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Separation of Functions and Communications Protocol
Applicable to Southern Power Company ("Separation Protocol")

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PREFACE

The Generation Technology Data Book (GTDB) is published annually by Southern Company Operations staff to provide input for evaluating viable generation technologies for inclusion in expansion plans for meeting future electric power generation needs. The information provided in the GTDB is intended for retail generation planning purposes only. All users of this information should have prior expressed consent from Generation Planning & Development and adhere to the confidentiality notice and separation protocol stated above.

CHANGES TO THIS VERSION OF THE GTDB INCLUDE:

- Technologies included were updated based on prior screening
- All capital and O&M pricing has been updated where possible

Values highlighted in yellow are considered **CONFIDENTIAL** and **TRADE SECRET** and will be redacted in any publicly available versions.

ACKNOWLEDGEMENTS

Appreciation is extended to the following individuals for their contributions in developing the information presented in this document.

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Generation Technology Data Book

Prepared by:

Generation Planning & Development

Technical Assistance by:

Engineering & Construction Services

Research & Development

Published:

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CONTENTS

STANDARD ASSUMPTIONS

The information provided in the Generation Technology Data Book is intended for retail generation planning purposes only. It represents the average cost and performance data for the "nth" deployment of a technology on a "generic" site. It does not include any site-specific conditions as those may cause the cost and performance data to vary widely. Although certain capital cost estimates (e.g. combined cycle) may be more accurate than others (e.g. nuclear and biomass), they should all be considered screening level because they are used concurrently for evaluating future generation technologies.

The following descriptions contain the standard assumptions for each technology unless otherwise noted in that individual section.

A. Performance Conditions

Unit outputs are net of station service.

1. Ambient Conditions

The following ambient conditions are assumed when calculating unit performance:

Season	Temperature (°F)	Relative Humidity (%)
Average Annual	**REDACTED**	**REDACTED**
Summer Peaking	**REDACTED**	**REDACTED**
Winter Peaking	**REDACTED**	**REDACTED**

2. New and Clean vs Degraded

All types of generators will experience some type of degradation at times during the life of the asset. To illustrate this performance loss, two sets of cost and performance data are included in this document; 'New and Clean' and 'Degraded.'

New and Clean values represent the best performance that can be achieved after initial startup of the asset. This assumes that performance has not yet been affected by any type of non-recoverable loss incurred as the asset continues to operate.

Degraded values represent the decreased performance of the asset factoring in the non-recoverable losses incurred during the normal operation of the asset. These non-recoverable losses cannot be recuperated through maintenance procedures. They are attributed to continuous thermal, mechanical, and environmental impacts that can result in changes to clearances, seals, and surfaces of the machinery and reduced performance of electrical components. Some factors that contribute to non-recoverable losses are:

- Air and fuel quality
- Proximity to dirt roads, sea coast, chemical plants, and cooling towers
- Maintenance practices
- Frequency of on-line and off-line water washes

- Number of starts, trips, and load swings
- Instrument calibration

3. Combustion Turbines (CT) Technologies

Combustion Turbine based technologies (Simple Cycle and Combined Cycle) assume the following conditions:

- **REDACTED** site elevation (**REDACTED** to CT centerline)
- **REDACTED** in use above **REDACTED** with **REDACTED** effectiveness
- Natural gas fuel (assumed natural gas compressor not required) with fuel gas heating to **REDACTED** .
- #2 Distillate oil fuel for oil based operations
- Fuel oil heating to **REDACTED**

B. Capital Costs

Project capital costs are grouped in one of the following three categories. They are expressed in the year specified and assume an immediate overnight commercial operation date. All per kW values are based on the summer peaking rating.

1. Engineering, Procurement, and Construction Cost (EPC)
2. Site Cost
3. Owner's Cost

1. EPC Cost

The EPC cost is equivalent in scope to what a turnkey contractor would quote for the project. The EPC costs include the following:

- All process equipment and materials associated with the plant (electrical scope to the high side of Generator Step-up Transformer (GSU), other terminal points for piping, etc. at the plant boundary line)
- Construction and construction management of all plant equipment and material (includes plant underground work and piling, all temporary construction related equipment, facilities and services)
- Plant engineering, project management and support services
- Gas metering and conditioning station for gas-fired technologies
- On-site rail spur for major equipment delivery and maintenance
- EPC cost contingency

2. Site Cost

Site related costs include the following components:

- Site preparation costs including site clearing and earthwork (excavation and backfill)
- Site improvements including site drainage, retention ponds, fencing, etc.
- Fuel storage and waste disposal area preparation
- One mile paved plant access road and paved plant parking lot
- Water source intake and pumping station
- Gas lateral and railroad beyond the plant boundary
- Assumed land cost ("Greenfield" site; plant proper, only)
- Costs associated with collector bus, breakers, and the connection line to the substation which are beyond the high side of the GSU (see diagram in Additional Included Costs)

3. Owner's Cost

Owner's costs include the following components:

- Start-up labor and materials
- Pre-Commercial Operation Date (COD) capital items such as plant vehicles, forklifts, carts, etc.

- Plant materials and supplies such as furniture, lab equipment and supplies, shop equipment, tools, test instruments, office equipment and supplies, etc.
- Pre-COD plant utilities and waste disposal
- Plant spare parts
- Project development costs including permitting, legal, public relations, taxes, insurance, etc.
- Electricity used during construction
- Net value of pre-COD fuel cost and revenue from test energy sales
- Taxes

C. O&M Costs

O&M models were developed based on knowledge of existing assets. O&M costs are categorized between fixed, variable, and capital expenditure costs. The scope of each cost is listed below. All O&M models assume a **REDACTED REDACTED REDACTED** to the extent applicable for the life of the plant.

- **FIXED:** Fixed O&M costs include plant personnel salaries and benefits, payroll taxes, property insurance, home office and management support but do not include the ad valorem taxes.
  - Fixed O&M rates are based on the summer peaking rating
- **VARIABLE:** Variable O&M costs include expenses for consumables, steam turbine maintenance, balance of plant maintenance, and all combustion turbine parts repair from scheduled major maintenance.
  - Variable O&M rates are based on the average annual rating and capacity factor.
- **CAPITAL EXPENDITURES FOR MAINTENANCE:** Capital expenditures for maintenance (CEM) include all new equipment parts or components from scheduled major maintenance and working capital.
  - CEM rates are based on the summer peaking rating

1. Asset Life

The expected lifespan of a newly deployed asset as referenced in this document is based upon adherence to the prescribed maintenance schedule and periodic upgrades of plant equipment. It is possible that the actual asset life may exceed the period referenced here. However the length of this extended life is unknown and cannot be guaranteed, therefore it is not included in any of the O&M calculations in this document.

2. Planned Maintenance

Planned Maintenance accounts for scheduled service time based on manufacturer recommendations for hours-based or starts-based maintenance. Different maintenance requirements will have different associated downtimes at milestone events. These downtimes have been averaged over the life of the asset to a representative number shown for each technology.

3. Unplanned Outages

EUOR is defined as the Equivalent Unplanned Outage Rate and is represented by the following formula:

EUOR = (Forced Outages) + (Unplanned Maintenance Outages) + (Unit Derates)

Note that EUOR does not account for planned maintenance outages.

The exception to the EUOR formula is for peaking units where EFORd, or Equivalent Forced Outage Rate at Demand, is the measurement of choice. EFORd represents the probability that the unit will not produce power when demanded.

D. Emissions

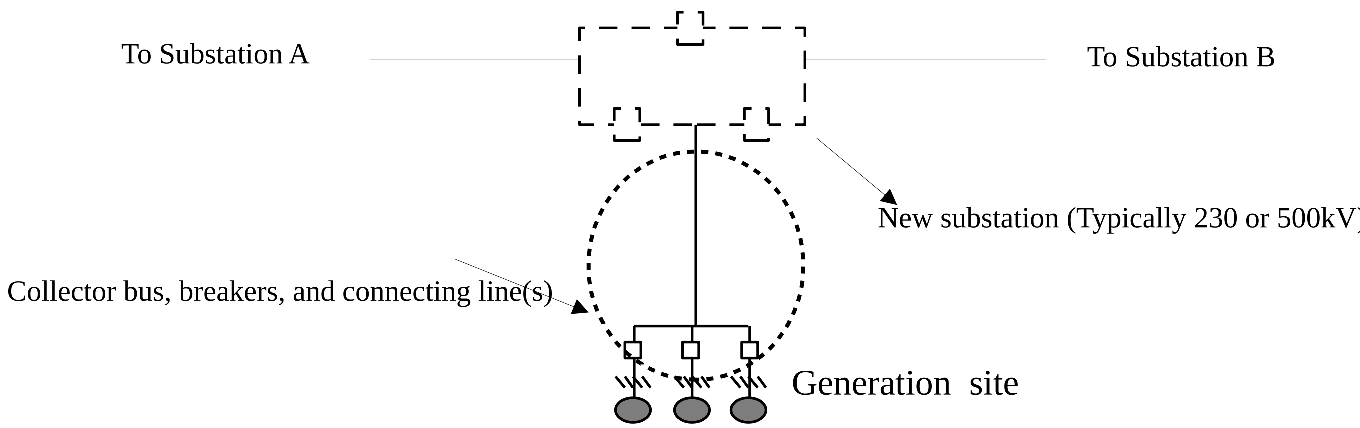
The emission estimates contained in this book should only be used to generally characterize emissions. The actual emission rates of a specific unit depend on many variables. Requirements for permits obtained in the future for each technology may vary from limitations used to develop the estimates shown here.

E. Additional Included Costs

Costs estimates were included for the items encompassed in the circle below and they are

- Required generating site facilities: the collector bus and breakers
- Transmission connecting line(s) which would be paid for by a generator in accordance with current industry practice

Generic Generation Site
Typical Connection Configuration



F. Excluded Costs

The following costs are not included in the Technology Data Book costs:

- Transmission system upgrades
- Initial fuel inventory
- Emission allowances or offsets
- Non-project specific general allocated overheads
- Allowance for Funds Used During Construction (AFUDC)

G. Project Schedules and Cash Flows

It should be noted that while generic indicative project schedules are provided, actual project schedules could vary based on the unique requirements of the project. The cash expenditure spread is expressed in percentages instead of the dollar amount to allow for differences between the expenditure spread and the schedule. The intent of the project expenditure data is to generically show when major outlays will happen (such as major equipment and construction costs), not to reflect all costs that may be necessary for a particular project or the exact time that they will occur.

Due to differences in technology deployments, site selection, and regulatory requirements, project schedules are only inclusive of permitting through COD. They do not include RFPs, additional monitoring, or jurisdictional specific regulatory requirements.

Due to variable project items such as pre-project activities, permitting activities, and post-project invoice spending, the project schedule and expenditure schedule may not be identical.

DATA SUMMARY (NEW AND CLEAN)

		Nuclear[1,2]	Biomass	Combined Cycle GT REDACTED Gas Only	Combined Cycle GT REDACTED Gas Only	Solar PV Single Axis	Solar PV Fixed Tilt
CAPACITY FACTOR	%	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
PEAKING OUTPUT	kW	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
PEAKING HEAT RATE	BTU/kWh	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
AVERAGE OUTPUT	kW	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
AVERAGE HEAT RATE	BTU/kWh	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
PLANT COST	$/kW	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
	$x1000	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
EPC COST	$/kW	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
	$x1000	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
SITE COST	$/kW	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
	$x1000	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
OWNER'S COST	$/kW	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
	$x1000	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
FIXED O&M	$/kW-yr	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
	$x1000	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
VARIABLE O&M	$/MWh	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
	$x1000	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
CAPITAL FOR MAINT.	$/kW-yr	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
	$x1000	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
STARTS PER YEAR	#	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
EUOR	%	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED

1 For planning purposes, the use of a range of costs for Nuclear may be appropriate. Recommended range +/- 10%
2 Nuclear assumes a 2-unit basis for all cost & performance data. All other technologies assume a single unit.

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DATA SUMMARY (NEW AND CLEAN)

		Simple Cycle GT REDACTED Gas Only	Simple Cycle GT REDACTED Gas Only	Simple Cycle GT REDACTED Dual Fuel	Simple Cycle GT REDACTED Dual Fuel
CAPACITY FACTOR	%	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
PEAKING OUTPUT	kW	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
PEAKING HEAT RATE	BTU/kWh	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
AVERAGE OUTPUT	kW	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
AVERAGE HEAT RATE	BTU/kWh	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
PLANT COST	$/kW	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
EPC COST	$/kW	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
SITE COST	$/kW	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
OWNER'S COST	$/kW	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
FIXED O&M	$/kW-yr	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
VARIABLE O&M	$/MWh	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
CAPITAL FOR MAINT.	$/kW-yr	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
STARTS PER YEAR	#	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
EFORd (Demand EFOR)	%	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**

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DATA SUMMARY (DEGRADED)

		Nuclear[1,2]	Biomass	Combined Cycle REDACTED Gas Only	Combined Cycle REDACTED Gas Only	Solar PV Single Axis	Solar PV Fixed Tilt
CAPACITY FACTOR	%	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
PEAKING OUTPUT	kW	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
PEAKING HEAT RATE	BTU/kWh	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
AVERAGE OUTPUT	kW	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
AVERAGE HEAT RATE	BTU/kWh	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
PLANT COST	$/kW	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
	$x1000	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
EPC COST	$/kW	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
	$x1000	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
SITE COST	$/kW	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
	$x1000	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
OWNER'S COST	$/kW	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
	$x1000	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
FIXED O&M	$/kW-yr	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
	$x1000	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
VARIABLE O&M	$/MWh	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
	$x1000	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
CAPITAL FOR MAINT.	$/kW-yr	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
	$x1000	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
STARTS PER YEAR	#	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
EUOR	%	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED

1 For planning purposes, the use of a range of costs for Nuclear may be appropriate. Recommended range +/- 10%
2 Nuclear assumes a 2-unit basis for all cost & performance data. All other technologies assume a single unit.

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DATA SUMMARY (DEGRADED)

		Simple Cycle GT REDACTED Gas Only	Simple Cycle GT REDACTED Gas Only	Simple Cycle GT REDACTED Dual Fuel	Simple Cycle GT REDACTED Dual Fuel
CAPACITY FACTOR	%	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
PEAKING OUTPUT	kW	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
PEAKING HEAT RATE	BTU/kWh	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
AVERAGE OUTPUT	kW	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
AVERAGE HEAT RATE	BTU/kWh	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
PLANT COST	$/kW	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
EPC COST	$/kW	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
SITE COST	$/kW	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
OWNER'S COST	$/kW	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
FIXED O&M	$/kW-yr	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
VARIABLE O&M	$/MWh	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
CAPITAL FOR MAINT.	$/kW-yr	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
STARTS PER YEAR	#	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**
EFORd (Demand EFOR)	%	**REDACTED**	**REDACTED**	**REDACTED**	**REDACTED**

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DISPATCHABLE GENERATION

Dispatchable generation includes those technologies that can be turned on or off and ramped up or down at the discretion of the system operator to meet system load. Although minimum up and down times, ramp rates, and dispatch boundaries may apply, those criteria do not affect the decision for inclusion in this category.

Some examples of traditional technologies in this category are:

Natural Gas Combined Cycle
Natural Gas Simple Cycle
Nuclear
Biomass

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NUCLEAR
REDACTED

PLANT DESCRIPTION AND DATA SUMMARY

I. GENERAL DESCRIPTION OF THE PLANT

- The **REDACTED** is an advanced **REDACTED** nuclear power plant that uses passive safety systems and simplicity of design to enhance plant safety and operations. The **REDACTED** Nuclear Steam Supply System (NSSS) plant configuration consists of **REDACTED** steam generators, **REDACTED** connected to the reactor pressure vessel by **REDACTED** There are **REDACTED** reactor coolant pumps that provide circulation of the reactor coolant for heat removal. A pressurizer is connected to **REDACTED** regulate pressure in the Reactor Coolant System (RCS). The NSSS is driving a **REDACTED REDACTED** steam turbine **REDACTED** Plant cost basis and features include:
- **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**
- **REDACTED REDACTED** Standby Diesel Generators (*non-safety related*) **REDACTED**
- Fuel design is based on **REDACTED** standard designs **REDACTED REDACTED REDACTED REDACTED**
- **REDACTED** reactor coolant pumps, **REDACTED REDACTED REDACTED REDACTED**
- Circulating water system, **REDACTED REDACTED REDACTED REDACTED**
- Plant systems, structures, and components including the support facilities needed to operate the plant (maintenance shop, offices, training center, warehouses, water intake structures, water-treatment facilities, etc.)

II. STATE OF THE TECHNOLOGY

Asset Life (Years)	**REDACTED**

- **REDACTED REDACTED**

A. Technology Forecast

Widely Available Commercial Operation	**Present**	**2019+**
Representative Technology:	**Certified Designs** Westinghouse AP1000 GE ESBWR *(Economic Simplified Boiling Water Reactor*) **NRC Review Suspended/Delayed** Areva (*Framtome*) (*Evolutionary Pressurized Water Reactor*) Mitsubishi US-APWR	**Certified Designs** Westinghouse AP1000 GE ESBWR *(Economic Simplified Boiling Water Reactor*) Korea Hydro & Nuclear Power (KHNP) APR-1400 NuScale Power Module (SMR) Mitsubishi US-APWR **Potential Design Certifications** Westinghouse SMR Holtec SMR-160 B&W mPower SMR **NRC Review Suspended/Delayed** Areva (*Framtome*) (*Evolutionary Pressurized Water Reactor*)

III. HEAT RATE AND OUTPUT

NEW AND CLEAN CONDITIONS

	Net Plant Heat Rate Btu/kWh	Net Unit Output kW
Peaking Condition	**REDACTED**	**REDACTED**
Annual Average	**REDACTED**	**REDACTED**
75%	**REDACTED**	**REDACTED**
50%	**REDACTED**	**REDACTED**
25%	**REDACTED**	**REDACTED**

Basis for Heat Rate and Output Data:

- Plant will be base loaded and not adjusted for peaking or operation at reduced power
  - Peaking condition vs annual average is representative of changes in seasonal ambient conditions
- Refer to Standard Assumptions in Introduction for additional detail

IV. CAPITAL COSTS

NEW AND CLEAN CONDITIONS

Project Spending (Years)	**REDACTED**

REDACTED REDACTED

	Per Kilowatt	Total
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Total Cost)		**REDACTED**

Basis for Plant Costs:

- Plant costs are overnight costs as of 7/1/2018
- Per kW costs based on the **REDACTED** rating
- Plant costs are being referenced to the **REDACTED REDACTED REDACTED REDACTED REDACTED** for budgetary purposes only
- Cost includes EPC Contract Price, Site Costs, Owner's Costs (including licensing and pre-contract activities), and additional scope change items
- Refer to Standard Assumptions in Introduction for additional detail

V. O&M COSTS

NEW AND CLEAN CONDITIONS

Asset Life (Years)	**REDACTED**
Capacity Factor	**REDACTED**
Starts per Year	**REDACTED**

Planned Maintenance (Days/18 month refuel cycle)	**REDACTED**
EUOR	**REDACTED**

Fixed O&M Costs

$/kW-Yr	**REDACTED**
Total/Yr	**REDACTED**

Variable O&M Costs

$/MWh	**REDACTED**
Total $/Yr	**REDACTED**

Capital Expenditures for Maintenance

$/kW-Yr	**REDACTED**
Total/Yr	**REDACTED**

Basis for O&M Costs:

- O&M costs are in 7/1/2018 dollars
- FOM costs are based on the **REDACTED** rating
- VOM costs for a Nuclear facility are assumed to be negligible
- Because nuclear units are base loaded, the number of starts per year will be as low as possible
- Refer to Standard Assumptions in Introduction for additional detail

VI. EMISSIONS

Standby and Ancillary Diesel Generators

REDACTED REDACTED REDACTED REDACTED

Pollutant Discharged	Lbs (per unit)
Particulate	**REDACTED**
Sulfur oxide	**REDACTED**
Carbon Monoxide (CO)	**REDACTED**
Hydrocarbons	**REDACTED**
Nitrogen Oxides (NO_X)	**REDACTED**

Basis for Emissions Data:

- **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**
- No. 2 Fuel Oil
- Emissions are based on **REDACTED** for each of the generators per unit
- These emissions estimates should only be used to generally characterize emissions
- Permits obtained in the future for this technology will require more stringent emission limitations than the estimates shown above

VII. INDICATIVE SPENDING SCHEDULE

The intent of the project expenditure data is to generically show when major expenditures (such as major equipment and construction costs) will happen, not to reflect all costs that may be necessary for a particular project.

Yearly Expenditure Data			
Year	Unit 1	Unit 2	Total
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**	**REDACTED**
Total	**REDACTED**	**REDACTED**	**REDACTED**

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VIII. INDICATIVE PROJECT SCHEDULE

REDACTED

REDACTED

BIOMASS
REDACTED

PLANT DESCRIPTION AND DATA SUMMARY

I. GENERAL DESCRIPTION OF THE PLANT

The power generating facility is based on a Jacobs study utilizing a **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**

The fuel blend is expected to be a maximum particle size of 3", although an onsite Hog, or grinder, for resizing larger particles is included in the design. Continuous delivery of biomass fuel would be scheduled to support the expected run profile. Two redundant storage piles are maintained as backup for up to **REDACTED** of operation without additional deliveries.

Plant cost basis and features include:

- Selective non-catalytic reduction (SNCR) system
- **REDACTED** steam turbine generator
- Air quality control systems (AQCS) including a selective non-catalytic reduction (SNCR) system, **REDACTED** , and a baghouse
- Material handling system for wood and ash and all associated appurtenances
- **REDACTED** of regenerative feedwater heating will be utilized
- Surface condenser
- **REDACTED** cooling tower
- Wood unloading facility
- Fly ash conveying and storage system
- Condensate storage and transfer system
- **REDACTED** cooling system
- Fire protection system
- Instrument compressed air system
- Plant drains
- Potable water distribution system
- Sanitary waste collection system
- Plant DCS

II. STATE OF THE TECHNOLOGY

Asset Life (Years)	**REDACTED**

This is a mature technology and currently available.

III. HEAT RATE AND OUTPUT

NEW AND CLEAN CONDITIONS

Case	**REDACTED REDACTED REDACTED**	**REDACTED REDACTED**	**REDACTED REDACTED REDACTED**
Gross Plant Output kW	**REDACTED**	**REDACTED**	**REDACTED**
Plant Aux Power kW	**REDACTED**	**REDACTED**	**REDACTED**
Plant Aux Power percent	**REDACTED**	**REDACTED**	**REDACTED**
Net Plant Output kW	**REDACTED**	**REDACTED**	**REDACTED**
Boiler Efficiency, HHV percent	**REDACTED**	**REDACTED**	**REDACTED**
NPHR, HHV Btu/kWh	**REDACTED**	**REDACTED**	**REDACTED**

Basis for Heat Rate Data and Output Data:

- Refer to Standard Assumptions in Introduction for additional detail

DEGRADED CONDITIONS

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

Case	**REDACTED REDACTED REDACTED**	**REDACTED REDACTED**	**REDACTED REDACTED REDACTED**
Gross Plant Output kW	**REDACTED**	**REDACTED**	**REDACTED**
Plant Aux Power kW	**REDACTED**	**REDACTED**	**REDACTED**
Plant Aux Power percent	**REDACTED**	**REDACTED**	**REDACTED**
Net Plant Output kW	**REDACTED**	**REDACTED**	**REDACTED**
Boiler Efficiency, HHV percent	**REDACTED**	**REDACTED**	**REDACTED**
NPHR, HHV Btu/kWh	**REDACTED**	**REDACTED**	**REDACTED**

Basis for Heat Rate Data and Output Data:

- Refer to Standard Assumptions in Introduction for additional detail

IV. CAPITAL COSTS

NEW AND CLEAN CONDITIONS

Project Spending (Years)	**REDACTED**

	Per Kilowatt	Total
EPC	**REDACTED**	**REDACTED**
Site	**REDACTED**	**REDACTED**
Owner's	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

DEGRADED CONDITIONS

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

	Per Kilowatt	Total
EPC	**REDACTED**	**REDACTED**
Site	**REDACTED**	**REDACTED**
Owner's	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

Basis for Plant Costs:

- Plant costs are overnight costs as of 7/1/2018
- Refer to Standard Assumptions in Introduction for additional detail
- Costs per kW are estimated at **REDACTED REDACTED REDACTED REDACTED**
- An EPC/Turnkey project execution methodology is assumed. SCS will procure the long-lead equipment, such as the boiler, STG, fuel handling equipment, and the emission

control filter and will assign these contracts to the EPC contractor. The EPC contractor will erect all equipment and provide the overall power plant performance guarantee.

V. O&M COSTS

NEW AND CLEAN CONDITIONS

Asset Life (Years)	**REDACTED**
Capacity Factor	**REDACTED**
Starts per Year	**REDACTED**

Planned Maintenance (Wks/Yr)	**REDACTED**
EUOR	**REDACTED**

Fixed O&M

$/kW-Yr	**REDACTED**
Total/Yr	**REDACTED**

Variable O&M

$/MWh	**REDACTED**
Total/Yr	**REDACTED**

Capital Expenditures for Maintenance

$/kW-Yr	**REDACTED**
Total/Yr	**REDACTED**

DEGRADED CONDITIONS

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

Fixed O&M Costs

$/kW-Yr	**REDACTED**
Total/Yr	**REDACTED**

Variable O&M Costs

$/MWh	**REDACTED**
Total/Yr	**REDACTED**

Capital Expenditures for Maintenance

$/kW-Yr	**REDACTED**
Total/Yr	**REDACTED**

Basis for O&M Costs:

- O&M costs are in 7/1/2018 dollars
- Refer to Standard Assumptions in Introduction for additional detail

VI. EMISSIONS

NEW AND CLEAN CONDITIONS

Particulate matter	**REDACTED**
Nitrogen oxides (NO_X)	**REDACTED**
Sulfur dioxide (SO_2)	**REDACTED**
Carbon monoxide (CO)	**REDACTED**
Volatile Organic Compounds (VOC)	**REDACTED**

- Refer to Standard Assumptions in Introduction for additional detail

VII. INDICATIVE SPENDING SCHEDULE

The intent of the project expenditure data is to generically show when major expenditures (such as major equipment and construction costs) will happen, not to reflect all costs that may be necessary for a particular project.

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

RETURN TO TABLE OF CONTENTS RETURN TO TOP OF SECTION

Month	Monthly	Cumulative
REDACTE D	**REDACTED**	**REDACTED**
REDACTE D	**REDACTED**	**REDACTED**
REDACTE D	**REDACTED**	**REDACTED**
REDACTE D	**REDACTED**	**REDACTED**
REDACTE D	**REDACTED**	**REDACTED**
REDACTE D	**REDACTED**	**REDACTED**
REDACTE D	**REDACTED**	**REDACTED**
REDACTE D	**REDACTED**	**REDACTED**
REDACTE	**REDACTED**	**REDACTED**

Month	Monthly	Cumulative
D		
REDACTE D	**REDACTED**	**REDACTED**
REDACTE D	**REDACTED**	**REDACTED**
REDACTE D	**REDACTED**	**REDACTED**
REDACTE D	**REDACTED**	**REDACTED**
REDACTE D	**REDACTED**	**REDACTED**
REDACTE D	**REDACTED**	**REDACTED**
REDACTE D	**REDACTED**	**REDACTED**

VIII. INDICATIVE PROJECT SCHEDULE

REDACTED

COMBINED CYCLE – NATURAL GAS ONLY
REDACTED
REDACTED

PLANT DESCRIPTION AND DATA SUMMARY

I. GENERAL DESCRIPTION OF THE PLANT

- The combined cycle unit is assumed to be located at a generic “Greenfield” site and is rated **REDACTED REDACTED** and **REDACTED REDACTED** at summer peaking conditions (**REDACTED**). Each unit utilizes advanced design large frame combustion turbine-generators **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED** heat recovery steam generators (HRSGs) **REDACTED REDACTED REDACTED REDACTED REDACTED** steam turbine, a steam condenser **REDACTED REDACTED** cooling tower **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**

IX. STATE OF THE TECHNOLOGY

Asset Life (Years)	**REDACTED**

This technology is currently available

A. Technology Forecast

Widely Available Commercial Operation	**2019+**
Representative Technology:	**REDACTED**
Average Annual Heat Rate (based on HHV)	**REDACTED**

Performance estimates based on the expected future technological advances

X. HEAT RATE AND OUTPUT

NEW AND CLEAN CONDITIONS (2X1)

Gas Operation	Net Plant Heat Rate (Based on HHV) Btu/kWh	Net Unit Output kW
Minimum @~50% CT Load Average Annual Conditions	REDACTED	REDACTED
Intermediate @ 75% CT Load Average Annual Conditions	REDACTED	REDACTED
Normal Operation 100% CT Load Average Annual Conditions	REDACTED	REDACTED
FP @ 100% CT Load Summer Peaking Conditions	REDACTED	REDACTED
FP @ 100% CT Load Winter Peaking Conditions	REDACTED	REDACTED

DEGRADED CONDITIONS (2X1)

Output Degradation	REDACTED
Heat Rate Degradation	REDACTED

Gas Operation	Net Plant Heat Rate (Based on HHV) Btu/kWh	Net Unit Output kW
Minimum @~50% CT Load Average Annual Conditions	REDACTED	REDACTED
Intermediate @ 75% CT Load Average Annual Conditions	REDACTED	REDACTED
Normal Operation 100% CT Load Average Annual Conditions	REDACTED	REDACTED
FP @ 100% CT Load Summer Peaking Conditions	REDACTED	REDACTED
FP @ 100% CT Load Winter Peaking Conditions	REDACTED	REDACTED

RETURN TO TABLE OF CONTENTS RETURN TO TOP OF SECTION

NEW AND CLEAN CONDITIONS (1X1)

Gas Operation	Net Plant Heat Rate (Based on HHV) Btu/kWh	Net Unit Output kW
Minimum @~50% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Intermediate @ 75% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Normal Operation 100% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
FP @ 100% CT Load Summer Peaking Conditions	**REDACTED**	**REDACTED**
FP @ 100% CT Load Winter Peaking Conditions	**REDACTED**	**REDACTED**

DEGRADED CONDITIONS (1X1)

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

Gas Operation	Net Plant Heat Rate (Based on HHV) Btu/kWh	Net Unit Output kW
Minimum @~50% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Intermediate @ 75% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Normal Operation 100% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
FP @ 100% CT Load Summer Peaking Conditions	**REDACTED**	**REDACTED**
FP @ 100% CT Load Winter Peaking Conditions	**REDACTED**	**REDACTED**

Basis for Heat Rate and Output Data:

- Refer to Standard Assumptions in Introduction for additional detail

XI. CAPITAL COSTS

NEW AND CLEAN CONDITIONS

Project Spending (Years)	**REDACTED**

REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

DEGRADED CONDITIONS

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

REDACTED REDACTED

	Per Kilowatt	**Total**
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

REDACTED

	Per Kilowatt	**Total**
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

REDACTED Basis for Plant Costs:

- Plant costs are overnight costs as of 7/1/2018
- Refer to Standard Assumptions in Introduction for additional detail

XII. O&M COSTS

NEW AND CLEAN CONDITIONS

Asset Life (Years)	**REDACTED**

	REDACTED	**REDACTED**
Capacity Factor	**REDACTED**	**REDACTED**
Starts per Year	**REDACTED**	**REDACTED**

Planned Maintenance (Wks/Yr)	**REDACTED**
EUOR	**REDACTED**

Fixed O&M

	REDACTED REDACTED	**REDACTED REDACTED**
$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Variable O&M

$/MWh	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Capital Expenditures for Maintenance

$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

DEGRADED CONDITIONS

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

Fixed O&M

	REDACTED REDACTED	**REDACTED REDACTED**
$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Variable O&M

$/MWh	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Capital Expenditures for Maintenance

$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Basis for O&M Costs:

- O&M costs are in 7/1/2018 dollars
- Refer to Standard Assumptions in Introduction for additional detail

XIII. EMISSIONS

NEW AND CLEAN CONDITIONS (**REDACTED**)

Emissions (Natural Gas)	ppm	lbs/mmbtu	lb/MWh
Carbon Monoxide (CO) with Catalyst	**REDACTED**	**REDACTED**	**REDACTED**
Carbon Dioxide (CO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Nitrogen Oxides (NO_X) with SCR	**REDACTED**	**REDACTED**	**REDACTED**
Particulate Matter (PM10 Front and Back Half)	**REDACTED**	**REDACTED**	**REDACTED**
Sulfur Dioxide (SO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Volatile Organics (VOC) with Catalyst	**REDACTED**	**REDACTED**	**REDACTED**

NEW AND CLEAN CONDITIONS (**REDACTED**)

Emissions (Natural Gas)	ppm	lbs/mmbtu	lb/MWh
Carbon Monoxide (CO) with Catalyst	**REDACTED**	**REDACTED**	**REDACTED**
Carbon Dioxide (CO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Nitrogen Oxides (NO_X) with SCR	**REDACTED**	**REDACTED**	**REDACTED**
Particulate Matter (PM10 Front and Back Half)	**REDACTED**	**REDACTED**	**REDACTED**
Sulfur Dioxide (SO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Volatile Organics (VOC) with Catalyst	**REDACTED**	**REDACTED**	**REDACTED**

Basis for Emissions Data:

- Values are **REDACTED**
- Natural gas emissions values reflect **REDACTED** ambient temperature, **REDACTED** load, **REDACTED REDACTED**, and **REDACTED REDACTED REDACTED**

RETURN TO TABLE OF CONTENTS RETURN TO TOP OF SECTION

- **REDACTED** exhaust constituents estimated with GateCycle model including conceptual HRSG, STG, and BOP
- **REDACTED** NO_X estimated at **REDACTED** lbs/mmbtu – HHV based on past projects
- **REDACTED** CO estimated at **REDACTED** lbs/mmbtu – HHV based on past projects
- **REDACTED** VOC as CH4 estimated at **REDACTED** lbs/mmbtu – HHV based on past projects
- Calculations use data provided by **REDACTED** at a site elevation of **REDACTED**
- SO2 emissions are estimated at .0006 lb/MMBtu per EPA AP-42 standard
- Values assume NO_X reduction through the SCR and CO and VOC reduction through the oxidation catalyst

XIV. INDICATIVE SPENDING SCHEDULE

The intent of the project expenditure data is to generically show when major expenditures (such as major equipment and construction costs) will happen, not to reflect all costs that may be necessary for a particular project.

Month	(Gas Only) Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACT	**REDACT**	**REDACTE**

Month	(Gas Only) Monthly	Cumulative
ED	**ED**	**D**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

(Gas Only)

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

XV. INDICATIVE PROJECT SCHEDULE

REDACTED

REDACTED

COMBINED CYCLE – DUAL FUEL
REDACTED
REDACTED

PLANT DESCRIPTION AND DATA SUMMARY

I. GENERAL DESCRIPTION OF THE PLANT

- See Natural Gas Only section

- **REDACTED REDACTED REDACTED** when operating on oil
- **REDACTED REDACTED** when operating on oil

XVI. STATE OF THE TECHNOLOGY

See Natural Gas Only section

A. Technology Forecast

See Natural Gas Only section

XVII. HEAT RATE AND OUTPUT

NEW AND CLEAN CONDITIONS (2X1)

Oil Operation	**Net Plant Heat Rate (Based on HHV) Btu/kWh**	**Net Unit Output kW**
Normal Operation 100% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Normal Operation 100% CT Load Summer Peaking Conditions	**REDACTED**	**REDACTED**
Normal Operation 100% CT Load Winter Peaking Conditions	**REDACTED**	**REDACTED**

DEGRADED CONDITIONS (2X1)

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

Oil Operation	**Net Plant Heat Rate (Based on HHV) Btu/kWh**	**Net Unit Output kW**
Normal Operation 100% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Normal Operation 100% CT Load Summer Peaking Conditions	**REDACTED**	**REDACTED**
Normal Operation 100% CT Load Winter Peaking Conditions	**REDACTED**	**REDACTED**

NEW AND CLEAN CONDITIONS (1X1)

Oil Operation	**Net Plant Heat Rate (Based on HHV) Btu/kWh**	**Net Unit Output kW**
Normal Operation 100% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Normal Operation 100% CT Load Summer Peaking Conditions	**REDACTED**	**REDACTED**
Normal Operation 100% CT Load Winter Peaking Conditions	**REDACTED**	**REDACTED**

DEGRADED CONDITIONS (1X1)

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

Oil Operation	**Net Plant Heat Rate (Based on HHV) Btu/kWh**	**Net Unit Output kW**
Normal Operation 100% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Normal Operation 100% CT Load Summer Peaking Conditions	**REDACTED**	**REDACTED**
Normal Operation 100% CT Load Winter Peaking Conditions	**REDACTED**	**REDACTED**

Basis for Heat Rate and Output Data:

- Performance guarantees are not provided by the manufacturers for oil operation unless requested. Overall plant performance estimates are therefore less accurate than on gas.
- Refer to Standard Assumptions in Introduction for additional detail

XVIII. CAPITAL COSTS

NEW AND CLEAN CONDITIONS

Project Spending (Years)	**REDACTED**

REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

DEGRADED CONDITIONS

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

REDACTED REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

REDACTED REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

REDACTED Basis for Plant Costs:

Plant costs are overnight costs as of 7/1/2018
Refer to Standard Assumptions in Introduction for additional detail

XIX. O&M COSTS

NEW AND CLEAN CONDITIONS

Asset Life (Years)	**REDACTED**

	REDACTED	**REDACTED**
Capacity Factor	**REDACTED**	**REDACTED**
Starts per Year	**REDACTED**	**REDACTED**

Planned Maintenance (Wks/Yr)	**REDACTED**
EUOR	**REDACTED**

Fixed O&M

	REDACTED REDACTED	**REDACTED REDACTED**
$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Variable O&M

$/MWh	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Capital Expenditures for Maintenance

$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

DEGRADED CONDITIONS

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

Fixed O&M

	REDACTED REDACTED	**REDACTED REDACTED**
$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Variable O&M

$/MWh	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Capital Expenditures for Maintenance

$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Basis for O&M Costs:

- O&M costs are in 7/1/2018 dollars
- Refer to Standard Assumptions in Introduction for additional detail

XX. EMISSIONS

NEW AND CLEAN CONDITIONS (**REDACTED**)

Emissions (Natural Gas)	ppm	lbs/mmbtu	lb/MWh
Carbon Monoxide (CO) with Catalyst	**REDACTED**	**REDACTED**	**REDACTED**
Carbon Dioxide (CO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Nitrogen Oxides (NO_X) with SCR	**REDACTED**	**REDACTED**	**REDACTED**
Particulate Matter (PM10 Front and Back Half)	**REDACTED**	**REDACTED**	**REDACTED**
Sulfur Dioxide (SO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Volatile Organics (VOC) with Catalyst	**REDACTED**	**REDACTED**	**REDACTED**

NEW AND CLEAN CONDITIONS (**REDACTED**)

Emissions (Natural Gas)	ppm	lbs/mmbtu	lb/MWh
Carbon Monoxide (CO) with Catalyst	**REDACTED**	**REDACTED**	**REDACTED**
Carbon Dioxide (CO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Nitrogen Oxides (NO_X) with SCR	**REDACTED**	**REDACTED**	**REDACTED**
Particulate Matter (PM10 Front and Back Half)	**REDACTED**	**REDACTED**	**REDACTED**
Sulfur Dioxide (SO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Volatile Organics (VOC) with Catalyst	**REDACTED**	**REDACTED**	**REDACTED**

Basis for Emissions Data:

- Values are **REDACTED**

- Oil emissions values reflect **REDACTED** ambient temperature, **REDACTED** load, **REDACTED**, and **REDACTED** exhaust constituents estimated with GateCycle model including conceptual HRSG, STG, and BOP
- **REDACTED** NO_X estimated at **REDACTED** lbs/mmbtu – HHV based on past projects
- **REDACTED** CO estimated at **REDACTED** lbs/mmbtu – HHV based on past projects
- **REDACTED** VOC as CH4 estimated at **REDACTED** lbs/mmbtu – HHV based on past projects
- Calculations use data provided by **REDACTED** at a site elevation of **REDACTED**
- SO_2 emissions are site and fuel specific
- Values assume NO_X reduction through the SCR and CO and VOC reduction through the oxidation catalyst

XXI. INDICATIVE SPENDING SCHEDULE

The intent of the project expenditure data is to generically show when major expenditures (such as major equipment and construction costs) will happen, not to reflect all costs that may be necessary for a particular project.

(Dual Fuel)

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
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REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACT	**REDACT**	**REDACTE**

(Dual Fuel)

Month	Monthly	Cumulative
ED	**ED**	**D**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
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REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
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REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

RETURN TO TABLE OF CONTENTS RETURN TO TOP OF SECTION

(Dual Fuel)

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

XXII. INDICATIVE PROJECT SCHEDULE

- See gas only projected schedule in previous section

SIMPLE CYCLE – NATURAL GAS ONLY
REDACTED
REDACTED

PLANT DESCRIPTION AND DATA SUMMARY

I. GENERAL DESCRIPTION OF THE PLANT

- These simple cycle units are assumed to be located at a generic “Greenfield” site. The model consists of **REDACTED REDACTED** large frame combustion turbine-generators **REDACTED REDACTED REDACTED**. Extensive factory modularization of systems and components results in low costs for peaking applications. The units utilize natural gas only. NO_X is controlled to 9 ppm by dry low NO_X combustors.

II. STATE OF THE TECHNOLOGY

Asset Life (Years)	**REDACTED**

- This peaking technology is currently available.

A. Technology forecast

Widely Available Commercial Operation	2019+
Representative Technology:	**REDACTED**
Peaking Heat Rate (based on HHV)	**REDACTED**

- Performance estimates based on the current trends as well as the anticipated equipment demand and technological enhancements

III. HEAT RATE AND OUTPUT

NEW AND CLEAN CONDITIONS (SINGLE UNIT)

Gas Operation	**Net Plant Heat Rate (Based on HHV) Btu/kWh**	**Net Unit Output kW**
Minimum @ ~30% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Intermediate @ 75% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Normal Operation @ 100% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Normal Operation @ 100% CT Load Summer Peaking Conditions	**REDACTED**	**REDACTED**
Normal Operation @ 100% CT Load Winter Peaking Conditions	**REDACTED**	**REDACTED**

DEGRADED CONDITIONS (SINGLE UNIT)

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

Gas Operation	**Net Plant Heat Rate (Based on HHV) Btu/kWh**	**Net Unit Output kW**
Minimum @ ~30% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Intermediate @ 75% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Normal Operation @ 100% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Normal Operation @ 100% CT Load	**REDACTED**	**REDACTED**

Summer Peaking Conditions		
Normal Operation @ 100% CT Load Winter Peaking Conditions	**REDACTED**	**REDACTED**

Basis for Heat Rate and Output Data:

- Refer to Standard Assumptions in Introduction for additional detail

IV. CAPITAL COSTS

NEW AND CLEAN CONDITIONS

Project Spending (Years)	**REDACTED**

REDACTED REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

REDACTED REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

DEGRADED CONDITIONS

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

REDACTED REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

REDACTED REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

Basis for Plant Cost:

- Plant costs are overnight costs as of 7/1/2018
- Refer to Standard Assumptions in Introduction for additional detail

V. O&M COSTS

NEW AND CLEAN CONDITIONS

Asset Life (Years)	**REDACTED**
Capacity Factor	**REDACTED**
Starts per Year	**REDACTED**

Planned Maintenance (Wks/Yr)	**REDACTED**
EFORd	**REDACTED**

Fixed O&M

	REDACTED REDACTED	**REDACTED REDACTED**
$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Variable O&M

$/MWh	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Capital Expenditures for Maintenance

$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

DEGRADED CONDITIONS

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

Fixed O&M

	REDACTED REDACTED	**REDACTED REDACTED**
$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Variable O&M

$/MWh	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Capital Expenditures for Maintenance

$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Basis for O&M Costs:

- O&M costs are in 7/1/2018 dollars
- Refer to Standard Assumptions in Introduction for additional detail

VI. EMISSIONS

NEW AND CLEAN CONDITIONS

Emissions (Natural Gas)	ppm	lbs/mmbtu	lb/MWh
Carbon Monoxide (CO)	**REDACTED**	**REDACTED**	**REDACTED**
Carbon Dioxide (CO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Nitrogen Oxides (NO_X)	**REDACTED**	**REDACTED**	**REDACTED**
Particulate Matter (PM10 Front and Back Half)	**REDACTED**	**REDACTED**	**REDACTED**
Sulfur Dioxide (SO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Volatile Organics (VOC)	**REDACTED**	**REDACTED**	**REDACTED**

Basis for Emissions Data:

- Values are **REDACTED**
- SO2 emissions are estimated **REDACTED** per EPA AP-42 standard
- Emissions values reflect **REDACTED** ambient temperature, **REDACTED** load **REDACTED**

VII. INDICATIVE SPENDING SCHEDULE

The intent of the project expenditure data is to generically show when major expenditures (such as major equipment and construction costs) will happen, not to reflect all costs that may be necessary for a particular project.

(GAS ONLY) **REDACTED**

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
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REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

RETURN TO TABLE OF CONTENTS RETURN TO TOP OF SECTION

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
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Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
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REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

(GAS ONLY) **REDACTED**

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
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REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDAC	**REDAC**	**REDAC**

Month	Monthly	Cumulat ive
TED	**TED**	**TED**
REDAC TED	**REDAC TED**	**REDAC TED**
REDAC TED	**REDAC TED**	**REDAC TED**
REDAC TED	**REDAC TED**	**REDAC TED**
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REDAC TED	**REDAC TED**	**REDAC TED**
REDAC TED	**REDAC TED**	**REDAC TED**
REDAC	**REDAC**	**REDAC**

RETURN TO TABLE OF CONTENTS RETURN TO TOP OF SECTION

Month	Monthly	Cumulative
TED	**TED**	**TED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

VIII. INDICATIVE PROJECT SCHEDULE

REDACTED

REDACTED

SIMPLE CYCLE – DUAL FUEL
REDACTED
REDACTED

PLANT DESCRIPTION AND DATA SUMMARY

I. GENERAL DESCRIPTION OF THE PLANT

See Natural Gas Only section

II. STATE OF THE TECHNOLOGY

See Natural Gas Only section

A. Technology Forecast

See Natural Gas Only Section

III. HEAT RATE AND OUTPUT

NEW AND CLEAN CONDITIONS (SINGLE UNIT)

For natural gas performance see the natural gas only information in previous section

Oil Operation	**Net Plant Heat Rate (Based on HHV) Btu/kWh**	**Net Unit Output kW**
Normal Operation @ 100% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Normal Operation @ 100% CT Load Summer Peaking Conditions	**REDACTED**	**REDACTED**
Normal Operation @ 100% CT Load Winter Peaking Conditions	**REDACTED**	**REDACTED**

DEGRADED CONDITIONS (SINGLE UNIT)

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

Oil Operation	**Net Plant Heat Rate (Based on HHV) Btu/kWh**	**Net Unit Output kW**
Normal Operation @ 100% CT Load Average Annual Conditions	**REDACTED**	**REDACTED**
Normal Operation @ 100% CT Load Summer Peaking Conditions	**REDACTED**	**REDACTED**
Normal Operation @ 100% CT Load Winter Peaking Conditions	**REDACTED**	**REDACTED**

Basis for Heat Rate and Output Data:

- Performance guarantees are not provided by the manufacturers for oil operation unless requested. Overall plant performance estimates are therefore less accurate than on gas.
- Refer to Standard Assumptions in Introduction for additional detail

IV. CAPITAL COSTS

NEW AND CLEAN CONDITIONS

Project Spending (Years)	**REDACTED**

REDACTED REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

REDACTED REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

DEGRADED CONDITIONS

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

REDACTED REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

REDACTED REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

Basis for Plant Cost:

- Plant costs are overnight costs as of 7/1/2018
- Refer to Standard Assumptions in Introduction for additional detail

V. O&M COSTS

NEW AND CLEAN CONDITIONS

Asset Life (Years)	**REDACTED**
Capacity Factor	**REDACTED**
Starts per Year	**REDACTED**

Planned Maintenance (Wks/Yr)	**REDACTED**
EFORd	**REDACTED**

Fixed O&M

	REDACTED REDACTED	REDACTED REDACTED
$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Variable O&M

$/MWh	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Capital Expenditures for Maintenance

$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

DEGRADED CONDITIONS

For gas conditions see the natural gas only information in previous section

	Oil
Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

Fixed O&M

	REDACTED REDACTED	**REDACTED REDACTED**
$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Variable O&M

$/MWh	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Capital Expenditures for Maintenance

$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Basis for O&M Costs:

- O&M costs are in 7/1/2018 dollars
- Refer to Standard Assumptions in Introduction for additional detail

VI. EMISSIONS

NEW AND CLEAN CONDITIONS

Emissions (Oil)	ppm	lbs/mmbtu	lb/MWh
Carbon Monoxide (CO)	**REDACTED**	**REDACTED**	**REDACTED**
Carbon Dioxide (CO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Nitrogen Oxides (NO_X)	**REDACTED**	**REDACTED**	**REDACTED**
Particulate Matter (PM10 Front and Back Half)	**REDACTED**	**REDACTED**	**REDACTED**
Sulfur Dioxide (SO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Volatile Organics (VOC)	**REDACTED**	**REDACTED**	**REDACTED**

Basis for Emissions Data:

- Values are **REDACTED**
- SO_2 emissions are site and fuel specific
- These emission estimates should only be used to generally characterize emissions. Permits obtained in the future for this technology may require more stringent emission limitations than the estimates shown above.
- Sulfur content in Oil is assumed to be **REDACTED** (Ultra Low Sulfur Diesel)
- Oil emissions values reflect **REDACTED** ambient temperature, **REDACTED** load **REDACTED**

VII. INDICATIVE SPENDING SCHEDULE

The intent of the project expenditure data is to generically show when major expenditures (such as major equipment and construction costs) will happen, not to reflect all costs that may be necessary for a particular project.

(DUAL FUEL) **REDACTED**

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
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REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
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REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

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Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

(DUAL FUEL) **REDACTED**

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
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REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
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REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

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Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACT	**REDACT**	**REDACT**

Month	Monthly	Cumulative
ED	**ED**	**ED**

VIII. INDICATIVE PROJECT SCHEDULE

- See gas only projected schedule in previous section

RECIPROCATING ENGINES REDACTED REDACTED REDACTED

PLANT DESCRIPTION AND DATA SUMMARY

I. GENERAL DESCRIPTION OF THE PLANT

- **REDACTED REDACTED**

- Large reciprocating engine-generator sets for utility applications are typically greater than 5 MW per engine with a total generating facility rating potential in the 20 MW to 200 MW range. They are capable of providing fast and frequent starting (without significant maintenance impact), fast ramp rates, and high efficiency. With proper permitting and interconnection configurations, these reciprocating engines are also capable of supporting peak load demands (this option may require additional studies and costs.)

A. Detailed Description

- **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**

- **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**.

- For reliability, the power block will include **REDACTED REDACTED** than is needed **REDACTED REDACTED REDACTED**

- **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**

- **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**

- The engines will be capable of firing only 100% ultra-low sulfur diesel fuel (dual fuel capability is not required).

- Each engine will be mounted on its own **REDACTED** diesel tank to provide up to **REDACTED** at full load operating capacity. Common bulk storage diesel piping is not included, but could be for additional cost.

- **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**
- Each engine will be provided in its own walk-in outdoor enclosure.
- **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**

II. STATE OF THE TECHNOLOGY

Asset Life (Years)	**REDACTED**

III. HEAT RATE AND OUTPUT

NEW AND CLEAN CONDITIONS

Peaking Output – Diesel Fuel

Number of Units	Net Plant Heat Rate (Based on HHV) Btu/kWh	Net Unit Output kW
REDACTED	REDACTED	REDACTED
REDACTED	REDACTED	REDACTED
REDACTED	REDACTED	REDACTED
REDACTED	REDACTED	REDACTED

IV. REDACTED REDACTED

Technology	Engines Required
REDACTED	REDACTED
REDACTED	REDACTED
REDACTED	REDACTED
REDACTED	REDACTED
REDACTED	REDACTED
REDACTED	REDACTED
REDACTED	REDACTED

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Basis for Starting Requirements:

- **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**
- **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**

V. CAPITAL COSTS

NEW AND CLEAN CONDITIONS

Project Spending (Years)	**REDACTED**

REDACTED REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**

REDACTED REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**

REDACTED REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**

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REDACTED REDACTED

	Per Kilowatt	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**

Basis for Plant Cost:

- Plant costs are overnight costs as of 1/1/2017
- Refer to Standard Assumptions in Introduction for additional detail

VI. O&M COSTS

NEW AND CLEAN CONDITIONS

Hours per Year	**REDACTED**
Starts per Year	**REDACTED**

Fixed O&M

	REDACTED	**REDACTED**
$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

	REDACTED	**REDACTED**
$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Variable O&M

	REDACTED	**REDACTED**
$/MWh	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

	REDACTED	**REDACTED**
$/MWh	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Capital Expenditures for Maintenance

	REDACTED	REDACTED
$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

	REDACTED	REDACTED
$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Basis for O&M Costs:

- O&M costs are in 1/1/2017 dollars
- Refer to Standard Assumptions in Introduction for additional detail

VII. EMISSIONS

NEW AND CLEAN CONDITIONS

Emissions (Diesel)	ppm	lbs/hr	lb/MWh
Carbon Monoxide (CO)	**REDACTED**	**REDACTED**	**REDACTED**
Carbon Dioxide (CO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Nitrogen Oxides (NO_X)	**REDACTED**	**REDACTED**	**REDACTED**
Particulate Matter (PM10 Front and Back Half)	**REDACTED**	**REDACTED**	**REDACTED**
Sulfur Dioxide (SO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Volatile Organics (VOC) – [Hydrocarbons only]	**REDACTED**	**REDACTED**	**REDACTED**

Basis for Emissions Data:

- Values are **REDACTED**

VIII. INDICATIVE SPEND SCHEDULE

The intent of the project expenditure data is to generically show when major expenditures (such as major equipment and construction costs) will happen, not to reflect all costs that may be necessary for a particular project.

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
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REDACTED	**REDACTED**	**REDACTED**
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REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDAC	**REDAC**	**REDAC**

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Separation of Functions and Communications Protocol Applicable

TED	**TED**	**TED**

IX. INDICATIVE PROJECT SCHEDULE

REDACTED

- **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**

NON-DISPATCHABLE GENERATION

Non-Dispatchable generation includes those technologies that can only be utilized when the natural resources required to power them are available. These facilities are not typically ramped or cycled to meet system load. They are considered ON when available and the energy generated from the facility is exported in full to the grid.

Some examples of traditional technologies in this category are:

Solar
Wind

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SOLAR PHOTOVOLTAIC (PV)
REDACTED

PLANT DESCRIPTION AND DATA SUMMARY

I. GENERAL DESCRIPTION OF THE PLANT

The facility is based on the conceptual design (reference plant) for both a **REDACTED** Single Axis Tracking and **REDACTED** Fixed Tilt solar photovoltaic (PV) plant located on a green field site in **REDACTED** .

The Solar Reference Plant was designed from a developer's perspective, optimizing the configuration to provide the most annual energy output. There are numerous situations – such as wholesale Power Sales Agreements – where this is the best design configuration to maximize revenues. However, for a self-build situation where benefits are determined not by sales of the solar facility output but by the avoided cost benefits to the customers, this configuration may not provide the best overall benefit.

The Solar Reference plant was then analyzed for alternate configurations to determine which provided the best overall net benefit to Southern Electric System (SES) customers. The analyses considered both the avoided cost benefit provided to the customer as well as the cost – if any –associated with changing the design parameters. The numbers below represent the "optimized" reference plant. While these results may provide general guidance regarding the design configuration for large scale solar implementations on the SES, the specifics of any particular implementation should be evaluated to determine whether those specifics may suggest a re-evaluation of one or more of these optimization parameters.

The power generating facility is capable of a peak output of **REDACTED** net utilizing crystalline modules and central inverters. The plant utilizes a DC/AC ratio of **REDACTED** .

Plant cost basis and features include:

- **REDACTED** (or equivalent) tier 1 modules
- **REDACTED** (or equivalent) utility grade central inverter skids
- Combiner boxes
- Tracker motors (for Single Axis Tracking)
- DC cabling from the strings to combiner boxes and inverters
- AC cabling from the high side of the inverter step up transformers to the substation
- Substation with control building
- Control system and related facility instrumentation
- Recent steel tariff and module tariff impacts are included

Area needed per MW:

Crystalline Fixed Tilt
REDACTED acres/ MW_{AC} (Ground Coverage Ratio [GCR] **REDACTED** **REDACTED** W modules, **REDACTED** efficient)

Crystalline Single Axis Tracking
REDACTED acres/ MW_{AC} (GCR **REDACTED** **REDACTED** modules, **REDACTED** efficient)

II. STATE OF THE TECHNOLOGY

Asset Life (Years)	**REDACTED**

Both Fixed Tilt and Single Axis Tracking plants will utilize mature technology that is commercially available at the present time.

III. HEAT RATE AND OUTPUT

DC/AC Ratio	**REDACTED**

NEW AND CLEAN CONDITIONS

	Heat Rate	Capacity Factor (%)
Single Axis Tracking (SAT) Output	-	**REDACTED**
Fixed Tilt Output	-	**REDACTED**

DEGRADED CONDITIONS

- **REDACTED REDACTED**

Basis for Heat Rate and Output Data:

- The capacity factor depends on numerous project specific parameters including, but not limited to, the solar resource available at the specific location, the technology selected, DC/AC ratio, GCR, shading, and temperature.
- Refer to Standard Assumptions in Introduction for additional detail

IV. CAPITAL COSTS

NEW AND CLEAN CONDITIONS

DC/AC Ratio	**REDACTED**

Project Spending (Years)	**REDACTED**

Single Axis Tracking

	Per Kilowatt ($/kW$_{AC}$)	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

Fixed Tilt

	Per Kilowatt ($/kW$_{AC}$)	Total
EPC Cost	**REDACTED**	**REDACTED**
Site Cost	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

Basis for Plant Costs:

- Plant costs are overnight costs as of 7/1/2018
- Refer to Standard Assumptions in Introduction for additional detail

V. O&M COSTS

NEW AND CLEAN CONDITIONS

DC/AC Ratio	**REDACTED**

Asset Life (Years)	**REDACTED**
Starts per Year	**REDACTED**

Planned Maintenance (Wks/Yr)	**REDACTED**
EUOR	**REDACTED**

	Single Axis	Fixed Tilt
Capacity Factor	**REDACTED**	**REDACTED**

Fixed O&M Costs

	Single Axis	Fixed Tilt
$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Variable O&M Costs

	Single Axis	Fixed Tilt
$/MWh	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Capital Expenditures for Maintenance

	Single Axis	Fixed Tilt
$/kW-Yr	**REDACTED**	**REDACTED**
Total/Yr	**REDACTED**	**REDACTED**

Basis for O&M Costs:

- O&M costs are in 7/1/2018 dollars
- Maintenance performed during non-daylight hours to avoid generation impact
- Refer to Standard Assumptions in Introduction for additional detail

VI. EMISSIONS

	lbs/MWh
Carbon Monoxide (CO)	-
Carbon Dioxide (CO_2)	-
Nitrogen Oxides (NO_X)	-
Particulate Matter (PM)	-
Sulfur Dioxide (SO_2)	-
Volatile Organics (VOC)	-

Basis for Emissions Data:

- Solar facilities have no air emissions

VII. INDICATIVE SPENDING SCHEDULE

The intent of the project expenditure data is to generically show when major expenditures (such as major equipment and construction costs) will happen, not to reflect all costs that may be necessary for a particular project.

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
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REDACTED	**REDACTED**	**REDACTED**
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REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
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REDACTED	**REDACTED**	**REDACTED**

VIII. INDICATIVE PROJECT SCHEDULE

REDACTED

ONSHORE WIND
REDACTED

PLANT DESCRIPTION AND DATA SUMMARY

I. GENERAL DESCRIPTION OF THE PLANT

In general, a wind turbine converts the kinetic energy from the wind into mechanical energy and then into electrical energy. There are several different ways of achieving this, but typically the turbine blades turn in the wind and respectively turn a shaft which operates the gears which transfers the mechanical energy to the generator creating electricity.

The amount of production from a wind farm depends on the wind resource in the region. The National Renewable Energy Lab (NREL) has data available to allow for an estimation of the region's wind resources. However, the best method of estimating the production from a wind farm is to strategically position meteorological towers fitted with anemometers at different heights and to record wind data for a minimum of one year. Using this data, the production from a wind farm can be estimated.

The design referenced for this chapter is a green-field site utilizing land lease agreements located in the Southeast U.S. This is a similar design to projects being constructed in the Midwest U.S. This **REDACTED** facility uses a total of **REDACTED** interconnected **REDACTED** wind turbine generators at **REDACTED** hub heights.

Note: The wind resource in the Southeast U.S. is very limited compared to a comparably sited green field project in the Midwest U.S.

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A. Size[1 2 3]

Area Needed: The amount of area needed is dependent on size of the wind turbine. The efficiencies improve if the wind patterns around a wind turbine have the chance to reestablish before they impact the next wind turbine.

Area needed per MW: While the area and impacts associated with physical infrastructure such as the wind turbines themselves may be the easiest to quantify, the more commonly cited land-use metric associated with wind power plants is the footprint of the project. However, unlike the area occupied by roads and pads, the total area is more challenging to define and subjective in nature. Generally, the total area of a wind power plant consists of the area within a perimeter surrounding all the turbines in the project. However, the perimeter is highly dependent on terrain, turbine size, current land use, and other considerations such as setback regulations. There is typically no uniform definition of the perimeter or boundary surrounding a wind power plant – in fact, the total area of a wind power plant could have several definitions. The boundary could be defined based on the required turbine spacing as a function of rotor diameter, or use a standardized setback from turbines at the edge of a project. Two definitions for land usage employed when discussing wind farms are the "Plant or Facility Boundary" and the "Operational Impacted Land". Per the Department of Energy, the plant boundary is the legal boundary of the site and can represent the landowners who are being compensated for land related to the wind project. The average land within the plant boundary for a wind farm is 85.24 acres/MW. Because most of the land is not directly affected by the turbines, it can be used for other purposes such as farming or ranching. The Department of Energy defines the operational impacted land as land used for permanent structures (access roads, tower foundations pads, transformer pads). This land cannot be used for another purpose during the life of the wind site. On average, the operational impact of a wind site is expected to be .74 acres/MW. Based on NREL data, land requirements for wind farms can range from 30 acres/MW to 140 acres/MW, depending on site-specific conditions.

In the Southeast, a wind farm is more likely to be built on a mountain ridgeline due to the wind speeds at that elevation and the lack of flat farmland when compared to the Midwest. Where a ridgeline project might not have as much of an operational impact when it comes to the area around each turbine due to its remote location, the length of transmission line to the point of interconnect can be substantial. Some ridgeline projects have transmission lines that extend 15-20 miles down the mountain. An internal study found that on average a wind project in the Midwest might have a land requirement of 69.5 acres/MW while a ridgeline project would require 154 acres/MW.

---

1 Land-Use Requirements of Modern Wind Power Plants in the United States Technical Report NREL/TP-6A2-45834, August 2009.

2 Wind Vision: A New Era for Wind Power in the United States, Chapter 2, March 2015.https://www.energy.gov/sites/prod/files/wv_chapter2_wind_power_in_the_united_states.pdf

3 Land use requirements based on sample of data received as part of an engineering study performed by SCS E&CS in 2017

B. Capacity[4]

Generic Peak Capacity is assumed to have a Capacity Factor (CF) with a range of **REDACTED** and an average of **REDACTED** for active projects in 2014. This change in CF is dependent on the wind resource in the region and how the region has adopted new turbine technology. For example, the generation-weighted average capacity factors for 2014 projects during 2015 were highest in the Interior region at **REDACTED** ; this is consistent with the relative wind quality data broken down by region. Additionally, in comparison to the West region, the Great Lakes region has more readily adopted new turbine designs and has achieved greater improvements in capacity factor. For 2015 the average CF for a project in the Midwest is approximately **REDACTED** compared to a CF of **REDACTED** for a project in the Southeast.

C.

4 DOE 2015 Wind Technologies Market Report, August 2016, https://energy.gov/sites/prod/files/2016/08/f33/2015-Wind-Technologies-Market-Report-08162016.pdf

II. STATE OF THE TECHNOLOGY

Asset Life (Years)	**REDACTED**

Wind power generation saw significant growth in 2015. DOE reports that the U.S. wind power market surged in 2015 with $14.5 billion invested and 8,598 MW of new capacity added, bringing the cumulative total to 73,992 MW. Texas installed the most capacity in 2015 with 3,615 MW, while twelve states meet or exceed 10% wind energy penetration.

A challenge with wind generation is that it is intermittent and land-based wind farms often experience their peak generation at night which is when utilities are seeing their smallest demand.

The wind resource in the Southeast U.S. is very limited. There are areas located in the Georgia and Alabama mountains that might have enough wind resource for potential wind generation. However, environmental issues, such as with volant animals and the "Not in my backyard" issues may prevent any exploration of taking advantage of this possible resource. Another possible location is offshore. A feasibility study was conducted by Southern Company and Georgia Tech looking at the potential wind resource off the coast of Georgia and a final report was prepared. A copy of this report can be obtained by contacting SCS Research & Environmental Affairs (see end of document for contact information).

In general, this work found that more research is needed to be done to better examine the potential wind resource off the Georgia coast. This would be accomplished by the strategic placement of meteorological towers. Once the wind resource is defined and a technology is built that can withstand the marine hazards and hurricane force winds, then this might provide another option for wind power generation.

A. Technology Forecast

The goal is to capture as much of the wind as possible, to best utilize the wind resource that is available, and to be able to survive environmental conditions such as cold weather and lightning strikes. Different turbine equipment designs, turbine blades, etc. are being developed to accomplish these goals. Current trends include increases in rotor diameter, hub height, and nameplate capacity. Rotor diameter increases are outpacing both hub height and nameplate increases, and specific to nameplate, this is resulting in lower specific power (MW/m^2 of rotor area). This is resulting in high capacity factors for a given wind resource. It is expected that these trends will continue, which will open more areas to viable wind development. Advances in turbine blade manufacturing and tower construction are expected to allow rotor diameters and hub heights to continue to increase. Below are tables showing the state of the current turbine technology of General Electric, Siemens, and Vestas.

GE Onshore Wind Turbines[5]					
Name	**Class**	**Hub Heights**	**Rotor Diameter**	**Nominal Power**	**Blade Lengths**
1.7-100	IEC TC IIIs	80m, 96m	100m	1.7 MW	48.7m
1.7-103	IEC TC IIIs	80m, 96m	103m	1.7 MW	50.2m
1.85-87	IEC IIs	80m	87m	1.85 MW	42m
1.85-82.5	IEC TC IIs	121.25m	82.5m	1.85 MW	40.3m
2.75-120	IEC IIIs, DiBT WZII	85m, 110m, 120m, 139m	120m	2.75 MW (or 2.5 MW)	60m
2.0-2.4MW Platform	IEC IIs/IIIs	80m, 90m, 94m	107m	2.0-2.4 MW	53.6m, 58.4m
3.2-103	IECIIb	98m, 75m, 85m	103m	3.2 MW (or 2.85 MW)	60m
3.2-3.8MW Platform	IEC2B, IEC3A, IEC3B	85m, 110m, 131m	130m-137m	3.2-3.8 MW	63.7m

Siemens Onshore Wind Turbines[6]					
Name	**Class**	**Hub Heights**	**Rotor Diameter**	**Nominal Power**	**Blade Lengths**
SWT-2.3-101	IIA	80m or site specific	101m	2.3 MW	49m
SWT-2.3-108	IIB	78.5-115m	108m	2.3 MW	53m
SWT-2.625-120	IIS	85.1m	120m	2.625 MW	59m
SWT-3.15-142	IIIA	109m, 129m, 165m	142m	3.15 MW	69.3m
SWT-3.2-101	IA	74.5m-94m	101m	3.2 MW	49m
SWT-3.4-101	IA	74.5m-94m	101m	3.4 MW	49m
SWT-3.2-108	IA	74.5m-94m	108m	3.2 MW	53m
SWT-3.4-108	IA	74.5m-94m	108m	3.4 MW	53m
SWT-3.2-113	IIA	83.5m-115m	113m	3.2 MW	55m
SWT-3.3-130 Low Noise	IIA	85m, 135m, 165m	130m	3.3 MW	63m
SWT-3.6-130	IIA	85m, 115m, 135m, 165m	130m	3.6 MW	63m

Vestas Onshore Wind Turbines[7]					
Name	**Class**	**Hub Heights**	**Rotor Diameter**	**Nominal Power**	**Blade Lengths**
V90-1.8/2.0 MW	IEC IIA, IEC IIIA	80m, 95m, 105m	90m	1.8/2.0 MW	44m
V100-2.0 MW	IEC IIB	80m, 95m	100m	2.0 MW	49m

5 GE wind turbine information obtained at https://www.gerenewableenergy.com/wind-energy/turbines.html
6 Siemens wind turbine information obtained at https://www.siemens.com/global/en/home/markets/wind/turbines-and-services.html
7 Vestas wind turbine information obtained at https://www.vestas.com/en/products/turbines#!

V110-2.0 MW	IEC IIIA	75m, 80m, 95m, 110m, 120m, 125m	110m	2.0 MW	54m
V116-2.0 MW	IEC IIB	Site specific	116m	2.0 MW	57m
V120-2.0 MW	IEC IIIB, IEC S	Site specific	120m	2.0 MW	59m
V105-3.45 MW	IEC IA	72.5m	105m	3.45 MW	54.7m
V112-3.45 MW	IEC IA	69m, 94m	112m	3.45 MW	54.7m
V117-3.45 MW	IEC IB, IEC IIA	80m, 91.5m, 116.5m	117m	3.45 MW	57.2m
V117-4.0/4.2 MW	IEC IB, IEC IIA	84m, 91.5m	117m	4.0/4.2 MW	57.2m
V126-3.45 MW	IEC IIB, IEC IIA	87m, 117m, 137m, 147m, 149m, 166m	126m	3.45 MW	61.7m
V136-3.45 MW	IEC IIB, IEC IIIA	82m,105m, 112m, 132m, 142m, 149m, 166m	136m	3.45 MW	66.7m
V136-4.0/4.2 MW	IEC IIB	Site specific	136m	4.0/4.2 MW	66.7m
V150-4.0/4.2 MW	IEC IIIB	Site specific	150m	4.0/4.2 MW	73.7m

III. HEAT RATE AND OUTPUT

	Net Plant Heat Rate (Based on HHV) Btu/kWh	**Net Unit Output kW**
Annual Average	N/A	**REDACTED**

Basis for Heat Rate and Output Data:

Composition of facility is dependent on nominal output of wind turbine generators selected for site.

IV. CAPITAL COSTS[8]

Project Spending (Years)	**REDACTED**

	Per Kilowatt	Per Turbine	Total
Turnkey EPC	**REDACTED**	**REDACTED**	**REDACTED**
Turbine Cost	**REDACTED**	**REDACTED**	**REDACTED**
Site (Land) Cost	**REDACTED**	**REDACTED**	**REDACTED**
Owner's Cost	**REDACTED**	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**	**REDACTED**

Basis for Plant Costs:

- Project spending is based on an average construction duration of 5 completed wind generation facilities (**REDACTED**) plus **REDACTED** for engineering and site reclamation
- EPC costs are based on an average cost per kilowatt of 5 completed wind generation facilities
- Turbine costs are based on an average cost per turbine using **REDACTED** turbines.
- Owner's cost includes Construction Management and O&M tooling and equipment
- Land Costs assume a **REDACTED** per turbine including any required easements
- Additional Site Costs assumed to be included in EPC contract
- Refer to Standard Assumptions in Introduction for additional detail

8 Cost information is based on a sample of data received as part of an engineering study performed by SCS E&CS in early 2017.

V. O&M COSTS[9]

NEW AND CLEAN CONDITIONS

Asset Life (Years)	**REDACTED**
Capacity Factor	**REDACTED**
Starts per Year	**REDACTED**

Planned Maintenance (Wks/Yr)	**REDACTED**
EUOR	**REDACTED**

Fixed O&M Costs

$/kW-Yr	**REDACTED**
Total/Yr	**REDACTED**

Variable O&M Costs

$/MWh	**REDACTED**
Total/Yr	**REDACTED**

Capital Expenditures for Maintenance

$/kW-Yr	**REDACTED**
Total/Yr	**REDACTED**

Basis for O&M Costs:

- O&M costs are in 1/1/2016 dollars
- Refer to Standard Assumptions in Introduction for additional detail

9 Cost information is based on a sample of data received as part of an engineering study performed by SCS E&CS in early 2017.

VI. EMISSIONS & ENVIRONMENTAL CONCERNS[10][11]

	lbs/MWh
Carbon Monoxide (CO)	-
Carbon Dioxide (CO_2)	-
Nitrogen Oxides (NO_X)	-
Particulate Matter (PM)	-
Sulfur Dioxide (SO_2)	-
Volatile Organics (VOC)	-

Basis for Emissions Data:

- Wind farms have no air emissions.

Other Environmental Concerns:

- Land Usage
  - Because of the spacing required and the size of the turbines, land is a key resource and concern when discussing wind projects. However, most of the land associated with the site is not taken up by the turbines and can be used for other purposes such as agriculture, grazing, roadways, and hiking trails. Another option to reduce the impact of land use is using a brownfield, or currently underused or abandoned industrial land, for the site.
- Wildlife and Habitat
  - Potential impacts to volant animals, such as birds and bats, should be considered. Bird and bat fatalities are known to occur because of collisions with turbines, changes in air pressure due to the turbines, or general habitat disruption. Per the National Wind Coordinating Committee, this effect does not pose a threat to the species populations. Current bird and bat protection strategies depend on wind turbine curtailments based on certain times of the day and year. New technologies are emerging to mitigate bird and bat strikes at wind facilities that won’t have such a drastic impact on power production.
    - For birds, a system based on artificial intelligence and high-precision optics can detect large birds (eagles, condors, etc.) from up to 1 kilometer away. The system will then track the birds speed and flight path. If patterns indicate a risk of collision, the wind turbine in the flight path can be shut down and then restarted once the bird has left the area.

10 Environmental Impacts of Wind Power. http://www.ucsusa.org/clean-energy/renewable-energy/environmental-impacts-wind-power#.WXERYeTfOAg

11 New Technology Looks Out for Eagles & Bats new Wind Farms. http://www.windpowerengineering.com/featured/new-technology-looks-eagles-bats-near-wind-farms/

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        - For bats, a system that uses ultrasonic speakers produces a range of frequencies to negate the bat's own signals which would turn the bats away from the sound of the turbine rotors.
- Public Health and Community
    - Sound Impact
        - Sound is one complaint received from community members who live near wind turbines. The sources of this sound are from the aerodynamic sound of the blades' motion and the mechanical sound of the turbine. Studies in Canada and Australia have concluded that this sound does not negatively impact public health. However, the wind industry is committed to developing and implementing technologies to combat this sound concern.
    - Visual Impact
        - The Federal Aviation Administration (FAA) requires that all structures over 200 feet tall – including wind turbines – have red or white lights. However, the FAA concluded that it is not necessary to light every tower in a multi-turbine farm if no gaps in lighting are greater than half a mile.
        - Shadow flickering is an effect that can be seen with certain lighting conditions and can be a nuisance. This can be lessened by careful siting, planting trees or installing window awnings, or pausing operations under certain lighting conditions.

The public opinion in regards to the aesthetics of wind turbines is mixed; some view them as attractive sites of innovation while others see them as eyesores to the natural landscape. These opinions are taken into consideration when a wind project is in the planning stages for a community.

VII. INDICATIVE SPENDING SCHEDULE

The intent of the project expenditure data is to generically show when major expenditures (such as major equipment and construction costs) will happen, not to reflect all costs that may be necessary for a particular project.

Month	Monthly	Cumulative
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

VIII. INDICATIVE PROJECT SCHEDULE

Construction for a **REDACTED** facility can be completed within **REDACTED** . The uncertainty with wind farm facilities is the length of time required for permitting and for interconnection.

REDACTED

STORAGE

Technologies discussed in this section are capable of storing energy to provide dispatchable capacity to support peak demand periods and the intermittent nature of non-dispatchable generation. These technologies are site and application specific and therefore may contain variations in the cost and performance data represented here.

Some examples of technologies in this category are:

Compressed Air Energy Storage (CAES)
Pumped Storage Hydro (PSH)

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COMPRESSED AIR ENERGY STORAGE (CAES)

I. GENERAL DESCRIPTION OF THE PLANT

CAES and other bulk energy storage technologies have the potential to help balance electrical supply and demand. CAES allows the compression of air and storage during off-peak hours, when supply is high and price is low. Then, during peaks, this stored air is extracted, preheated and expanded to generate electric power. Additionally, the operational characteristics of CAES offer the potential to support non-dispatchable resources, such as wind and solar.

Potential advantages of a CAES plant are as follows:

- Power Arbitrage – buying inexpensive off-peak energy and selling higher-priced on-peak energy
- Load Regulation – depending on plant configuration, flexibility to provide load following in the range from 20% to 70% of the CAES plant capacity within ~3-7 minutes
- Synchronous Reserve – depending on plant configuration, sudden load response up to 70% of the CAES plant capacity within ~3-7 minutes
- Enhancement of operations and economics of renewable resources
- Higher unit output per mmbtu of natural gas consumption than equivalent simple cycle unit

II. STATE OF THE TECHNOLOGY

A. Technology Discussion

Originally, CAES technology was developed as a load management tool to increase load factor of baseload plants during off-peak hours and then utilize stored energy during peak hours. Two CAES plants have operated for many years, using excess electricity to compress air into underground salt caverns and then using the compressed air to power turbo-generators when demand and prices are high. Both plants use a single power train, with self-synchronizing clutches, which are utilized to select whether motor/generator is to be used to drive the compressor or to generate power to the grid. The first CAES plant in the world was E.ON Kraftwerk's 320 MW plant in Huntorf, Germany in 1978. The plant has an 80 MW compressor, which can fill the salt caverns in 8 hours at an air mass flow rate of 106 kg/s while the 320 MW turbine can operate for 2 hours at an air mass flow rate of 417 kg/s. The second CAES plant was built by PowerSouth Energy Cooperative in McIntosh, Alabama. This plant went commercial in 1991 and generates 110MW. Its design is similar to the Huntorf plant. It takes about 41 hours to compress the air into caverns and the turbo-generator can then operate at full capacity for 26 hours. One difference, however, is that the McIntosh plant recuperates the waste heat from the expanders and uses it to heat the compressed air, boosting the plant efficiency by almost 25%. Both Huntorf and McIntosh plants have operated reliably for many years. These two plants are first generation single-shaft multiple component turbo-machinery design with the following deficiencies:

- No flexibility for specific compressor and expander power requirements
- Operational and maintenance complications
- Restrictions for plant optimization for specific grid and economic requirements and specific storage parameters

Several second generation (CAES2) plant concepts provide flexibility to meet a variety of operational and economic conditions and alleviate these deficiencies. Based on the available technical information, the second generation F-Class CT based CAES concept with Bottoming Cycle Air Expander and Inlet Chilling (CAES-BCE-IC) is suitable for Southern Company needs because of the following reasons:

- The total plant capacity is higher
- The fuel related heat rate is lowest among all options
- Energy ratio (kWh-in/kWh-out) is favorable
- Design is relatively simple
- CT modification or changes in the OEM permissives may not be required

This and other similar second generation CAES designs have been patented by Dr. Michael Nakhamkin. In 2008, Public Service Electric & Gas and Dr. Nakhamkin formed a Joint Venture company (Energy Storage & Power LLC) to license second generation CAES technology in North America.

The major components of this second generation CAES plant are as follows:

- **REDACTED** natural gas fired combustion turbine (**REDACTED**)
- **REDACTED REDACTED** compressors **REDACTED REDACTED**
- **REDACTED** industrial air expanders **REDACTED REDACTED REDACTED**
- **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**
- Below ground compressed air storage

The simplified schematic of the CAES-BCE-IC (Figure 1) illustrates the main features of the plant. During off-peak hours, motor-driven compressors utilize any renewable or base load energy and store it in the form of compressed air in an underground reservoir. During peak hours, the stored air is extracted from the storage, preheated and expanded in the BCE to generate electric power. The BCE is optimized to have the exhaust flow equal to the CT inlet flow and the exhaust temperature of approximately ~50 °F. The BCE exhaust is injected into the CT inlet. Since this CT inlet temperature will be lower than the summer ambient, the CT output, and therefore, the overall CAES plant output will be increased.

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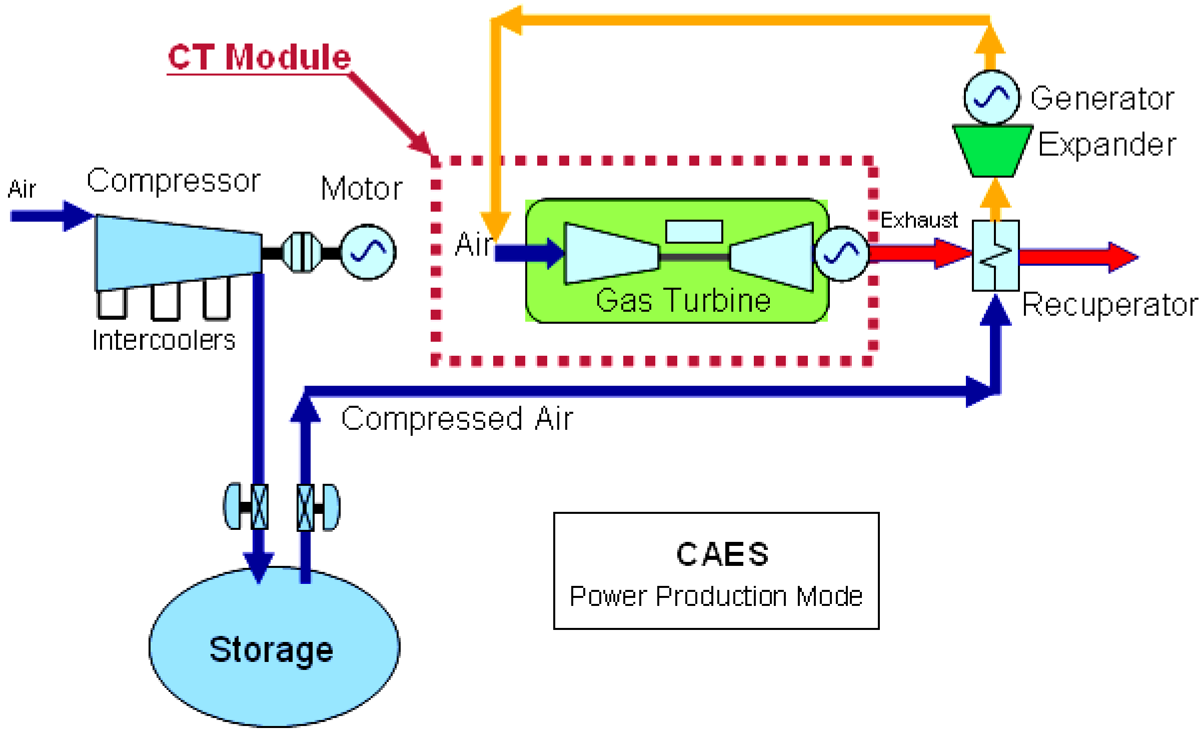

Figure 1

Below are some examples of recent developments:

- Pacific Gas and Electric received federal funds for the first stage of a 300-MW CAES plant in Kern Co., CA
- First Energy owns the rights to an abandoned limestone mine in Norton, Ohio, that has the potential for 2,700 MW of CAES
- New York State Electric & Gas has plans for a 150MW-10hr demo plant using a salt cavern

It should be noted that cost and performance data can vary significantly depending on the site conditions. By performing an engineering and cost trade-off study of available turbo-machinery (CTs, expanders and compressors), which includes the cavern solution mining costs for CAES caverns at different depths, and different max and min pressures, one can calculate the lowest cost of the overall CAES plant as a function of depth. The overall CAES plant capital cost (on a $/kW basis) can change by as much as 50% depending on selection of the cavern depth (which sets the max pressure the cavern can withstand). The cavern max pressure will then set the minimum pressure, air flow rate and many other thermodynamic parameters for the above ground CAES plant turbo-machinery.

There are three potential unit configurations (Figure 2) that can provide different capabilities for rapid startup of the CAES2 unit:

a. "Standard"- In this configuration there are no auxiliary burners of any kind. The unit is started by starting the GT and when the exhaust heat starts to increase the temperature of the recuperator the expander is started. Power becomes available at approximately 7 minutes after the start sequence is initiated. Once the GT is at full-speed-no-load conditions the turbo expanders can be quickly brought to about 60% of their rated power although some expander power is available before the GT is up to full speed. The startup time is principally determined by the startup time of the combustion turbine. It is estimated that power will be available in about 7 minutes after the start sequence is initiated. The startup emissions are solely those of the combustion turbine.

b. "Duct burners" (DB)- In this configuration low NO_X duct burners are installed in the input to the recuperator on the GT side. The DB's are fired as soon as the GT is at sufficient speed to have purged the recuperator and is supplying sufficient air flow to support DB operation. These types of low NO_X duct burners are commercially available and modular in configuration. Given their very short time of operation, permitting should be fairly simple in most jurisdictions. It is estimated that power will be available from the expanders approximately 5 minutes after the start sequence is initiated. The startup emissions are those of the combustion turbine plus the duct burners. It is believed that DB's are available with emissions of less than 9 ppm, corrected to 15% O_2. The DBs are only operated for periods of less than 15 minutes during a fast startup and should have a very small annual tonnage contribution to the plant. For a normal startup they would not be operated at all.

c. "In-line burners" - In this configuration, high pressure in-line burners are installed in the air supply from the compressed air storage between the recuperator and the turbo expander. In starting the unit the turbo expanders are started as soon as the high pressure compressed air line and the expanders are purged and the high pressure burners are fired. This allows the turbo expanders to begin generating power before the GT is up to speed. Their operation is phased out within a few minutes as the GT is brought on-line. Power becomes available as soon as three minutes after the start sequence is initiated. The disadvantage of this configuration is that custom designed high pressure burners are required. These types of burners are not readily available and would need to be custom designed and fabricated.

With the in-line burner configuration it is also possible to have the turbo expanders continuously synchronized to the grid at a minimum power level and the in-line burners continuously fired. This would permit the entire expander plant output capacity to contribute to synchronous reserves. It should be noted that there would be a continual usage of compressed air and natural gas required to accomplish this so it would need to be economically evaluated. Permitting might also be more difficult.

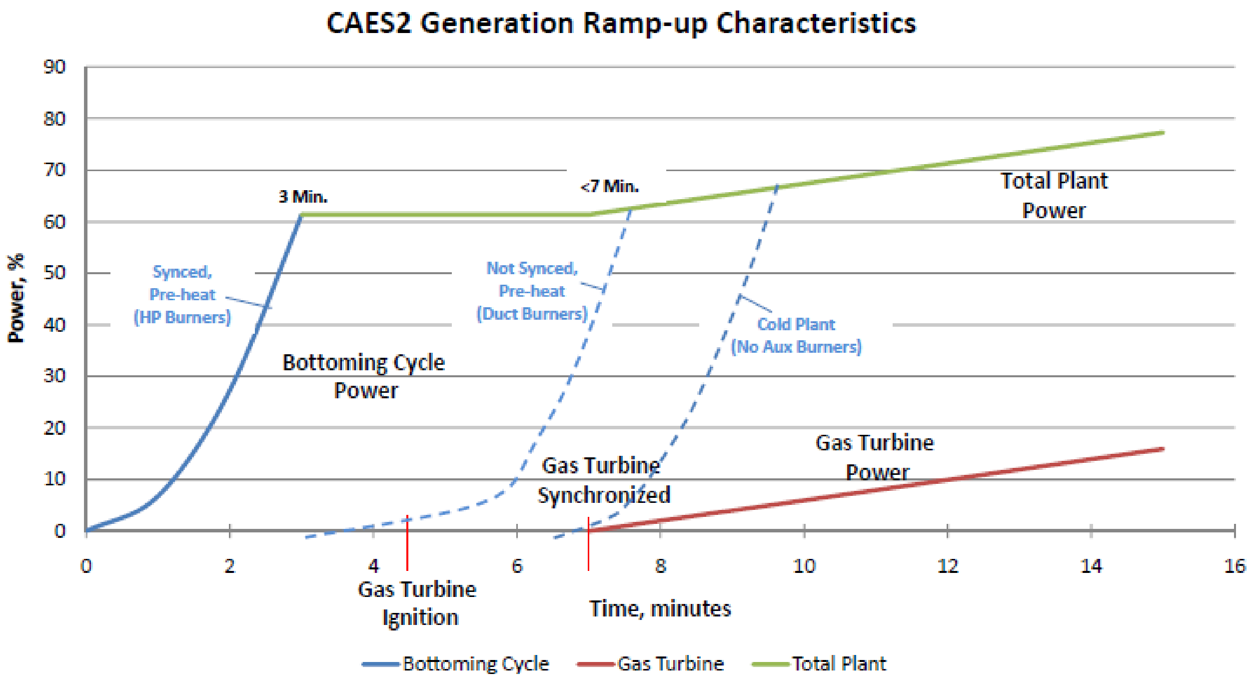
CAES2 Generation Ramp-up Characteristics
Power, %
90
80
70
60
50
40
30
20
10
0
3 Min.
<7 Min.
Synced,
Pre-heat
(HP Burners)
Not Synced,
Pre-heat
(Duct Burners)
Cold Plant
(No Aux Burners)
Bottoming Cycle
Power
Total Plant
Power
Gas Turbine
Synchronized
Gas Turbine
Power
0
2
4
6
8
10
12
14
16
Gas Turbine
Ignition
Time, minutes
Bottoming Cycle
Gas Turbine
Total Plant

Figure 2

III. HEAT RATE AND OUTPUT

Total Power (Net) From CAES Plant, MW: **REDACTED**

Heat Rate (HHV) of CAES Plant, Btu/kWh-Out: **REDACTED REDACTED**

Energy Ratio of CAES Plant, kWh-In/kWh-Out: **REDACTED**

Compressor Capacity, MW's: **REDACTED**

Max Pressure in Cavern, psia: **REDACTED**

Min Pressure in Cavern, psia: **REDACTED**

Note: The max and min pressures will enable the generation cycle to last **REDACTED** when the cavern starts to discharge at max pressure, and the compression cycle to get back from the min cavern pressure to the max cavern pressure to be **REDACTED** . Thus, each hour of compression at the max power of the compressors will produce one hour of generation, net, at max power, which is the max power from the CT and the max power from the Expander, minus about **REDACTED** MW of losses. Due to the nature of the preliminary analysis performed, the numbers stated above have an accuracy of about **REDACTED**

IV. CAPITAL COSTS

	Per Kilowatt
Total Plant Cost	**REDACTED**

Basis for Plant Costs

The estimate was factored from our simple cycle reference plant estimates and available literature concerning CAES plant capital cost. The estimate does not include the following:

- Cavern Development
- Land Cost
- Gas Lateral to Plant Site
- Transmission Interconnect Cost (scope ends at high side of GSUs and Motors)
- Pre COD O&M Capital Cost
- Project Development/Permitting Cost
- AFUDC
- Escalation (costs are 2013 “overnight” dollars)

V. O&M COSTS

Fixed O&M Costs

- Factored from the GTDB CT and CC FOM data

$/kW-Yr	**REDACTED**

Variable O&M Costs

- From EPRI CAES Demonstration Newsletter, July 2010

$/MWh	**REDACTED**

EMISSIONS

	lbs/mmbtu-HHV
Sulfur Dioxide (SO_2)	**REDACTED**
Nitrogen Oxides (NO_X)	**REDACTED**
Particulate Matter (PM)	**REDACTED**
Carbon Monoxide (CO)	**REDACTED**
Volatile Organics (VOC)	**REDACTED**

VI. PLANT LIFE (YRS)

REDACTED

VII. AVERAGE PLANNED MAINTENANCE TIME (WEEKS/YR)

REDACTED

VIII. EQUIVALENT UNPLANNED OUTAGE RATE

(Includes forced outages/deratings and maintenance outages/deratings) **REDACTED**

IX. EXPENDITURE DATA ATTACHED?

REDACTED

X. PROJECT SCHEDULE:

A typical EPC schedule from Notice to Proceed (start of engineering/procurement) to COD is approx. **REDACTED** months including cavern development. Some conceptual engineering and permitting activities would occur prior to NTP. From construction mobilization (sitework/cavern mining & development) to COD is **REDACTED** months.

XI. EXPECTED PLANT DEGRADATION

REDACTED

XII. CAPITAL EXPENDITURE FOR MAINTENANCE

REDACTED

PUMPED STORAGE HYDRO (PSH)

DESCRIPTION

Pumped Storage Hydro (PSH) is a type of hydroelectric power generation that allows energy to be stored by pumping water into an elevated reservoir (Upper Reservoir). Later, the stored water is used to generate power using a hydroelectric turbine generator as the water flows back down to a second reservoir (Lower Reservoir). Reversible pump/turbine and motor/generator assemblies that act as both a pump and a turbine allow these two functions to be performed by one common set of equipment.

PERFORMANCE AND COST

Typically, water is pumped up to the Upper Reservoir for storage during the night and on weekends using low-cost energy, and the stored water is released to generate power during periods of high demand to displace high-cost generation. As a result, much of the PSH value is derived from peak/off-peak price differentials. PSH stations are actually a net consumer of electricity, as they consume 1.25 MWH of energy for every 1 MWH they produce. Overnight cost is estimated to be in the range of **REDACTED** to **REDACTED** . Site-specific geological studies should narrow this range.

PSH is the largest-capacity and one of the most cost-effective forms of grid energy storage available. In addition to converting low-value off-peak energy into high-value peak energy, PSH systems also provide ancillary electrical grid services such as network frequency control and reserve generation. Similar to other storage options, PSH facilities can help to levelize system load and mitigate loading issues during off-peak periods for base loaded units (bottoming out), as well as offer the potential to support non-dispatchable resources, such as wind and solar

Underground Reservoir Pumped Storage Hydro (URPSH) is a variation of PSH technology that utilizes an underground Lower Reservoir. Overnight cost for URPSH technology is expected to be **REDACTED** /kW to **REDACTED** /kW or higher.

Deployment time for PSH varies widely as a function of site selection and licensing processes. Depending on the size of the planned facility, local geology, and water requirements, initial civil work may also vary by several years.

The nature of PSH, as discussed above, is such that a “generic” option is not provided. Determination of a generic cost or performance is therefore impractical. Each potential application must be evaluated individually based on the requirements and project economics.

SUPPLEMENTAL

Technologies discussed in this section are presented as information and for general planning purposes. These technologies vary in maturity of technology development; number, sizes and types of installations; and quality of cost and performance estimates provided. Limitations of the information provided may be due to the particular technology being application or technology specific in nature or information being unavailable.

Some examples of technologies in this category are:

Landfill Gas to Energy (LFGTE)
Combined Heat and Power (CHP)

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SIMPLE CYCLE COMBUSTION TURBINE WITH SELECTIVE CATALYTIC REDUCTION (CT W/ SCR)

REDACTED
REDACTED

PLANT DESCRIPTION AND DATA SUMMARY

I. GENERAL DESCRIPTION OF THE PLANT

- These simple cycle units are assumed to be located at a generic "Greenfield" site. The model consists of **REDACTED** industrial combustion turbine-generators nominally rated at **REDACTED** each. Extensive factory modularization of systems and components results in low costs for peaking applications. The units may either utilize natural gas or No. 2 distillate fuel. NO_x is controlled to 9 ppm on natural gas by dry low NO_x combustors and 42-ppm on No. 2 distillate using water injection. Further NO_x control is accomplished by SCR.

- Historically, simple cycle units have not been equipped with an SCR for NO_x control, but due to technology improvements and changing environmental regulations, the inclusion of SCRs on the larger frame engines is being considered. SCR technology involves the catalytic reaction of ammonia, which is injected into the exhaust to consume NO_x and produce molecular nitrogen and water vapor. The optimum operating temperature for the typical SCR system is between 500 to 700°F. In a combined cycle application, the catalyst is strategically placed in the HRSG in a position to operate in this optimum temperature range. In a simple cycle application, where there is no HRSG that cools the hot exhaust gas, the SCR system either operates at a significantly higher temperature or a dilution air system is required to reduce the temperature of the hot gas. The "mid-range" catalysts (Vanadium/Titanium) with dilution air are typically used. A vast amount of experience has been gained since the mid-1990s on aero-derivative combustion turbines using "mid-range" catalysts with dilution air. Additional ducting, dilution fans, and catalyst cause the back pressure on the combustion turbine to be greater than a traditional simple cycle. This increase in back pressure causes an increase in plant heat rate.

- Reference the non-SCR Simple Cycle sections above for additional details

- Fuel oil contains small amounts of metals including some that may poison the catalyst such as iron, nickel, sodium and potassium. Presence of sulfur in fuel oil is also detrimental to the high temperature catalyst. Therefore, dual fuel based information has been omitted from this chapter. Although the issue of fuel oil impacts to the catalyst are expected to be resolved at the OEM level prior to any legislation mandating SCR use on simple cycle CT configurations.

II. COST & PERFORMANCE SUMMARY

NEW AND CLEAN CONDITIONS

		REDACTED Gas Only w/ SCR	REDACTED Gas Only w/ SCR
CAPACITY FACTOR	%	**REDACTED**	**REDACTED**
PEAKING OUTPUT	kW	**REDACTED**	**REDACTED**
PEAKING HEAT RATE	BTU/kWh	**REDACTED**	**REDACTED**
AVERAGE OUTPUT	kW	**REDACTED**	**REDACTED**
AVERAGE HEAT RATE	BTU/kWh	**REDACTED**	**REDACTED**
PLANT COST	$/kW	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
EPC COST	$/kW	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
SITE COST	$/kW	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
OWNER'S COST	$/kW	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
FIXED O&M	$/kW-yr	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
VARIABLE O&M	$/MWh	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
CAPITAL FOR MAINT.	$/kW-yr	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
STARTS PER YEAR	#	**REDACTED**	**REDACTED**
EFORd (Demand EFOR)	%	**REDACTED**	**REDACTED**

DEGRADED CONDITIONS

		REDACTED Gas Only w/ SCR	REDACTED Gas Only w/ SCR
CAPACITY FACTOR	%	**REDACTED**	**REDACTED**
PEAKING OUTPUT	kW	**REDACTED**	**REDACTED**
PEAKING HEAT RATE	BTU/kWh	**REDACTED**	**REDACTED**
AVERAGE OUTPUT	kW	**REDACTED**	**REDACTED**
AVERAGE HEAT RATE	BTU/kWh	**REDACTED**	**REDACTED**
PLANT COST	$/kW	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
EPC COST	$/kW	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
SITE COST	$/kW	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
OWNER'S COST	$/kW	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
FIXED O&M	$/kW-yr	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
VARIABLE O&M	$/MWh	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
CAPITAL FOR MAINT.	$/kW-yr	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
STARTS PER YEAR	#	**REDACTED**	**REDACTED**
EFORd (Demand EFOR)	%	**REDACTED**	**REDACTED**

Notes

- Plant costs are overnight costs as of 7/1/2018
- Refer to Standard Assumptions in Introduction for additional detail

III. EMISSIONS

NEW AND CLEAN CONDITIONS

Emissions (Natural Gas)	ppm	lbs/mmbtu	lb/MWh
Carbon Monoxide (CO) with Catalyst	**REDACTED**	**REDACTED**	**REDACTED**
Carbon Dioxide (CO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Nitrogen Oxides (NO_X) with SCR	**REDACTED**	**REDACTED**	**REDACTED**
Particulate Matter (PM10 Front and Back Half)	**REDACTED**	**REDACTED**	**REDACTED**
Sulfur Dioxide (SO_2)	**REDACTED**	**REDACTED**	**REDACTED**
Volatile Organics (VOC) with Catalyst	**REDACTED**	**REDACTED**	**REDACTED**

Basis for Emissions Data:

- Values are **REDACTED**
- These emission estimates should only be used to generally characterize emissions. Permits obtained in the future for this technology may require more stringent emission limitations than the estimates shown above.
- Emissions values reflect **REDACTED** ambient temperature, **REDACTED**
- SO2 emissions are estimated at **REDACTED** per EPA AP-42 standard

LANDFILL GAS TO ENERGY (LFGTE)
REDACTED

PLANT DESCRIPTION AND DATA SUMMARY

I. GENERAL DESCRIPTION OF THE PLANT

- The landfill-gas-to-energy (LFGTE) facility is based on **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**. These engine-generator sets combust landfill gas (predominately methane) produced from the natural anaerobic decomposition of municipal solid waste in a sanitary landfill. LFGTE facilities are easily scaled to match the gas production of a given landfill site by simply adding incremental engines to the plant. Small landfills producing only enough gas sufficient to operate one engine are typically developed with containerized designs in which a single engine-generator set and auxiliary equipment is housed in a pad-mounted container. For 2-Engine plant designs and larger, standard practice calls for the construction of a brick and mortar facility that houses the majority of equipment and includes a plant control room.
- Plant cost basis and features for the facility include:
  - **REDACTED REDACTED REDACTED REDACTED REDACTED**
  - Fuel Gas Compressor
  - Switchgear and Motor-Control Center
  - Pad-mounted Generator Step-Up Transformer
  - Architectural Block Building
- Assumptions:
  - Landfill gas collection facility will be installed and/or operated by landfill entity to deliver landfill gas to plant boundary.
  - Energy produced at facility can be delivered onto the electric distribution or transmission system at a reasonably close interconnection point.

II. STATE OF THE TECHNOLOGY

- This is a mature technology and currently available

Asset Life (Years)	**REDACTED**

A. Technology discussion

Landfill-Gas-to-Energy Technology

With the uncertainty surrounding government actions on climate change and the increasing desire for sustainable "green" technologies, landfill-gas-to-energy projects have been on the rise as a viable source of renewable generation. As landfills collect and dispose of waste, the natural decomposition of the organic material produces methane and carbon dioxide. If uncontrolled, landfill gas escaping into the air can contribute to smog, create an unpleasant odor, and present other safety and health hazards. Additionally, according to the EPA, methane has greater than 20 times more impact than CO_2 as a greenhouse gas. As landfills produce nearly 23% of human-made methane, the EPA has set regulations under the Clean Air Act requiring landfills, which meet particular size and emissions thresholds, to collect and destroy the landfill gas. These requirements typically come out of the New Source Performance Standards (NSPS) of the Clean Air Act, and landfills which fall under NSPS must follow specified procedures for installing a gas collection system, destroying the landfill gas, and submitting the appropriate reports to demonstrate compliance. Once a collection system is in place, the gas destruction is often accomplished by simply flaring the gas, but alternatives have been developed to utilize the energy content of the methane for beneficial purposes. The three primary options for the gas are as follows: electricity generation, direct use as a commercial fuel (industrial boilers, cement kilns, etc.), or refinement to pipeline-quality natural gas. For the purposes of this discussion, the focus will be on the use of landfill gas for electricity generation.

In order to collect the gas from a landfill (whether voluntary or required by NSPS), the landfill will install collection wells into the various cells where the waste has been compacted for decomposition. These wells are then connected by headers which feed into a blower that keeps the wellfield under a vacuum to draw the gas from the ground into the wells and ultimately to the flare or other end use. Prior to utilizing the gas in an electric generator, condensate and particulates will be removed from the gas stream, and depending on the particular application and gas quality, additional pretreatment may be required (to eliminate contaminants such as H_2S and siloxanes). Figure 1 below depicts a basic configuration for a landfill-gas-to-energy facility located adjacent to a landfill.

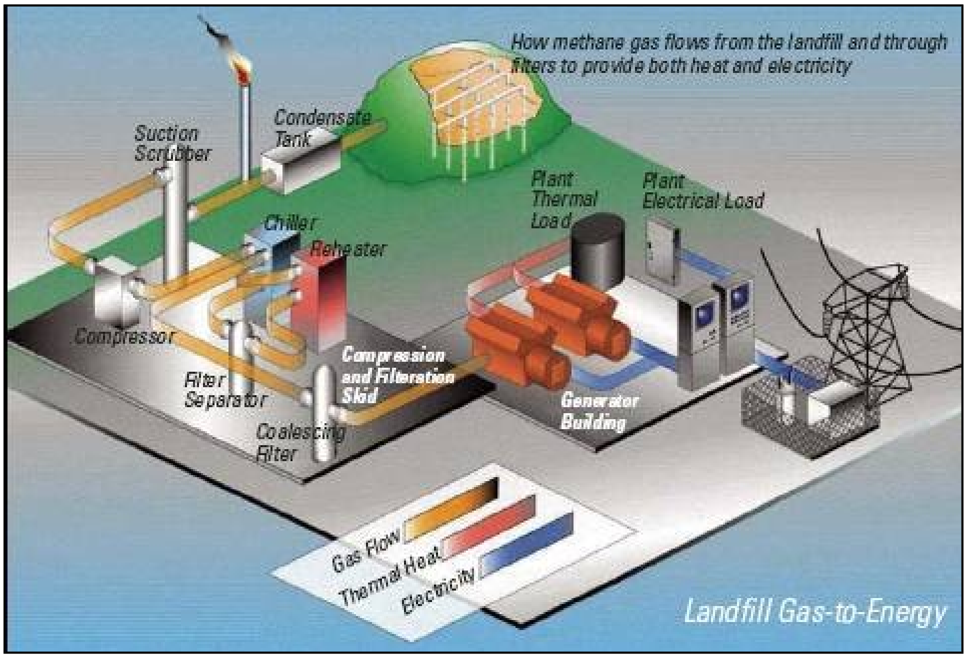

Figure 0-1: Typical Landfill-Gas-to-Energy Facility[1]

There are three principal electric generating technologies for landfill gas applications. The first technology, and by far the most popular, is the internal combustion engine (reciprocating engine). These engines, usually between 800 kW and 3 MW, are built to combust the low-BTU landfill gas and can often handle greater amounts of impurities in the fuel without requiring pretreatment. Because of their rugged design, low capital cost and low O&M costs relative to the other technologies, reciprocating engines tend to be quite attractive. The manufacturers of reciprocating engines which have the largest presence in the U.S. are Caterpillar, Wärtsilä, and Jenbacher (subsidiary of GE Energy). Combustion turbines are the second landfill gas technology, and these are usually seen for projects 3 MW and larger. Combustion turbines may provide better emissions characteristics than do the reciprocating engines, but higher capital costs often put the turbines out of reach. The principal seller of small combustion turbines capable of burning landfill gas is Solar, which is a Caterpillar-owned company. The final technology represented in the landfill gas industry is microturbines. There have been many successful microturbine installations using landfill gas at commercial or industrial facilities, but as these are only 30 kW to 250 kW in size, it is usually not economic for a utility interconnect application. Figure 2 depicts a comparison of the number of projects with each generating technology for landfill gas.

1 Landfill Methane Outreach Program (LMOP). U.S. Environmental Protection Agency. <http://www.epa.gov/lmop/>.

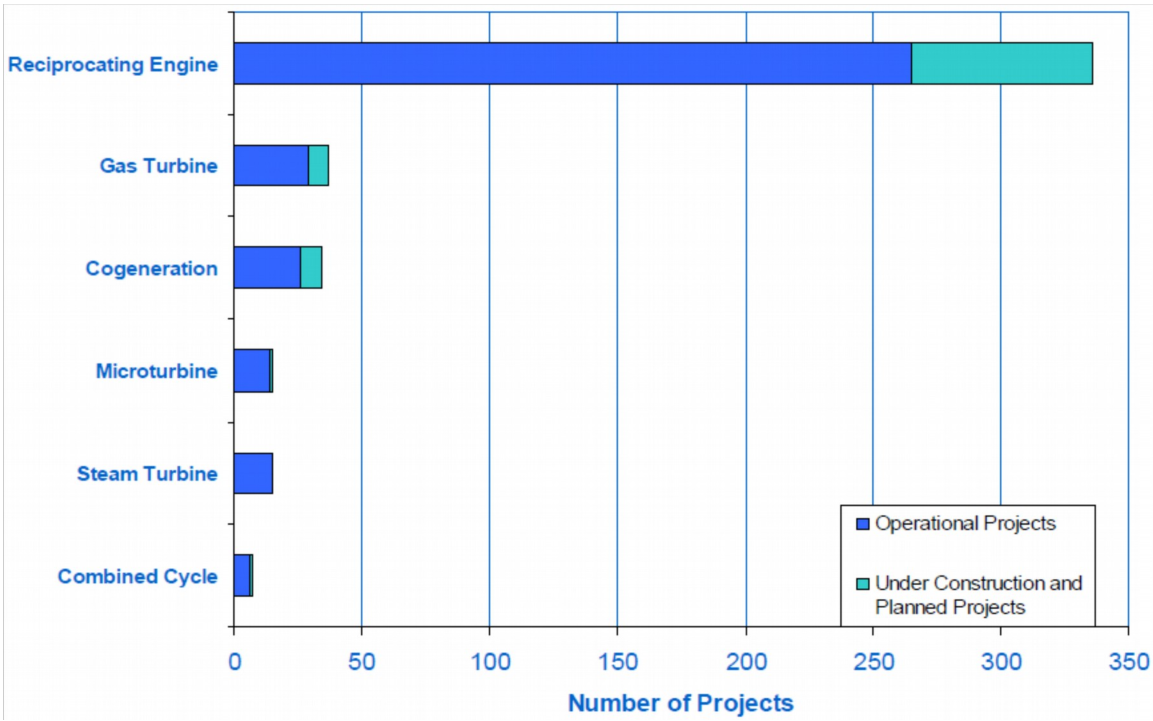

Figure 0-2: Landfill Gas Technology Utilization[2]

2 Landfill Methane Outreach Program (LMOP). U.S. Environmental Protection Agency. <http://www.epa.gov/lmop/>.

III. HEAT RATE AND OUTPUT

NEW AND CLEAN CONDITIONS

	Net Plant Heat Rate (Based on HHV) Btu/kWh	**Net Unit Output kW**
Annual Average	**REDACTED**	**REDACTED**

Basis for Heat Rate and Output Data:

- Performance is net of **REDACTED** of station service.
- Heat Rate assumes quality of landfill gas at **REDACTED** methane content equating to a lower heating value of approximately **REDACTED** mmbtu/ft^3.

IV. CAPITAL COSTS

NEW AND CLEAN CONDITIONS

Project Spending (Years)	**REDACTED**

	Per Kilowatt	Total
Turnkey EPC	**REDACTED**	**REDACTED**
Site	**REDACTED**	**REDACTED**
Owner's	**REDACTED**	**REDACTED**
Total Cost	**REDACTED**	**REDACTED**
Land (Included in Site)		**REDACTED**

Basis for Plant Costs:

- Plant costs are overnight costs as of 1/1/2014
- Per kW costs based on the **REDACTED** rating
- Generic "Greenfield" site located on or adjacent to landfill (**REDACTED REDACTED REDACTED REDACTED**)
- Refer to Standard Assumptions in Introduction for additional detail
- All Site Costs assumed to be included in Turnkey EPC contract
- Interconnection Costs not included
- **REDACTED REDACTED**
- **REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED REDACTED**

V. O&M COSTS

NEW AND CLEAN CONDITIONS

Asset Life (Years)	**REDACTED**
Capacity Factor	**REDACTED**
Starts per Year	**REDACTED**

Planned Maintenance (Wks/Yr)	**REDACTED**
EUOR	**REDACTED**

Output Degradation	**REDACTED**
Heat Rate Degradation	**REDACTED**

Fixed O&M Costs

$/kW-Yr	**REDACTED**
Total/Yr	**REDACTED**

- (Based on **REDACTED** Rating).

Variable O&M Costs

$/MWh	**REDACTED**
Total/Yr	**REDACTED**

- (Based on **REDACTED** Rating).

Capital Expenditures for Maintenance

$/kW-Yr	**REDACTED**

Basis for O&M Costs:

- O&M costs are in 1/1/2014 dollars
- **REDACTED REDACTED REDACTED**
- FOM based on the **REDACTED** rating
- VOM based on the **REDACTED** rating and capacity factor
- Refer to Standard Assumptions in Introduction for additional detail

VI. EMISSIONS

	2-Recip. Engines lbs/mmbtu
Sulfur Dioxide (SO_2)	**REDACTED**
Nitrogen Oxides (NO_X)	**REDACTED**
Particulate Matter (PM)	**REDACTED**
Carbon Monoxide (CO)	**REDACTED**
Carbon Dioxide (CO_2)	**REDACTED**
Volatile Organics (VOC)	**REDACTED**
Mercury (Hg)	**REDACTED**

Basis for Emissions Data:

- **REDACTED** emissions based on**REDACTED** steady state operating conditions assuming a fuel lower heating value (LHV) of **REDACTED** Btu/ft^3
- These emission estimates should only be used to generally characterize emissions. Permits obtained in the future for this technology may require more stringent emission limitations than the estimates shown above.

VII. INDICATIVE SPENDING SCHEDULE

The intent of the project expenditure data is to generically show when major expenditures (such as major equipment and construction costs) will happen, not to reflect all costs that may be necessary for a particular project.

Month	**Monthly**	**Cumulative**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**
REDACTED	**REDACTED**	**REDACTED**

VIII. INDICATIVE PROJECT SCHEDULE

REDACTED

COMBINED HEAT & POWER (CHP)

DESCRIPTION

Combined heat and power (CHP) is the generation of electric power and production of useful thermal energy from a single fuel source. CHP is used either to replace or supplement conventional separate heat and power systems. By producing both electric and thermal energy, CHP yields increased overall efficiency and may also result in reduced emissions.

Economic CHP is achieved when the cost savings from increased efficiency and overall customer cost savings offset the cost of installing and operating a CHP facility.

APPLICATION

CHP is commonly used within industries with heat intensive processes such as pulp & paper mills, chemical production, automotive manufacturing, and oil refineries. CHP is also used in commercial applications for dehumidification, space heating and cooling (including absorption chilling). Commercial applications include hospitals, schools, hotels, and district heating among others.

CHP applications vary greatly and are a function of each individual deployment. Customer requirements for steam or hot water temperature, pressure, quantity, quality, and loads are all unique. CHP technologies can include traditional boilers, combustion turbines, heat recovery steam generators, steam turbines, and reciprocating engines and may include a range of fuels.

PERFORMANCE & COSTS

Deployment time for CHP varies widely as a function of technology and may be on the order of months to several years and on par with conventional power generation facilities.

The nature of CHP, as discussed above, is such that a “generic” option is not provided. Determination of a generic cost or performance is therefore impractical. Each potential application must be evaluated individually based on the requirements and project economics.

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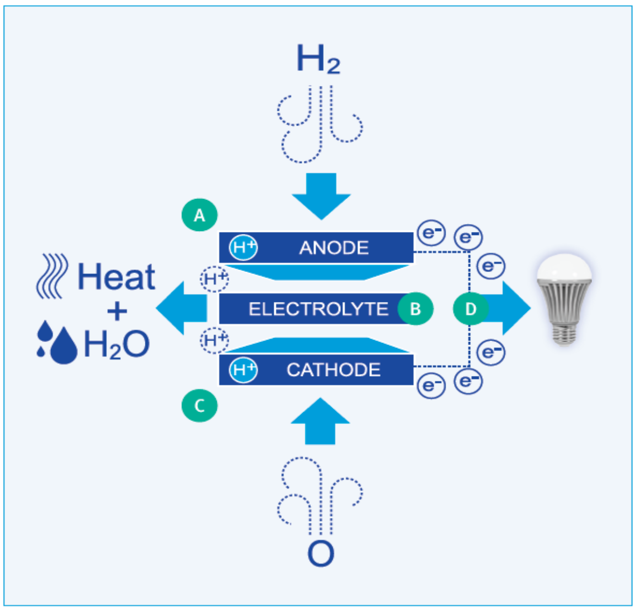
FUEL CELL REDACTED
REDACTED

PLANT DESCRIPTION AND DATA SUMMARY

I. GENERAL DESCRIPTION OF THE PLANT

A fuel cell is an electrochemical device that combines hydrogen fuel and oxygen to produce electricity, heat, and water. Fuel cells operate without combustion, so they are virtually pollution free. Since the fuel is converted directly to electricity and heat, a fuel cell's total system efficiency can be much higher than internal combustion engines, extracting more energy from the same amount of fuel. The fuel cell itself has no moving parts, making it a quiet and reliable source of power.



Each fuel cell is composed of an anode (a negative electrode that provides electrons), an electrolyte in the center, and a cathode (a positive electrode that accepts electrons). As hydrogen flows into the fuel cell anode, a catalyst layer on the anode helps to separate the hydrogen atoms into protons (hydrogen ions) and electrons. The electrolyte in the center allows only the protons to pass through the electrolyte to the cathode side of the fuel cell. The electrons cannot pass through this electrolyte and, therefore, must flow through an external circuit in the form of electric current. This current can power an electric load.

Individual fuel cells are combined into a fuel cell "stack" to increase the total electrical output. For example, a commercial solid oxide fuel system available today has five 50kW fuel cell stacks which would be dispatched as a single 250kW system. The fuel cell stack then forms one of the major components of the system, the others being the reformer (converts natural gas to hydrogen), a thermal management system, an inverter (DC to AC), and a control system.

At a high level, the system can be thought of as having four major processes:

1. The fuel processor converts pipeline natural gas to hydrogen to feed the fuel cell stack.

2. Hydrogen gas and oxygen from air are combined in an electrochemical process that produces Direct Current (DC) power, pure water and heat.

3. The DC power provided by the fuel cell stack is conditioned to provide high quality Alternating Current (AC) power output.

4. Useful heat is recovered internal to the system.

The package offers "air permit" free siting and low noise and vibration.

The fuel cell considered in this chapter is **REDACTED** . This is a **REDACTED** technology. One feature of this particular fuel cell system is that all useful energy it produces is in the form of electrical power. **REDACTED** currently does not provide CHP options. This allows customers to develop projects quickly and allows for prompt installation.

II. STATE OF THE TECHNOLOGY

Asset Life (Years)	**REDACTED**

Within the "large scale" fuel cell business, **REDACTED** competitors are **REDACTED** **REDACTED** and **REDACTED** , though these companies use different fuel cell chemistries. Continued improvements are expected to drive electrical efficiencies into the **REDACTED** range.

I. HEAT RATE AND OUTPUT

Net Plant Heat Rate (Based on HHV) Btu/kWh	**Net Unit Output kW**
REDACTED	**REDACTED**

Basis for Heat Rate and Output Data:

- Provided by vendor

III. CAPITAL COSTS

	Per Kilowatt
Total Cost	**REDACTED**

Basis for Capital Costs:

- Costs are overnight as of 7/1/2016.
- Provided by vendor

IV. O&M COSTS

Capacity Factor	**REDACTED**

Fixed O&M

$/kW-Yr	**REDACTED**
Total/Yr	**REDACTED**

Variable O&M

$/MWh	**REDACTED**
Total/Yr	**REDACTED**

Capital Expenditures for Maintenance

$/kW-Yr	**REDACTED**
Total/Yr	**REDACTED**

Basis for O&M Costs:

- O&M costs are in 7/1/2016 dollars
- Vendor provided service agreement
- Majority of costs associated with major component replacement

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V. EMISSIONS

Aside from CO2, other emissions are virtually nonexistent.

	Concentration (ppmvd @15% O_2)	**lb/MWh**
Sulfur Oxides (SO_X)	**REDACTED**	**REDACTED**
Nitrogen Oxides (NO_X)	**REDACTED**	**REDACTED**
Particulate Matter (PM - filterable)	**REDACTED**	**REDACTED**
Carbon Monoxide (CO)	**REDACTED**	**REDACTED**
Carbon Dioxide (CO_2)	**REDACTED**	**REDACTED**
Volatile Organics (VOC as CH4)	**REDACTED**	**REDACTED**

Basis for Emissions Data:

- Provided by vendor

CARBON CAPTURE AND COMPRESSION (CCC) COST & PERFORMANCE IMPACTS

The following are screening level estimates for projects that include Carbon Capture and Compression:

			Increase in GTDB estimates for:				
	Capture Rate	**Output**	**Heat Rate**	**Capital**	**FOM**	**VOM**	**Capital for Maintenance**
PC	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
IGCC	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED
CC	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED	REDACTED

- Cost and performance impacts are considered to be a screening level estimate only
- Values only apply to new construction and <u>do not</u> represent the impacts of retrofitting a CCC system to existing units
- Values only consider the cost of capture and compression and <u>do not</u> include any transportation, sequestration, or utilization

I. DATA SUMMARY TABLES

New & Clean Conditions		REDACTED CC Gas Only	REDACTED CC Gas Only
PEAKING OUTPUT	kW	**REDACTED**	**REDACTED**
PEAKING HEAT RATE	BTU/kWh	**REDACTED**	**REDACTED**
AVERAGE OUTPUT	kW	**REDACTED**	**REDACTED**
AVERAGE HEAT RATE	BTU/kWh	**REDACTED**	**REDACTED**
PLANT COST	$/kW	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
FIXED O&M	$/kW-yr	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
VARIABLE O&M	$/MWh	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
CAPITAL FOR MAINT.	$/kW-yr	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**

Degraded Conditions		REDACTED CC Gas Only	REDACTED CC Gas Only
PEAKING OUTPUT	kW	**REDACTED**	**REDACTED**
PEAKING HEAT RATE	BTU/kWh	**REDACTED**	**REDACTED**
AVERAGE OUTPUT	kW	**REDACTED**	**REDACTED**
AVERAGE HEAT RATE	BTU/kWh	**REDACTED**	**REDACTED**
PLANT COST	$/kW	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
FIXED O&M	$/kW-yr	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
VARIABLE O&M	$/MWh	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**
CAPITAL FOR MAINT.	$/kW-yr	**REDACTED**	**REDACTED**
	$x1000	**REDACTED**	**REDACTED**

ACRONYMS

Does not include units of measure or chemical symbols

AFUDC	Allowance for Funds Used During Construction
AGP	Advanced Gas Path
AQCS	Air Quality Control Systems
REDACTED	**REDACTED REDACTED**
BOP	Balance of Plant
CAES	Compressed Air Energy Storage
CC	Combined Cycle
CCC	Carbon Capture and Compression
CCS	Carbon Capture and Sequestration
CCUS	Carbon Capture Utilization and Sequestration
CEM	Capital Expenditures for Maintenance
REDACTED	**REDACTED REDACTED**
CHP	Combined Heat & Power
CI	Combustion Inspection
COD	Commercial Operation Date
CT	Combustion Turbine
REDACTED	**REDACTED REDACTED**
DCS	Distributed Control System
REDACTED	**REDACTED REDACTED REDACTED**
DOE	Department of Energy
E&CS	Engineering and Construction Services
EC	Evaporative Cooling
EFORd	Demand Equivalent Forced Outage Rate
EPC	Engineering Procurement and Construction (cost)
REDACTED	**REDACTED REDACTED REDACTED REDACTED**
EUOR	Equivalent Unplanned Outage Rate
FOM	Fixed Operations and Maintenance
FP	Full Pressure
FT	Fixed Tilt (Solar PV)
GCR	Ground Cover Ratio
REDACTED	**REDACTED REDACTED**
GSU	Generator Step-Up (transformer)
GT	Gas Turbine

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GTDB	Generation Technology Data Book
HARP	Heater Above Reheat Point
HGP	Hot Gas Path (inspection)
HHV	Higher Heating Value
HR	Heat Rate
HRSG	Heat Recovery Steam Generator
LFGTE	Landfill Gas to Energy
LTSA	Long Term Service Agreement
REDACTED	**REDACTED REDACTED REDACTED**
MM	Major Maintenance
NPHR	Net Plant Heat Rate
NSSS	Nuclear Steam Supply System
NTP	Notice to Proceed
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
PSH	Pumped Storage Hydro
PV	Photovoltaic (solar)
RCS	Reactor Coolant System
RFP	Request for Proposal
RH	Relative Humidity
RHR	Residual Heat Removal (heat exchanger)
SAT	Single Axis Tracking (Solar PV)
SCR	Selective Catalytic Reduction
SNCR	Selective Non-Catalytic Reduction
ST	Steam Turbine
STG	Steam Turbine Generator
TIT	Turbine Inlet Temperature
TPC	Total Plant Cost
REDACTED	**REDACTED**
URPSH	Underground Reservoir Pumped Storage Hydro
VGV	Variable Guide Vane

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VOM	Variable Operations and Maintenance
VWO	Valves Wide Open
WC	Wet Compression
REDACTED	**REDACTED REDACTED**