California Energy Commission
Staff Workshop
Present and Future Central Station Renewable Plant Costs
April 16, 2009

Input for Levelized Cost of Generation Model

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Workshop Presentation

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Central Plant Renewable Energy – Technology and Cost Profiles

Approach and Methodology

Biomass

Geothermal

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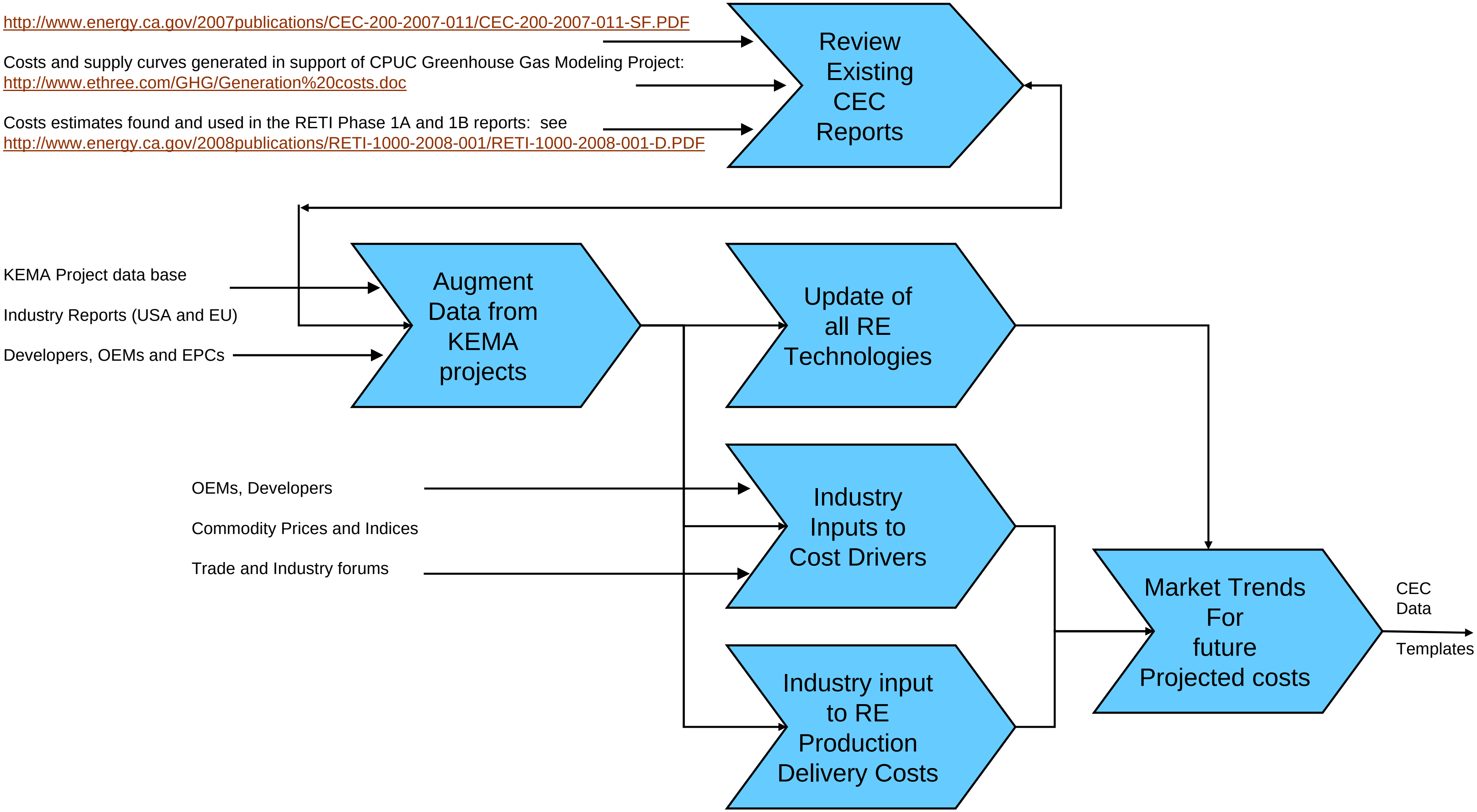
Reference to IEPR 2007 data

Approach and Methodology

The research team undertook the following approach:

- Conducted a technical and analytical critique of reference documents, including:
- Comparative Costs of California Central Station Electricity Generation Technologies. California Energy Commission Final Staff Report. December 2007. CEC-200-2007-011-SF.
- Costs and supply curves generated in support of CPUC Greenhouse Gas Modeling Project: http://www.ethree.com/GHG/Generation%20costs.doc
- Costs estimates found and used in the RETI Phase 1A and 1B reports: see http://www.energy.ca.gov/2008publications/RETI-1000-2008-001/RETI-1000-2008-001-D.PDF
- Recommended utility-scale RE technologies for cost analysis with technical and market justification. Utility-scale RE technologies are generally defined as those over 20MW.
- Identified the primary existing commercial embodiment of each utility-scale technology in California.
- Identified the expected primary commercial embodiment in the year 2018.
- Note that the research team will revisit Task 1 for the community and building-scale technologies in the second phase of the project and include findings in the Final Project Report.

Approach & Methodology – Tasks 1 to 4



Technology Selection Criteria

The research team used selection criteria similar to the following:

Example Sample criteria:

- is the technology commercially available and is anyone using it?
- how many projects worldwide are initiated?
- is the technology commercial somewhere, not necessarily in CA.
- what is the industrial capacity that would apply to CA?
- are there any things that make it difficult to make it viable in CA?
- what's going on in the world, what's commercial, what's being purchased,
- what's viable in CA and what could become viable, and what would it take to make it viable?
- political climate (for nuclear, off shore wind, etc)

Renewable Energy Technologies - Central Station

Technology List	Gross Capacity (MW)	Data Start Date
Biomass		
Biomass Combustion - Fluidized Bed Boiler	28	Current
Biomass Combustion - Stoker Boiler	38	Current
Biomass Cofiring	20	Current
Biomass Co-Gasification IGCC	30	2018
Geothermal		
Geothermal – Binary	50	Current
Geothermal - Flash	50	Current
Hydropower		
Hydro - Small Scale (developed sites without power)	15	Current
Hydro - Capacity upgrade for developed sites with power	80	Current
Solar		
Solar - Parabolic Trough	250	Current
Solar - Photovoltaic (Single Axis)	25	Current
Wind		
Onshore Wind - Class 5	50	Current
Onshore Wind - Class 3/4	50	Current
Offshore Wind - Class 5	350	2018
Wave		
Ocean Wave	40	2018
IGCC without carbon capture - Current commercial scale: single or multiple 300 MW trains	300	Current
Nuclear		
Nuclear: WESTINGHOUSE - AP1000	1100	Current

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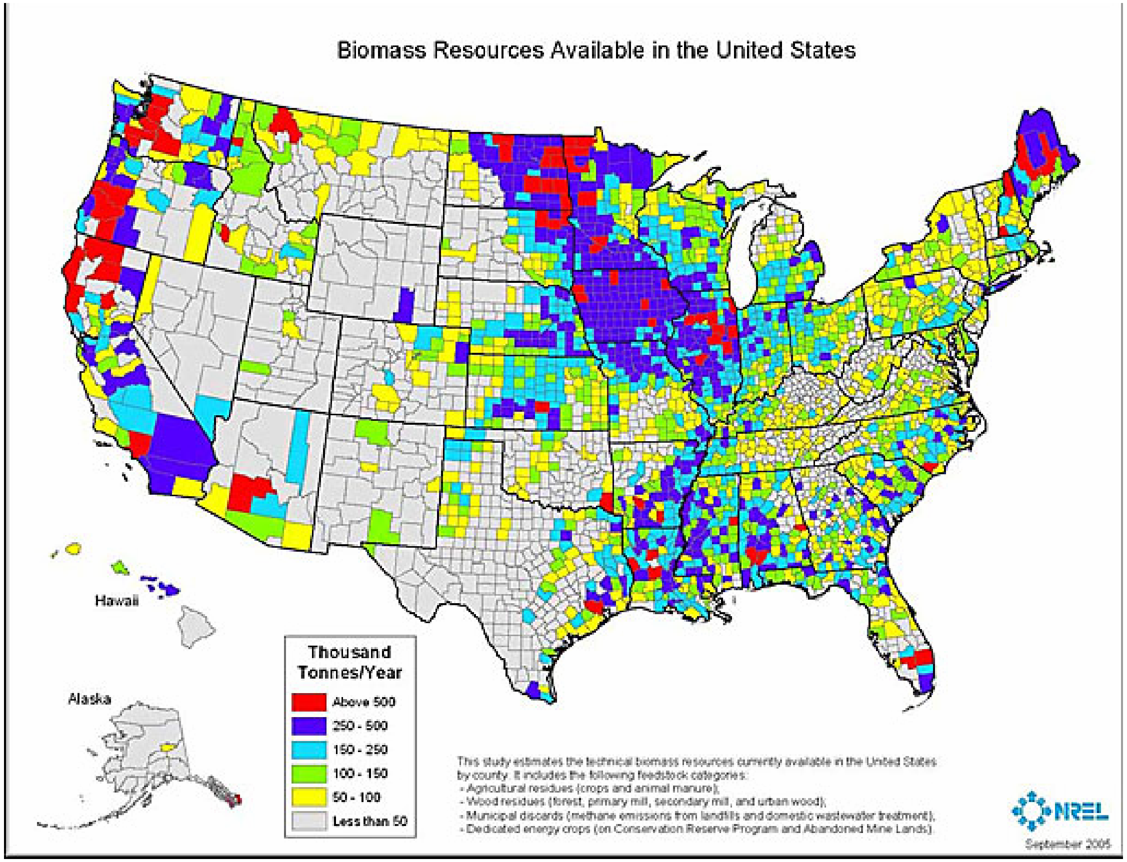
Biomass – Technologies / US Resource Map

California has significant biomass potential – in both northern and southern geographies.

Biomass Technologies Selected:

- ❑Biomass Combustion – Stoker Boiler
- ❑Biomass Combustion – Fluidized Bed Boiler
- ❑Biomass Cofiring
- ❑Biomass Co-Gasification IGCC



Biomass – Stocker Boiler Technology Selection Criteria

Biomass combusted using Stocker boiler technology in ~40MW unit size was selected based on reference plants in operation

Technology Reference Material and Key Assumptions	**Biomass Combustion with Stoker Boiler** Stoker boilers have been a standard technology option for biomass as well as coal for many years. A stoker boiler is an excellent combustor of cellulose waste such as wood, garbage, bagasse, industrial residue, peanut shells and shredded tires. Most of these fuels can be burned without auxiliary fuel given proper attention to moisture content. In a stoker boiler, biomass is added in a thin layer on a grate near the bottom of the boiler. This provides a more even distribution of feed material. Mature, most commonly used technology. Incremental improvements being made to increase steam temperature and pressure
	Reference Material: see "Task 1- Central Plant Technologies.xls"

Biomass – Stoker Boiler
Selected Technology Description

Biomass combusted using Stoker boiler technology in ~40MW unit size was selected based on reference plants in operation

Typical Plant	Description
 Burney Plant CHP, woody Biomass Stoker Boiler 1 x 28.4MW	In a **stoker boiler**, biomass is added in a thin layer on a grate near the bottom of the boiler. This provides a more even distribution of feed material. Mature, most commonly used technology. Incremental improvements being made to increase steam temperature and pressure

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Biomass – Stoker Boiler Cost Drivers

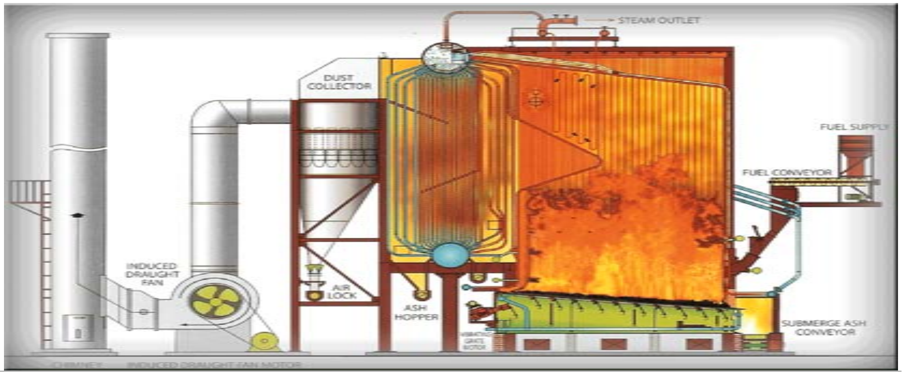
Stoker Boiler Technology is well established and a simple BTU extraction process

Cost Drivers

Key Cost Drivers

- Type of Biomass used
- Fuel (Biomass) transport and handling equipment
- The boiler island cost
- Type and cost of emission control equipment (SCR/SNCR).
- Greenfield or retrofit of existing plant

Plant Configuration Data Overview



PLANT DATA	Average	High	Low
Gross Capacity (MW)	38	38	25
Station Service (%)	2.40%	2.40%	2.40%
Net Capacity (MW)	37.09	37.09	24.40
Net Energy (GWh)	276	309	160
Transformer Losses	0.50%	0.50%	0.50%
Tranmission losses	1.49%	1.49%	1.49%
Load Center Delivered Capacity (MW)	36.35	36.35	23.92
Net Capacity Factor (NCF)	85.00%	95.00%	75.00%
Planned Percent of Year Operational	85.43%	97.57%	75.47%
Average Percent Output	100.0%	100.0%	100.0%
Net Energy Delivered to Load Center (GWh)	270.68	302.53	157.13
Forced Outage Rate (FOR)	0.50%	1.50%	0.25%
Scheduled Outage Factor (SOF)	0.77%	1.15%	0.38%
Curtailment (Hours)	60	120	0
Degradation Factors			
Capacity Degradation (%/Year)	0.10%	0.20%	0.00%
Heat Rate Degradation (%/Year)	0.15%	0.20%	0.10%
Emission Factors			
NOX (lbs/MWh)	0.075	0.075	0.075
VOC/ROG (Lbs/MWh)	0.012	0.012	0.012
CO (Lbs/MWh)	0.105	0.105	0.105
CO2 (lbs/MWh)	0.000	0.000	0.000
SOX (lbs/MWh)	0.034	0.034	0.034
PM10 (lbs/MWh)	0.100	0.200	0.025

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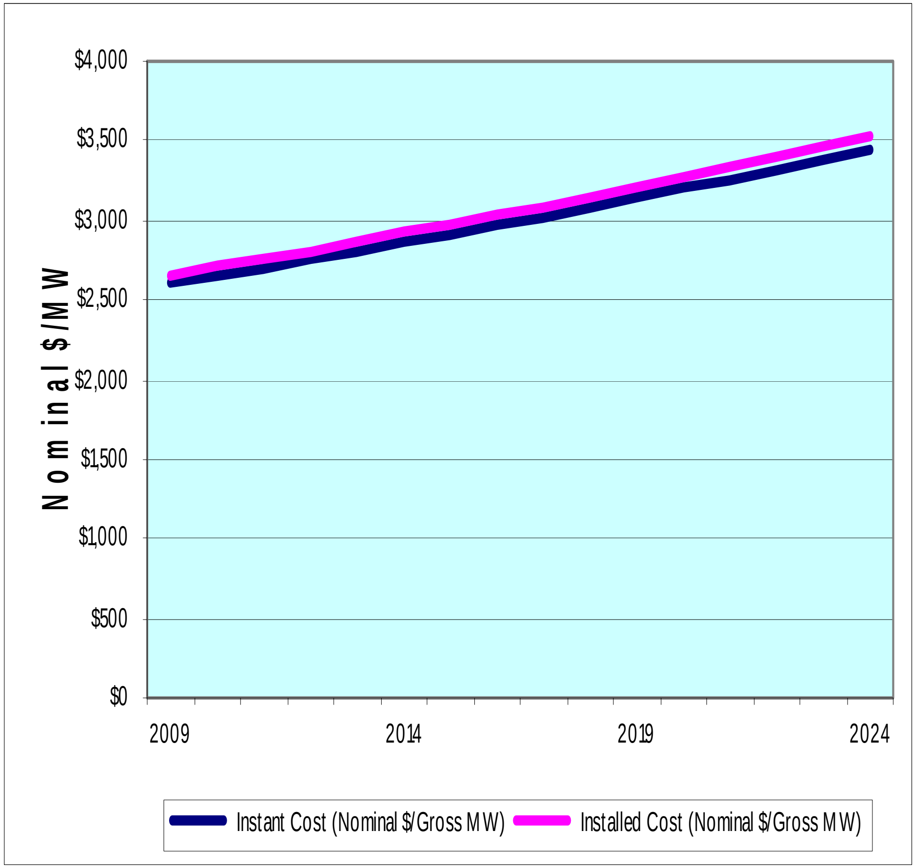
Biomass – Stoker Boiler
Current Cost and Cost Trajectory

Current Costs

	Start Year	2009
PLANT COST DATA		
Average		
Instant Cost (Nominal $/Gross MW)		$2,600
Installed Cost (Nominal $/Gross MW)		$2,658
% Cost of last year of construction		80%
% Cost next to last year of construction		20%
% Cost of previous year of construction		
High		
Instant Cost (Nominal $/Gross MW)		$3,250
Installed Cost (Nominal $/Gross MW)		$3,323
% Cost first year of construction		50%
% Cost second year of construction		40%
% Cost third year of construction		10%
Low		
Instant Cost (Nominal $/Gross MW)		$1,750
Installed Cost (Nominal $/Gross MW)		$1,789
% Cost first year of construction		90%
% Cost second year of construction		10%
% Cost third year of construction		

Year=2009, Value & Dollars	Average	High	Low
Fixed Cost ($/kW-Year)	$16.01	$20.00	$10.78
Variable Cost ($/MWh)	$6.98	$8.73	$4.70

Projections



Biomass – Fluidized Bed Boiler Technology Selection Criteria

Biomass combusted using Fluidized Bed boiler technology in ~30MW unit size was selected based on reference plants in operation

Technology Reference Material and Key Assumptions	**Biomass Combustion with Fluidized Bed Boiler** Circulating fluidized bed (CFB) technology is used for combustion of solid fuels. It was first used due to its ability to handle low quality, high sulphur coals. One of the main advantages of the CFB technology is that it allows the owner to optimize profitability by selecting a wide range of fuels (bituminous coal, bituminous gob or high-ash waste coal, subbituminous coal, lignite and brown coal, anthracite culm, coal cleaning tailings and petroleum coke). Other fuels such as wood, shredded tires, and sludge are fuel candidates depending on their heat input, moisture content and emissions requirements. This type of boiler provides economy and flexibility. In a fluidized-bed boiler, combustors burn biomass fuel in a bed of hot granular material. Air is injected at a high-rate underneath the bed to create the appearance of a boiling liquid. This helps to evenly distribute the fuel. Relatively mature technology - fluidized bed combustors are becoming the systems of choice for biomass fuels, due to good fuel flexibility and good emissions characteristics
	Reference Material: see "Task 1- Central Plant Technologies.xls"

Biomass – Fluidized Bed Boiler
Selected Technology Description

Biomass combusted using Fluidized Bed boiler technology in ~30MW unit size was selected based on reference plants in operation

Typical Plant	Description
 Fibrominn, Benson Plant, Turkey Litter Plant, MN	Compared to a stoker boiler system a fluidized-bed boiler: — Proven technology which optimizes combustion for a variety of fuels — Achieves a higher carbon burn-out. — Ensures more fuel flexibility due to the good mixing that occurs on the fluidized bed. — The relatively low combustion temperature ensures reduced NOx emissions, and the CFB process allows for the addition of certain minerals into the bed to control SOx emissions.

Biomass – Fluidized Bed Boiler Cost Drivers

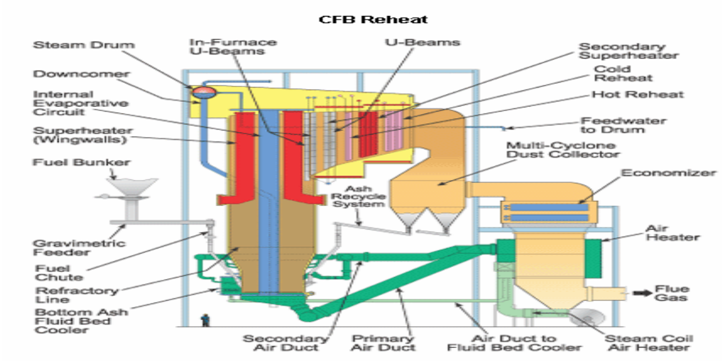
Fluidized Bed Boiler Technology is well established, efficient BTU extraction process

Cost Drivers

Key Cost Drivers

- Type of Biomass used
- Fuel (Biomass) transport and handling equipment
- The boiler island cost
- Type and cost of emission control equipment (SCR/SNCR).
- Greenfield or retrofit of existing plant
- O&M costs

Plant Configuration Data Overview



PLANT DATA	Average	High	Low
Gross Capacity (MW)	28	28	15
Station Service (%)	2.50%	2.50%	3.00%
Net Capacity (MW)	27.30	27.30	14.55
Net Energy (GWh)	203	215	96
Transformer Losses	0.50%	0.50%	0.50%
Tranmission losses	1.49%	1.49%	1.49%
Load Center Delivered Capacity (MW)	26.76	26.76	14.26
Net Capacity Factor (NCF)	85.00%	90.00%	75.00%
Planned Percent of Year Operational	85.86%	92.43%	75.66%
Average Percent Output	100.0%	100.0%	100.0%
Net Energy Delivered to Load Center (GWh)	199.25	210.97	93.70
Forced Outage Rate (FOR)	1.00%	1.50%	0.50%
Scheduled Outage Factor (SOF)	0.77%	1.15%	0.38%
Curtailment (Hours)	60	120	0
Degradation Factors			
Capacity Degradation (%/Year)	0.10%	0.20%	0.00%
Heat Rate Degradation (%/Year)	0.15%	0.20%	0.10%
Emission Factors			
NOX (lbs/MWh)	0.074	0.074	0.074
VOC/ROG (Lbs/MWh)	0.009	0.009	0.009
CO (Lbs/MWh)	0.079	0.079	0.079
CO2 (lbs/MWh)	0.000	0.000	0.000
SOX (lbs/MWh)	0.020	0.020	0.020
PM10 (lbs/MWh)	0.100	0.200	0.025

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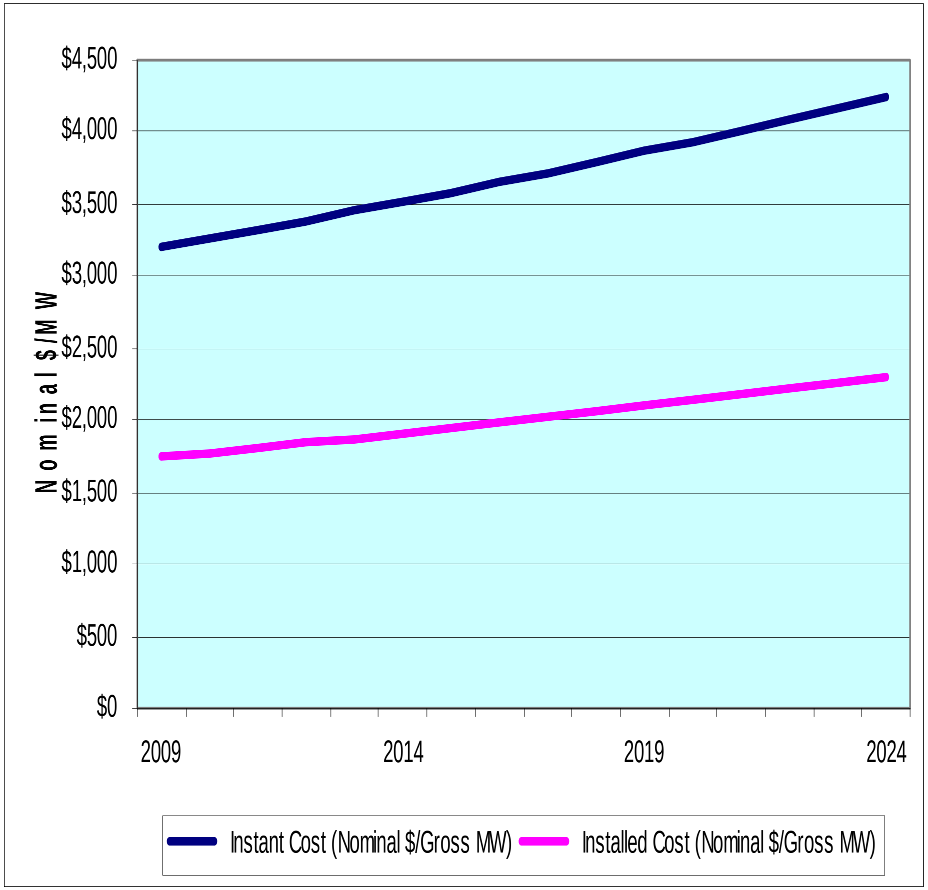
Biomass – Fluidized Bed Boiler
Current Cost and Cost Trajectory

Current Costs

PLANT COST DATA	Start Year 2009
Average	
Instant Cost (Nominal $/Gross MW)	$3,200
Installed Cost (Nominal $/Gross MW)	$1,740
% Cost of last year of construction	80%
% Cost next to last year of construction	20%
% Cost of previous year of construction	
High	
Instant Cost (Nominal $/Gross MW)	$4,800
Installed Cost (Nominal $/Gross MW)	$4,975
% Cost first year of construction	60%
% Cost second year of construction	40%
% Cost third year of construction	0%
Low	
Instant Cost (Nominal $/Gross MW)	$1,600
Installed Cost (Nominal $/Gross MW)	$1,740
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	

Year=2009, Value & Dollars	Average	High	Low
Fixed Cost ($/kW-Year)	$15.0	$9.95	$7.00
Variable Cost ($/MWh)	$10.00	$4.47	$3.00

Projections



Biomass – Cofiring
Technology Selection Criteria

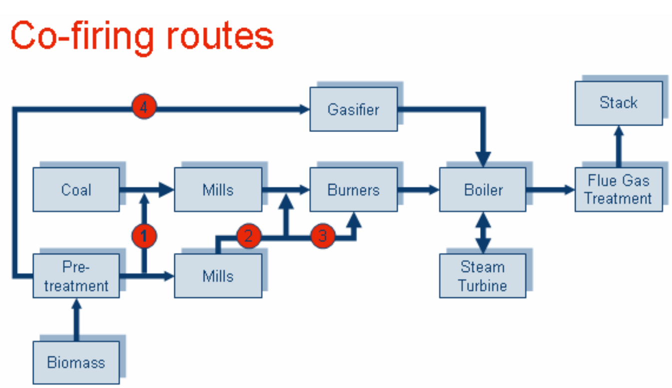
Cofiring Biomass combusted using an existing coal fired plant is an optimal use of existing assets to displace coal BTUs

Technology Reference Material and Key Assumptions	**<u>Cofiring Biomass in existing Coal Plant</u>** Biomass co-fi ring at coal-burning power plants helps to reduce net carbon dioxide emissions, providing a necessary break for the environment. Co-firing is also economically attractive for electricity producers as many national governments provide tax benefits and other statutory and financial incentives to encourage the practice. Moreover, biomass co-fi ring is a good way for a power producer to demonstrate awareness of its corporate social responsibilities. There is much more to co-fi ring than simply adding a secondary fuel to the coal. A power producer wishing to introduce a bio-fuel to the mix used at a plant must address numerous economic, logistic, technical and environmental considerations: • Is the capital cost justified by the economic benefits of supplying green power or reducing CO2 emissions? • How do we decide on the best ratio of biomass to coal? • How will biomass co-fi ring influence the plant in the shorter and longer term? • Will emissions from the plant still be within the legal limits? And will the ash produced still be saleable? At a minimum, it is necessary to gain a clear picture of the risks involved and the options for managing them.
	Reference Material: see "Task 1- Central Plant Technologies.xls"

Biomass – Cofiring
Selected Technology Description

Biomass can be cofired in any coal plant and from 5% to 30% ratio. We selected a nominal 100MW Coal Plant

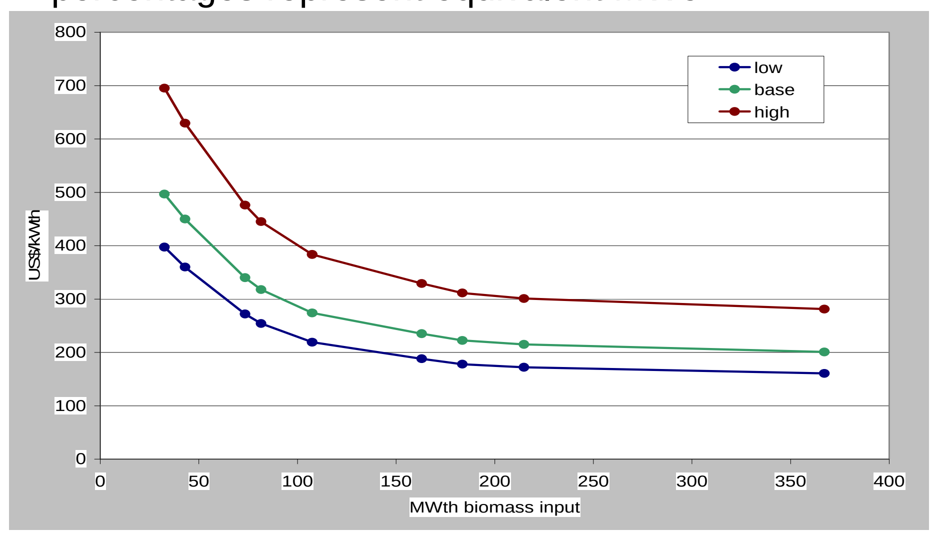
Typical Plant



1. Co-milling of biomass with coal
2. Separate milling, injection in pf-lines, combustion in coal burners
3. Separate milling, combustion in dedicated biomass burners
4. Biomass gasification, syngas combusted in furnace boiler

Description

- Cofiring technology makes use of an existing coal fired power plant
- Experience has been gained in injection of Biomass in various points into the fuel feed or combustion point
- The analysis has selected – low (10%), average (20%) and high (40%) cases where the cofiring percentages represent equivalent MWe



Biomass – Cofiring
Cost Drivers

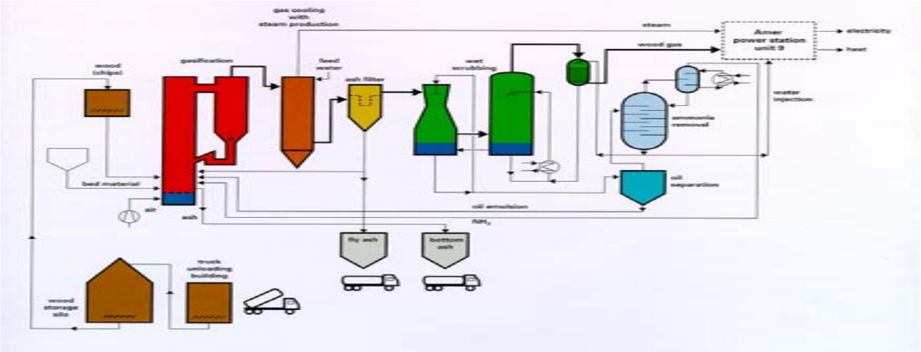
Cofiring Technology is well established and an optimal way to replace coal with renewable energy

Cost Drivers

Key Cost Drivers

- Type of Biomass used
- Fuel (Biomass) transport and handling equipment
- Fuel feed modifications
- Type and cost of emission control equipment (SCR/SNCR).
- Percentage of cofiring deployed

Plant Configuration Data Overview



PLANT DATA	Average	High	Low
Gross Capacity (MW)	20	40	10
Station Service (%)	2.40%	2.40%	2.40%
Net Capacity (MW)	19.52	39.04	9.76
Net Energy (GWh)	154	308	73
Transformer Losses	0.50%	0.50%	0.50%
Tranmission losses	1.49%	1.49%	1.49%
Load Center Delivered Capacity (MW)	19.13	38.27	9.57
Net Capacity Factor (NCF)	90.00%	90.00%	85.00%
Planned Percent of Year Operational	90.45%	91.97%	85.41%
Average Percent Output	100.0%	100.0%	100.0%
Net Energy Delivered to Load Center (GWh)	150.84	301.69	71.23
Forced Outage Rate (FOR)	0.50%	1.00%	0.10%
Scheduled Outage Factor (SOF)	0.77%	1.15%	0.38%
Curtailment (Hours)	0	0	0
Degradation Factors			
Capacity Degradation (%/Year)	0.00%	0.00%	0.00%
Heat Rate Degradation (%/Year)	0.00%	0.00%	0.00%
Emission Factors			
NOX (lbs/MWh)	0.093	0.064	0.064
VOC/ROG (Lbs/MWh)	0.023	0.018	0.018
CO (Lbs/MWh)	0.093	0.050	0.050
CO2 (lbs/MWh)	1083.844	828.140	828.140
SOX (lbs/MWh)	0.009	0.007	0.007
PM10 (lbs/MWh)	0.065	0.028	0.028

Biomass – Cofiring
Current Cost and Cost Trajectory

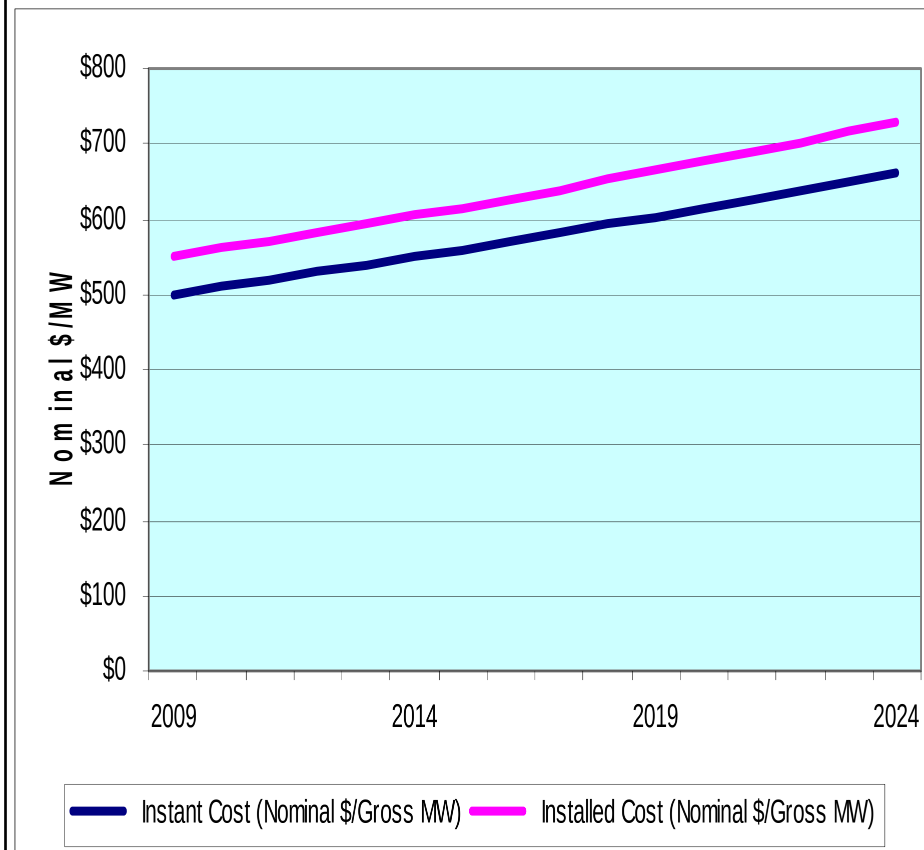
Very attractive costs per MW!

Current Costs

PLANT COST DATA	Start Year 2009
Average	
Instant Cost (Nominal $/Gross MW)	$500
Installed Cost (Nominal $/Gross MW)	$550
% Cost of last year of construction	100%
% Cost next to last year of construction	
% Cost of previous year of construction	
High	
Instant Cost (Nominal $/Gross MW)	$700
Installed Cost (Nominal $/Gross MW)	$770
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	
Low	
Instant Cost (Nominal $/Gross MW)	$400
Installed Cost (Nominal $/Gross MW)	$440
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	

Year=2009, Value & Dollars	Average	High	Low
Fixed Cost ($/kW-Year)	$15.0	$21.00	$12.00
Variable Cost ($/MWh)	$1.27	$1.78	$1.02

Projections



Biomass – Co-Gasification IGCC Technology Selection Criteria

Co Gasification of Biomass using IGCC

Technology Reference Material and Key Assumptions	**Co Gasification using IGCC** This technology gives biomass access to the higher efficiencies of gas fired power generation and combined cycles Key characteristics of the system is: Direct (single stage and autothermal), pressurized, fluidized bed gasifier Heat exchanger to 400C prior to hot gas filter for dust removal (tar removal is not necessary) Cleaned gas is a combusted in a gas turbine, which also supplies the gasifier with pressurized air from the compressor Residual heat is used in a steam cycle Commercial deployment of this technology can only be justified with a large plant and a sound biomass supply infrastructure. Demonstration plants have been built, mainly in Europe with many technology and reliability issues emerging
	Reference Material: see "Task 1- Central Plant Technologies.xls"

Biomass – Co Gasification IGCC
Selected Technology Description

Biomass can be gasified and the syngas used in a classical IGCC plant

Typical Plant	Description
 ?	• This technology gives biomass access to the higher efficiencies of gas fired power generation and combined cycles • Key characteristics of the system we will profile — Direct (single stage and autothermal), pressurized, fluidized bed gasifier — Heat exchanger to 400C prior to hot gas filter for dust removal (tar removal is not necessary) — Cleaned gas is a combusted in a gas turbine, which also supplies the gasifier with pressurized air from the compressor — Residual heat is used in a steam cycle • Commercial deployment of the technology has not occurred. One demonstration BIGCC unit has been built in Europe but it is no longer in operation. — Information on actual capital and operating costs is limited

Biomass – Co Gasification IGCC
Cost Drivers

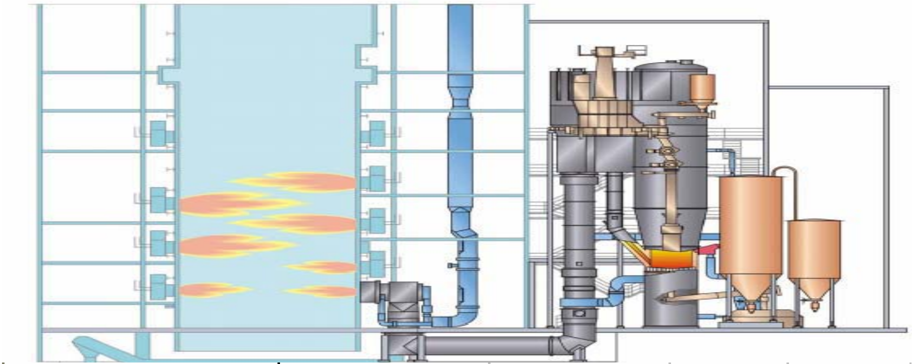
Co Gasification with IGCC is an emerging technology

Cost Drivers

Key Cost Drivers

- Type of Biomass used
- Fuel (Biomass) transport and handling equipment
- Type of gasification used (i.e Shell, FB gasifier...)
- Type and cost of emission control equipment (SCR/SNCR).
- Type of cycle selected (CT CC or Direct into Boiler)

Plant Configuration Data Overview



PLANT DATA	Average	High	Low
Gross Capacity (MW)	30	40	25
Station Service (%)	3.50%	4.50%	2.50%
Net Capacity (MW)	28.95	38.20	24.38
Net Energy (GWh)	190	284	128
Transformer Losses	0.50%	0.50%	0.50%
Tranmission losses	1.49%	1.49%	1.49%
Load Center Delivered Capacity (MW)	28.38	37.44	23.89
Net Capacity Factor (NCF)	75.00%	85.00%	60.00%
Planned Percent of Year Operational	78.95%	96.71%	65.10%
Average Percent Output	100.0%	100.0%	100.0%
Net Energy Delivered to Load Center (GWh)	186.43	278.80	125.58
Forced Outage Rate (FOR)	5.00%	6.00%	4.00%
Scheduled Outage Factor (SOF)	5.50%	6.50%	4.00%
Curtailment (Hours)	0	0	0
Degradation Factors			
Capacity Degradation (%/Year)	0.00%	0.00%	0.00%
Heat Rate Degradation (%/Year)	0.20%	0.20%	0.20%
Emission Factors			
NOX (lbs/MWh)	0.074	0.074	0.074
VOC/ROG (Lbs/MWh)	0.009	0.009	0.009
CO (Lbs/MWh)	0.029	0.029	0.029
CO2 (lbs/MWh)	0.000	0.000	0.000
SOX (lbs/MWh)	0.020	0.020	0.020
PM10 (lbs/MWh)	0.100	0.200	0.025

Biomass – Co Gasification IGCC
Current Cost and Cost Trajectory

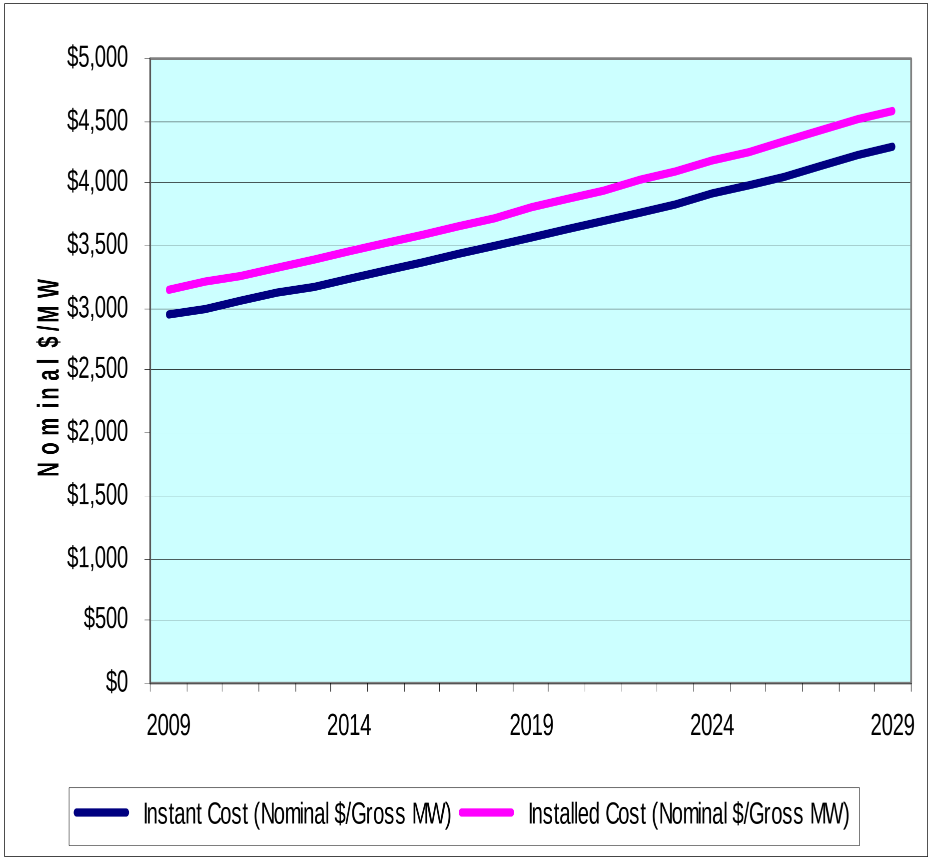
This technology is projected to be viable in 2018

Current Costs

PLANT COST DATA	Start Year 2009
Average	
Instant Cost (Nominal $/Gross MW)	$2,950
Installed Cost (Nominal $/Gross MW)	$3,150
% Cost of last year of construction	75%
% Cost next to last year of construction	25%
% Cost of previous year of construction	
High	
Instant Cost (Nominal $/Gross MW)	$3,688
Installed Cost (Nominal $/Gross MW)	$3,938
% Cost first year of construction	50%
% Cost second year of construction	40%
% Cost third year of construction	10%
Low	
Instant Cost (Nominal $/Gross MW)	$2,655
Installed Cost (Nominal $/Gross MW)	$2,835
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	

Year=2009, Value & Dollars	Average	High	Low
Fixed Cost ($/kW-Year)	$150.0	$175.00	$125.00
Variable Cost ($/MWh)	$4.00	$4.50	$3.00

Projections



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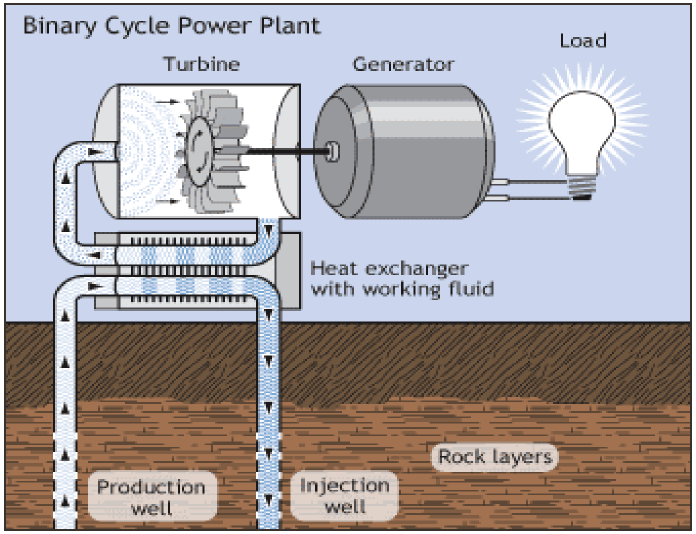
Geothermal - Binary
Technology Selection Criteria

Geothermal technology deploys the basic technology of the Steam Turbine Generator.

Technology Reference Material and Key Assumptions	**Geothermal – Technologies** There are four commercial types of geothermal power plants: (a) flash power plants, (b) dry steam power plants, (c) binary power plants, and (d) flash/binary combined power plants The analysis focuses on Fash and Binary geothermal power plants
	Reference Material: see “Task 1- Central Plant Technologies.xls”

Geothermal - Binary
Selected Technology Description

Geothermal – Binary technology ......

Typical Plant	Description
 ?	Binary Power Plant: Recent advances in geothermal technology have made possible the economic production of electricity from geothermal resources lower than 150°C (302°F). Known as binary geothermal plants, the facilities that make this possible reduce geothermal energy's already low emission rate to zero. Binary plants typically use an Organic Rankine Cycle system. The geothermal water (called "geothermal fluid" in the accompanying image) heats another liquid, such as isobutane or other organic fluids such as pentafluoropropane, which boils at a lower temperature than water. The two liquids are kept completely separate through the use of a heat exchanger, which transfers the heat energy from the geothermal water to the working fluid. The secondary fluid expands into gaseous vapor. The force of the expanding vapor, like steam, turns the turbines that power the generators. All of the produced geothermal water is injected back into the reservoir.

Geothermal - Binary
Cost Drivers

Geothermal Binary technology uses a heat exchanger to

Cost Drivers

Key Cost Drivers

- Site geographies
- Turbine Island
- Exploration
- Confirmation Drilling
- Steam gathering
- Royalties
- O&M

Plant Configuration Data Overview

PLANT DATA	Average	High	Low
Gross Capacity (MW)	50	50	50
Station Service (%)	0.50%	0.50%	0.50%
Net Capacity (MW)	49.75	49.75	49.75
Net Energy (GWh)	405	405	405
Transformer Losses	0.50%	0.50%	0.50%
Tranmission losses	1.49%	1.49%	1.49%
Load Center Delivered Capacity (MW)	48.76	48.76	48.76
Net Capacity Factor (NCF)	93%	93%	93%
Planned Percent of Year Operational	100.0%	100.0%	100.0%
Average Percent Output	93.84%	93.84%	93.84%
Net Energy Delivered to Load Center (GWh)	397	397	397
Forced Outage Rate (FOR)	0.6%	0.6%	0.6%
Scheduled Outage Factor (SOF)	0.30%	0.30%	0.30%
Curtailment (Hours)	0.0	0.0	0.0
Degradation Factors			
Capacity Degradation (%/Year)	4.00%	4.00%	4.00%
Heat Rate Degradation (%/Year)	N/A	N/A	N/A
Emission Factors			
NOX (lbs/MWh)	N/A	N/A	N/A
VOC/ROG (Lbs/MWh)	N/A	N/A	N/A
CO (Lbs/MWh)	N/A	N/A	N/A
CO2 (lbs/MWh)	N/A	N/A	N/A
SOX (lbs/MWh)	N/A	N/A	N/A
PM10 (lbs/MWh)	N/A	N/A	N/A

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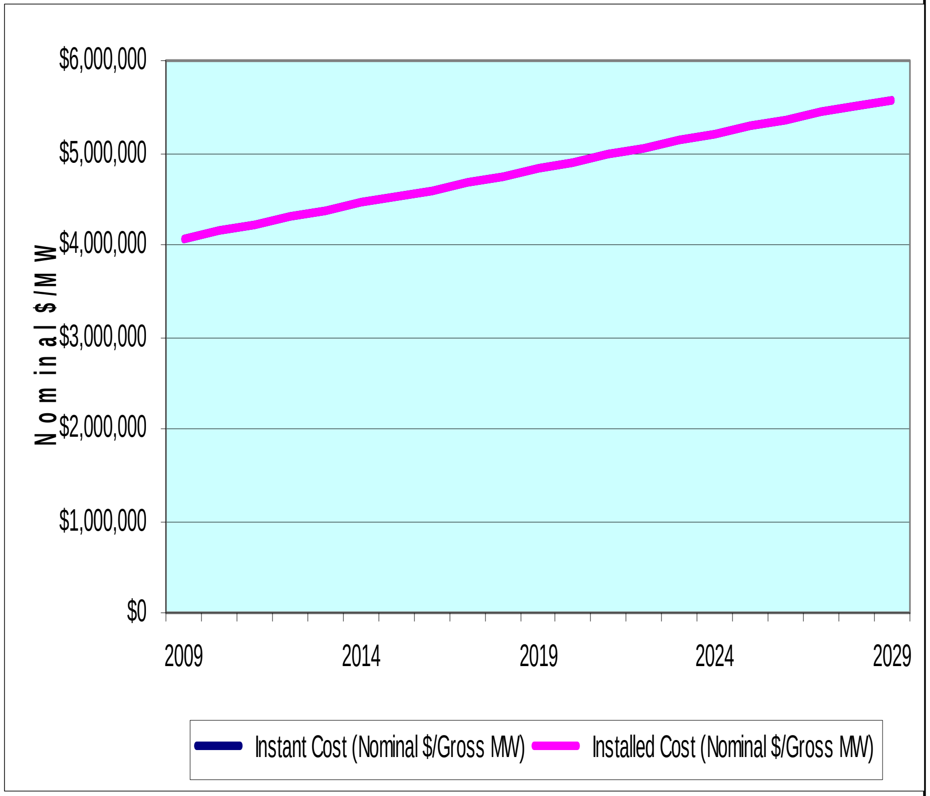
Geothermal - Binary
Current Cost and Cost Trajectory

Current Costs

PLANT COST DATA	Start Year 2009
Average	
Instant Cost (Nominal $/Gross MW)	$4,070,000
Installed Cost (Nominal $/Gross MW)	$4,070,000
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	
High	
Instant Cost (Nominal $/Gross MW)	$4,070,000
Installed Cost (Nominal $/Gross MW)	$4,070,000
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	
Low	
Instant Cost (Nominal $/Gross MW)	$4,070,000
Installed Cost (Nominal $/Gross MW)	$4,070,000
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	

Year=2009, Value & Dollars	Average	High	Low
Fixed Cost ($/kW-Year)	$47.44	$47.44	$47.44
Variable Cost ($/MWh)	$4.40	$4.40	$4.40

Projections



Geothermal - Flash
Technology Selection Criteria

Geothermal – Flash ......

Technology Reference Material and Key Assumptions	**<u>Geothermal – Flash</u>** Flash Power Plant: Geothermally heated water under pressure is separated in a surface vessel (called a steam separator) into steam and hot water (called “brine” in the accompanying image). The steam is delivered to the turbine, and the turbine powers a generator. The liquid is injected back into the reservoir. Other configurations employ both Flash and Binary in a Combined Cycle: This type of plant, which uses a combination of flash and binary technology, has been used effectively to take advantage of the benefits of both technologies. In this type of plant, the portion of the geothermal water which “flashes” to steam under reduced pressure is first converted to electricity with a backpressure steam turbine and the low-pressure steam exiting the backpressure turbine is condensed in a binary system.
	Reference Material: see “Task 1- Central Plant Technologies.xls”

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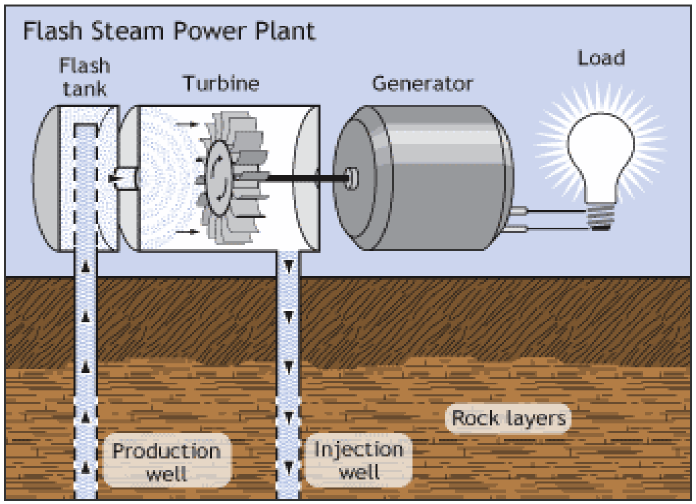
Geothermal - Flash
Selected Technology Description

Geothermal – Flash technology results in direct geo steam coming into contact with the turbine

Typical Plant	Description
 ?	Flash Power Plant: Geothermally heated water under pressure is separated in a surface vessel (called a steam separator) into steam and hot water (called "brine" in the accompanying image). The steam is delivered to the turbine, and the turbine powers a generator. The liquid is injected back into the reservoir..

Geothermal - Flash
Cost Drivers

Geothermal Binary emerging technology

Cost Drivers

Key Cost Drivers

- Site geographies
- Turbine Island
- Exploration
- Confirmation Drilling
- Steam gathering
- Royalties
- O&M

Plant Configuration Data Overview

PLANT DATA	Average	High	Low
Gross Capacity (MW)	50	50	50
Station Service (%)	0.50%	0.50%	0.50%
Net Capacity (MW)	49.75	49.75	49.75
Net Energy (GWh)	392	392	392
Transformer Losses	0.50%	0.50%	0.50%
Tranmission losses	1.49%	1.49%	1.49%
Load Center Delivered Capacity (MW)	48.76	48.76	48.76
Net Capacity Factor (NCF)	90%	90%	90%
Planned Percent of Year Operational	100.0%	100.0%	100.0%
Average Percent Output	90.82%	90.82%	90.82%
Net Energy Delivered to Load Center (GWh)	384	384	384
Forced Outage Rate (FOR)	0.6%	0.6%	0.6%
Scheduled Outage Factor (SOF)	0.30%	0.30%	0.30%
Curtailment (Hours)	0.0	0.0	0.0
Degradation Factors			
Capacity Degradation (%/Year)	4.00%	4.00%	4.00%
Heat Rate Degradation (%/Year)	N/A	N/A	N/A
Emission Factors			
NOX (lbs/MWh)	0.191	0.191	0.191
VOC/ROG (Lbs/MWh)	0.011	0.011	0.011
CO (Lbs/MWh)	0.058	0.058	0.058
CO2 (lbs/MWh)	N/A	N/A	N/A
SOX (lbs/MWh)	0.026	0.026	0.026
PM10 (lbs/MWh)	N/A	N/A	N/A

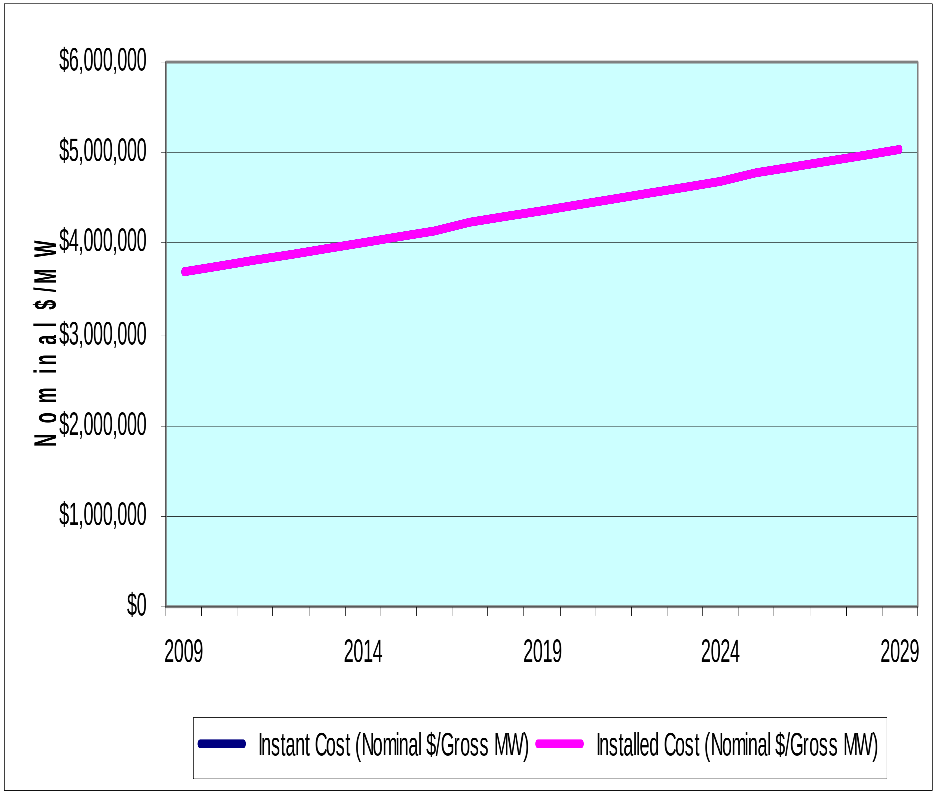
Geothermal - Flash
Current Cost and Cost Trajectory

Current Costs

	Start Year	2009
PLANT COST DATA		
Average		
Instant Cost (Nominal $/Gross MW)		$3,675,000
Installed Cost (Nominal $/Gross MW)		$3,675,000
% Cost first year of construction		100%
% Cost second year of construction		
% Cost third year of construction		
High		
Instant Cost (Nominal $/Gross MW)		$3,675,000
Installed Cost (Nominal $/Gross MW)		$3,675,000
% Cost first year of construction		100%
% Cost second year of construction		
% Cost third year of construction		
Low		
Instant Cost (Nominal $/Gross MW)		$3,675,000
Installed Cost (Nominal $/Gross MW)		$3,675,000
% Cost first year of construction		100%
% Cost second year of construction		
% Cost third year of construction		

Year=2009, Value & Dollars	Average	High	Low
Fixed Cost ($/kW-Year)	$54.38	$54.38	$54.38
Variable Cost ($/MWh)	$5.28	$5.28	$5.28

Projections



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Central Plant Renewable Energy – Technology and Cost Profiles

Approach and Methodology

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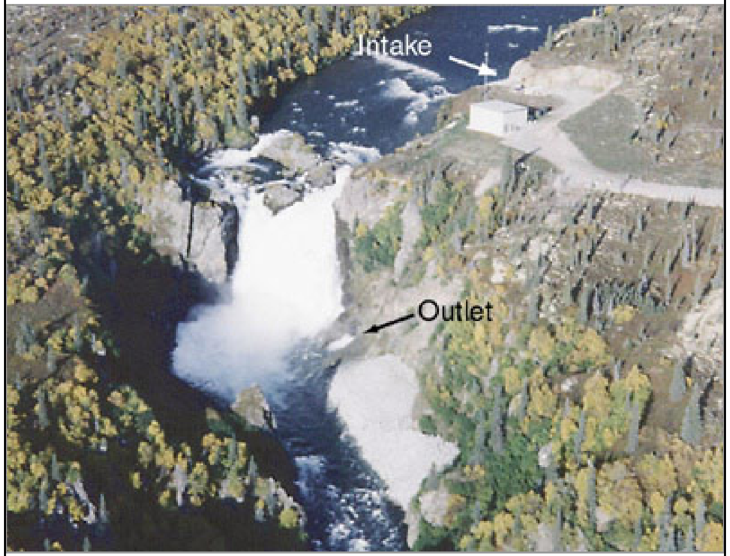
Reference to IEPR 2007 data

Hydro Generation - General

Technology Reference Material and Key Assumptions	**Hydro:** Hydroelectric power is generated by capturing the kinetic energy of water as it moves from a higher elevation to a lower elevation by passing it through a turbine. T he amount of kinetic energy captured by a turbine is dependent on the head (vertical height the water is falling) and the flow rate of the water. Often, the water is raised to a higher potential energy by blocking its natural flow with a dam. If a dam is not feasible, it is possible to divert water out of the natural waterway, through a penstock, and back to the waterway. Such applications allow for hydroelectric generation without the impact of damming the waterway. There are three main types of hydropower facilities: Impoundment Hydropower - utilizes a dam to store water in a reservoir. Water can be released from the reservoir to generate electricity. Run-of-River - utilizes the flow of water within a river, requiring very little or no impoundment. Run-of-River hydropower is typically designed for large flows with low head or small flows with high head. Diversion Hydropower – diverts a portion of river flows through a canal or penstock to generate electricity.
	Reference Material: see “Task 1- Central Plant Technologies.xls”

Hydro – Small Scale
Selected Technology Description

Small Scale Hydro ......

Typical Plant	Description
 ?	The most common type of hydroelectric power plant is an impoundment facility. An impoundment facility, typically a large hydropower system, uses a dam to store river water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. The water may be released either to meet changing electricity needs or to maintain a constant reservoir level. In-Conduit Hydropower: Developed within man-made conduits instead of natural rivers, streams or creeks. Key advantages include no impact on wildlife, reduced O&M due to the cleanliness of the water, more streamlined permitting processes, and often less civil works. "Man-made conduits" include pipelines, aqueducts, irrigation ditches and canals.

Hydro – Small Scale
Cost Drivers

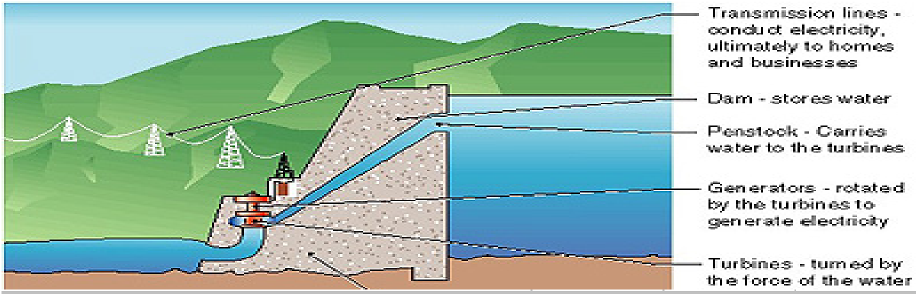
Small Scale Hydro selected in ranges from 1.5MW, 15MW and 30MW

Cost Drivers

Key Cost Drivers

- Site geographies
- Licensing
- Environmental mitigation
- Fixed and variable O&M
- FERC annual Charge

Plant Configuration Data Overview



PLANT DATA	Average	High	Low
Gross Capacity (MW)	15	30	1.5
Station Service (%)	0.10%	0.10%	0.10%
Net Capacity (MW)	14.99	29.97	1.50
Net Energy (GWh)	72	144	7
Transformer Losses	0.50%	0.50%	0.50%
Tranmission losses	1.49%	1.49%	1.49%
Load Center Delivered Capacity (MW)	14.69	29.38	1.47
Net Capacity Factor (NCF)	54.87%	54.87%	54.87%
Planned Percent of Year Operational	100.0%	100.0%	100.0%
Average Percent Output	55.76%	55.76%	55.76%
Net Energy Delivered to Load Center (GWh)	71	141	7
Forced Outage Rate (FOR)	1.3%	1.3%	1.3%
Scheduled Outage Factor (SOF)	0.30%	0.30%	0.30%
Curtailment (Hours)	0.0	0.0	0.0
Degradation Factors			
Capacity Degradation (%/Year)	2.00%	2.00%	2.00%
Heat Rate Degradation (%/Year)	N/A	N/A	N/A
Emission Factors			
NOX (lbs/MWh)	N/A	N/A	N/A
VOC/ROG (Lbs/MWh)	N/A	N/A	N/A
CO (Lbs/MWh)	N/A	N/A	N/A
CO2 (lbs/MWh)	N/A	N/A	N/A
SOX (lbs/MWh)	N/A	N/A	N/A
PM10 (lbs/MWh)	N/A	N/A	N/A

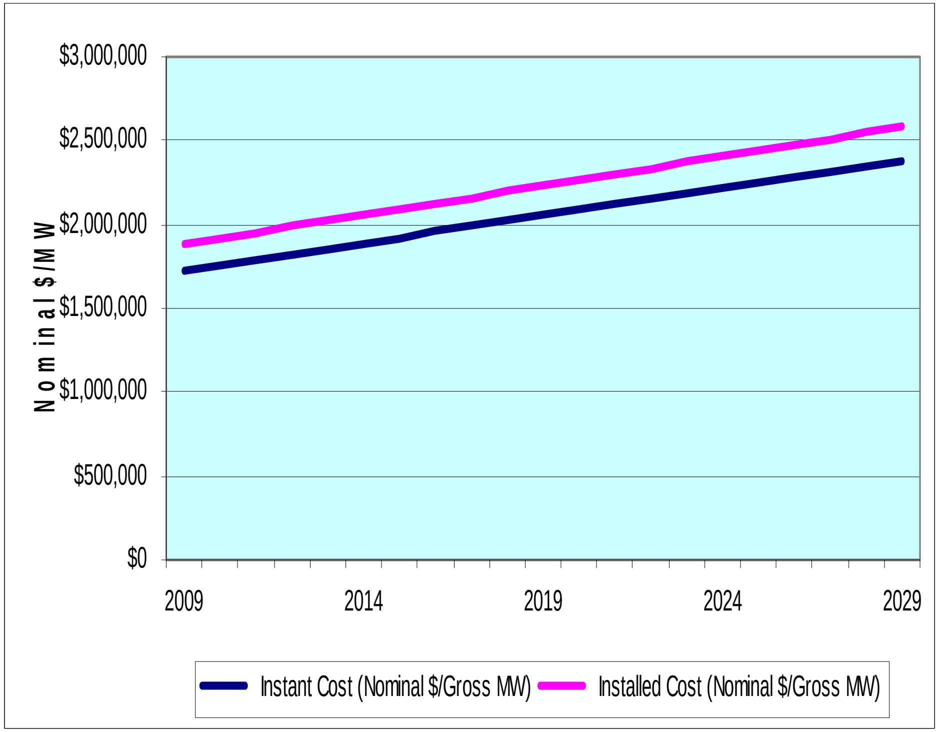
Hydro – Small Scale
Current Cost and Cost Trajectory

Current Costs

PLANT COST DATA	Start Year 2009
Average	
Instant Cost (Nominal $/Gross MW)	$1,730,000
Installed Cost (Nominal $/Gross MW)	$1,882,000
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	
High	
Instant Cost (Nominal $/Gross MW)	$1,503,000
Installed Cost (Nominal $/Gross MW)	$1,628,000
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	
Low	
Instant Cost (Nominal $/Gross MW)	$2,770,000
Installed Cost (Nominal $/Gross MW)	$3,046,000
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	

Year=2009, Value & Dollars	Average	High	Low
Fixed Cost ($/kW-Year)	$17.57	$15.26	$31.57
Variable Cost ($/MWh)	$3.48	$3.02	$5.54

Projections



Hydro – Capacity Upgrades
Technology Selection Criteria

Technology Reference Material and Key Assumptions	**<u>Hydro – Capacity Upgrades</u>** Hydro - Capacity upgrade for developed sites with power: Some existing hydroelectric facilities in California and the surrounding states are developed with power generation in place, but with potential to increase generation output. This can be accomplished through increasing reservoir size, upgrading total turbine capacity, increasing the number of turbines, or any combination thereof.
	Reference Material: see "Task 1- Central Plant Technologies.xls"

Hydro – Capacity Upgrades
Selected Technology Description

Hrdro Capacity Upgrades build off current assets and create new MW's from an existing head of water

Typical Plant	Description
 ?	• Hydroelectric power is a well established technology. The United States hydroelectric plant population is comprised of 2,388 licensed plants (not including pumped storage plants) according to the 1998 version Federal Energy Regulatory Commission's Hydroelectric Resource Assessment (HPRA) database (FERC 1998). These plants range in capacity from less than 100 kW to over 6,000 MW and have a total capacity of 74,872 MW. The plants are owned by 1,134 owners which include owners in the public and private sectors • Upgrades to existing facilities can result in new MW capacities from 2MW, 80MW and up to 600MW

Hydro – Capacity Upgrades Cost Drivers

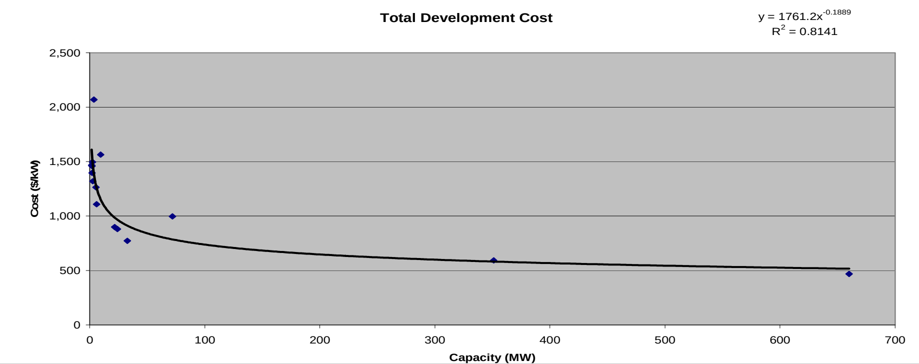
Capacity Upgrades Hydro

Cost Drivers

Key Cost Drivers

- Site geographies
- Licensing
- Environmental mitigation
- Fixed and variable O&M
- FERC annual Charge

Plant Configuration Data Overview



PLANT DATA	Average	High	Low
Gross Capacity (MW)	80	600	2
Station Service (%)	0.10%	0.10%	0.10%
Net Capacity (MW)	79.92	599.40	2.00
Net Energy (GWh)	384	2881	10
Transformer Losses	0.50%	0.50%	0.50%
Tranmission losses	1.49%	1.49%	1.49%
Load Center Delivered Capacity (MW)	78.34	587.52	1.96
Net Capacity Factor (NCF)	54.87%	54.87%	54.87%
Planned Percent of Year Operational	100.0%	100.0%	100.0%
Average Percent Output	55.76%	55.76%	55.76%
Net Energy Delivered to Load Center (GWh)	377	2824	9
Forced Outage Rate (FOR)	1.3%	1.3%	1.3%
Scheduled Outage Factor (SOF)	0.30%	0.30%	0.30%
Curtailment (Hours)	0.0	0.0	0.0
Degradation Factors			
Capacity Degradation (%/Year)	2.00%	2.00%	2.00%
Heat Rate Degradation (%/Year)	N/A	N/A	N/A
Emission Factors			
NOX (lbs/MWh)	N/A	N/A	N/A
VOC/ROG (Lbs/MWh)	N/A	N/A	N/A
CO (Lbs/MWh)	N/A	N/A	N/A
CO2 (lbs/MWh)	N/A	N/A	N/A
SOX (lbs/MWh)	N/A	N/A	N/A
PM10 (lbs/MWh)	N/A	N/A	N/A

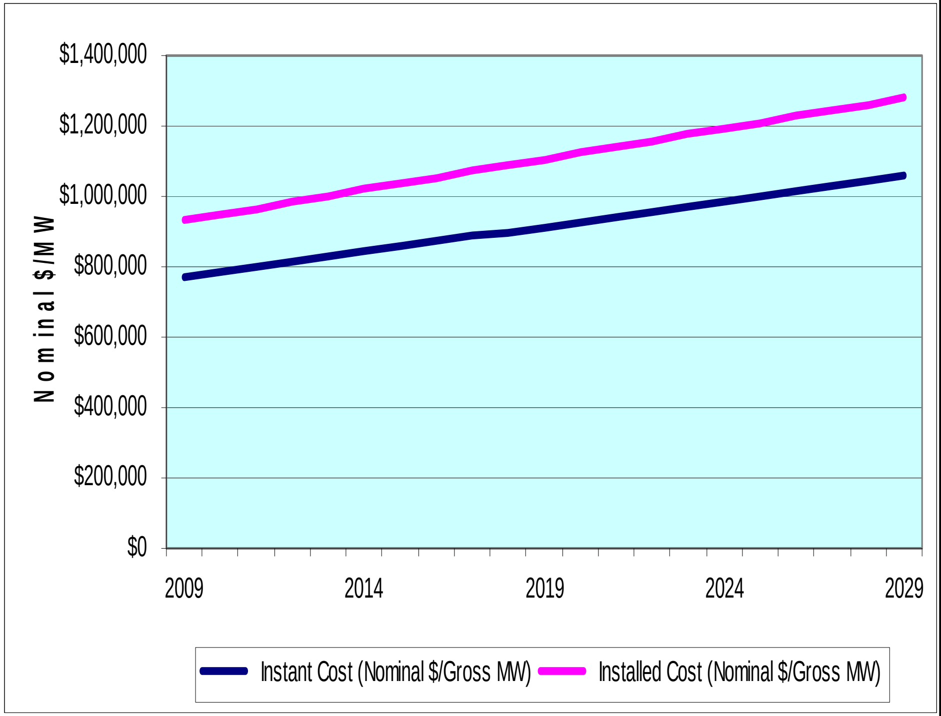
Hydro – Capacity Upgrades
Current Cost and Cost Trajectory

Current Costs

PLANT COST DATA	Start Year 2009
Average	
Instant Cost (Nominal $/Gross MW)	$771,000
Installed Cost (Nominal $/Gross MW)	$932,000
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	
High	
Instant Cost (Nominal $/Gross MW)	$514,000
Installed Cost (Nominal $/Gross MW)	$637,000
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	
Low	
Instant Cost (Nominal $/Gross MW)	$1,638,000
Installed Cost (Nominal $/Gross MW)	$1,871,000
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	

Year=2009, Value & Dollars	Average	High	Low
Fixed Cost ($/kW-Year)	$12.59	$8.77	$27.05
Variable Cost ($/MWh)	$2.39	$1.60	$5.00

Projections



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Nuclear

Reference to IEPR 2007 data

Solar – Parabolic Trough
Technology Selection Criteria

Technology Reference Material and Key Assumptions	**Solar Parabolic Trough** The research team selected parabolic trough technology because it is commercially available. Installations are producing electricity with a capacity of 354 MW since 1990. With Andasol 1 -3 one parabolic trough system with 50 MW is commercially running in Spain and two additional 50 MW plants are under construction. Storage technology (molten salt) for 7 full load hours is included in the Andasol project. Storage or combined operation with gas leads to extended operation hours per day. Additional projects in Greece and Spain are under planning. Primary commercial embodiment in California – need information here on the applications that have been filed for California. In the year 2018, the research team expects that the primary commercial embodiment will tend towards larger systems. The current primary worldwide commercial embodiment today is in Spain, where feed-in tariffs have encouraged solar development, but system sizes are less than 50 MW due to restrictions in the feed-in tariff system. Solar Millennium has announced a 250 MW parabolic trough power station in Nevada.[1] An engineer at Solar Millennium told our research team that the system will consist of one 250 MW steam turbine (not 50 MW modules). According to the engineer at Solar Millennium, the company believes 250 MW and expects to be the optimal size for parabolic trough systems and expects future systems to range from 200 to 300 MW. For smaller systems the turbine is too small (and therefore too expensive) and for bigger systems the losses in the solar collector field would be too high. Solar Millenium Corporate News. April 3, 2009. Nevada Energy, Solar Millennium and MAN Ferrostaal cooperate in the development of projects
	Reference Material: see "Task 1- Central Plant Technologies.xls"

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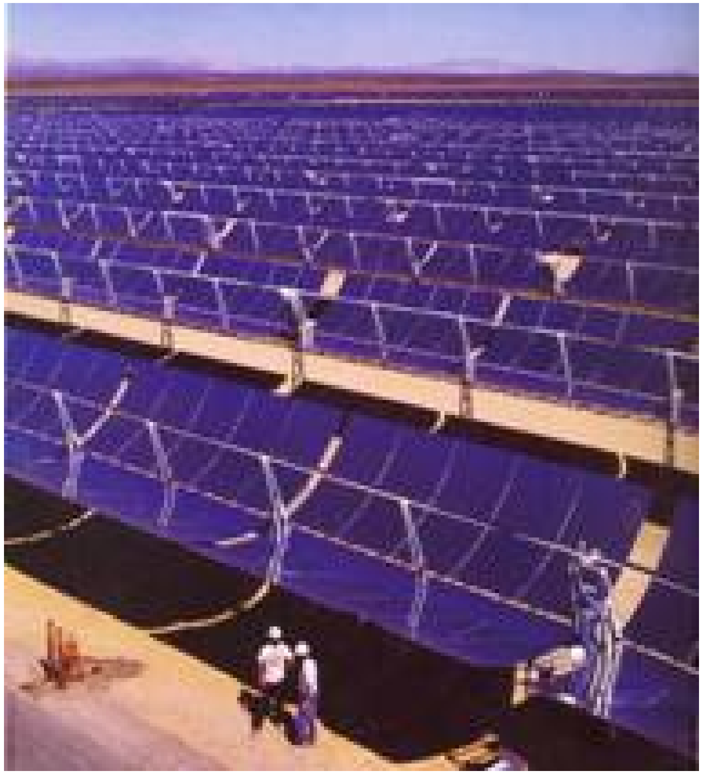
Solar – Parabolic Trough
Selected Technology Description

Solar Parabolic Tough systems act as collectors of heat to create a boiler, steam and drive a TG set

Typical Plant	Description
 ?	For 2009, the Spanish Government has announced a change in the feed-in tariff. This will reduce the amount of new registered projects in Spain. Nevada Energy, Solar Millenium and MAN Ferrostaal have announced a solar thermal power plant with a capacity of 250 MW and thermal storage capacity. Abengoa Solar has signed an agreement with Arizona Public Service (APS) to build and operate what will be the largest solar power plant in the world. The plant will be installed about 100 kilometers southwest of Phoenix, near Gila Bend. Solana, with 280 MWe of power output capacity, is based on parabolic trough technology and thermal storage using molten salts. It uses a single steam turbine.

Solar – Parabolic Trough Cost Drivers

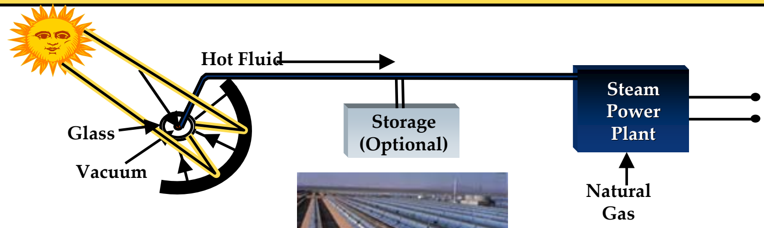
Parabolic can be integrated into existing steam cycle

Cost Drivers

Key Cost Drivers

- Steam system
- Parabolic apparatus
- Land acquisition
- Fixed and variable O&M

Plant Configuration Data Overview



PLANT DATA	Average	High	Low
Gross Capacity (MW)	50	50	50
Station Service (%)	2.40%	2.40%	2.40%
Net Capacity (MW)	48.80	48.80	48.80
Net Energy (GWh)	115	120	111
Transformer Losses	0.50%	0.50%	0.50%
Tranmission losses	1.49%	1.49%	1.49%
Load Center Delivered Capacity (MW)	47.83	47.83	47.83
Net Capacity Factor (NCF)	27.00%	28.00%	26.00%
Planned Percent of Year Operational	28.72%	29.79%	27.66%
Average Percent Output	90.0%	100.0%	80.0%
Net Energy Delivered to Load Center (GWh)	113.13	117.32	108.94
Forced Outage Rate (FOR)	6.00%	6.00%	6.00%
Scheduled Outage Factor (SOF)	0.00%	0.00%	0.00%
Curtailment (Hours)	0	0	0
Degradation Factors			
Capacity Degradation (%/Year)	0.50%	1.00%	0.25%
Heat Rate Degradation (%/Year)	0.00%	0.00%	0.00%
Emission Factors			
NOX (lbs/MWh)	0.000	0.000	0.000
VOC/ROG (Lbs/MWh)	0.000	0.000	0.000
CO (Lbs/MWh)	0.000	0.000	0.000
CO2 (lbs/MWh)	0.000	0.000	0.000
SOX (lbs/MWh)	0.000	0.000	0.000
PM10 (lbs/MWh)	0.000	0.000	0.000

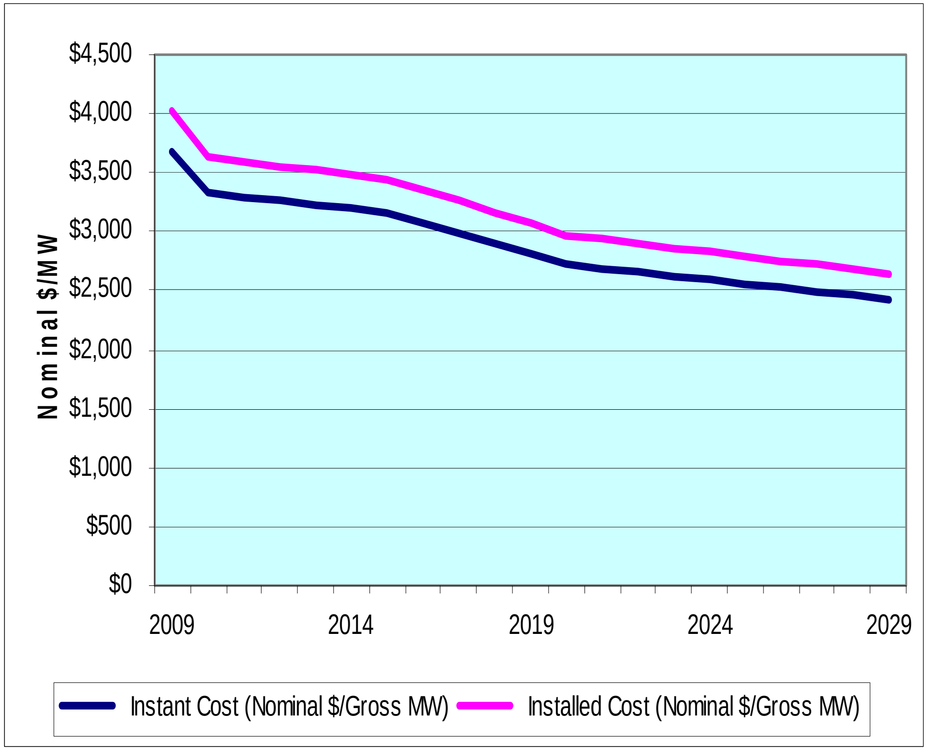
Solar – Parabolic Trough
Current Cost and Cost Trajectory

Current Costs

PLANT COST DATA	Start Year: 2009
Average	
Instant Cost (Nominal $/Gross MW)	$3,687
Installed Cost (Nominal $/Gross MW)	$4,019
% Cost of last year of construction	100%
% Cost next to last year of construction	0%
% Cost of previous year of construction	
High	
Instant Cost (Nominal $/Gross MW)	$3,900
Installed Cost (Nominal $/Gross MW)	$4,251
% Cost first year of construction	100%
% Cost second year of construction	0%
% Cost third year of construction	
Low	
Instant Cost (Nominal $/Gross MW)	$3,408
Installed Cost (Nominal $/Gross MW)	$3,715
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	

Year=2009, Value & Dollars	Average	High	Low
Fixed Cost ($/kW-Year)	$68.0	$92.00	$60.00
Variable Cost ($/MWh)	$0.00	$0.00	$0.00

Projections



Solar – Photovoltaic
Technology Selection Criteria

Solar PV

Technology Reference Material and Key Assumptions	**<u>Solar PV</u>** Flat-plate Photovoltaic (FPV) modules are commercially available worldwide. The solar electricity market is booming. By the end of 2007, the cumulative installed capacity of solar PV systems around the world had reached more than 9,200 MW. This compares with a figure of 1,200 MW at the end of 2000. Installations of PV cells and modules around the world have been growing at an average annual rate of more than 35% since 1998 There are almost 880 photovoltaic power plants (put into service in 2007 or earlier), each with peak power of 200 kWp or more, are listed. Cumulative power of all these photovoltaic power plants is about 955 MWp and average plant power output is slightly more than 1.24 MWp. More than 390 large-scale photovoltaic plants are located in Germany, 225 in USA and more than 130 in Spain (source: pvresources). The PV modules can be mounted on fixed tilt strucures or on one or two axis tracking devices. As of December 2007, the market share of fixed arrays was 73% of the total installed capacity in large-scale PV installations, only 27% were tracking systems (source: pvresources). However in situations with a high proportion of direct normal insolation, such as in California, the one-axis tracking system could increase the sunlight capture by up to 25% over traditional fixed-tilt systems, while significantly reducing land use requirements
	Reference Material: see "Task 1- Central Plant Technologies.xls"

Solar – Photovoltaic
Selected Technology Description

PV fixed axis installations.

Typical Plant	Description
 ?	• Spain's PV market reached 2,600 MW in 2008 (annual growth rate of more than 400%) and now accounts for 44% of the world market. Germany reached a moderate increase to 1,500 MW, while the United States increased by 220% to 500 MW. It became the world's third largest market even in front of Japan, once the world leader, which stayed stable at a level of 230 MW. (Source: BSW-Solar/EPIA/NNPVA) • World Solar cell production doubled in comparison to 2007 (3,436 MW). Chinese manufacturers raised their share in 2008. Meanwhile, thin film production reached a remarkable market share (2007: 12%). (We expect actual market numbers for 2008 later in March from Solarbuzz). • In 2008 an interesting trend could be observed in Spain: many large scaled PV installations have come into operation with capacities in the range of 20 to 60 MW (Source: Photon).

KEMA

Solar – Photovoltaic
Cost Drivers

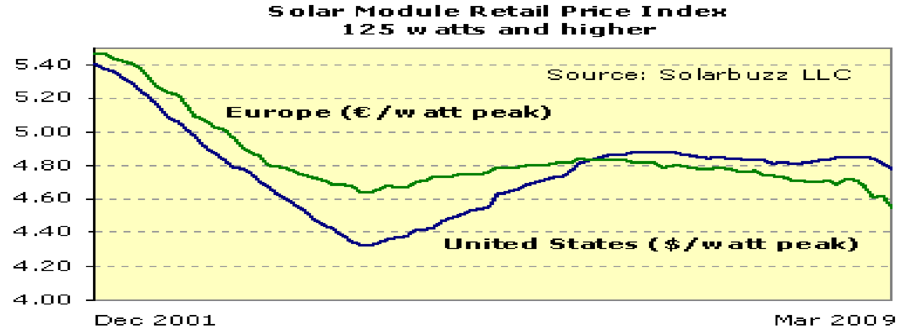
PV increasing in capacity, driving costs down.

Cost Drivers

Key Cost Drivers

- PV Module costs
- Silicon Production capacity
- New manufacturing Capacity
- Land acquisition
- Fixed O&M

Plant Configuration Data Overview



PLANT DATA	Average	High	Low
Gross Capacity (MW)	23	23	23
Station Service (%)	1.00%	1.00%	1.00%
Net Capacity (MW)	22.77	22.77	22.77
Net Energy (GWh)	54	56	52
Transformer Losses	0.50%	0.50%	0.50%
Tranmission losses	1.49%	1.49%	1.49%
Load Center Delivered Capacity (MW)	22.32	22.32	22.32
Net Capacity Factor (NCF)	27.00%	28.00%	26.00%
Planned Percent of Year Operational	27.27%	28.28%	26.26%
Average Percent Output	90.0%	100.0%	80.0%
Net Energy Delivered to Load Center (GWh)	52.79	54.74	50.83
Forced Outage Rate (FOR)	1.00%	1.00%	1.00%
Scheduled Outage Factor (SOF)	0.00%	0.00%	0.00%
Curtailment (Hours)	0	0	0
Degradation Factors			
Capacity Degradation (%/Year)	0.50%	1.00%	0.25%
Heat Rate Degradation (%/Year)	0.00%	0.00%	0.00%
Emission Factors			
NOX (lbs/MWh)	0.000	0.000	0.000
VOC/ROG (Lbs/MWh)	0.000	0.000	0.000
CO (Lbs/MWh)	0.000	0.000	0.000
CO2 (lbs/MWh)	0.000	0.000	0.000
SOX (lbs/MWh)	0.000	0.000	0.000
PM10 (lbs/MWh)	0.000	0.000	0.000

KEMA

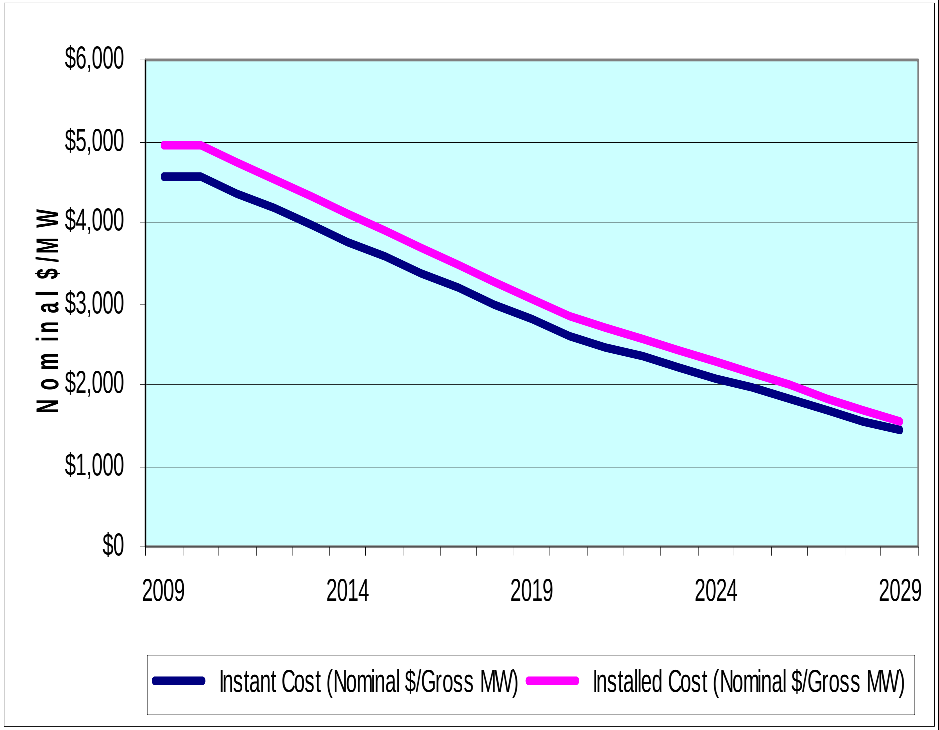
Solar – Photovoltaic
Current Cost and Cost Trajectory

Current Costs

PLANT COST DATA	Start Year 2009
Average	
Instant Cost (Nominal $/Gross MW)	$4,550
Installed Cost (Nominal $/Gross MW)	$4,960
% Cost of last year of construction	100%
% Cost next to last year of construction	0%
% Cost of previous year of construction	
High	
Instant Cost (Nominal $/Gross MW)	$5,005
Installed Cost (Nominal $/Gross MW)	$5,455
% Cost first year of construction	100%
% Cost second year of construction	0%
% Cost third year of construction	
Low	
Instant Cost (Nominal $/Gross MW)	$4,095
Installed Cost (Nominal $/Gross MW)	$4,464
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	

Year=2009, Value & Dollars	Average	High	Low
Fixed Cost ($/kW-Year)	$68.0	$92.00	$60.00
Variable Cost ($/MWh)	$0.00	$0.00	$0.00

Projections



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IGCC

Nuclear

Reference to IEPR 2007 data

Wind – Onshore
Technology Selection Criteria

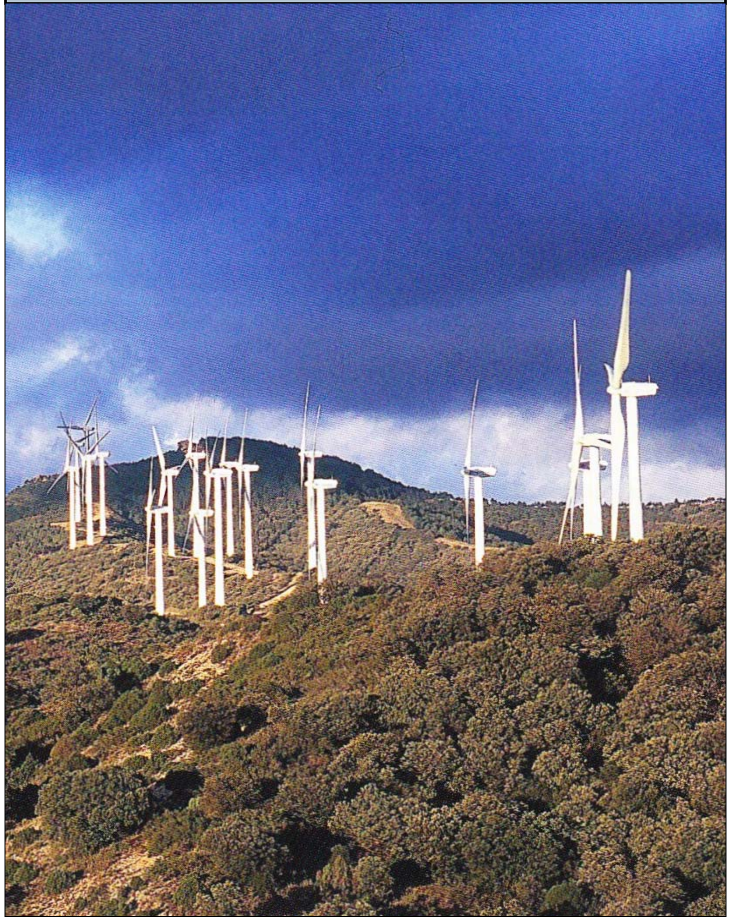
Onshore Wind......

Technology Reference Material and Key Assumptions	**Wind – Onshore** Essentially wind turbine concepts are as follows: the rotor blades drive the main shaft which rotational movement is speeded up in a gearbox and drives the generator. The electricity is converted to high voltage by a transformer in the wind turbine. Gearbox, generator and transformer are all located in the nacelle. Some wind turbines use direct drive generators so one doesn't need a gearbox being a critical component from a maintenance perspective.
	Reference Material: see "Task 1- Central Plant Technologies.xls"

Wind - Onshore
Selected Technology Description

Wind farms located in areas with Wind Energy Category 3 or 4

Typical Plant



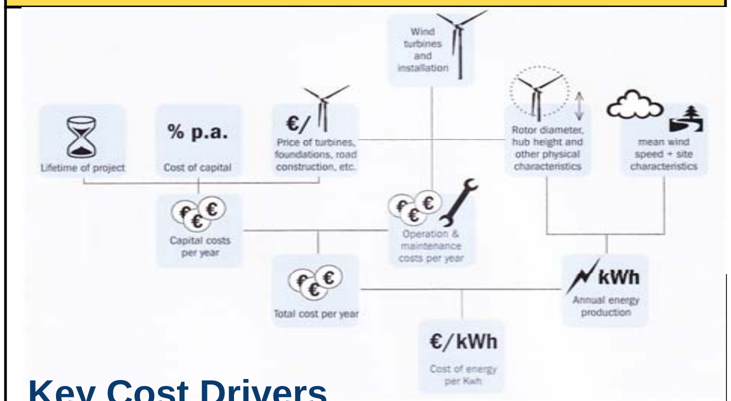
Description

- A 50 MW wind development consisting of multiple wind turbines atop steel towers. Typical facilities today consist of 1.5 to 2.5 MW turbines atop 80m towers.
- In the future, wind farms are likely to see a continued evolution towards larger rotors, turbine sizes, and tower heights.
- Since installed costs and performance vary with turbine size, tower height and site conditions. NCI assumes some typical turbine sizes, tower heights, and site conditions to develop the cost estimates, recognizing that actual wind farm configurations will see a wider range.
- The expected or typical wind regime is uncertain as new wind developments are likely to be in poorer wind regimes, but re-powering at existing good wind sites like Altamont and Tehachapi is also likely.

Wind - Onshore
Cost Drivers

Onshore Wind classes 3, 4 and 5

Cost Drivers



Key Cost Drivers

- Turbine cost
- Reliability
- Permitting and site selection
- Land acquisition
- Transmission costs

Plant Configuration Data Overview

Year=2009, Value & Dollars PLANT DATA	Class 3/4 Average	Class 5 Average
Gross Capacity (MW)	50	50
Station Service (%)	0.10%	0.10%
Net Capacity (MW)	49.95	49.95
Net Energy (GWh)	79	96
Transformer Losses	0.50%	0.50%
Tranmission losses	1.49%	1.49%
Load Center Delivered Capacity (MW)	48.96	48.96
Net Capacity Factor (NCF)	18%	22%
Planned Percent of Year Operational	100.0%	100.0%
Average Percent Output	18.29%	22.36%
Net Energy Delivered to Load Center (GWh)	77	94
Forced Outage Rate (FOR)	1.3%	1.3%
Scheduled Outage Factor (SOF)	0.30%	0.30%
Curtailment (Hours)	0.0	0.0
Degradation Factors		
Capacity Degradation (%/Year)	1.00%	1.00%
Heat Rate Degradation (%/Year)	N/A	N/A
Emission Factors		
NOX (lbs/MWh)	N/A	N/A
VOC/ROG (Lbs/MWh)	N/A	N/A
CO (Lbs/MWh)	N/A	N/A
CO2 (lbs/MWh)	N/A	N/A
SOX (lbs/MWh)	N/A	N/A
PM10 (lbs/MWh)	N/A	N/A

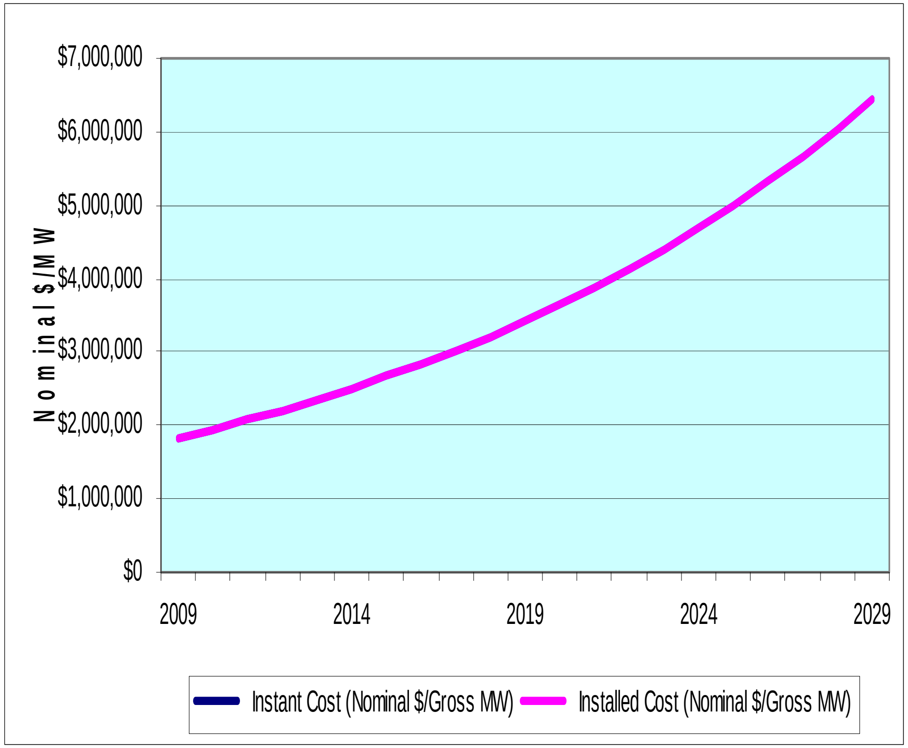
Wind - Onshore
Current Cost and Cost Trajectory

Current Costs

	Start Year	2009
PLANT COST DATA		
Average		
Instant Cost (Nominal $/Gross MW)		$1,825,000
Installed Cost (Nominal $/Gross MW)		$1,825,000
% Cost first year of construction		100%
% Cost second year of construction		
% Cost third year of construction		
High		
Instant Cost (Nominal $/Gross MW)		$1,825,000
Installed Cost (Nominal $/Gross MW)		$1,825,000
% Cost first year of construction		100%
% Cost second year of construction		
% Cost third year of construction		
Low		
Instant Cost (Nominal $/Gross MW)		$1,825,000
Installed Cost (Nominal $/Gross MW)		$1,825,000
% Cost first year of construction		100%
% Cost second year of construction		
% Cost third year of construction		

Year=2009, Value & Dollars	Average	High	Low
Fixed Cost ($/kW-Year)	$0.00	$0.00	$0.00
Variable Cost ($/MWh)	$22.00	$22.00	$22.00

Projections



Wind – Offshore
Technology Selection Criteria

Offshore Wind has been analyzed in Wind Categories of 5 or greater..

Technology Reference Material and Key Assumptions	**<u>Wind – Offshore</u>** One of the advantages of offshore wind is that it has the potential to produce more electricity than onshore wind farms. Offshore wind projects can have high performance characteristics due to high Capacity Factors. This is a result of stronger, more constant wind and areas where the wind resource is classified as a 5 or greater Analyzing Wind potential around the world has shown that at the height of a wind turbine, offshore wind is on average 90 percent stronger than onshore wind. That's because hills, trees, buildings and other structures don't get in the way of winds blowing over the ocean.
	Reference Material: see "Task 1- Central Plant Technologies.xls"

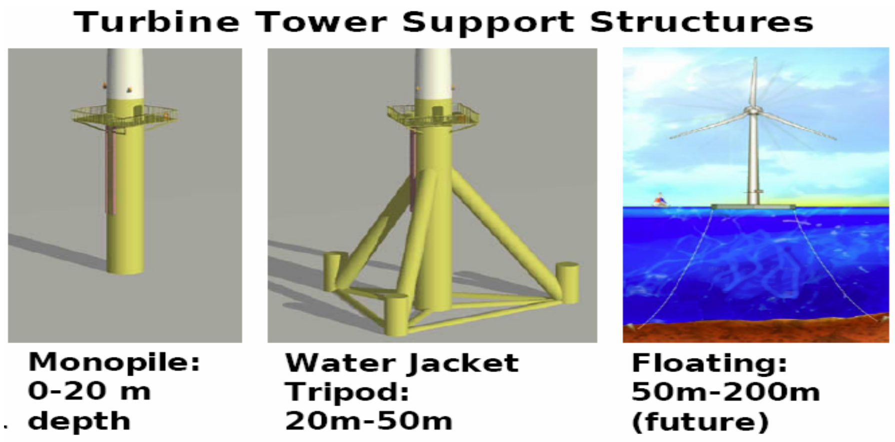
Wind - Offshore
Selected Technology Description

Wind potential high offshore, but projects difficult to realize

Typical Plant

?

Description



Wind - Offshore
Cost Drivers

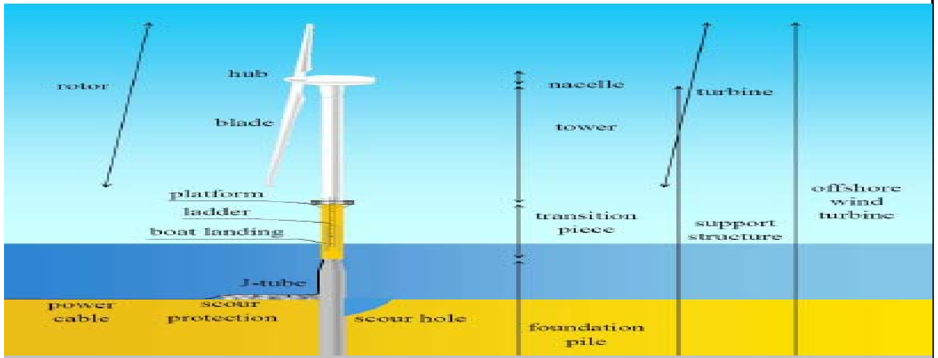
Offshore Wind costs are heavily influenced by location, sea depth and transmission distance

Cost Drivers

Key Cost Drivers

- Foundations
- Turbine cost
- Reliability and maintenance
- Permitting and site selection
- Lease costs
- Transmission costs

Plant Configuration Data Overview



PLANT DATA	Average	High	Low
Gross Capacity (MW)	350	350	350
Station Service (%)	0.10%	0.10%	0.10%
Net Capacity (MW)	349.65	349.65	349.65
Net Energy (GWh)	674	674	674
Transformer Losses	0.50%	0.50%	0.50%
Tranmission losses	1.49%	1.49%	1.49%
Load Center Delivered Capacity (MW)	342.72	342.72	342.72
Net Capacity Factor (NCF)	22%	22%	22%
Planned Percent of Year Operational	100.0%	100.0%	100.0%
Average Percent Output	22.36%	22.36%	22.36%
Net Energy Delivered to Load Center (GWh)	660	660	660
Forced Outage Rate (FOR)	1.3%	1.3%	1.3%
Scheduled Outage Factor (SOF)	0.30%	0.30%	0.30%
Curtailment (Hours)	0.0	0.0	0.0
Degradation Factors			
Capacity Degradation (%/Year)	1.00%	1.00%	1.00%
Heat Rate Degradation (%/Year)	N/A	N/A	N/A
Emission Factors			
NOX (lbs/MWh)	N/A	N/A	N/A
VOC/ROG (Lbs/MWh)	N/A	N/A	N/A
CO (Lbs/MWh)	N/A	N/A	N/A
CO2 (lbs/MWh)	N/A	N/A	N/A
SOX (lbs/MWh)	N/A	N/A	N/A
PM10 (lbs/MWh)	N/A	N/A	N/A

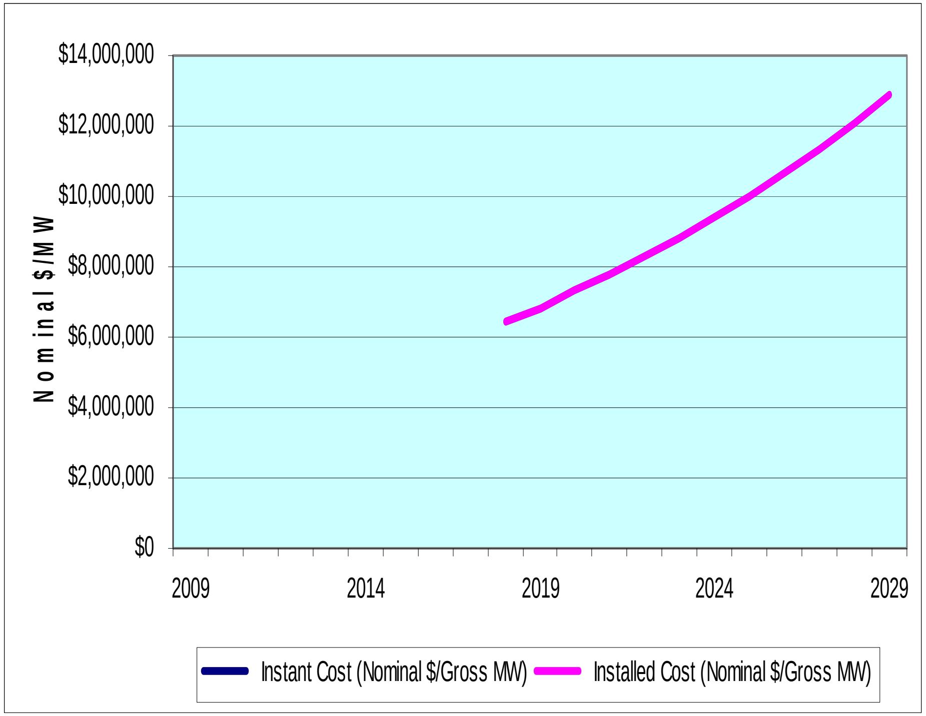
Wind - Offshore
Current Cost and Cost Trajectory

Current Costs

PLANT COST DATA	Start Year 2018
Average	
Instant Cost (Nominal $/Gross MW)	$6,433,382
Installed Cost (Nominal $/Gross MW)	$6,433,382
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	
High	
Instant Cost (Nominal $/Gross MW)	$6,433,382
Installed Cost (Nominal $/Gross MW)	$6,433,382
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	
Low	
Instant Cost (Nominal $/Gross MW)	$6,433,382
Installed Cost (Nominal $/Gross MW)	$6,433,382
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	

Year=2009, Value & Dollars	Average	High	Low
Fixed Cost ($/kW-Year)	$0.00	$0.00	$0.00
Variable Cost ($/MWh)	$44.00	$44.00	$44.00

Projections



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Reference to IEPR 2007 data

Wave - Ocean
Technology Selection Criteria

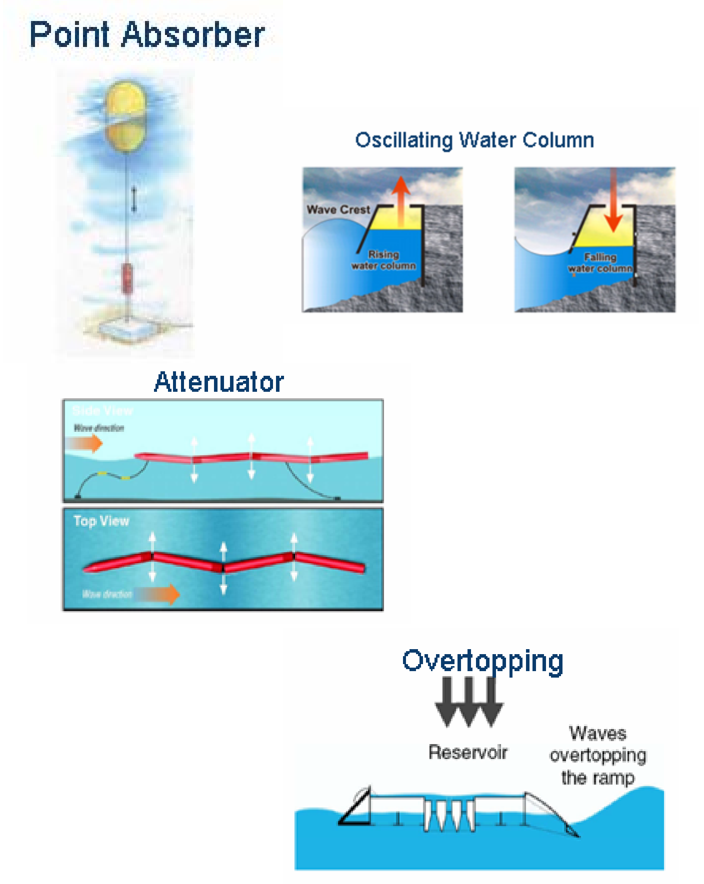
Wave energy extraction can be performed in a number of ways

Technology Reference Material and Key Assumptions	**Wave- Ocean** **Wave energy extraction** is complex and many device designs have been proposed. For understanding the device technology, it is helpful introduce these in terms of their physical arrangements and energy conversion mechanisms. • Distance from shore – Wave energy devices may convert wave power at the shoreline, near to the shore (defined as shallow water where the depth is less than one half of the wavelength) or offshore. • Bottom mounted or floating – Wave energy devices may be either bottom-mounted or floating. **Wave energy devices** can be classified by means of the type of displacement and reaction system employed. Various hydraulic or pneumatic power take off systems are used and in some cases the mechanical motion of the displacer is converted directly to electrical power (direct-drive) Four of the most well-known device concepts are: • Symmetrical point absorber – A bottom mounted or floating structure that absorbs energy. The power take-off system may take a number of forms, depending on the configuration of displacers/reactors. The key characteristic of a point absorber is that it can absorb more energy then available within the devices width if the device is tuned • Oscillating Water Column (OWC) –Nearshore or offshore, this is a partially submerged chamber with air trapped above a column of water. As waves enter and exit the chamber, the water column moves up and down and acts like a piston on the air, pushing it back and forth. The air is forced through a turbine/generator to produce electricity. • Overtopping terminator – A floating reservoir structure with a ramp over which the waves topple and hydro turbines/generators through which the water returns to the sea. • Attenuator – One form of the attenuator principle is a long floating structure which is orientated parallel to the direction of the waves. The structure is composed of multiple sections which rotate in pitch and yaw relative to each other. That motion is then converted to electricity using an electro-hydraulic power conversion machine.
	Reference Material: see "Task 1- Central Plant Technologies.xls"

Wave - Ocean
Selected Technology Description

Wave multiple technologies

Typical Plant



Description

Composite Estimates of cost of Wave Energy extraction.

Cost Factor	Current ($2009)	CEC ($2007)	CPUC ($2008)	RETI ($2008)
Capacity (MW)	40	0.75	NA	100
Total Overnight Installed Cost ($/kW)	$2,590	$6,970	NA	$2,800 - $5,200
Transmission & Undersea Cables ($/kW)	$279	$1,340	NA	
Equipment ($/kW)	$1,274	$4,000	NA	
Facilities ($/kW)	$509	$0	NA	
Installation ($/kW)	$346	$990	NA	
Construction Management and Permitting ($/kW)	$181	$640	NA	
Fixed O&M ($/kW-yr)	$36	$30	NA	$150-$270
Variable O&M ($/MWh)	$12	$25	NA	Inc. in FOM
Capacity Factor (%)	26%	15%	NA	25%-45%

Wave - Ocean
Cost Drivers

Wave energy extraction technology is projected to be viable in 2018.

Cost Drivers

Key Cost Drivers

- Turbine cost
- Reliability
- Permitting and site selection
- Licensing
- Transmission costs

Plant Configuration Data Overview

PLANT DATA	Average	High	Low
Gross Capacity (MW)	40	100	5
Station Service (%)	1.00%	1.00%	1.00%
Net Capacity (MW)	39.60	99.00	4.95
Net Energy (GWh)	90	225	11
Transformer Losses	0.50%	0.50%	0.50%
Tranmission losses	2.00%	2.00%	2.00%
Load Center Delivered Capacity (MW)	38.61	96.53	4.83
Net Capacity Factor (NCF)	26.00%	26.00%	26.00%
Planned Percent of Year Operational	100.0%	100.0%	100.0%
Average Percent Output	26.42%	26.42%	26.42%
Net Energy Delivered to Load Center (GWh)	88	220	11
Forced Outage Rate (FOR)	1.3%	1.3%	1.3%
Scheduled Outage Factor (SOF)	0.30%	0.30%	0.30%
Curtailment (Hours)	0.0	0.0	0.0
Degradation Factors			
Capacity Degradation (%/Year)	1.00%	1.00%	1.00%
Heat Rate Degradation (%/Year)	N/A	N/A	N/A
Emission Factors			
NOX (lbs/MWh)	N/A	N/A	N/A
VOC/ROG (Lbs/MWh)	N/A	N/A	N/A
CO (Lbs/MWh)	N/A	N/A	N/A
CO2 (lbs/MWh)	N/A	N/A	N/A
SOX (lbs/MWh)	N/A	N/A	N/A
PM10 (lbs/MWh)	N/A	N/A	N/A

KEMA

Wave - Ocean
Current Cost and Cost Trajectory

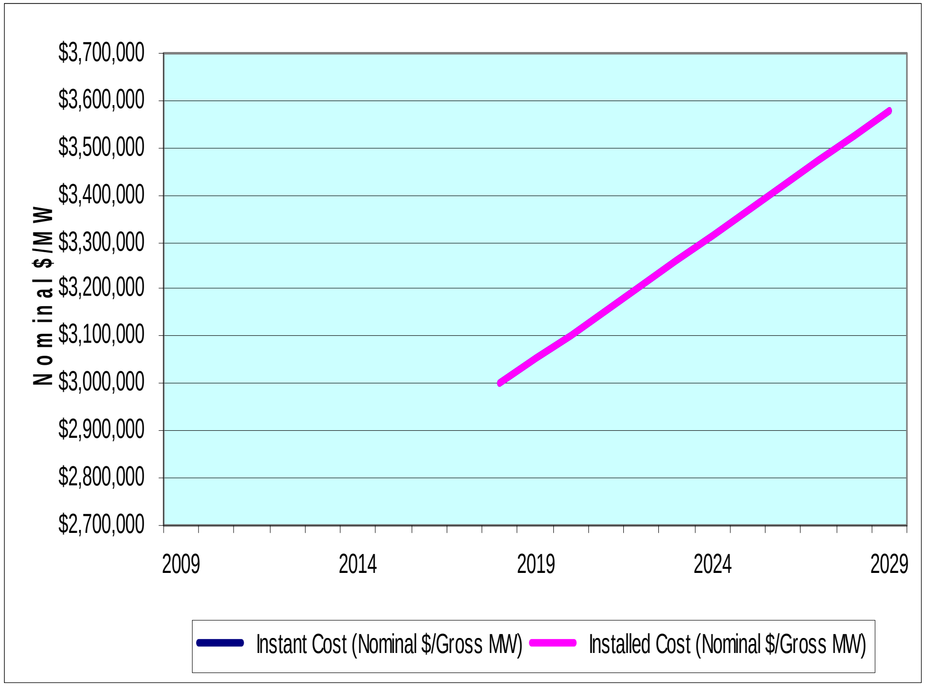
As this technology matures and more experience is gained the best configuration will merge in 2018

Current Costs (2018)

PLANT COST DATA	Start Year 2018
Average	
Instant Cost (Nominal $/Gross MW)	$3,000,000
Installed Cost (Nominal $/Gross MW)	$3,000,000
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	
High	
Instant Cost (Nominal $/Gross MW)	$3,000,000
Installed Cost (Nominal $/Gross MW)	$3,000,000
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	
Low	
Instant Cost (Nominal $/Gross MW)	$3,000,000
Installed Cost (Nominal $/Gross MW)	$3,000,000
% Cost first year of construction	100%
% Cost second year of construction	
% Cost third year of construction	

Year=2009, Value & Dollars	Average	High	Low
Fixed Cost ($/kW-Year)	$36.00	$36.00	$36.00
Variable Cost ($/MWh)	$12.00	$12.00	$12.00

Projections



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Coal - IGCC
Technology Selection Criteria

Clean Coal IGCC technology in 300MW unit size was selected based on reference plants in operation

Technology Reference Material and Key Assumptions	**Integrated Gasification Combined Cycle (IGCC)** Therefore the selected IGCC technology for this study is based on the current worldwide practice for coal-fueled IGCC technology at a scale of 300 MW. This results in the selection of the oxygen-blown entrained flow gasifier process technology. The oxygen blown IGCC process: A process schematic of a typical oxygen blown IGCC process is given in figure 1.2.1 Part of the air compressed in the gas turbine is fed to an elevated pressure ASU (air separation unit). The larger part from the air required air in the ASU is supplied by an independent compressor driven by an electric motor. In the ASU the air is split in oxygen and nitrogen. In the gasification island coal (either supplied in slurry or in powder form) is gasified is the reactor into raw gas. Apart from the raw gas also flash and slag are formed. The raw gas contains: 1. combustible components CO and H2 2. incombustible harmless components H2O, N2, Ar 3. greenhouse gas CO2 4. traces of environmentally and/or technically harmful gaseous components: Sulphur: H2S and COS, Halogens: HCl and HF, Nitrogen: NH3, HCN, traces of alkali and heavy metals (such as mercury) The raw gas is purified in the gas cleanup, that is stripped of the sulphur, halogen, nitrous compounds and alkali and heavy metals. During this process waste water and some tailgas is produced. The tail gas is recycled back into the gasification island while the waste water is cleaned in the waste water treatment plant. During this process clean distillate and residue are produced. The distillate is reused in the power plant. The cleaned syngas is moisturized to achieve a lower heating value. This contributes to lower NOx-emisisons from the also. Also the heat rate is improved marginally. To improve the heat rate further the humid syngas is heated with feed water from the water steam circuit between gasification island and steam cycle. Subsequently the heated syngas is mixed with heated nitrogen from the ASU. The diluted syngas is combusted under pressure in the gas turbine used ambient air pressurized by the gas turbine's compressor. The hot combustion gases drive the gas turbine's expander providing electric power to drive compressor and generator. The exhaust gases are lead into the steam cycle where steam is produced in the waste heat boiler and is expanded in the steam turbine installation, producing electricity.
	Reference Material: see "Task 1- Central Plant Technologies.xls"

Coal – IGCC
Selected Technology Description

Integrated Gasification Combined Cycle is a power plant using syngas (developed from coal) as a source of clean fuel.

Typical Plant

Tampa Electric Integrated Gasification Combined Cycle Plant

Description

- Integrated Gasification Combined Cycle, or IGCC, is a power plant using synthetic gas (syngas) as a source of clean fuel. Syngas is produced in a gasification unit built for Combined Cycle purposes. Steam generated by waste heat boilers of the gasification process is utilized to help power steam turbines.
- Heavy petroleum residues, coal, and even biomass are possible feeds for gasification process.
- IGCC plants in units of 300MW is being analyzed since it may offer a low-cost long-term option for the reduction of carbon dioxide emissions (through capture and storage).
- The main inhibiting factor for IGCC is high capital cost, but new plants have been recently constructed which are demonstration reliability.

Coal – IGCC
Cost Drivers

Fuel gasification process is a large part of the construction and operating costs

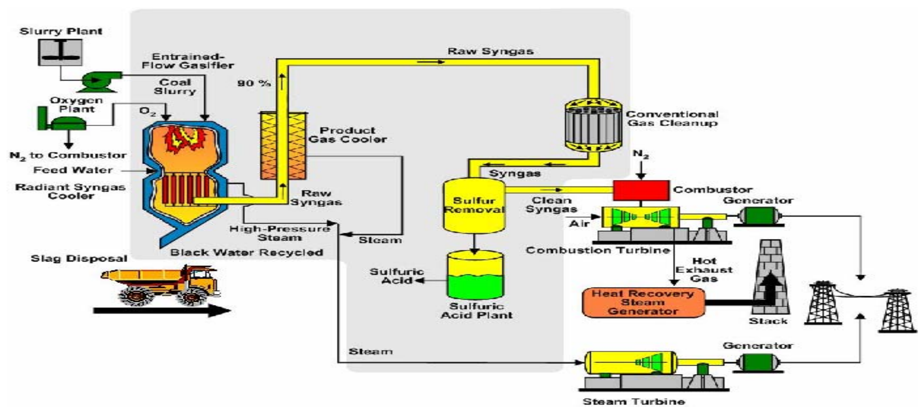
Cost Drivers

Relative expressed cost drivers	Basis	%
Equipment & Material	% TPC 2)	50
Labour	% TPC 2)	20
Engineering	% TPC 2)	15
Owners cost	% TPC 2)	15
Gas cleanup (primary Air Emission Controls)	% TPC 2)	10
O&M integral (typically)	% CoE 3)	20
Fuel cost (typically)	% CoE 3)	20

Key Cost Drivers

- The construction cost of building the plant.
- Flue gas cleanup systems construction and maintenance.

Plant Configuration Data Overview



PLANT DATA	Average	High	Low
Gross Capacity (MW)	300	300	300
Station Service (%)	1.50%	1.75%	1.25%
Net Capacity (MW)	295.50	294.75	296.25
Net Energy (GWh)	2071	2324	1817
Transformer Losses	0.50%	0.50%	0.50%
Tranmission losses	1.49%	1.49%	1.49%
Load Center Delivered Capacity (MW)	289.64	288.91	290.38
Net Capacity Factor (NCF)	80.00%	90.00%	70.00%
Planned Percent of Year Operational	84.21%	125.54%	77.62%
Average Percent Output	100.0%	100.0%	100.0%
Net Energy Delivered to Load Center (GWh)	2029.81	2277.74	1780.59
Forced Outage Rate (FOR)	5.00%	7.50%	2.50%
Scheduled Outage Factor (SOF)	15.00%	22.50%	7.50%
Curtailment (Hours)	0	0	0
Degradation Factors			
Capacity Degradation (%/Year)	0.05%	0.10%	0.00%
Heat Rate Degradation (%/Year)	0.10%	0.20%	0.10%
Emission Factors			
NOX (lbs/MWh)	0.220	0.314	0.126
VOC/ROG (Lbs/MWh)	0.009	0.009	0.009
CO (Lbs/MWh)	0.079	0.079	0.079
CO2 (lbs/MWh)	1532.000	1631.000	1433.000
SOX (lbs/MWh)	0.063	0.094	0.031
PM10 (lbs/MWh)	0.031	0.031	0.031

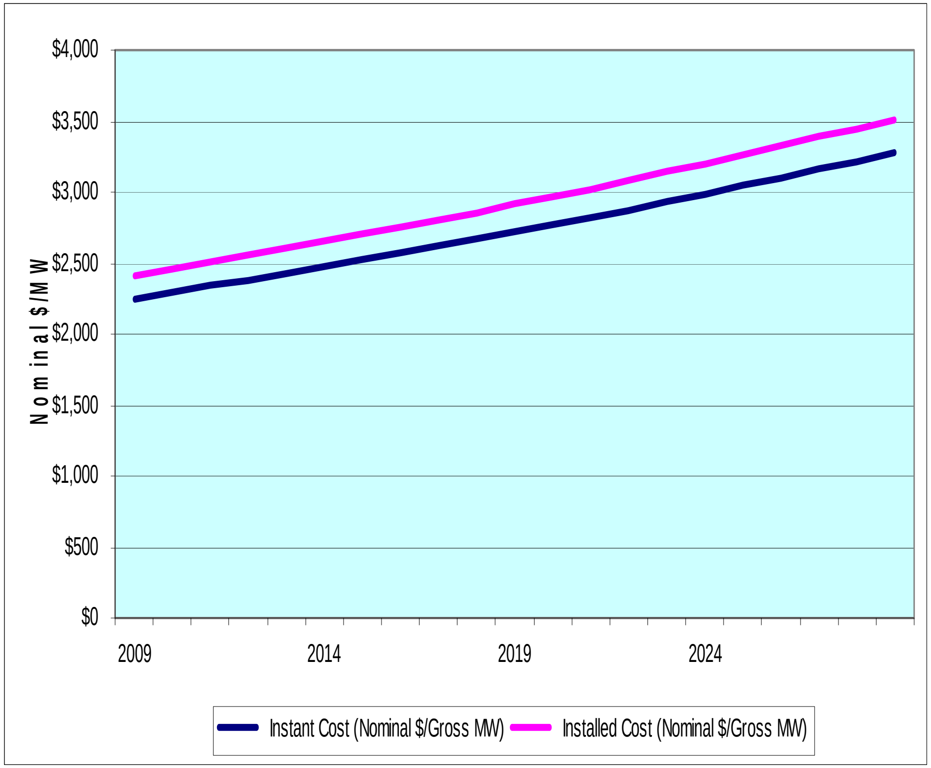
Clean Coal (IGCC)
Current Cost and Cost Trajectory

Current Costs

PLANT COST DATA	Start Year 2009
Average	
Instant Cost (Nominal $/Gross MW)	$2,250
Installed Cost (Nominal $/Gross MW)	$2,412
% Cost of last year of construction	80%
% Cost next to last year of construction	20%
% Cost of previous year of construction	
High	
Instant Cost (Nominal $/Gross MW)	$2,800
Installed Cost (Nominal $/Gross MW)	$2,951
% Cost first year of construction	60%
% Cost second year of construction	40%
% Cost third year of construction	0%
Low	
Instant Cost (Nominal $/Gross MW)	$1,500
Installed Cost (Nominal $/Gross MW)	$1,608
% Cost first year of construction	80%
% Cost second year of construction	20%
% Cost third year of construction	

Year=2009, Value & Dollars	Average	High	Low
Fixed Cost ($/kW-Year)	$41.7	$52.00	$31.67
Variable Cost ($/MWh)	$6.67	$8.33	$5.00

Projections



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Nuclear
Technology Selection Criteria

AP1000 PWR technology was selected based on proven technology, references and numerous license applications in process

Technology Reference Material and Key Assumptions	PWR nuclear technology was selected to supply new nuclear plants in China and other countries. Its' design of the AP-1000 system has been accepted on the world basis. The most recent announcements from China regarding the plans to purchase 100 AP-1000 plants over the next 25 years is an indication of an international acceptance of this design. Furthermore, the AP1000 has been identified as the technology of choice for no less than 12 new projected plants in the United States. The AP1000 is ideally suited for the worldwide and the USA nuclear power marketplace based on the following assumptions. The AP1000 is: -- The safest, most advanced, yet proven nuclear power plant currently available in the worldwide marketplace -- Based on standard Westinghouse pressurized water reactor (PWR) technology that has achieved more than 2,500 reactor years of highly successful operation -- An 1100MWe design that is ideal for providing baseload generating capacity -- Modular in design, promoting ready standardization and high construction quality -- Economical to construct and maintain (less concrete and steel and fewer components and systems mean there is less to install, inspect and maintain) -- Designed to promote ease of operation (features most advanced instrumentation and control in the industry) References: http://www.ap1000.westinghousenuclear.com.
	Reference Material: see "Task 1- Central Plant Technologies.xls"

Nuclear – AP1000

Technology Description

The AP100 is the most advanced US Nuclear Power technology based on the advanced NRC approval process.

Typical Plant

- 1117 MWe, 2-loop PWR, 33% efficiency
- Evolutionary design, based on AP-600 designs
- 60 years design life
- Simplified design with less components
- Passive safety systems
- TCDF ~ 5xE-7/year
- In-vessel retention of molten core
- 1st GEN III+ design certified by the USNRC
- 4 units being built in China

Description

WESTINGHOUSE - AP1000 Synonyms: Advanced Passive 1000:

- Approximate Capacity (electric): 1117-1154 MWe, Reactor Type: Pressurized Water Reactor
- NRC Design Certification Status: Certified after December 2005, though amendments have since been proposed.
- Supporting Generating Companies (potential site): Duke Power (Cherokee County), Progress Energy (Harris), Southern Company (Vogtle), NuStart Energy-Tennessee Valley Authority (Bellefonte)
- The AP1000 design is favored for construction at five to six potential sites (ten to twelve reactors) in the United States. The AP1000 is an enlargement of the AP600, designed to almost double the reactor's target electricity output without proportionately increasing the total cost of building the reactor. Westinghouse anticipates that operating costs should be below the average of reactors now operating in the United States. While Westinghouse owns rights to several other designs, the AP1000 is the principal product that the company now promotes in the United States for near term deployment. The AP1000 includes innovative, passive safety features and a much simplified design intended to reduce the reactor's material and construction costs while improving operational safety. During 2007 or 2008 it is anticipated that the AP1000 will be the subject of combined license (COL) applications to build and operate new reactors in the United States. In early 2005 Westinghouse submitted a bid to build a version of the AP1000 to build as many as four AP1000s at two sites in China.
- Further Information: http://www.nrc.gov/reactors/new-licensing/design-cert/ap1000.html http://www.ap1000.westinghousenuclear.com/ http://en.wikipedia.org/wiki/AP1000 http://www.nei.org/doc.asp?docid=770

Nuclear
Cost Drivers

Decommissioning costs are a significant component in the overall costs for Nuclear

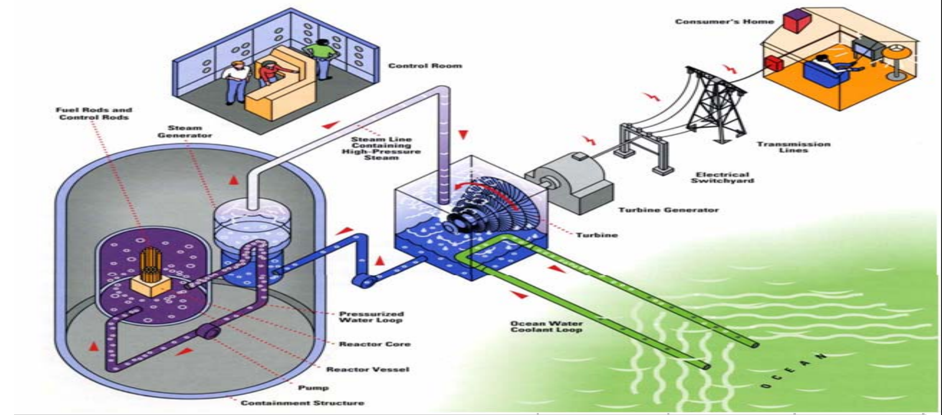
Cost Drivers

Cost Driver Header	Percentage Cost
LICENSING OF THE NUCLEAR POWER PLANTS	1%
PLANT CONSTRUCTION	65%
O & M OPERATION AND MAINTENANCE	5%
FUEL PRODUCTION	3%
NUCLEAR WASTE - TRANSPORTATION	2%
FUEL STORAGE AND DISPOSAL	4%
PLANT DECOMMISSIONING	20%

Key Cost Drivers

- The construction cost of building the plant.
- The operating cost of running the plant and generating energy.
- The cost of waste disposal from the plant.
- The cost of decommissioning the plant.

Plant Configuration Data Overview



PLANT DATA	Average	High	Low
Gross Capacity (MW)	1000	1000	1000
Station Service (%)	3.00%	3.00%	3.00%
Net Capacity (MW)	970.00	970.00	970.00
Net Energy (GWh)	7223	6852	7571
Transformer Losses	0.50%	0.50%	0.50%
Tranmission losses	1.49%	1.60%	1.43%
Load Center Delivered Capacity (MW)	950.77	949.71	951.35
Net Capacity Factor (NCF)	85.00%	80.64%	89.10%
Planned Percent of Year Operational	86.73%	100.00%	100.00%
Average Percent Output	100.0%	100.0%	100.0%
Net Energy Delivered to Load Center (GWh)	7079.43	6708.80	7425.43
Forced Outage Rate (FOR)	2.00%	4.00%	1.00%
Scheduled Outage Factor (SOF)	13.27%	16.00%	10.00%
Curtailment (% or Hours)	-	-	-
Degradation Factors			
Capacity Degradation (%/Year)	0.20%	0.20%	0.20%
Heat Rate Degradation (%/Year)	0.20%	0.20%	0.20%
Emission Factors			
NOX (lbs/MWh)	0.000	0.000	0.000
VOC/ROG (Lbs/MWh)	0.000	0.000	0.000
CO (Lbs/MWh)	0.000	0.000	0.000
CO2 (lbs/MWh)	0.000	0.000	0.000
SOX (lbs/MWh)	0.000	0.000	0.000
PM10 (lbs/MWh)	0.000	0.000	0.000

Nuclear
Current Costs and Cost Trajectory

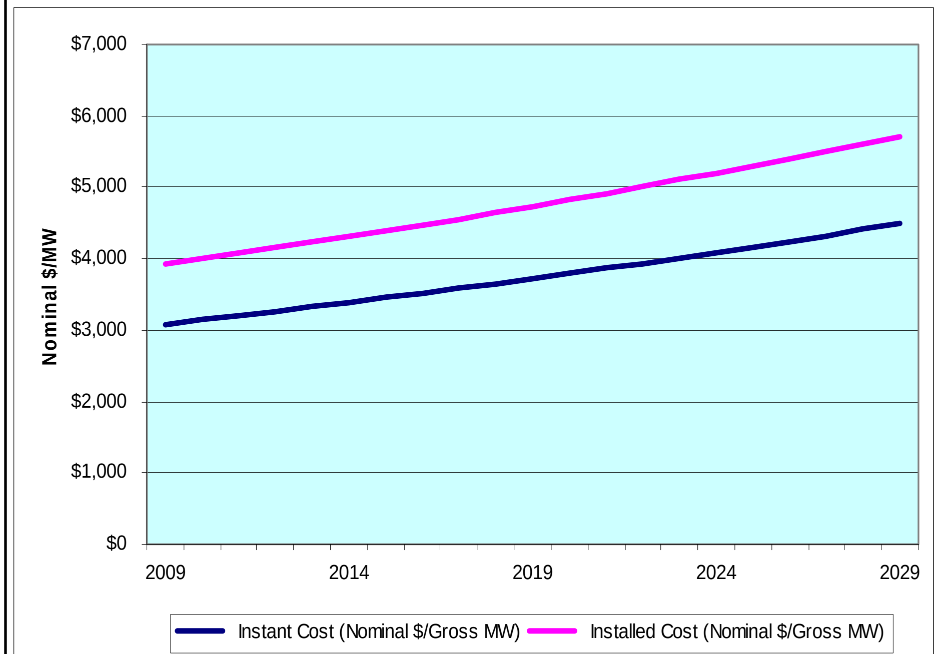
Decommission costs are built in as a reserve in the operation costs

Current Costs

	Start Year	2009
PLANT COST DATA		
Average		
Instant Cost (Nominal $/Gross MW)		$3,081
Installed Cost (Nominal $/Gross MW)		$3,921
% Year0 (Last Year of Contruction)		6%
% Year1 (Next to Last Year of Contruction)		17%
% Year2 (2 years Before Last Year)		30%
% Year3 (3rd years Before Last Year)		29%
% Year4 (4th Year before Last Year)		14%
% Year5 (First Year of Contruction)		4%
High		
Instant Cost (Nominal $/Gross MW)		$4,622
Installed Cost (Nominal $/Gross MW)		$5,882
% Year0 (Last Year of Contruction)		6%
% Year1 (Last Year of Contruction)		17%
% Year2 (Last Year of Contruction)		30%
% Year3 (Last Year of Contruction)		29%
% Year4 (Last Year of Contruction)		14%
% Year5 (Last Year of Contruction)		4%
Low		
Instant Cost (Nominal $/Gross MW)		$2,311
Installed Cost (Nominal $/Gross MW)		$2,941
% Year0 (Last Year of Contruction)		6%
% Year1 (Last Year of Contruction)		17%
% Year2 (Last Year of Contruction)		30%
% Year3 (Last Year of Contruction)		29%
% Year4 (Last Year of Contruction)		14%
% Year5 (Last Year of Contruction)		4%

Year=2009	Average	High	Low
Fixed Cost ($/kW-Year)	$147.7	$147.7	$147.7
Variable Cost ($/MWh)	$5.27	$5.27	$5.27

Projections



KEMA

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Geothermal – Flash Analysis Comparison

Geothermal - Flash	2007 IEPR	2009 Update
	2006	2009
Plant Capacity (MW)[1]	50	50
Project Life (yrs)	20	30
Overnight Installed Cost ($/kW)[2]	$2,750	$3,675
Fixed O&M ($/kW-yr)[3]	$80	$54
Variable O&M ($/MWh)[4]	$5	$5
Typical Net Capacity Factor (%)	95%	90%
Fuel Cost ($/MMBtu)	n/a	n/a
Heat Rate (HHV)	n/a	n/a
HHV Efficiency (%)	n/a	n/a
Annual Output Degradation (%/yr)	4%	4%

Reference to IEPR 2007 Data

Solar Parabolic Trough Analysis Comparison

Solar - Parabolic Trough

	2007 IEPR	2009 Update
	2006	2009
Gross Plant Capacity (kW)1	63,500	50,000
Net Plant Capacity (kW)1	50,000	48,800
Annual Output Degradation (%/yr)2	0.20%	0.50%
Project Life (yrs)	30	20
Overnight Cost ($/kWp)3	3,900	3,687
Fixed O&M ($/kW-yr)4	60	68
Variable O&M ($/MWh)	NA	NA
Development Time (months)	20	20
Construction Time (months)	12	12
Scheduled Outage Factor (%)1	NA	NA
Forced Outage Rate (%)1	6%	6%
Typical Net Capacity Factor (%)2	27%	27%
Fuel Cost ($/MMBtu)	NA	NA
HHV Efficiency (%)	NA	NA

Reference to IEPR 2007 Data

Wind - Onshore Analysis Comparison

Onshore Wind

	2007 IEPR	2009 Update
	2006	**2009**
Plant Capacity (MW)	50	50
Turbine Size (range) (MW)	2.0 (1.5-2.5)	2.0 (1.5-2.5)
Tower Height (range) (m)	80 (60 – 80)	80 (60 – 80)
Project Life (yrs)	30	30
Overnight Cost ($/kW)	$1,900	$1,825
Fixed O&M ($/kW-yr)	$30	$0
Variable O&M ($/MWh)		**22**
Scheduled Outage Factor (%)	0.30%	0.30%
Forced Outage Rate (%)	1.30%	1.30%
Typical Net Capacity Factor – Class 5 (%)	34%	22%
Typical Net Capacity Factor – Class 4 (%)	31%	22%
Typical Net Capacity Factor – Class 3 (%)	28%	22%
Annual Output Degradation (%/yr)	0.25%	1.00%

End

Thank you for your attention

QUESTIONS?