant Consulting accounted for NOx and SOx charges that emitters will have to pay, along with the aforementioned carbon charges. See the appendix for NOx and SOx prices assumed.

2. For RE, Navigant Consulting is assuming most RE facilities in Florida will be owned by Independent Power Producers (IPP) and subsequently assumed IPP financing structures for RE technologies.

Navigant Consulting factored in insurance, property tax, tax rates, and land lease costs.

Item	Value Used	Notes/Source
Federal Tax Rate	35%	Internal Revenue Service
State Tax Rate	5.5%	Florida Department of Revenue
Insurance Cost	0.8%/Yr of system book value for traditional technologies, 1%/Yr of system book value for RE technologies assuming RE technologies carry an extra risk premium because of their limited deployment in Florida's hurricane environment.	Stakeholder input and interviews
Land Lease Costs	3% of revenue per year for onshore wind and PV	Assumes the land is leased and the system owner pays a fee to the land owner. Source is Navigant Consulting, November 2008
Property Tax	1.5%/Year	The value varies significantly by county, this represents an average

Navigant Consulting calculated LCOEs of traditional technologies to assess the competitiveness of RE technologies.

Traditional Technology LCOEs

- Navigant Consulting calculated the LCOE of the following traditional technologies. Refer to the appendix for the Economic and Performance assumptions used for each technology.
  - Natural Gas Combined Cycle Plants
  - Natural Gas Combustion Turbine Plants
  - New Nuclear Plants
  - Coal Fired Steam Cycle Plants
- For these traditional power plants, Navigant Consulting assumed IOU ownership with the following financing:
  - 55% debt/45% equity
  - 6.2% cost of debt. This was an average calculated based on IOU's SEC 10-K filings.
  - 11.75% cost of equity. This was assumed to be equal to IOU's authorized return on equity, provided by the FPSC.
- For customer sited systems, Navigant Consulting used the following competitors:
  - Retail Electricity Rates for competition with Farm Waste and Waste Water Treatment Plant Anaerobic Digester Systems.
    - A weighted average commercial electricity rate for the state was created using each IOU's existing rate structure and weighted by what % of FL's generation the IOU provides, relative to the other IOU's.
  - An 80% efficient 2 MWth natural gas fired water heater supplied with natural gas at commercial retail rates for competition with Solar Water Heating systems
    - Navigant Consulting used average retail natural gas rates across the state (currently at ~ $1/therm).

Navigant Consulting selected a traditional technology for comparison to each RE technology, depending on its output characteristics.

Resource and Conversion Technology	Competition	Type of Generation	Output
Solar – PV – Ground Mounted	Natural Gas Combustion Turbine	Peaking	Non-Firm
Solar – Water Heating > 2 MW_{th}	Natural Gas Fired Water Heater	Peaking	Non-Firm
Solar – CSP	Natural Gas Combustion Turbine	Peaking	Non-Firm
Wind – Onshore	Natural Gas Combined Cycle	Intermediate	Non-Firm
Wind – Offshore	Natural Gas Combined Cycle	Intermediate	Non-Firm
Biomass – Solid Biomass – Direct Combustion	Natural Gas Combined Cycle	Baseload	Firm
Biomass – Solid Biomass – Co-Firing	Coal Plant	Baseload	Firm
Biomass – Solid Biomass – Repowering	Coal Plant	Baseload	Firm
Biomass – Solid Biomass – Waste to Energy	Natural Gas Combined Cycle	Baseload	Firm
Biomass – Solid Biomass – BIGCC	Natural Gas Combined Cycle	Baseload	Firm
Biomass – Land Fill Gas	Natural Gas Combined Cycle	Baseload	Firm
Biomass – Anaerobic Digester Gas – Farm Waste	Retail Electricity	Baseload	Firm
Biomass – Anaerobic Digester Gas – WWTP	Retail Electricity	Baseload	Firm
Waste Heat	Natural Gas Combined Cycle	Baseload	Firm
Ocean Current	Natural Gas Combined Cycle	Intermediate	Non-Firm

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	RE LCOE Results[1] (including emissions credits and all incentive) – Unfavorable for RE [¢/kWh]											
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Biomass – ADG – Farm Waste	16.73	16.91	16.96	17.01	17.05	17.10	17.14	17.09	17.04	16.99	16.94	16.88
Biomass – ADG - WWTP	6.75	6.81	6.83	6.85	6.87	6.89	6.91	6.89	6.86	6.84	6.82	6.79
Biomass - LFG	3.95	5.07	5.09	5.10	5.11	5.13	5.14	5.15	5.17	5.18	5.20	5.21
Biomass – Solid Biomass - BIGCC	16.13	15.68	14.75	13.87	13.02	12.22	11.46	11.34	11.22	11.10	10.99	10.86
Biomass – Solid Biomass – Co-Firing	0.72	0.61	0.74	0.64	0.54	0.42	0.11	0.01	-0.11	-0.19	-0.28	-0.36
Biomass – Solid Biomass – Direct Combustion	10.08	11.55	11.57	11.59	11.61	11.63	11.65	11.67	11.68	11.70	11.72	11.74
Biomass – Solid Biomass - Repowering	7.40	7.37	7.40	7.43	7.46	7.49	7.52	7.54	7.57	7.59	7.61	7.63
Biomass – Solid Biomass – Waste to Energy	15.34	16.48	16.68	16.89	17.09	17.29	17.49	17.71	17.92	18.14	18.36	18.90
Ocean - Current	N/A	N/A	N/A	N/A	N/A	N/A	19.11	18.12	17.12	16.12	15.13	14.13
Solar - CSP	28.01	27.88	27.87	27.85	27.83	27.82	27.80	27.50	34.90	34.52	34.14	33.75
Solar – Ground Mounted PV	33.41	29.13	28.11	27.10	26.09	25.08	24.06	23.09	28.84	27.62	26.42	25.24
Solar – Water Heating	9.20	8.16	8.25	8.33	8.42	8.51	8.59	8.47	10.94	10.78	10.62	10.47
Waste Heat	6.41	6.50	6.60	6.70	6.80	6.90	7.00	7.10	7.21	7.32	7.42	7.53
Wind – Offshore - Class 4	N/A	25.11	24.44	23.79	23.14	22.51	21.88	21.45	21.03	20.61	20.21	19.80
Wind – Offshore - Class 5	N/A	22.53	21.91	21.30	20.69	20.11	19.52	19.16	18.80	18.45	18.10	17.76
Wind - Onshore	18.85	20.25	20.39	20.28	20.16	20.05	19.94	19.85	19.77	19.68	19.60	19.51

Note: 1. A negative LCOE demonstrates a VERY favorable LCOE relative to traditional technologies.

	RE LCOE Results[1] (including REC revenue, emissions credits and all incentive) – Unfavorable for RE [¢/kWh]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass – ADG – Farm Waste	16.33	16.51	16.56	16.61	16.65	16.70	16.74	16.69	16.64	16.59	16.54	16.48
Biomass – ADG - WWTP	6.35	6.41	6.43	6.45	6.47	6.49	6.51	6.49	6.46	6.44	6.42	6.39
Biomass - LFG	3.55	4.67	4.69	4.70	4.71	4.73	4.74	4.75	4.77	4.78	4.80	4.81
Biomass – Solid Biomass - BIGCC	15.73	15.28	14.35	13.47	12.62	11.82	11.06	10.94	10.82	10.70	10.59	10.46
Biomass – Solid Biomass – Co-Firing	0.32	0.21	0.34	0.24	0.14	0.02	-0.29	-0.39	-0.51	-0.59	-0.68	-0.76
Biomass – Solid Biomass – Direct Combustion	9.68	11.15	11.17	11.19	11.21	11.23	11.25	11.27	11.28	11.30	11.32	11.34
Biomass – Solid Biomass - Repowering	7.00	6.97	7.00	7.03	7.06	7.09	7.12	7.14	7.17	7.19	7.21	7.23
Biomass – Solid Biomass – Waste to Energy	14.94	16.08	16.28	16.49	16.69	16.89	17.09	17.31	17.52	17.74	17.96	18.18
Ocean - Current	N/A	N/A	N/A	N/A	N/A	N/A	18.71	17.72	16.72	15.72	14.73	13.73
Solar - CSP	13.32	15.43	16.66	17.48	18.70	20.02	21.41	24.59	31.92	31.37	30.98	30.52
Solar – Ground Mounted PV	15.17	13.66	14.20	14.21	14.75	15.39	16.13	19.49	25.13	23.71	22.51	21.22
Solar – Water Heating	-6.63	-5.26	-3.83	-2.84	-1.42	0.10	1.71	2.61	4.18	4.11	4.05	3.98
Waste Heat	6.05	6.14	6.24	6.34	6.44	6.54	6.63	6.74	6.85	6.95	7.06	7.17
Wind – Offshore - Class 4	N/A	10.11	10.94	11.29	12.14	13.11	14.18	17.95	17.43	16.81	16.41	15.90
Wind – Offshore - Class 5	N/A	7.53	8.41	8.80	9.69	10.71	11.82	15.66	15.20	14.65	14.30	13.86
Wind - Onshore	0.60	4.79	6.47	7.39	8.82	10.36	12.00	16.25	16.06	15.77	15.68	15.49

Note: 1. The above data includes REC revenues. Navigant Consulting made the simplifying assumption of a uniform REC price across all technologies. This might result in a negative LCOE in some cases if the assumed REC amount exceeds a technology's LCOE. A negative LCOE demonstrates a VERY favorable LCOE relative to traditional technologies.

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	RE LCOE Results[1] (including emissions credits and all incentive) – Mid Favorable for RE [¢/kWh]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass – ADG – Farm Waste	16.62	16.80	16.85	16.90	16.94	16.99	17.03	16.98	16.93	16.88	16.82	16.77
Biomass – ADG - WWTP	6.46	6.51	6.53	6.55	6.56	6.58	6.60	6.58	6.55	6.53	6.51	6.48
Biomass - LFG	3.73	3.78	3.80	3.81	3.82	3.83	3.84	4.92	4.93	4.94	4.95	4.96
Biomass – Solid Biomass - BIGCC	15.95	14.11	13.22	12.37	11.56	10.79	10.06	11.38	11.26	11.14	11.03	10.90
Biomass – Solid Biomass – Co-Firing	3.31	3.07	2.82	2.58	2.36	2.12	1.90	1.68	1.46	1.25	1.03	0.82
Biomass – Solid Biomass – Direct Combustion	10.45	10.47	10.48	10.49	10.50	10.52	10.53	11.96	11.97	11.98	11.99	12.00
Biomass – Solid Biomass - Repowering	8.04	8.01	8.04	8.07	8.09	8.12	8.15	8.17	8.19	8.20	8.22	8.24
Biomass – Solid Biomass – Waste to Energy	12.58	12.76	12.95	13.13	13.32	13.51	13.70	14.85	15.05	15.26	15.46	15.66
Ocean - Current	N/A	N/A	N/A	N/A	N/A	N/A	17.42	17.59	16.63	15.66	14.69	13.72
Solar - CSP	26.29	26.17	26.15	26.13	26.12	26.10	26.08	25.80	25.52	25.23	32.58	32.21
Solar – Ground Mounted PV	30.63	26.70	25.77	24.84	23.90	22.97	22.04	21.15	20.27	19.41	24.69	23.59
Solar – Water Heating	8.41	7.46	7.54	7.62	7.70	7.78	7.85	7.74	7.63	7.51	9.91	9.76
Waste Heat	6.05	6.14	6.23	6.32	6.41	6.51	6.60	6.70	6.80	6.90	7.00	7.10
Wind – Offshore - Class 4	N/A	21.91	21.28	20.66	20.05	19.44	18.85	20.46	20.06	19.66	19.27	18.89
Wind – Offshore - Class 5	N/A	19.47	18.88	18.30	17.73	17.17	16.61	18.29	17.95	17.61	17.28	16.95
Wind - Onshore	17.55	17.03	16.93	16.82	16.72	16.61	16.51	18.63	18.55	18.47	18.39	18.30

Note: 1. A negative LCOE demonstrates a VERY favorable LCOE relative to traditional technologies.

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	RE LCOE Results[1] (including REC revenue, emissions credits and all incentive) – Mid Favorable for RE [¢/kWh]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass – ADG – Farm Waste	15.92	16.10	16.15	16.20	16.24	16.29	16.43	16.38	16.33	16.28	16.22	16.17
Biomass – ADG - WWTP	5.76	5.81	5.83	5.85	5.86	5.88	6.00	5.98	5.95	5.93	5.91	5.88
Biomass - LFG	3.03	3.08	3.10	3.11	3.12	3.13	3.24	4.32	4.33	4.34	4.35	4.36
Biomass – Solid Biomass - BIGCC	15.25	13.41	12.52	11.67	10.86	10.09	9.46	10.78	10.66	10.54	10.43	10.30
Biomass – Solid Biomass – Co-Firing	2.61	2.37	2.12	1.88	1.66	1.42	1.30	1.08	0.86	0.65	0.43	0.22
Biomass – Solid Biomass – Direct Combustion	9.75	9.77	9.78	9.79	9.80	9.82	9.93	11.36	11.37	11.38	11.39	11.40
Biomass – Solid Biomass - Repowering	7.34	7.31	7.34	7.37	7.39	7.42	7.55	7.57	7.59	7.60	7.62	7.64
Biomass – Solid Biomass – Waste to Energy	11.88	12.06	12.25	12.43	12.62	12.81	13.10	14.25	14.45	14.66	14.86	15.06
Ocean - Current	N/A	N/A	N/A	N/A	N/A	N/A	16.82	16.99	16.03	15.06	14.09	13.12
Solar - CSP	13.80	14.51	16.57	18.64	19.45	20.69	21.59	22.05	22.60	22.73	30.50	30.38
Solar – Ground Mounted PV	15.17	12.27	13.91	15.56	15.66	16.27	16.47	16.51	16.67	16.32	22.12	21.32
Solar – Water Heating	-5.00	-5.05	-2.74	-0.42	0.55	1.97	3.03	3.72	4.50	4.83	7.67	7.79
Waste Heat	5.42	5.51	5.60	5.69	5.78	5.88	6.06	6.16	6.26	6.36	6.46	6.56
Wind – Offshore - Class 4	N/A	7.91	9.78	11.66	12.05	12.94	13.45	15.96	16.56	16.66	16.77	16.69
Wind – Offshore - Class 5	N/A	5.47	7.38	9.30	9.73	10.67	11.21	13.79	14.45	14.61	14.78	14.75
Wind - Onshore	2.09	2.60	5.07	7.54	8.47	9.91	10.94	13.99	14.94	15.37	15.81	16.04

Note: 1. The above data includes REC revenues. Navigant Consulting made the simplifying assumption of a uniform REC price across all technologies. This might result in a negative LCOE in some cases if the assumed REC amount exceeds a technology's LCOE. A negative LCOE demonstrates a VERY favorable LCOE relative to traditional technologies.

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	RE LCOE Results[1] (including emissions credits and all incentive) – Favorable for RE [¢/kWh]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass – ADG – Farm Waste	16.63	16.80	16.85	16.90	16.94	16.99	17.03	16.98	16.93	16.88	16.83	16.77
Biomass – ADG - WWTP	6.19	6.24	6.26	6.27	6.29	6.30	6.32	6.29	6.27	6.25	6.22	6.20
Biomass - LFG	3.55	3.60	3.61	3.62	3.63	3.63	3.64	3.65	3.66	3.67	3.68	3.69
Biomass – Solid Biomass - BIGCC	15.82	14.03	13.18	12.37	11.59	10.85	10.15	10.03	9.91	9.78	9.66	9.54
Biomass – Solid Biomass – Co-Firing	0.61	-0.02	-0.15	-0.60	-1.04	-1.50	-2.25	-2.70	-3.17	-3.62	-4.08	-4.53
Biomass – Solid Biomass – Direct Combustion	10.86	10.88	10.88	10.88	10.89	10.89	10.89	10.89	10.89	10.89	10.89	10.89
Biomass – Solid Biomass - Repowering	8.69	8.66	8.68	8.71	8.73	8.76	8.78	8.80	8.82	8.83	8.85	8.86
Biomass – Solid Biomass – Waste to Energy	9.89	10.06	10.23	10.41	10.58	10.75	10.93	11.12	11.31	11.50	11.69	11.88
Ocean - Current	N/A	N/A	N/A	N/A	N/A	N/A	17.07	16.12	15.17	14.22	13.27	12.32
Solar - CSP	24.60	24.47	24.46	24.44	24.42	24.41	24.39	24.13	23.86	23.60	23.33	23.06
Solar – Ground Mounted PV	28.32	24.68	23.82	22.95	22.09	21.22	20.36	19.53	18.72	17.93	17.14	16.37
Solar – Water Heating	7.71	6.85	6.92	6.99	7.06	7.13	7.20	7.09	6.99	6.88	6.78	6.67
Waste Heat	5.64	5.72	5.81	5.89	5.98	6.06	6.15	6.24	6.34	6.43	6.52	6.61
Wind – Offshore - Class 4	N/A	20.89	20.28	19.69	19.11	18.53	17.97	17.57	17.19	16.81	16.43	16.06
Wind – Offshore - Class 5	N/A	18.56	18.00	17.45	16.90	16.37	15.84	15.51	15.18	14.86	14.54	14.23
Wind - Onshore	16.38	15.89	15.80	15.70	15.60	15.50	15.40	15.32	15.25	15.17	15.09	15.01

Note: 1. A negative LCOE demonstrates a VERY favorable LCOE relative to traditional technologies.

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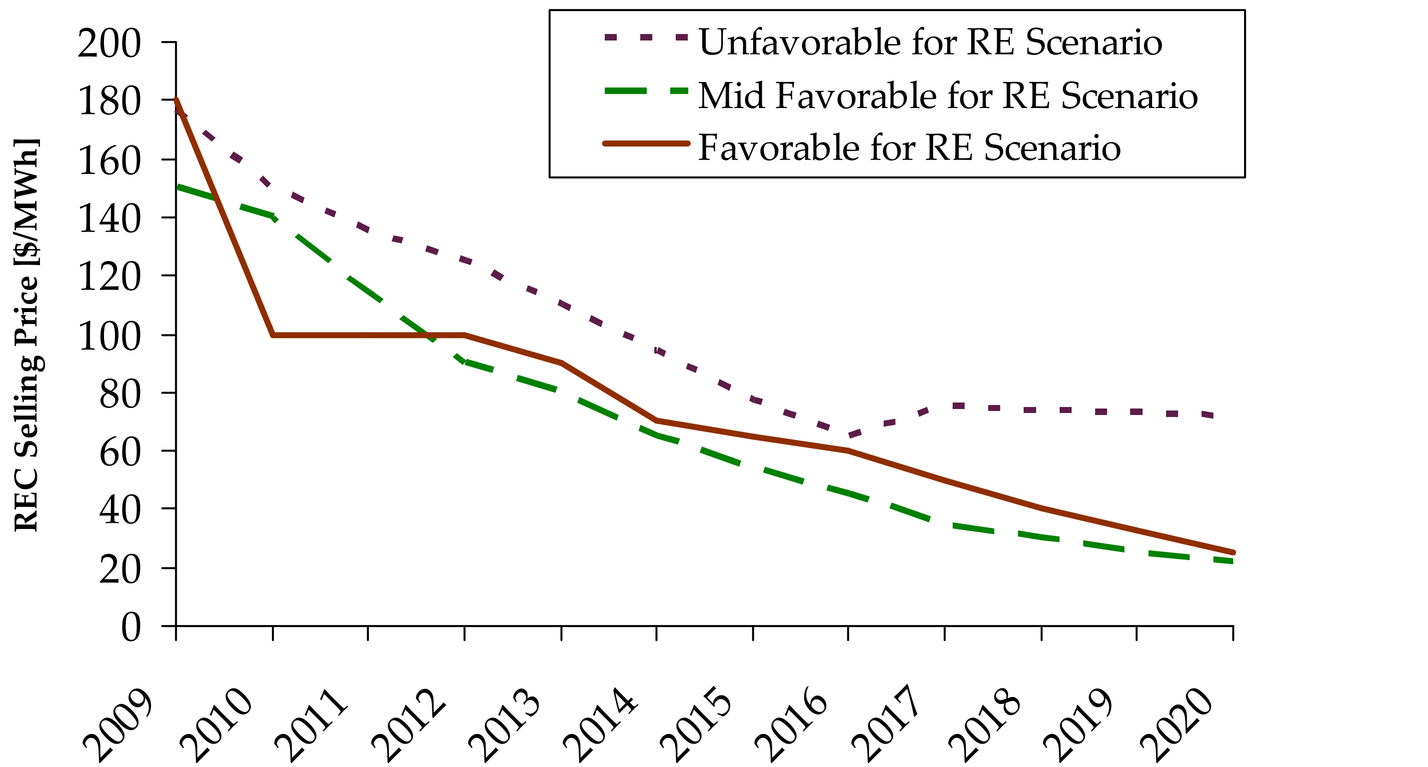
	RE LCOE Results[1] (including REC revenue, emissions credits and all incentive) – Favorable for RE [¢/kWh]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass – ADG – Farm Waste	14.83	15.00	15.05	15.20	15.34	15.49	15.73	15.68	15.73	15.78	15.73	15.77
Biomass – ADG - WWTP	4.39	4.44	4.46	4.57	4.69	4.80	5.02	4.99	5.07	5.15	5.12	5.20
Biomass - LFG	1.75	1.80	1.81	1.92	2.03	2.13	2.34	2.35	2.46	2.57	2.58	2.69
Biomass – Solid Biomass - BIGCC	14.02	12.23	11.38	10.67	9.99	9.35	8.85	8.73	8.71	8.68	8.56	8.54
Biomass – Solid Biomass – Co-Firing	-1.19	-1.82	-1.95	-2.30	-2.64	-3.00	-3.55	-4.00	-4.37	-4.72	-5.18	-5.53
Biomass – Solid Biomass – Direct Combustion	9.06	9.08	9.08	9.18	9.29	9.39	9.59	9.59	9.69	9.79	9.79	9.89
Biomass – Solid Biomass - Repowering	6.89	6.86	6.88	7.01	7.13	7.26	7.48	7.50	7.62	7.73	7.75	7.86
Biomass – Solid Biomass – Waste to Energy	8.09	8.26	8.43	8.71	8.98	9.25	9.63	9.82	10.11	10.40	10.59	10.98
Ocean - Current	N/A	N/A	N/A	N/A	N/A	N/A	15.77	14.82	13.97	13.12	12.17	11.32
Solar - CSP	9.77	16.24	16.22	16.21	17.01	18.64	19.04	19.19	19.74	20.30	20.61	21.01
Solar – Ground Mounted PV	9.76	14.37	13.51	12.64	12.81	14.01	13.66	13.35	13.57	13.80	13.74	13.79
Solar – Water Heating	-8.24	-2.02	-1.94	-1.87	-0.92	0.92	1.44	1.77	2.56	3.34	3.85	4.45
Waste Heat	4.03	4.11	4.20	4.37	4.55	4.72	4.99	5.08	5.26	5.45	5.54	5.72
Wind – Offshore - Class 4	N/A	10.89	10.28	9.69	10.11	11.53	11.47	11.57	12.19	12.81	13.13	13.56
Wind – Offshore - Class 5	N/A	8.56	8.00	7.45	7.90	9.37	9.34	9.51	10.18	10.86	11.24	11.73
Wind - Onshore	-2.17	5.58	5.49	5.39	6.32	8.28	8.70	9.14	10.09	11.05	11.69	12.44

Note: 1. The above data includes REC revenues. Navigant Consulting made the simplifying assumption of a uniform REC price across all technologies. This might result in a negative LCOE in some cases if the assumed REC amount exceeds a technology's LCOE. A negative LCOE demonstrates a VERY favorable LCOE relative to traditional technologies.

Included in the preceding LCOEs were the REC price assumptions below.

Class I REC Selling Price, By Year [$/MWh]

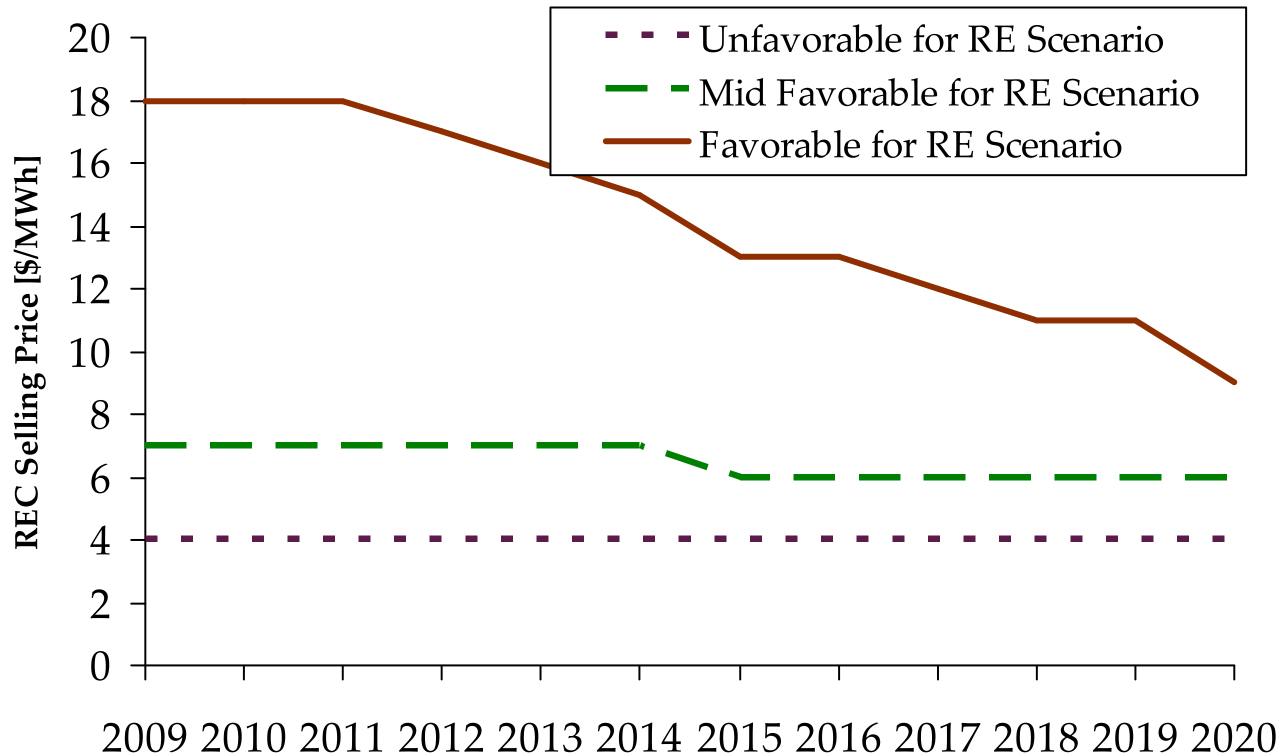


Source: Navigant Consulting November, 2008

In each year of analysis and each scenario, Navigant Consulting iteratively solved for a REC price that maximized generation (i.e. created enough of an incentive to install RE), but did not exceed the scenario's REC expenditure cap.

Included in the preceding LCOEs were the REC price assumptions below.

Class II REC Selling Price, By Year [$/MWh]



Source: Navigant Consulting November, 2008

In each year of analysis and each scenario, Navigant Consulting iteratively solved for a REC price that maximized generation (i.e. created enough of an incentive to install RE), but did not exceed the scenario's REC expenditure cap.

	Traditional Energy LCOE Results – Unfavorable for RE Scenario [¢/kWh]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Coal	7.44	7.79	7.89	8.18	8.45	8.74	9.17	9.37	9.59	9.77	9.97	10.15
Gas Fired Water Heater[1]	4.23	4.18	4.14	4.10	4.06	4.02	3.98	3.94	3.90	3.86	3.81	3.77
Natural Gas Combined Cycle	6.47	6.37	6.11	5.97	6.13	6.36	6.63	6.80	6.97	7.02	7.07	7.12
Natural Gas Combustion Turbine	13.98	14.16	14.09	14.18	14.69	15.28	15.94	16.35	16.77	17.02	17.27	17.52
Nuclear	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12.77	12.78	12.84	12.90	12.97
Retail Electricity[1]	8.50	8.42	8.34	8.26	8.17	8.09	8.01	7.93	7.84	7.76	7.68	7.60

	Traditional Energy LCOE Results – Mid Favorable for RE Scenario [¢/kWh]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Coal	7.94	8.60	8.84	9.28	9.72	10.17	10.77	11.14	11.52	11.88	12.26	12.62
Gas Fired Water Heater[1]	4.39	4.51	4.63	4.76	4.88	5.00	5.12	5.25	5.37	5.49	5.61	5.74
Natural Gas Combined Cycle	8.64	8.50	8.27	8.12	8.38	8.72	9.13	9.42	9.71	9.84	9.96	10.09
Natural Gas Combustion Turbine	17.07	17.29	17.37	17.56	18.30	19.15	20.10	20.77	21.45	21.89	22.34	22.78
Nuclear	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12.77	12.78	12.84	12.90	12.97
Retail Electricity[1]	8.83	9.08	9.33	9.57	9.82	10.07	10.31	10.56	10.81	11.05	11.30	11.55

	Traditional Energy LCOE Results – Favorable for RE Scenario [¢/kWh]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Coal	8.60	9.41	9.76	10.36	10.95	11.55	12.37	12.90	13.44	13.96	14.49	15.02
Gas Fired Water Heater[1]	4.60	4.93	5.26	5.59	5.92	6.25	6.58	6.91	7.25	7.58	7.91	8.24
Natural Gas Combined Cycle	11.24	11.28	10.79	10.58	10.97	11.49	12.11	12.54	12.98	13.19	13.41	13.62
Natural Gas Combustion Turbine	20.73	21.29	21.13	21.36	22.37	23.58	24.92	25.87	26.84	27.49	28.14	28.80
Nuclear	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12.77	12.78	12.84	12.90	12.97
Retail Electricity[1]	9.25	9.92	10.59	11.25	11.92	12.59	13.25	13.92	14.59	15.25	15.92	16.58

Notes: 1.) The values for Gas Fired Water Heater and Retail Electricity are rates rather than LCOEs.

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Our team used a simple payback equation that accounts for upfront and annual cash flows.

Simple Payback Period Calculation

Residential

One-time costs

Simple Payback = [Installed Cost – Federal Incentives – Capacity Based Incentives + tax rate*rebate amount]
[Annual Electric Bill Savings + Performance Based Incentives – O&M]

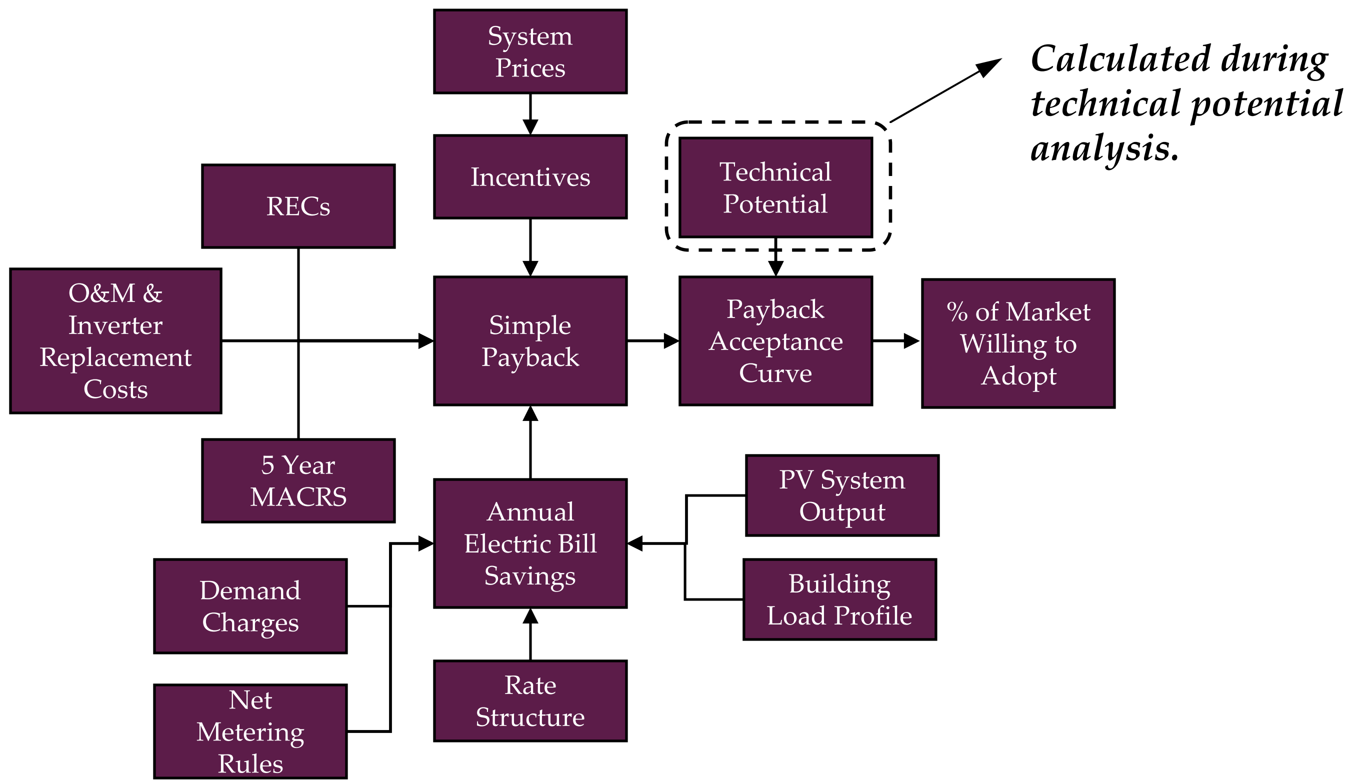
Annual cash flows

Commercial

Simple Payback = [Installed Cost – Federal Incentives – Capacity Based Incentives + tax rate*rebate amount]
[(1-tax rate)*(Annual Electric Bill Savings-O&M Costs) + Performance Based Incentives + Amortized MACRS savings]

The flow diagram below outlines Navigant Consulting's PV Market Penetration model.

Components of Navigant Consulting's Market Penetration Model[1]



Notes:

1. For full details on Navigant Consulting's PV market penetration model, refer to *Rooftop Photovoltaics Market Penetration Scenarios*, NREL/SR-581-42306, February 2008

Navigant Consulting took data from a variety of sources.

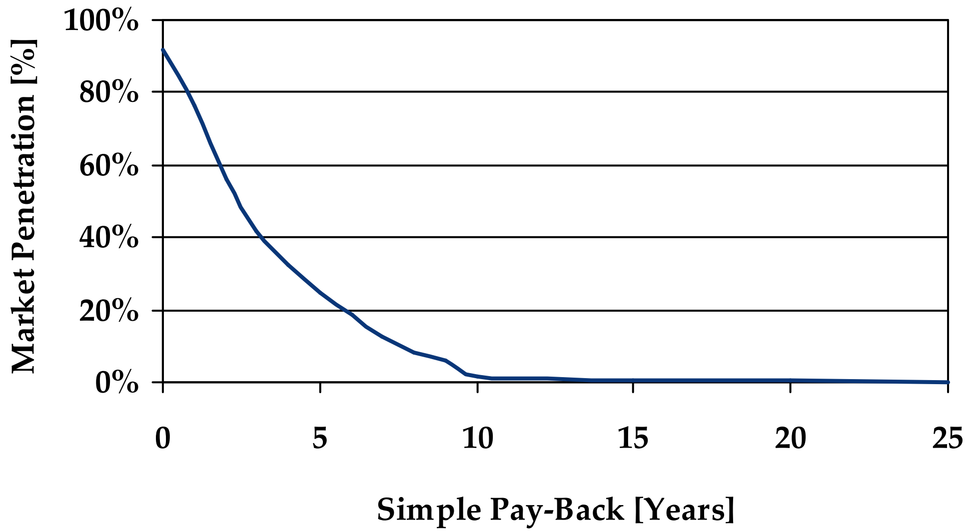
Input	Data Source
PV System Prices	Refer to *Technical Potential and Economic & Performance Characteristics* portion of this study.
Incentives	Federal and state incentives were used per defined in the *Scenarios* section of this report.
RECs	RECs were calculated based upon caps defined in the *Scenarios* section of this report.
O&M and Inverter Replacement Costs	Refer to *Technical Potential and Economic & Performance Characteristics* portion of this study.
5 Year MACRS	Navigant Consulting used 5 year Modified Accelerated Cost Recovery Schedule for commercial PV systems.
Demand Charges	Navigant Consulting obtained each IOU's demand charge structures.
Net Metering Rules	Navigant Consulting used FL's current rule that systems < 2 MW can sell back to the utility at retail rates.
Rate Structures	Navigant Consulting obtained each IOU's actual Standard and Time-of-Use rate structures. Rates were escalated over time assuming current rates come to parity with the fuel price projections defined in the *Scenarios* section of this report.
Building Load Profiles	Navigant Consulting used Florida specific building load profiles from in house models and data provided from the IOUs.[1]
PV System Output	Navigant Consulting used Florida specific PV output profiles from in house models and from the IOUs.[1]

Sources:

1. *Rooftop Photovoltaics Market Penetration Scenarios*, NREL/SR-581-42306, February 2008

We used empirically derived payback acceptance curves.

Payback Acceptance Curve



Comments

- Navigant Consulting based market penetration upon two sets of curves
  - Kastovich[1] calculated market penetration curves for retrofit and new construction markets of energy technologies
  - Navigant Consulting produced a curve based on field interviews, consumer surveys, and market data on adoption of efficient energy technologies in the market.
- Based upon interviews with key stakeholders, Navigant Consulting used a different curve for new construction because builders are (generally) reluctant to add PV as a standard feature and require shorter pay backs before making it standard.

Sources:

1. Kastovich, J.C., Lawrence, R.R., Hoffman, R.R., and Pavlak, C., 1982, "Advanced Electric Heat Pump Market and Business Analysis.". The curves apply simple payback as the criteria, and were developed for the residential market.
2. Proprietary data belonging to Navigant Consulting. Developed by the Navigant team while at Arthur D. Little, based on HVAC penetration experience for the Building Equipment Division, Office of Building Technologies, U.S. Department of Energy (DoE) in 1995. The Navigant curve is used by the DoE in its evaluation of energy efficiency and distributed energy technologies, which was confirmed in an interview with Steve Wade in January 2004. sited in *Energy Consumption Characteristics of Commercial Building HVAC Systems Volume III: Energy Savings Potential*. July, 2002, Kurt W. Roth et al. TIAX LLC: pg 2-5.

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Technology Adoption

- For this study, Navigant Consulting assumed that RE technology adoption would be feasible when the RE technology's LCOE was less than its competing traditional technology's LCOE.
- However, just because a technology is cost competitive or a certain portion of the market would be willing to adopt a technology does not guarantee that it will be adopted all at once. Technologies are typically adopted over time.
- The following slide discusses how Navigant Consulting calculated adoption rates for each technology, using technology adoption curves.
- After developing a technology adoption curve for each technology, Navigant Consulting projected a technology's adoption (in terms of nameplate capacity) once it becomes competitive.
  - If in a given year, a technology becomes uncompetitive (for example, if a federal incentive expires) Navigant Consulting assumes it will not be adopted.
  - This had been demonstrated in the boom-bust cycles of the US wind industry corresponding to availability of the Federal Production Tax Credit

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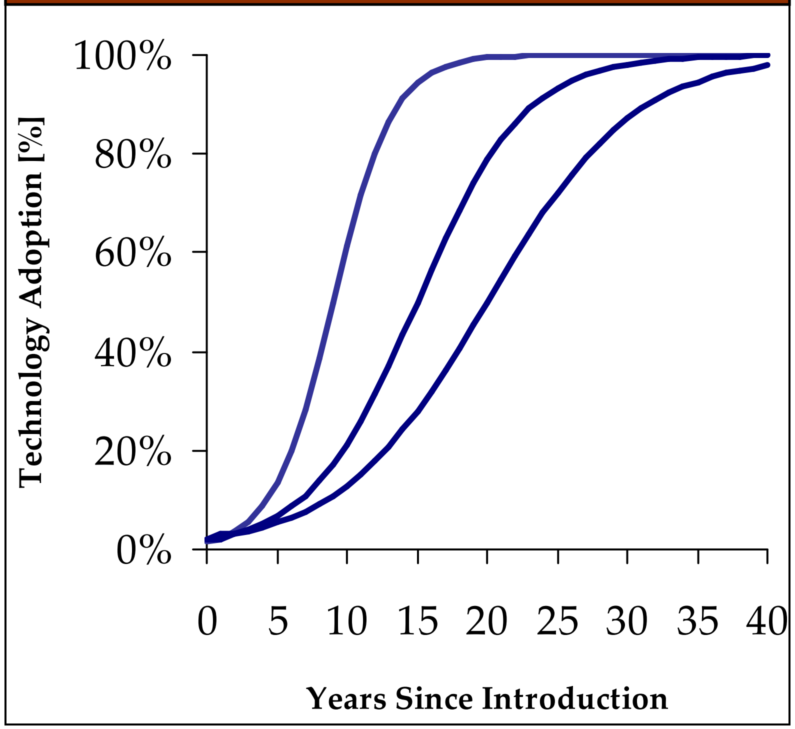
When the RE technologies had favorable LCOEs, their adoption was estimated using a family of technology adoption curves.

- 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



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

For this portion of the analysis, Navigant Consulting accounted for competing resource uses.

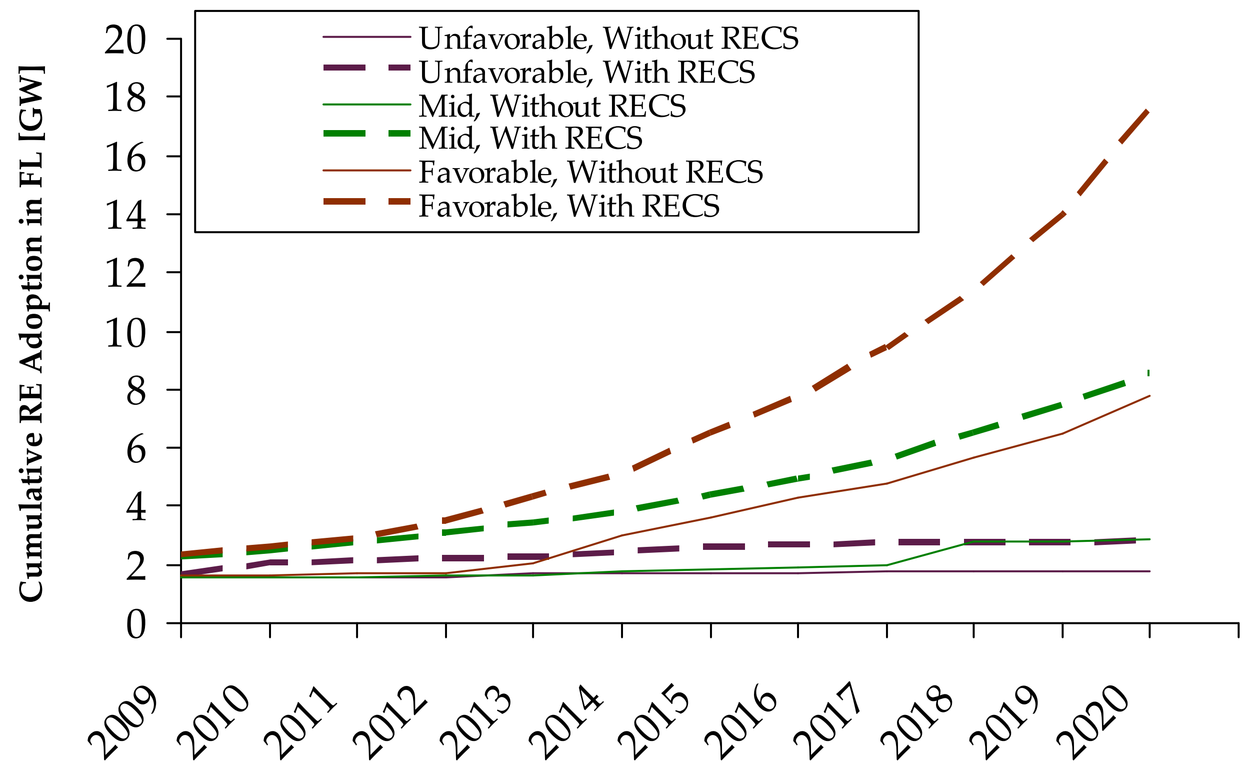
Technologies Competing	Discussion/Resolution
Biomass power competing for resources with biofuels applications	In an analysis by the Governor's Action Team on Energy and Climate Change, it was assumed that by 2020, there would be a demand for 5 million dry tons/yr of biomass for biofuels production of about 500 million gallons/yr. For this analysis, Navigant Consulting will assume the solid biomass power technical potential is 5 million dry tons less by 2020.
Wind and ground mounted PV competing for land	There is ~1,000 acres of overlap between the land identified for onshore wind and ground mounted PV. For this analysis, NCI assumes wind will get the land.
Different uses for biomass resources (i.e. direct combustion vs. BIGCC)	Navigant Consulting BIGCC technologies would overtake Direct Combustion when the LCOE of BIGCC was 10% less than that of Direct Combustion (to account for the technology risk that might accompany pioneering BIGCC).
Ground mounted PV and biomass crops competing for land	Only non-forested and non-planted land was assessed for PV installations, and for biomass crops planted on degraded mining land, different land areas were considered (reference the appendix for the land use types considered for each technology.

Notes:

1. When you produce biofuels from lignocellulosic biomass, there will always be residues from biofuels production that can be used for combined heat and power applications. This could lead to 150- 500 more MW of biomass power available.

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[1,2,3] 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

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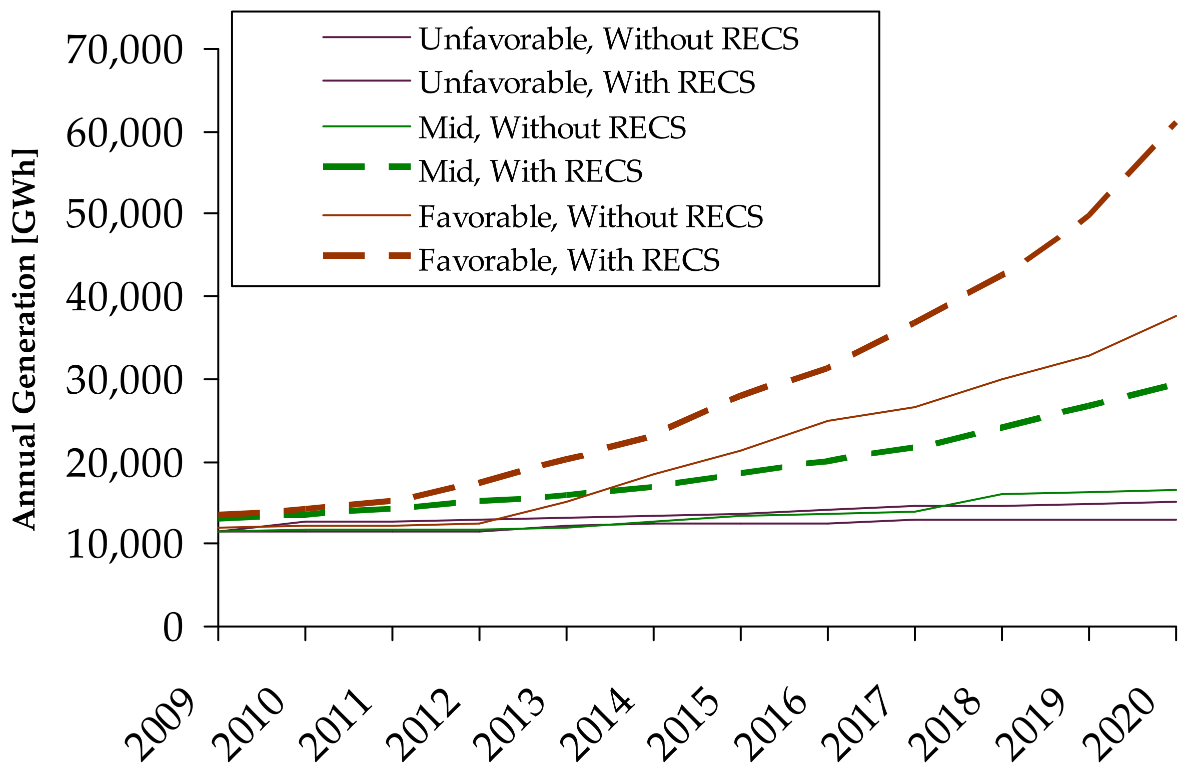
Applying capacity factors to the capacity projections shows that Florida could generate between 15,000 and 61,000 GWh of RE by 2020.

Annual Florida RE Generation[1] [GWh]

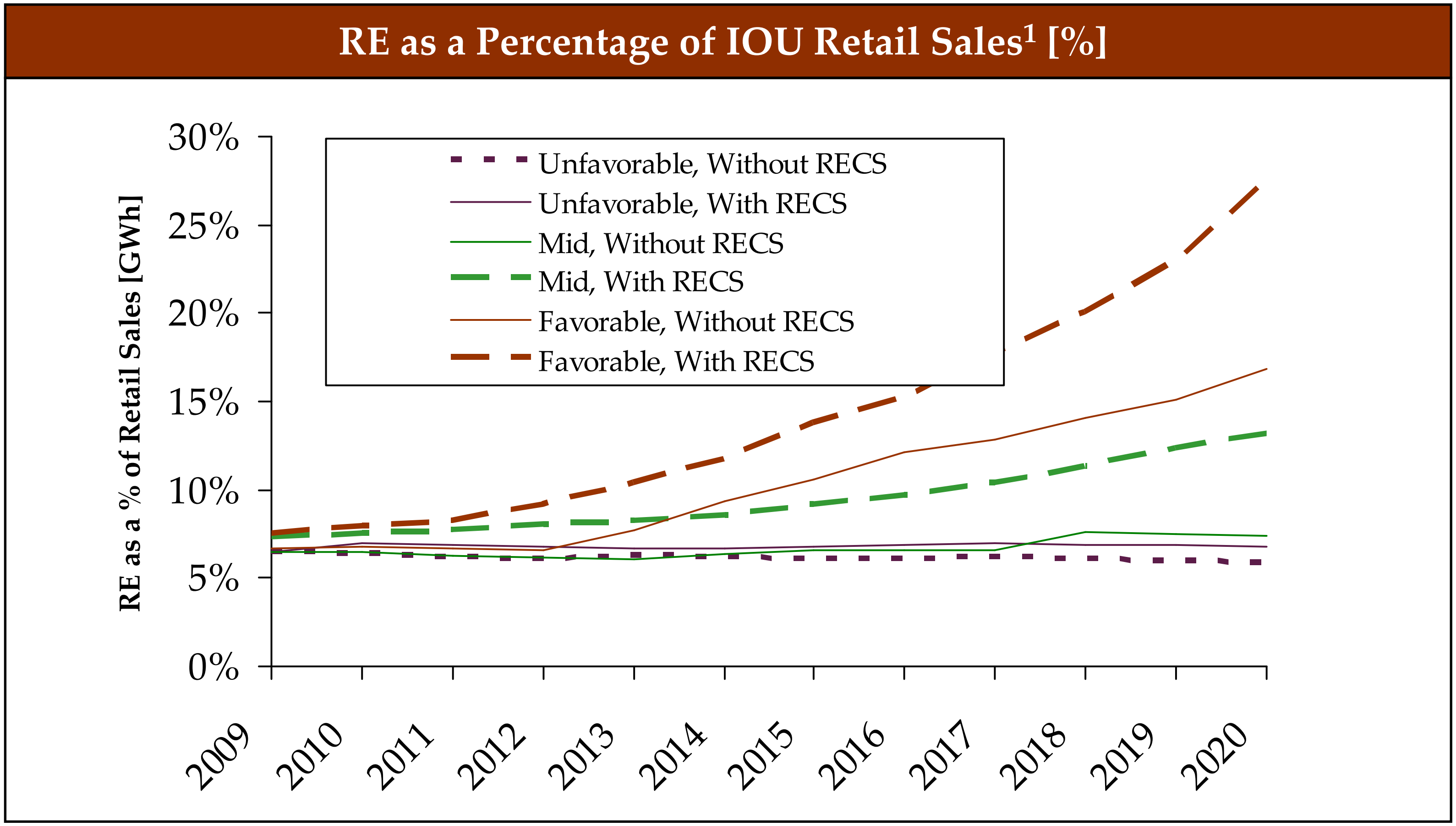


Notes:

1. Refer to the appendix for details on generation by each 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.



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.

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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Appendix

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Appendix

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Navigant Consulting used the following land use types for each technology, as depicted in the following tables.

Land Use Code[1]	Ground Mounted PV	Onshore Wind	Dedicated Energy Crops on Degraded Mining Land
1000: Urban and built up			
1100: Residential, low density - less than 2 dwelling units/acre			
1180: Rural residential			
1190: Low density under construction			
1200: Residential, medium density - 2-5 dwelling units/acre			
1290: Medium density under construction			
1300: Residential, high density - 6 or more dwelling units/acre			
1390: High density under construction			
1400: Commercial and services			
1460: Oil & gas storage (except areas assoc. with industrial)			
1480: Cemeteries			
1490: Commercial & services under construction			
1500: Industrial			
1510: Food processing			
1520: Timber processing			
1523: Pulp and paper mills			
1530: Mineral processing			
1540: Oil & gas processing			
1550: Other light industrial			
1560: Other heavy industrial			

Notes:

1. Land use codes shown are taken from the 5 Florida Water Management District's Land Use Surveys.

Navigant Consulting used the following land use types for each technology, as depicted in the following tables.

Land Use Code[1]	Ground Mounted PV	Onshore Wind	Dedicated Energy Crops on Degraded Mining Land
1561: Ship building & repair			
1562: Pre-stressed concrete plants (includes 1564)			
1563: Metal fabrication plants			
1590: Industrial under construction			
1600: Extractive			
1610: Strip mines			
1611: Clays			X
1612: Peat			
1613: Heavy metals			
1620: Sand & gravel pits (must be active)			
1630: Rock quarries			
1632: Limerock or dolomite			
1633: Phosphates			
1640: Oil & gas fields			
1650: Reclaimed lands			X
1660: Holding ponds			
1670: Abandoned mining lands	X	x	
1700: Institutional			
1730: Military			
1750: Governmental - for Kennedy Space Center only			

Notes:

1. Land use codes shown are taken from the 5 Florida Water Management District's Land Use Surveys.

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Navigant Consulting used the following land use types for each technology, as depicted in the following tables.

Land Use Code[1]	Ground Mounted PV	Onshore Wind	Dedicated Energy Crops on Degraded Mining Land
1800: Recreational			
1810: Swimming beach			
1820: Golf courses			
1830: Race tracks			
1840: Marinas & fish camps			
1850: Parks and zoos			
1860: Community recreational facilities			
1870: Stadiums - facilities not associated with high schools, colleges, or universities			
1890: Other recreational (stables, go-carts, ...)			
1900: Open land	x	x	
1920: Inactive land with street pattern but no structures	x	x	
2000: Agriculture			
2100: Cropland and pastureland			
2110: Improved pastures (monocult, planted forage crops)			
2120: Unimproved pastures			
2130: Woodland pastures			
2140: Row crops			
2143: Potatoes and cabbage			
2150: Field crops			
2160: Mixed crop			

Notes:

1. Land use codes shown are taken from the 5 Florida Water Management District's Land Use Surveys.

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Navigant Consulting used the following land use types for each technology, as depicted in the following tables.

Land Use Code[1]	Ground Mounted PV	Onshore Wind	Dedicated Energy Crops on Degraded Mining Land
2200: Tree crops			
2210: Citrus groves			
2240: Abandoned tree crops			
2300: Feeding operations			
2310: Cattle feeding operations			
2320: Poultry feeding operations			
2400: Nurseries and vineyards			
2410: Tree nurseries			
2420: Sod farms			
2430: Ornamentals			
2431: shade ferns			
2432: hammock ferns			
2450: Floriculture			
2500: Specialty farms			
2510: Horse farms			
2520: Dairies			
2540: Aquaculture			
2600: Other open lands - rural	x	x	
2610: Fallow cropland			
3000: Upland Nonforested			

Notes:

1. Land use codes shown are taken from the 5 Florida Water Management District's Land Use Surveys.

Navigant Consulting used the following land use types for each technology, as depicted in the following tables.

Land Use Code[1]	Ground Mounted PV	Onshore Wind	Dedicated Energy Crops on Degraded Mining Land
3100: Herbaceous upland nonforested			
3200: Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub oak)			
3300: Mixed upland nonforested		x	
4000: Upland Forests (25% forested cover)			
4100: Upland coniferous forests			
4110: Pine flatwoods			
4120: Longleaf pine - xeric oak			
4130: Sand pine			
4200: Upland hardwood forests			
4210: Xeric oak			
4280: Cabbage palm			
4300: Upland mixed forest			
4340: Upland mixed coniferous/hardwood			
4370: Australian pine			
4400: Tree plantations			
4410: Coniferous pine			
4430: Forest regeneration			
5000: Water			
5100: Streams and waterways			
5200: Lakes			

Notes:

1. Land use codes shown are taken from the 5 Florida Water Management District's Land Use Surveys.

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Navigant Consulting used the following land use types for each technology, as depicted in the following tables.

Land Use Code[1]	Ground Mounted PV	Onshore Wind	Dedicated Energy Crops on Degraded Mining Land
5250: Open water within a freshwater marsh / Marshy Lakes			
5300: Reservoirs - pits, retention ponds, dams			
5400: Bays and estuaries			
5430: Enclosed saltwater ponds within a salt marsh			
5500: Major springs			
5600: Slough waters			
6000: Wetlands			
6100: Wetland hardwood forests			
6110: Bay swamp (if distinct)			
6120: Mangrove swamps			
6170: Mixed wetland hardwoods			
6180: Cabbage palm wetland			
6181: Cabbage palm hammock			
6182: Cabbage palm savannah			
6200: Wetland coniferous forests			
6210: Cypress			
6220: Pond pine			
6250: Hydric pine flatwoods			
6300: Wetland forested mixed			
6400: Vegetated non-forested wetlands			

Notes:

1. Land use codes shown are taken from the 5 Florida Water Management District's Land Use Surveys.

Navigant Consulting used the following land use types for each technology, as depicted in the following tables.

Land Use Code[1]	Ground Mounted PV	Onshore Wind	Dedicated Energy Crops on Degraded Mining Land
6410: Freshwater marshes			
6420: Saltwater marshes			
6430: Wet prairies			
6440: Emergent aquatic vegetation			
6460: Mixed scrub-shrub wetland			
6500: Non-vegetated wetland			
7000: Barren land	x	x	
7100: Beaches other than swimming beaches			
7200: Sand other than beaches		x	
7400: Disturbed land			
7410: Rural land in transition without positive indicators of intended activity			
7420: Borrow areas			
7430: Spoil areas			
8000: Transportation, Communication, and Utilities			
8100: Transportation			
8110: Airports			
8120: Railroads			
8130: Bus and truck terminals			
8140: Roads and highways (divided 4-lanes with medians)			
8150: Port facilities			

Notes:

1. Land use codes shown are taken from the 5 Florida Water Management District's Land Use Surveys.

Navigant Consulting used the following land use types for each technology, as depicted in the following tables.

Land Use Code[1]	Ground Mounted PV	Onshore Wind	Dedicated Energy Crops on Degraded Mining Land
8160: Canals and locks			
8180: Auto parking facilities			
8200: Communications			
8300: Utilities			
8310: Electrical power facilities			
8320: Electrical power transmission lines			
8330: Water supply plants			
8340: Sewage treatment			
8350: Solid waste disposal			
8360: Treatment ponds (non-sewage)			
8370: Surface water collection ponds			
9999: Missing LUCODE or outside WMD			

Notes:

1. Land use codes shown are taken from the 5 Florida Water Management District's Land Use Surveys.

Appendix

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	Natural Gas Combined Cycle Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Plant Capacity (MW)	510	510	510
Project Life (yrs)	25	25	25
Installed Cost ($/kW)	910	1,150	1,250
Fixed O&M ($/kW-yr)[3]	0	0	0
Non-Fuel Variable O&M ($/MWh)	4.2	4.9	5.3
Fuel/Energy Cost ($/kWh)	See Scenario section for range of costs assumed, by Scenario.		

Sources: Stakeholder data submitted to the Florida Public Service Commission, September 2008; Navigant Consulting, October 2008

	Natural Gas Combined Cycle Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Net Capacity Factor (%)	85%	85%	85%
Heat Rate (Btu/kWh)	7,100	7,000	6,900
CO2 (lb/MWh)[1]	760	750	740
NOx (lb/MWh)[2]	0.05	0.05	0.05
SO2 (lb/MWh)	0.0035	0.0034	0.0034

Sources: Stakeholder data submitted to the Florida Public Service Commission, September 2008; Navigant Consulting, October 2008; New Source Review data from the Florida Department of Environmental Protection.

Notes:

1. Assumes 0.38tons/MWh of emissions.
2. Assumes 2 PPM NOx emissions, based upon recently permitted plants in Florida.

	Natural Gas Combustion Turbine Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Plant Capacity (MW)	169	169	169
Project Life (yrs)	20	20	20
Installed Cost ($/kW)	670	850	940
Fixed O&M ($/kW-yr)	0	0	0
Non-Fuel Variable O&M ($/MWh)	10.4	12.2	13.1
Fuel/Energy Cost ($/kWh)	See Scenario section for range of costs assumed, by Scenario.		

Sources: Stakeholder data submitted to the Florida Public Service Commission, September 2008; Navigant Consulting, October 2008

	Natural Gas Combustion Turbine Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Net Capacity Factor (%)	15%	15%	15%
Heat Rate (Btu/kWh)	10,700	10,700	10,700
CO2 (lb/MWh)[1]	2280	2280	2280
NOx (lb/MWh)[2]	0.0668	0.0668	0.0668
SO2 (lb/MWh)	0.0048	0.0048	0.0048

Sources: Stakeholder data submitted to the Florida Public Service Commission, September 2008; Navigant Consulting, October 2008; New Source Review data from the Florida Department of Environmental Protection.

Notes:

1. Assumes 1.14 tons/MWh of emissions in 2009.
2. Assumes 2 PPM NOx emissions, based upon recently permitted plants in Florida.

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	New Nuclear Economic Assumptions for Given Year of Installation (2008$)		
	2008[1]	**2016[1]**	**2020**
Plant Capacity (MW)	N/A	1,100	1,100
Project Life (yrs)	N/A	40	40
Installed Cost ($/kW)[2]	N/A	7,700	7,700
Fixed O&M ($/kW-yr)[3]	N/A	120	120
Non-Fuel Variable O&M ($/kWh)	N/A	0.015	0.015
Fuel/Energy Cost ($/kWh)	N/A	0.01	0.01

Sources: Stakeholder data submitted to the Florida Public Service Commission, September 2008; Navigant Consulting, October 2008

Notes:

1. The first new nuclear plant is not expected to be commissioned until ~2016.

	New Nuclear Economic Assumptions for Given Year of Installation (2008$)		
	2008[1]	2016[1]	2020
Net Capacity Factor (%)	N/A	94%	94%
Heat Rate (BTU/kWh)	N/A	10,400	10,400
CO2 (lb/MWh)	N/A	0	0
NOx (lb/MWh)	N/A	0	0
SO2 (lb/MWh)	N/A	0	0

Sources: Stakeholder data submitted to the Florida Public Service Commission, September 2008; Navigant Consulting, October 2008

Notes:

1. The first new nuclear plant is not expected to be commissioned until ~2016.

	Coal Fired Steam Cycle Economic Assumptions for Given Year of Installation (2008$)		
	2009	**2015**	**2020**
Plant Capacity (MW)	650	650	650
Project Life (yrs)	30	30	30
Installed Cost ($/kW)[2]	2,740	3,470	3,800
Fixed O&M ($/kW-yr)[3]	0	0	0
Non-Fuel Variable O&M ($/MWh)	6.3	7.4	7.9
Fuel/Energy Cost ($/kWh)	See Scenario section for range of costs assumed, by Scenario.		

Sources: Stakeholder data submitted to the Florida Public Service Commission, September 2008; Navigant Consulting, October 2008

	Coal Fired Steam Cycle Economic Assumptions for Given Year of Installation (2008$)		
	2008	**2015**	**2020**
Net Capacity Factor (%)	85%	85%	85%
Heat Rate (BTU/kWh)	9,750	9,480	9,480
CO2 (lb/MWh)[1]	1986	1931	1931
NOx (lb/MWh)[2]	5.6	5.4	5.4
SO2 (lb/MWh)[2]	28.5	27.7	27.7

Sources: Stakeholder data submitted to the Florida Public Service Commission, September 2008; Navigant Consulting, October 2008

Notes:

1. Assumes emissions of 0.993 tons/MWh
2. For this analysis, Navigant Consulting has assumed Biomass Co-firing and Biomass Repowering are the only technologies competing against coal because the state's 10 year load and resource plan does not show any new coal plants scheduled to be built. Thus, only existing coal plants will be competing against RE technologies. These costs presented to estimate what the LCOE of a coal plant is today and in the future. Also, for co-firing Navigant Consulting only looked at plants without SCR technology, thus the relatively higher emissions factors.

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Assumed NOx Costs [$/ton]

Source: Ventyx, Inc October 2008

Note: Annual NOx prices are expected to vary over the course of a year. Navigant Consulting assumed an average selling price over the course of a year.

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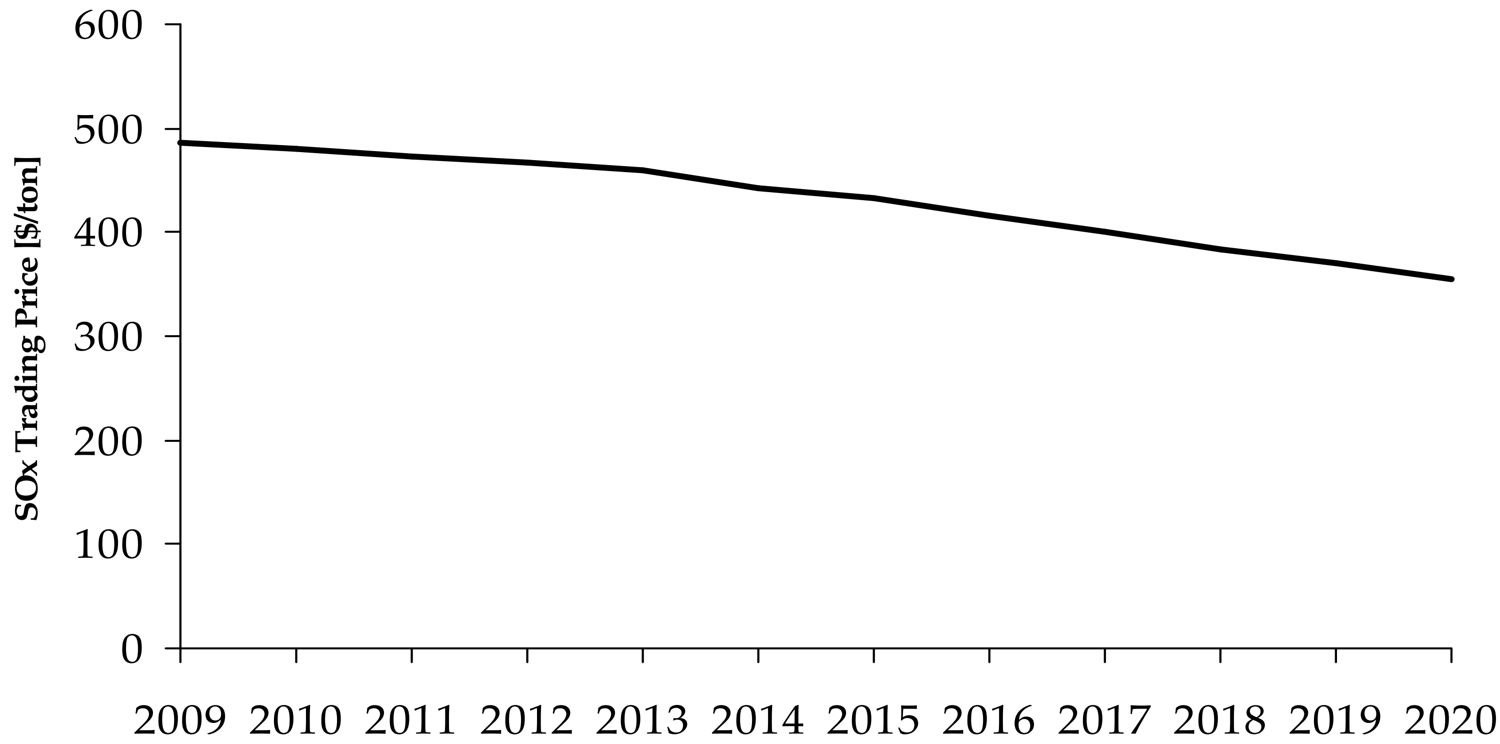
Assumed SOx Costs [$/ton]



Source: Ventyx, Inc October 2008

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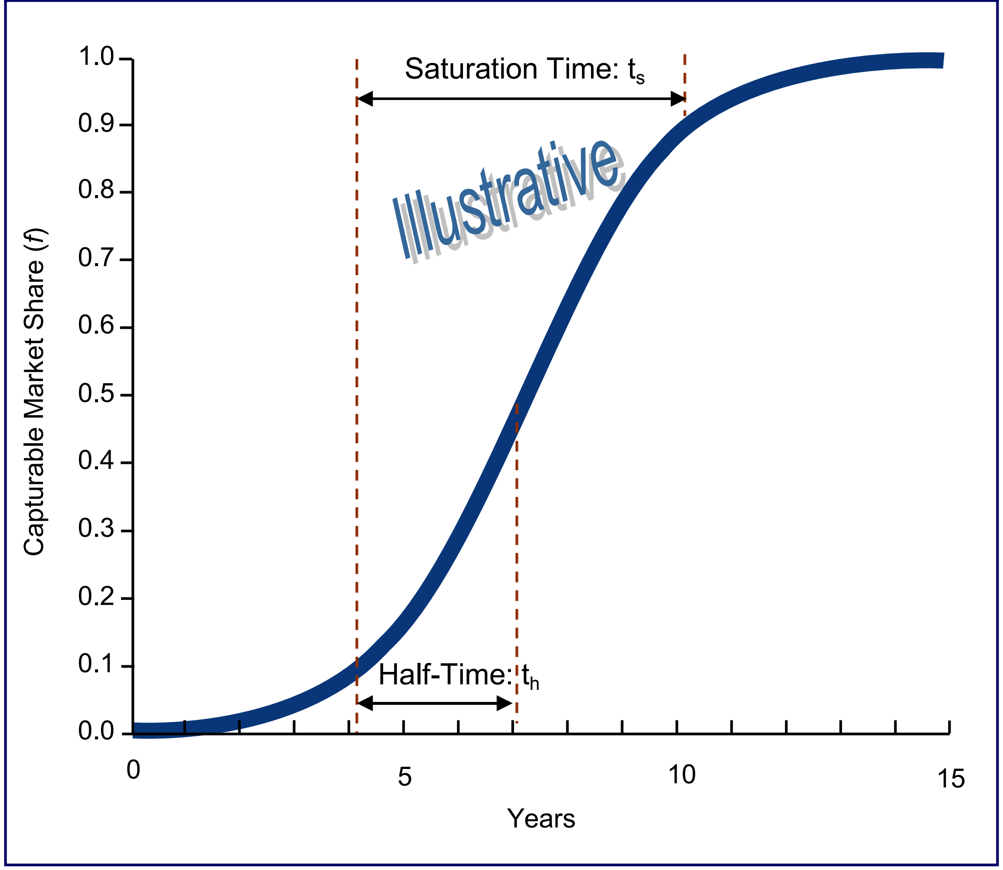
The Fisher-Pry technology substitution model is used to estimate the rate at which the marketplace will adopt a new technology.

- In 1971 Fisher and Pry[1] published a paper describing a model of technological change, which is extremely effective in modeling the competitive substituting of one technology by another in industrial processes.
  - Navigant Consulting chose to adapt this industrial processes model to RE.
- The Fisher-Pry technology substitution model predicts market adoption rate for an existing market of known size.
  - Navigant Consulting used this model because utilities and consumers are replacing traditional technologies with RE technologies.
  - The market of known size comes from technical potential and market potential calculations.
- The fraction of market adoption, *f*, by technology substitution for an existing segment is represented as:

$$f = \frac{1}{1+e^{-\alpha(t-t_h)}}$$

- α is an empirical constant
- The half time t_h is the time at which $f = 0.5$.
- The takeover time t_s is the time between $f = 0.1$ and $f = 0.9$.

Segment Adoption Curves

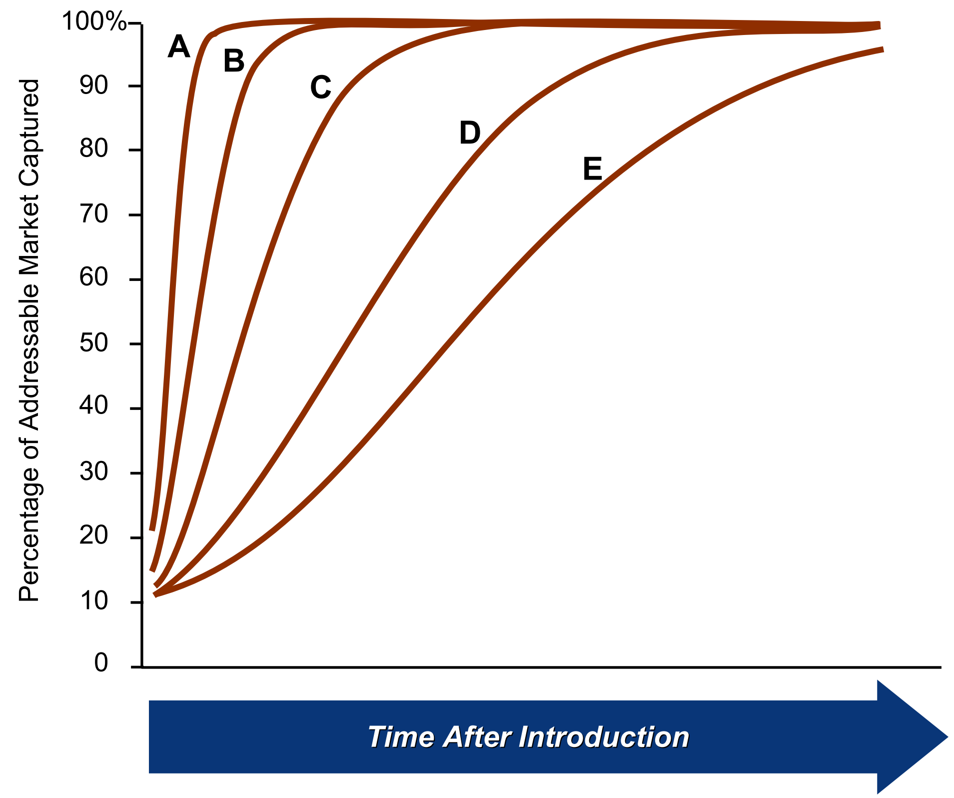


Source: 1. Fisher, J.C. and R.H. Pry, A Simple Substitution Model of Technological Change, *Technological Forecasting and Social Change*, Vol 3, Pages 75 – 99, 1971

To aid in projecting RE adoption, a few important criteria were used to characterize the technology-segment interaction.

- The rate at which technologies penetrate the segment depends on:
  - Technology characteristics (e.g., technology economics, new vs. retrofit)
  - Industry characteristics (e.g., industry growth, competition)
  - External factors (e.g., government regulation, trade restrictions)
- Historical data* reveals that major classes of technology/segment with common segment-penetration characteristics can be classified into five categories, each with its own time to segment saturation.

Segment Saturation Curves



*The last 3 pages of this report discuss historical data used.

In addition to the 17 substitutions listed in Fisher-Pry's 1971 paper, at least 200 other application examples of the Fisher-Pry model, from a range of industries and historical periods, are in the public record.

Original Fisher-Pry Examples

Synthetics for natural leather	Plastic versus other pleasure boat hulls	Water-based versus oil-based paints
Synthetic fibers for natural fibers	Plastic versus metal in cars	T102 for ZnO and PbO paint pigments
Detergents for soap	Open hearth versus Bessemer steel	Plastic for hardwood in residential floors
Basic oxygen furnace for open hearth steel	Electric arc versus open hearth steel	Synthetic rubber for natural rubber
Synthetic versus natural tire fibers	Sulfate versus tree tapped turpentine	Margarine for butter
Organic versus inorganic insecticides		

Other Substitutions Which Follow Fisher-Pry Patterns

Steam power for sail	Centralized railroad traffic control for block control	Corn combines for mechanical corn pickers
Diesel power for locomotives	Tufted carpet for woven carpet	Hydrocracking for catalytic cracking
Simulator training for airplane flight hours	Electromechanical switching for manual	Stressed skin aircraft for truss-type structure
Aluminum cans for steel cans	Digital switching for analog	Pressurized for non-pressurized aircraft
Factory versus on-site construction	Strip-mining for underground mining	Mechanical loaders for hand loading coal
Carpet for hardwood flooring	Turbojets for reciprocating engines	Float glass for plate glass
Aluminum for copper	Telephone for letter mail	Electronic switching for electromechanical
Catalytic cracking for thermal cracking	Transistors for vacuum tubes	Disk brakes for drum brakes
Computer process controls for automatic controls	Electrons for paper and ink	
Jet aircraft for piston-engine aircraft	Airplanes for passenger trains	
	Hybrid corn for normal corn	

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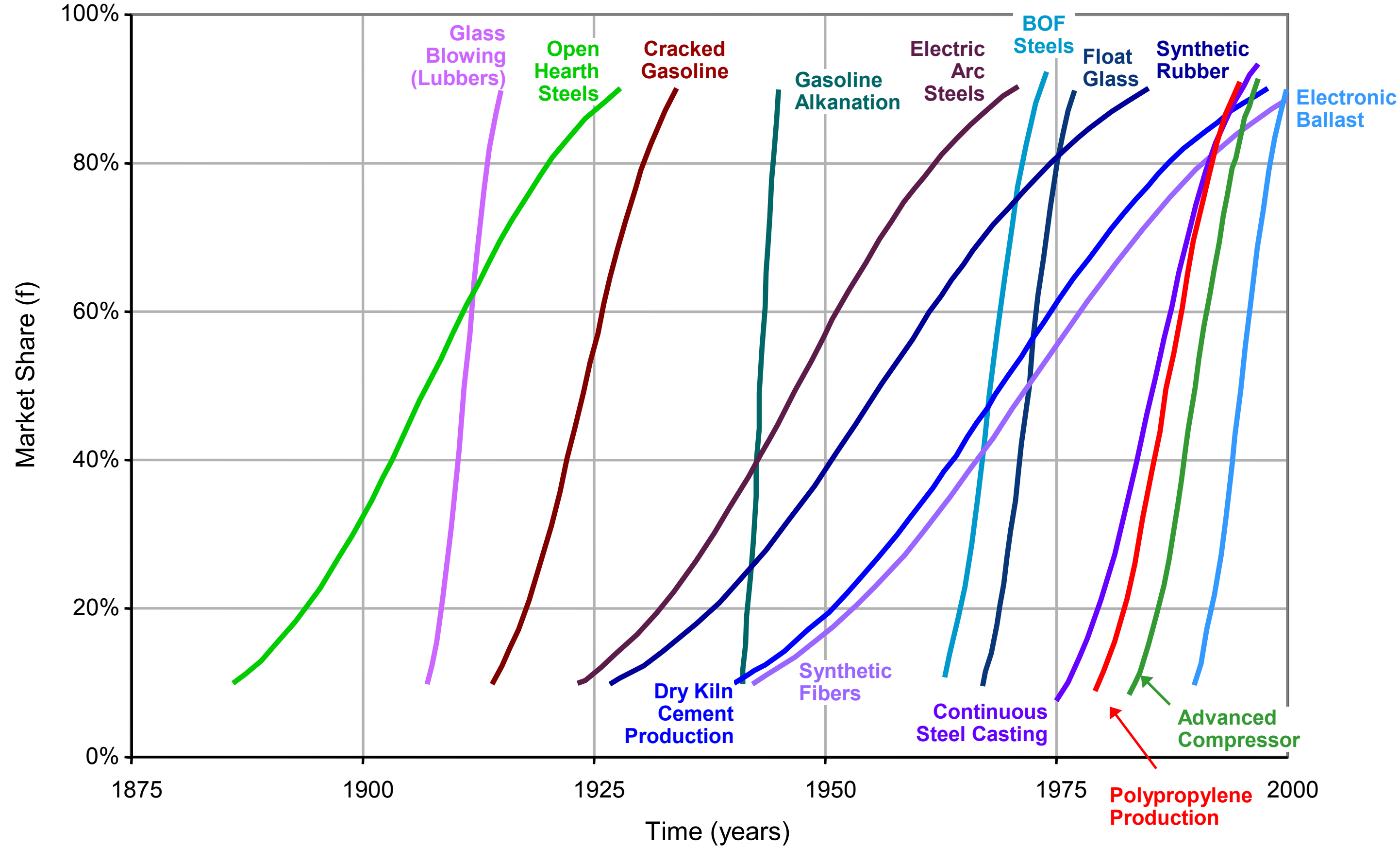
Market acceptance data were gathered for selected technologies introduced over the past 120 years.



Data were fitted with formula $f = \frac{1}{1+e^{-c_{12}(t-t_h)}}$

Market share calculated as percentage of installed base

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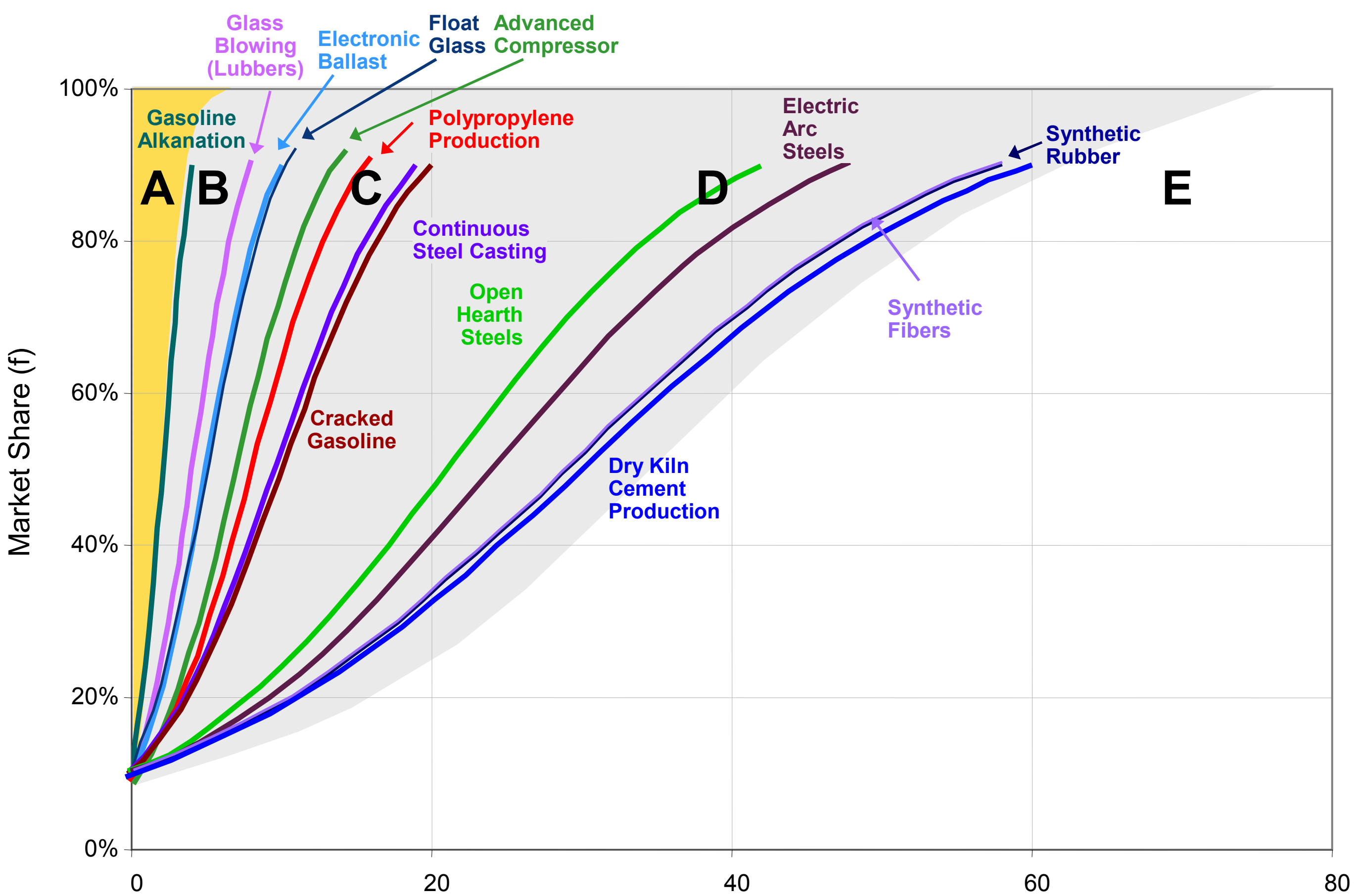
The data were normalized with respect to technology introduction, leading to distinctive classes as mentioned earlier.



Data were fitted with formula $f = \frac{1}{1+e^{-c_{12}(t-t_h)}}$

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	RE Cumulative Nameplate Capacity – Unfavorable for RE Scenario, Without RECs [MW]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass – ADG – Farm Waste	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – ADG - WWTP	0	0	0	0	0	1	1	1	1	1	2	2
Biomass - LFG	59	60	62	64	66	70	74	79	85	92	99	107
Biomass – Solid Biomass - BIGCC	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – Solid Biomass – Co-Firing	50	50	50	50	50	50	50	50	100	100	100	100
Biomass – Solid Biomass – Direct Combustion	571	571	571	571	571	571	571	571	571	571	571	571
Biomass – Solid Biomass - Repowering	0	0	0	0	50	50	50	50	50	50	50	50
Biomass – Solid Biomass – Waste to Energy	520	520	520	520	520	520	520	520	520	520	520	520
Ocean - Current	0	0	0	0	0	0	0	0	0	0	0	0
Solar - CSP	0	0	0	0	0	0	0	0	0	0	0	0
Solar – Ground Mounted PV	0	0	0	0	0	0	0	0	0	0	0	0
Solar – Water Heating	0	0	0	0	0	0	0	0	0	0	0	0
Waste Heat	370	370	370	370	370	370	370	370	370	370	370	370
Wind – Offshore - Class 4	0	0	0	0	0	0	0	0	0	0	0	0
Wind – Offshore - Class 5	0	0	0	0	0	0	0	0	0	0	0	0
Wind - Onshore	0	0	0	0	0	0	0	0	0	0	0	0
Solar – Residential PV	2	2	2	2	2	2	2	2	2	2	2	2
Solar – Commercial PV	0	0	1	1	2	3	8	16	16	16	16	16

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	RE Cumulative Nameplate Capacity – Unfavorable for RE Scenario, With RECs [MW]											
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Biomass – ADG – Farm Waste	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – ADG - WWTP	0	0	0	0	0	1	1	1	1	1	2	2
Biomass - LFG	59	60	62	64	66	70	74	79	85	92	99	107
Biomass – Solid Biomass - BIGCC	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – Solid Biomass – Co-Firing	50	50	50	50	50	50	50	50	100	100	100	100
Biomass – Solid Biomass – Direct Combustion	571	571	571	571	571	571	571	571	571	571	571	571
Biomass – Solid Biomass - Repowering	0	0	0	50	50	50	50	50	50	50	50	50
Biomass – Solid Biomass – Waste to Energy	520	520	520	520	520	520	520	520	520	520	520	520
Ocean - Current	0	0	0	0	0	0	0	0	0	0	0	0
Solar - CSP	0	0	0	0	0	0	0	0	0	0	0	0
Solar – Ground Mounted PV	0	395	424	458	526	625	769	769	769	769	769	769
Solar – Water Heating	22	26	31	36	43	51	60	71	71	71	71	71
Waste Heat	370	380	380	380	380	380	380	403	410	418	428	428
Wind – Offshore - Class 4	0	0	0	0	0	0	0	0	0	0	0	0
Wind – Offshore - Class 5	0	0	0	0	0	0	0	0	0	0	0	0
Wind - Onshore	0	24	24	24	24	24	24	24	24	24	24	24
Solar – Residential PV	15	23	31	42	52	62	82	96	96	96	96	118
Solar – Commercial PV	8	12	16	21	27	33	40	51	51	52	57	68

	RE Cumulative Nameplate Capacity – Mid Favorable for RE Scenario, Without RECs [MW]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass – ADG – Farm Waste	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – ADG - WWTP	0	0	0	0	0	1	1	1	2	3	4	5
Biomass - LFG	64	68	73	79	88	98	110	124	138	152	164	175
Biomass – Solid Biomass - BIGCC	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – Solid Biomass – Co-Firing	50	50	50	50	50	50	100	100	100	150	150	150
Biomass – Solid Biomass – Direct Combustion	571	571	571	571	571	571	571	571	571	571	571	571
Biomass – Solid Biomass - Repowering	0	0	0	0	0	50	50	50	50	50	50	50
Biomass – Solid Biomass – Waste to Energy	520	520	520	520	520	520	520	520	520	520	520	520
Ocean - Current	0	0	0	0	0	0	0	0	0	0	0	0
Solar - CSP	0	0	0	0	0	0	0	0	0	0	0	0
Solar – Ground Mounted PV	0	0	0	0	0	0	0	0	0	692	692	692
Solar – Water Heating	0	0	0	0	0	0	0	0	0	0	0	0
Waste Heat	370	380	383	386	391	397	404	414	426	440	458	478
Wind – Offshore - Class 4	0	0	0	0	0	0	0	0	0	0	0	0
Wind – Offshore - Class 5	0	0	0	0	0	0	0	0	0	0	0	0
Wind - Onshore	0	0	0	0	0	0	0	0	0	0	0	0
Solar – Residential PV	2	2	2	2	2	2	26	50	77	107	107	107
Solar – Commercial PV	0	1	2	3	5	8	16	23	30	45	45	45

	RE Cumulative Nameplate Capacity – Mid Favorable for RE Scenario, With RECs [MW]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass – ADG – Farm Waste	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – ADG - WWTP	0	0	0	0	0	1	1	1	2	3	4	5
Biomass - LFG	64	68	73	79	88	98	110	124	138	152	164	175
Biomass – Solid Biomass - BIGCC	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – Solid Biomass – Co-Firing	50	50	50	50	50	50	100	100	100	150	200	200
Biomass – Solid Biomass – Direct Combustion	571	571	571	571	571	571	571	571	571	571	571	571
Biomass – Solid Biomass - Repowering	0	0	0	50	50	50	50	50	50	50	50	50
Biomass – Solid Biomass – Waste to Energy	520	520	520	520	520	520	520	520	520	520	520	520
Ocean - Current	0	0	0	0	0	0	0	0	0	0	0	0
Solar - CSP	0	0	75	75	75	75	75	75	75	75	75	75
Solar – Ground Mounted PV	627	788	971	1199	1479	1820	2273	2783	3397	4130	4999	6018
Solar – Water Heating	22	27	33	40	49	60	73	89	108	130	130	130
Waste Heat	370	380	383	386	391	397	404	414	426	440	458	478
Wind – Offshore - Class 4	0	0	0	0	0	0	0	0	0	0	0	0
Wind – Offshore - Class 5	0	0	0	0	0	0	0	0	0	0	0	0
Wind - Onshore	0	24	31	40	40	40	40	40	40	40	40	40
Solar – Residential PV	12	23	28	32	46	59	88	116	136	175	175	175
Solar – Commercial PV	7	12	14	17	22	27	37	46	51	71	71	71

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	RE Cumulative Nameplate Capacity – Favorable for RE Scenario, Without RECs [MW]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass – ADG – Farm Waste	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – ADG - WWTP	0	0	0	0	1	1	2	3	5	7	9	12
Biomass - LFG	73	81	93	107	124	141	158	172	184	192	198	202
Biomass – Solid Biomass - BIGCC	0	0	0	0	0	0	0	0	0	166	232	387
Biomass – Solid Biomass – Co-Firing	50	50	50	50	100	100	150	200	250	303	343	372
Biomass – Solid Biomass – Direct Combustion	605	629	629	629	898	1052	1266	1550	1550	1550	1550	1550
Biomass – Solid Biomass - Repowering	0	0	0	0	0	50	50	50	50	50	50	50
Biomass – Solid Biomass – Waste to Energy	520	520	520	520	520	552	564	579	600	626	660	833
Ocean - Current	0	0	0	0	0	0	0	0	0	0	0	0
Solar - CSP	0	0	0	0	0	0	5	8	11	16	22	31
Solar – Ground Mounted PV	0	0	0	0	0	660	874	1136	1474	1908	2459	3157
Solar – Water Heating	0	0	0	0	0	0	0	0	0	22	28	36
Waste Heat	370	380	384	389	397	407	422	440	464	494	530	570
Wind – Offshore - Class 4	0	0	0	0	0	0	0	0	0	0	0	0
Wind – Offshore - Class 5	0	0	0	0	0	0	0	0	0	0	0	0
Wind - Onshore	0	0	0	0	0	0	0	0	0	0	0	0
Solar – Residential PV	2	2	2	3	15	34	72	110	175	253	336	434
Solar – Commercial PV	0	1	3	5	9	14	24	35	46	64	85	129

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	RE Cumulative Nameplate Capacity – Favorable for RE Scenario, With RECs [MW]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass – ADG – Farm Waste	0	0	0	0	0	0	0	0	0	0	6	7
Biomass – ADG - WWTP	0	0	0	0	1	1	2	3	5	7	9	12
Biomass - LFG	73	81	93	107	124	141	158	172	184	192	198	202
Biomass – Solid Biomass - BIGCC	0	0	0	0	0	0	0	0	157	224	312	518
Biomass – Solid Biomass – Co-Firing	50	50	50	50	100	100	150	150	250	303	343	372
Biomass – Solid Biomass – Direct Combustion	605	629	666	789	898	1052	1266	1266	1266	1266	1266	1266
Biomass – Solid Biomass - Repowering	0	0	0	50	50	50	50	50	50	50	100	100
Biomass – Solid Biomass – Waste to Energy	520	520	520	520	520	552	564	579	600	626	660	833
Ocean - Current	0	0	0	0	0	0	0	0	0	0	0	0
Solar - CSP	0	0	75	75	75	75	75	75	75	75	75	75
Solar – Ground Mounted PV	627	830	1075	1395	1806	2329	3041	3883	4925	6195	7716	9500
Solar – Water Heating	22	28	36	47	60	77	98	124	156	195	241	295
Waste Heat	370	380	384	389	397	407	422	440	464	494	530	570
Wind – Offshore - Class 4	0	0	0	0	163	163	337	484	694	993	1417	2015
Wind – Offshore - Class 5	0	0	0	0	8	12	18	25	36	52	74	105
Wind - Onshore	0	24	34	47	66	92	126	172	231	304	392	491
Solar – Residential PV	16	16	28	50	76	100	161	226	283	348	543	1,212
Solar – Commercial PV	8	9	13	21	29	37	57	81	99	116	140	175

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	RE Annual Generation – Unfavorable for RE Scenario, Without RECs [GWh]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass – ADG – Farm Waste	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – ADG - WWTP	0	0	0	0	0	7	7	7	7	7	15	15
Biomass - LFG	439	447	462	477	491	521	551	588	633	685	737	797
Biomass – Solid Biomass - BIGCC	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – Solid Biomass – Co-Firing	372	372	372	372	372	372	372	372	745	745	745	745
Biomass – Solid Biomass – Direct Combustion	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252
Biomass – Solid Biomass - Repowering	0	0	0	0	372	372	372	372	372	372	372	372
Biomass – Solid Biomass – Waste to Energy	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872
Ocean - Current	0	0	0	0	0	0	0	0	0	0	0	0
Solar - CSP	0	0	0	0	0	0	0	0	0	0	0	0
Solar – Ground Mounted PV	0	0	0	0	0	0	0	0	0	0	0	0
Solar – Water Heating	0	0	0	0	0	0	0	0	0	0	0	0
Waste Heat	2,593	2,593	2,593	2,593	2,593	2,593	2,593	2,593	2,593	2,593	2,593	2,593
Wind – Offshore - Class 4	0	0	0	0	0	0	0	0	0	0	0	0
Wind – Offshore - Class 5	0	0	0	0	0	0	0	0	0	0	0	0
Wind - Onshore	0	0	0	0	0	0	0	0	0	0	0	0
Solar – Residential PV	3	3	3	3	3	3	3	3	3	3	3	3
Solar – Commercial PV	0	0	1	2	3	4	12	25	25	25	25	26

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	RE Annual Generation – Unfavorable for RE Scenario, With RECs [GWh]											
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Biomass – ADG – Farm Waste	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – ADG - WWTP	0	0	0	0	0	7	7	7	7	7	15	15
Biomass - LFG	439	447	462	477	491	521	551	588	633	685	737	797
Biomass – Solid Biomass - BIGCC	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – Solid Biomass – Co-Firing	372	372	372	372	372	372	372	372	745	745	745	745
Biomass – Solid Biomass – Direct Combustion	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252
Biomass – Solid Biomass - Repowering	0	0	0	372	372	372	372	372	372	372	372	372
Biomass – Solid Biomass – Waste to Energy	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872
Ocean - Current	0	0	0	0	0	0	0	0	0	0	0	0
Solar - CSP	0	0	0	0	0	0	0	0	0	0	0	0
Solar – Ground Mounted PV	0	865	929	1,003	1,152	1,369	1,684	1,684	1,751	1,751	1,751	1,751
Solar – Water Heating	35	41	49	57	68	80	95	112	112	112	112	112
Waste Heat	2,593	2,663	2,663	2,663	2,663	2,663	2,663	2,824	2,873	2,929	2,999	2,999
Wind – Offshore - Class 4	0	0	0	0	0	0	0	0	0	0	0	0
Wind – Offshore - Class 5	0	0	0	0	0	0	0	0	0	0	0	0
Wind - Onshore	0	38	38	39	39	39	40	40	40	41	41	42
Solar – Residential PV	24	39	51	70	86	103	136	160	160	160	161	196
Solar – Commercial PV	13	19	25	33	42	52	64	81	81	81	90	107

	RE Annual Generation – Mid Favorable for RE Scenario, Without RECs [GWh]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass – ADG – Farm Waste	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – ADG - WWTP	0	0	0	0	0	7	7	7	15	22	30	37
Biomass - LFG	477	506	544	588	655	730	819	923	1,028	1,132	1,221	1,303
Biomass – Solid Biomass - BIGCC	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – Solid Biomass – Co-Firing	372	372	372	372	372	372	745	745	745	1,117	1,117	1,117
Biomass – Solid Biomass – Direct Combustion	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252
Biomass – Solid Biomass - Repowering	0	0	0	0	0	372	372	372	372	372	372	372
Biomass – Solid Biomass – Waste to Energy	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872
Ocean - Current	0	0	0	0	0	0	0	0	0	0	0	0
Solar - CSP	0	0	0	0	0	0	0	0	0	0	0	0
Solar – Ground Mounted PV	0	0	0	0	0	0	0	0	0	1,576	1,576	1,576
Solar – Water Heating	0	0	0	0	0	0	0	0	0	0	0	0
Waste Heat	2,593	2,663	2,684	2,705	2,740	2,782	2,831	2,901	2,985	3,084	3,210	3,350
Wind – Offshore - Class 4	0	0	0	0	0	0	0	0	0	0	0	0
Wind – Offshore - Class 5	0	0	0	0	0	0	0	0	0	0	0	0
Wind - Onshore	0	0	0	0	0	0	0	0	0	0	0	0
Solar – Residential PV	3	3	3	3	3	3	43	83	128	179	179	179
Solar – Commercial PV	0	1	2	5	8	13	25	36	48	70	70	70

	RE Annual Generation – Mid Favorable for RE Scenario, With RECs [GWh]											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass – ADG – Farm Waste	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – ADG - WWTP	0	0	0	0	0	7	7	7	15	22	30	37
Biomass - LFG	477	506	544	588	655	730	819	923	1,028	1,132	1,221	1,303
Biomass – Solid Biomass - BIGCC	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – Solid Biomass – Co-Firing	372	372	372	372	372	372	745	745	745	1,117	1,489	1,489
Biomass – Solid Biomass – Direct Combustion	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252
Biomass – Solid Biomass - Repowering	0	0	0	372	372	372	372	372	372	372	372	372
Biomass – Solid Biomass – Waste to Energy	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872	3,872
Ocean - Current	0	0	0	0	0	0	0	0	0	0	0	0
Solar - CSP	0	0	151	151	151	151	151	151	151	151	151	151
Solar – Ground Mounted PV	1,373	1,726	2,126	2,626	3,239	3,986	4,978	6,095	7,737	9,406	11,386	13,707
Solar – Water Heating	35	43	52	63	77	95	115	140	170	205	205	205
Waste Heat	2,593	2,663	2,684	2,705	2,740	2,782	2,831	2,901	2,985	3,084	3,210	3,350
Wind – Offshore - Class 4	0	0	0	0	0	0	0	0	0	0	0	0
Wind – Offshore - Class 5	0	0	0	0	0	0	0	0	0	0	0	0
Wind - Onshore	0	38	49	65	65	65	67	67	67	68	68	70
Solar – Residential PV	20	38	47	54	76	98	147	193	226	291	291	291
Solar – Commercial PV	11	18	23	27	35	43	59	72	81	112	112	112

	RE Annual Generation – Favorable for RE Scenario, Without RECs [GWh]											
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Biomass – ADG – Farm Waste	0	0	0	0	0	0	0	0	0	0	0	0
Biomass – ADG - WWTP	0	0	2	3	5	9	14	23	35	51	70	89
Biomass - LFG	541	604	689	797	921	1,052	1,177	1,284	1,369	1,432	1,477	1,507
Biomass – Solid Biomass - BIGCC	0	0	0	0	0	0	0	0	0	1,236	1,730	2,882
Biomass – Solid Biomass – Co-Firing	372	372	372	372	745	745	1,117	1,489	1,884	2,257	2,555	2,771
Biomass – Solid Biomass – Direct Combustion	4,507	4,684	4,684	4,684	6,684	7,834	9,423	11,54 4	11,54 4	11,544	11,54 4	11,54 4
Biomass – Solid Biomass - Repowering	0	0	0	0	0	372	372	372	372	372	372	372
Biomass – Solid Biomass – Waste to Energy	3,872	3,872	3,872	3,872	3,872	4,113	4,199	4,314	4,466	4,664	4,917	6,199
Ocean - Current	0	0	0	0	0	0	0	0	0	0	0	0
Solar - CSP	0	0	0	0	0	0	11	16	22	32	45	63
Solar – Ground Mounted PV	0	0	0	0	0	1,445	1,914	2,489	3,358	4,345	5,602	7,190
Solar – Water Heating	0	0	0	0	0	0	0	0	0	34	44	57
Waste Heat	2,593	2,661	2,689	2,728	2,782	2,855	2,954	3,084	3,252	3,461	3,711	3,995
Wind – Offshore - Class 4	0	0	0	0	0	0	0	0	0	0	0	0
Wind – Offshore - Class 5	0	0	0	0	0	0	0	0	0	0	0	0
Wind - Onshore	0	0	0	0	0	0	0	0	0	0	0	0
Solar – Residential PV	3	3	3	5	25	57	120	183	290	421	559	722
Solar – Commercial PV	0	2	4	8	14	23	38	55	72	100	134	204

RE Annual Generation – Favorable for RE Scenario, With RECs [GWh]												
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass – ADG – Farm Waste	0	0	0	0	0	0	0	0	0	0	45	52
Biomass – ADG - WWTP	0	0	0	0	7	7	15	22	37	52	67	89
Biomass - LFG	544	603	692	797	923	1,050	1,176	1,281	1,370	1,430	1,474	1,504
Biomass – Solid Biomass - BIGCC	0	0	0	0	0	0	0	0	1,169	1,668	2,323	3,857
Biomass – Solid Biomass – Co-Firing	372	372	372	372	745	745	1,117	1,117	1,862	2,256	2,554	2,770
Biomass – Solid Biomass – Direct Combustion	4,505	4,684	4,959	5,875	6,687	7,833	9,427	9,427	9,427	9,427	9,427	9,427
Biomass – Solid Biomass - Repowering	0	0	0	372	372	372	372	372	372	372	745	745
Biomass – Solid Biomass – Waste to Energy	3,872	3,872	3,872	3,872	3,872	4,113	4,199	4,314	4,466	4,664	4,917	6,199
Ocean - Current	0	0	0	0	0	0	0	0	0	0	0	0
Solar - CSP	0	0	151	151	151	151	151	151	151	151	151	151
Solar – Ground Mounted PV	1,373	1,818	2,354	3,055	3,955	5,101	6,660	8,504	11,21 7	14,110	17,57 4	21,63 7
Solar – Water Heating	35	44	57	74	95	121	155	196	246	307	380	465
Waste Heat	2,593	2,663	2,691	2,726	2,782	2,852	2,957	3,084	3,252	3,462	3,714	3,995
Wind – Offshore - Class 4	0	0	0	0	500	500	1,063	1,526	2,189	3,219	4,593	6,708
Wind – Offshore - Class 5	0	0	0	0	28	42	65	90	129	191	272	396
Wind - Onshore	0	38	54	76	107	149	210	286	384	519	670	860
Solar – Residential PV	27	27	47	83	126	166	268	377	472	579	905	2,018
Solar – Commercial PV	13	14	21	33	46	58	90	128	156	183	221	275

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Appendix

Below is a list of acronyms used by Navigant Consulting throughout the report.

Acronyms	Definitions
AC	Alternating Current
ADG	Anaerobic Digester Gas
BIGCC	Biomass Integrated Gasification Combined Cycle
CSP	Concentrating Solar Power
DC	Direct Current
GHG	Greenhouse Gas
GW	Gigawatt
GWh	Gigawatt hours
kW_{pAC}	Peak Kilowatts of Alternating Current (used for PV)
kWh_{AC}	Kilowatt hours of Alternating Current
kW_{pDC}	Peak Kilowatts of Direct Current (used for PV)
kWh_{DC}	Kilowatt hours of Direct Current
kW	Kilowatts
kWh	Kilowatt-hours
LCOE	Levelized Cost of Electricity[1]
LFG	Landfill Gas
LFGTE	Landfill Gas to Energy
MACRS	Modified Accelerated Cost Recovery System
MSW	Municipal Solid Waste
MW	MegaWatt

Acronyms	Definitions
MWh	MegaWatt-hours
NCI	Navigant Consulting, Inc.
NREL	National Renewable Energy Laboratory
O&M	Operation and Maintenance
OTEC	Ocean Thermal Energy Conversion
PPA	Power Purchase Agreement
PTC	Production Tax Credit
PV	Photovoltaic(s)
REC	Renewable Energy Certificate
RPS	Renewable Portfolio Standard
WWTP	Waste Water Treatment Plant

1. The LCOE is the total lifecycle cost, expressed in real (constant) dollars, of producing electricity from a given project. It includes all the capital charges, fuel, and non-fuel O&M costs over the economic life of the project. Annual capital charges are computed based on the discount rate, cost of equity, debt/equity ratio, tax rate, depreciation schedule, property tax and insurance requirements. Thus the annual capital charges will vary significantly for different entities such as municipal utilities vs. private developers.