SPO PLANNING ANALYSIS

GENERATION TECHNOLOGY ASSESSMENT

Technology Cost & Performance

OCTOBER 2014

Entergy®

TECHNOLOGY ASSESSMENT PROCESS & OVERVIEW

- An understanding of generation technology cost and performance is a necessary input to planning and decision support activities. SPO Planning Analysis monitors and assesses generation alternatives on an on-going basis. This analysis uses a **generic long-term capital structure** of 11.0% ROE and 7.0% long-term debt and assumes 50% equity and 50% debt.

- The process has **two main steps**. First a screening level analysis is performed and then a detailed analysis is performed.

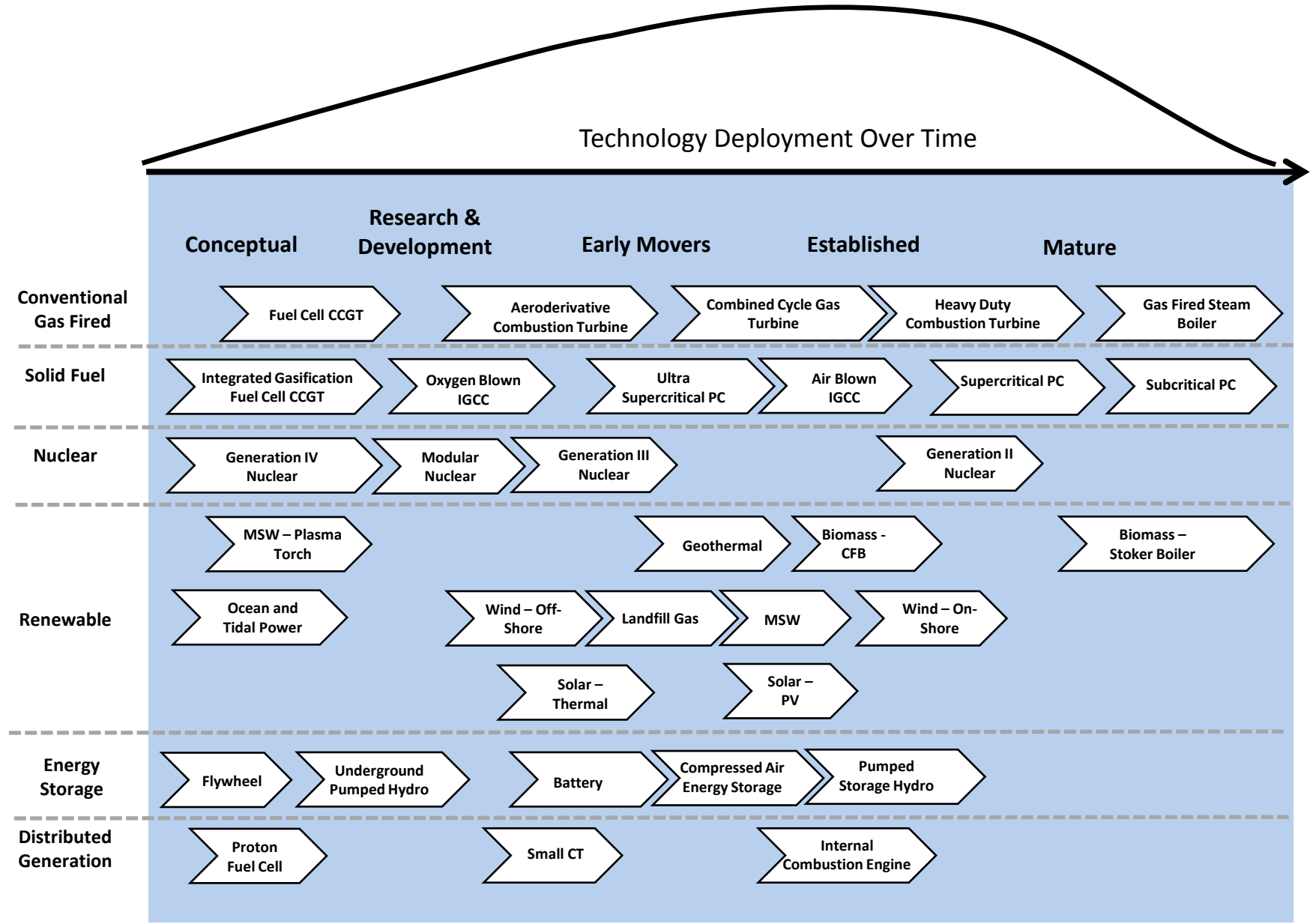
- The 2014 Generation Technology Assessment began by surveying available central state electricity generation technologies, generally those that are two megawatts or greater. The objective is to identify a reasonably wide a range of generation technologies. The initial list was subject to a screening analysis to identify generation technologies that are technologically mature and could reasonably be expected to be operational in or around the Entergy regulated service territory.

- The Entergy Operating Companies prefer technologies that are **proven on a commercial scale**. Some technologies identified in this document lack the commercial track record to demonstrate their technical and operational feasibility. A cautious approach to technology development and deployment is therefore reasonable and appropriate in order to maintain System reliability and to protect Operating Company customers from undue risks. The Entergy Operating Companies generally do not plan to be the "first movers" for emerging, unproven technologies.

- SPO Planning Analysis through this Technology Screen has selected certain traditional and renewable generation technology alternatives which may reasonably be expected to meet primary objectives of cost, risk mitigation, and reliability. For each selected technology Planning Analysis developed the necessary cost and performance parameter inputs into the detailed modeling used to develop the reference technologies comprising the IRP Portfolio.

- SPO Planning Analysis will monitor the technologies eliminated as a result of the initial screen and incorporate changes into future technology assessments and IRPs.

A Variety of Supply Side Resources Alternatives Are Available



TECHNOLOGIES SCREENED

- Pulverized Coal
  - Subcritical Pulverized Coal
  - Supercritical Pulverized Coal
  - Ultra Supercritical Pulverized Coal
- Fluidized Bed
  - Atmospheric Fluidized Bed
  - Pressurized Fluidized Bed
- Integrated Gasification ("IGCC")
  - Oxygen-Blown IGCC
  - Air-Blown IGCC
  - Integrated Gasification Fuel Cell Combined Cycle
- Combustion Turbine / Combined Cycle / Other Natural Gas
  - Combustion Turbine
  - Combined Cycle
  - Large & Small Scale Aeroderivative
  - Steam Boiler
- Fuel Cells
  - Molten Carbonate
  - Solid Oxide
  - Phosphoric Acid
  - Proton Exchange Membrane
  - Fuel Cell Combined Cycle
- Nuclear
  - Advanced Boiling Water Reactor
  - Generation IV
  - Modular Reactors
- Energy Storage
  - Pumped Hydro
  - Underground Pumped Hydro
  - Battery
  - Flywheel
  - Compressed Air Energy Storage
- Renewable Technologies
  - Biomass
  - Solar Photovoltaic (Fixed Tile and Tracking)
  - Solar Thermal
  - Wind Power
  - Municipal Solid Waste
  - Landfill Gas
  - Geothermal
  - Ocean & Tidal

Technologies Selected For Detailed Analysis

The following technologies are being carried forward for development of detailed planning assumptions

- Pulverized Coal
  - Supercritical Pulverized Coal with carbon capture and storage*
- Natural Gas Fired
  - Combustion Turbine ("CT")
  - Combined Cycle Gas Turbine ("CCGT")
  - Large Scale Aeroderivative CT
  - Small Scale Aeroderivative CT
  - Internal Combustion Engine

**Proposed EPA regulations on CO_2 have basically eliminated all new coal plants without carbon capture.*

- Nuclear
  - Advanced Boiling Water Reactor
- Renewable Technologies
  - Biomass
  - Wind Power
  - Solar PV (Fixed Tilt and Tracking)
- Battery Storage

Technology Assumptions for Combined Cycle Application

Cost & Performance Appropriate For Technology Deployment in MISO South		2x1 F Frame CCGT	2x1F Frame w/ Supplemental Capacity	2x1 G Frame CCGT	2x1G Frame w/ Supplemental Capacity
Net Max Capacity (Summer)	(MW)	587	764	746	932
Installed Cost, 2014 (Summer)	($/kW)[1]	$1,300	$1,045	$1,190	$985
Full Load Heat Rate (Summer)	(Btu/kWh)	6,750	7,180	6,620	7,030
Net Max Capacity (ISO)	(MW)	624	800	769	980
Installed Cost, 2014 (ISO)	($/kW)[1]	$1,220	$1,000	$1,155	$940
Full Load Heat Rate (ISO)	(Btu/kWh)	6,600	7,035	6,550	7,030
Typical Capacity Factor	(%)	65%-85%	65%-85%	65%-85%	65%-85%
Fixed O&M (Summer)	($/kW-yr)	$25.90	$20.10	$24.00	$19.90
Variable O&M (Summer)	($/MWh)	$1.50	$1.15	$1.50	$1.15
Inlet Air Conditioning Assumption		Evaporative Coolers			
NOx Control Technology		SCR	SCR	SCR	SCR
NOx emissions, post control	(lbs/MMBtu)	0.01	0.01	0.01	0.01

- Levelized 30 year gas price (reference case, real terms) is $4.94/mmbtu
- Supplemental capacity (duct firing) is valued at $250/kW

Technology Assumptions for Peaking Applications

Cost & Performance Appropriate For Technology Deployment in MISO South		F Frame CT	F Frame CT w/ SCR	E Frame CT	Large Aeroderivative CT	Internal Combustion
Net Max Capacity (Summer)	(MW)	194	194	76	102	18.8
Installed Cost, 2014	($/kW)[1]	$820	$915	$1,035	$1,275	$1,360
Full Load Heat Rate – Summer	(Btu/kWh)	10,200	10,400	13,200	9,125	8,440
Net Max Capacity (ISO)	(MW)	217	217	83	104	18.8
Installed Cost, 2014 (ISO)	($/kW)[1]	$735	$820	$950	$1,250	$1,360
Full Load Heat Rate (ISO)	(Btu/kWh)	9,931	10,130	11,800	8,960	8,325
Typical Capacity Factor	(%)	0%-10%	0%-40%	0%-5%	0%-40%	0%-40%
Fixed O&M	($/kW-yr)	$11.80	$12.80	$8.35	$13.20	$29.30
Variable O&M	($/MWh)	$0.50	$1.00	$0.50	$1.00	$2.25
Inlet Air Conditioning Assumption		-	-	-	Inlet Chillers	-
NOx Control Technology		Dry Low NOx burners	SCR	Dry Low NOx burners	SCR	SCR
NOx emissions, post control	(lbs/MMBtu)	0.03	0.01	0.03	0.01	0.01

- Levelized 30 year gas price (reference case, real terms) is $4.94/mmbtu

Technology Assumptions for Solid Fuel & Renewable Applications

		PC With 90% CCS	Biomass	Nuclear	Wind	Solar PV (fixed tilt)	Solar PV (tracking)	Battery Storage (Lead Acid Batteries)
Net Max Capacity	(MW)	800	100	1,310	200	100	100	50
Installed Cost, 2014	($/kW)[1]	$4,900	$4,760	$8,000	$2,050	$2,600	$2,900	$2,400
Full Load Heat Rate – Summer	(Btu/kWh)	13,200	12,900	10,200	-	-	-	-
Levelized Fuel Cost	($/mmbtu)	$3.12	$3.04	$0.90	-	-	-	-
Typical Capacity Factor	(%)	85%	85%	90%	34%	18%	21%	20%
Fixed O&M	($/kW-yr)	$140.00	$104.60	$115.60	$22.10	$19.00	$23.00	$0.00
Charging Cost	($/MWh)	n/a	n/a	n/a	n/a	n/a	n/a	$25.00
Expected Useful Life		40	30	40	20	25	25	20

- Capacity for these technologies is not significantly affected by ambient air temperature
- All O&M is considered fixed.

Lifecycle Resource Cost, Levelized Nominal $/MWh For 2015 Resources

Based on Generic Cost of Capital[4]		No CO_2			With CO_2		
Technology	Capacity Factor	Reference Fuel	High Fuel	Low Fuel	Reference Fuel	High Fuel	Low Fuel
F Frame CT	10%	$198	$224	$179	$204	$230	$184
F Frame CT w/ SCR	20%	$141	$167	$121	$146	$173	$126
E Frame CT	10%	$240	$274	$215	$247	$281	$222
Large Aeroderivative CT	40%	$108	$131	$91	$113	$136	$95
Small Aeroderivative CT	40%	$125	$150	$106	$130	$156	$112
Internal Combustion	40%	$115	$137	$99	$120	$141	$104
2x1 F Frame CCGT	65%	$79	$97	$67	$83	$100	$70
2x1 F Frame CCGT w/ Supplemental	65%	$75	$93	$61	$78	$97	$65
2x1 G Frame CCGT	65%	$76	$93	$63	$79	$96	$67
2x1 G Frame CCGT with Supplemental	65%	$72	$90	$59	$76	$94	$63
1x1 F Frame CCGT	65%	$82	$100	$69	$86	$104	$73
PC With CCS	85%	$163	$230	$94	$165	$232	$96
Biomass	85%	$175	$321	$142	$175	$321	$142
Nuclear	90%	$157	$169	$157	$157	$169	$157
Wind (No Subsidy)[1]	34%	$115	$115	$115	$115	$115	$115
Wind (Ten Yr. $22/MWh PTC)[1]	34%	$102	$102	$102	$102	$102	$102
Solar PV with 30% ITC (fixed tilt)[2]	18%	$190	$190	$190	$190	$190	$190
Solar PV with 30% ITC (tracking)[2]	21%	$179	$179	$179	$179	$179	$179
Battery Storage[3]	20%	$217	$217	$217	$217	$217	$217

1. Includes capacity match-up cost $47.88/MWh due to wind's 14.1% capacity value in MISO
2. Includes capacity match-up cost of $23.57/MWh assuming a 25.0% capacity value in MISO
3. Includes cost of $25/MWh required to charge batteries.
4. Includes capacity Levelized Nominal Lifecycle Cost of Resources Deployed in 2015, $/MWh
5. CO_2 Beginning 2023 $7.54/U.S. Ton Nominal $, Reaches $66.44/ton in 2043

Additional Supply Considerations

Schedule and location can influence which technology is preferred for a given application

Technology	Time to Market	Environmental	Gas Supply	Flexibility
CCGT	◐	●	◐	◐
Frame CT w/ SCR	◕	●	◐	◐
Small Aeroderivative	●	●	○	◕
Large Aeroderivative	◕	●	○	◕
Internal Combustion Engine	●	◐	●	●
Nuclear	○	◕		○
Coal	◔	○		●
Wind	●	●		○
Solar	●	●		○
Biomass	◐	●		◐
Considerations included in category	• Permitting Requirements • Lead time of major components • Engineering Required • Installation Time	• Impact of Non-Attainment Zone • NOx Emissions • SOx Emissions • COx Emissions • Residual Fuel	• Gas Pressure Required	• Ramp Rate • Turndown Ratio • Start Time • Performance at Part Load

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Relatively best — Relatively worst

Considerations are scored relative to each other

Capital Cost Projections

Capital Cost Installed (Nominal)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
F Frame CT	$820	$838	$860	$885	$918	$951	$982	$1,001	$1,027	$1,040	$1,056	$1,077
F Frame CT with SCR	$915	$935	$960	$988	$1,024	$1,061	$1,095	$1,117	$1,146	$1,160	$1,179	$1,202
E Frame CT	$1,035	$1,058	$1,086	$1,118	$1,158	$1,200	$1,239	$1,264	$1,296	$1,312	$1,333	$1,360
Small Aeroderivative	$1,550	$1,585	$1,626	$1,674	$1,735	$1,797	$1,856	$1,893	$1,941	$1,966	$1,997	$2,036
Large Aeroderivative	$1,275	$1,303	$1,337	$1,377	$1,427	$1,478	$1,526	$1,557	$1,597	$1,617	$1,642	$1,675
Internal Combustion	$1,360	$1,390	$1,400	$1,425	$1,476	$1,537	$1,580	$1,624	$1,670	$1,710	$1,751	$1,786
2x1 F Frame CCGT	$1,300	$1,329	$1,347	$1,379	$1,432	$1,492	$1,538	$1,577	$1,616	$1,639	$1,751	$1,786
2x1 F Frame CCGT w/ supplemental	$1,045	$1,068	$1,083	$1,108	$1,151	$1,199	$1,237	$1,268	$1,299	$1,317	$1,669	$1,702
2x1 G Frame CCGT	$1,190	$1,217	$1,233	$1,262	$1,311	$1,366	$1,408	$1,443	$1,479	$1,500	$1,342	$1,368
2x1 G Frame CCGT w/ supplemental	$985	$1,007	$1,020	$1,045	$1,085	$1,131	$1,166	$1,195	$1,224	$1,242	$1,528	$1,558
1x1 F Frame CCGT	$1,350	$1,380	$1,398	$1,432	$1,487	$1,549	$1,597	$1,638	$1,678	$1,702	$1,733	$1,768
PC With CCS	$4,905	$5,015	$5,043	$5,130	$5,308	$5,524	$5,673	$5,836	$6,009	$6,176	$6,335	$6,462
Biomass	$4,760	$4,867	$4,894	$4,978	$5,152	$5,361	$5,505	$5,664	$5,831	$5,993	$6,148	$6,271
Nuclear	$8,000	$8,179	$8,391	$8,638	$8,953	$9,276	$9,578	$9,769	$10,020	$10,145	$10,305	$10,511
Wind (no subsidy) [1]	$2,050	$2,075	$2,087	$2,061	$2,131	$2,203	$2,279	$2,334	$2,408	$2,472	$2,537	$2,588
Solar PV (fixed tilt)[2]	$2,600	$2,361	$2,178	$2,050	$1,976	$1,914	$1,861	$1,819	$1,785	$1,760	$1,738	$1,723
Solar PV (tracking)[2]	$2,900	$2,633	$2,429	$2,286	$2,204	$2,135	$2,076	$2,029	$1,991	$1,963	$1,939	$1,922
Battery Storage	$2,400	$2,453	$2,471	$2,515	$2,605	$2,712	$2,789	$2,865	$2,946	$3,017	$3,090	$3,151

1. Does not include any Production Tax Credits
2. Includes Investment Tax Credit of 30%