IGCC Development In Delaware

Coal Without Compromise

September 15, 2006

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- IGCC In Delaware
- Why IGCC vs. Other Options
- Project Status
  - Permitting
  - Gasification technology selection
A wholesale power generation company with operations in the United States and internationally

- Interests in 50 power projects with an aggregate net generation capacity of approximately 22,793 MW (7,976 MW coal-fired)
- Approximately 7,900 MW of capacity is in the Northeast region
- Approximately 1,200 MW located in PJM (900 MW coal-fired)
NRG’s NE development plan expected to result in lower emission rates across all pollutants.

Northeast Existing Capacity

<table>
<thead>
<tr>
<th>Region</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>PJM</td>
<td></td>
</tr>
<tr>
<td>Indian River</td>
<td>737</td>
</tr>
<tr>
<td>Keystone &amp; Con.</td>
<td>127</td>
</tr>
<tr>
<td>Vienna</td>
<td>170</td>
</tr>
<tr>
<td>NEPOOL</td>
<td></td>
</tr>
<tr>
<td>Somerset</td>
<td>127</td>
</tr>
<tr>
<td>Middletown</td>
<td>770</td>
</tr>
<tr>
<td>Montville</td>
<td>497</td>
</tr>
<tr>
<td>Devon</td>
<td>124</td>
</tr>
<tr>
<td>Norwalk</td>
<td>342</td>
</tr>
<tr>
<td>CT Jets</td>
<td>104</td>
</tr>
<tr>
<td>New York</td>
<td></td>
</tr>
<tr>
<td>Astoria</td>
<td>553</td>
</tr>
<tr>
<td>Arthur Kill</td>
<td>841</td>
</tr>
<tr>
<td>Huntley</td>
<td>552</td>
</tr>
<tr>
<td>Dunkirk</td>
<td>522</td>
</tr>
<tr>
<td>Oswego</td>
<td>1,634</td>
</tr>
<tr>
<td>TOTAL</td>
<td>7,099</td>
</tr>
</tbody>
</table>
Indian River

- 784 MW total capacity
- Four coal fired steam units
- One combustion turbine
- Two types of coal
- 170 employees
- Dispatched through PJM (transmission system operator)
NRG and Indian River are committed to:

- Meeting environmental regulations
- Providing electricity reliably
- Being a low cost provider
Why Add Generation..............Why Delaware?

- **Reliability**
  - **Growth** - Delaware is seeing unprecedented population growth – 17.6% average with 38% growth in Sussex County.
  - **Demand** - (PJM) peak summer use is expected to grow at 1.6% as a whole, while Delaware @ 2% each year
  - **Demand** - Delmarva Power summer use is expected to grow from 4070 Mw to 4313 by 2010 and 4729 by 2015.
  - **Shortage** - Industry experts estimate shortfall in capacity beginning in 2008 in Delaware and across all of PJM, impacting Delaware’s import capabilities
  - **Import/Export** - Delaware, a power importer, needs to add new generation in order to ensure an adequate power supply for the future
  - **New capacity Needs** - There are currently only 3 projects in the PJM queue for new capacity in Delaware for a total of 8MW

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Why Add Generation.............. Why Delaware?

- **Price Stability**
  - **Consumers** - Delmarva Power retail customer rates were increased by 59% effective 5/1/06

- **Other Options** - Natural gas prices remain high and continue to drive electric wholesale costs

- **Fuel Diversity** - Adequate supply and fuel diversity is key to stabilizing electricity prices

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Why Add Generation................Why Delaware?

- **Environmental Impact**
  - **Clean Coal Generation** – Desire for new sources with low emissions.
  - **Clean Air Interstate Rule (CAIR)** – It contains an annual SO2 cap-and-trade program, as well as an annual and Ozone Season NOx cap-and-trade program, dependent on a state’s contribution to downwind PM and Ozone concentrations.
  - **Clean Air Mercury Rule (CAMR)** – It is a mercury cap-and-trade program affecting new and existing coal fired units greater than 25 MW. Phase I starts in 2010 and has a national cap of 38 TPY; Phase II starts in 2018 and has a national cap of 15 TPY.
  - **Delaware** - DNREC is currently in the process of developing new multi-pollutant regulations for reducing emissions from Delaware power plants

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Indian River Plan – New and existing investment

- New Generation IGCC Technology
  - Construction of a new, base-load, clean coal facility.
  - New plant will assist the state in becoming less reliant on natural gas, contribute much needed base-load generation to stabilize electricity prices and will reducing overall emission rates per kwh of output.

- Existing Plant Emissions Reduction Technology
  - Installation of emissions controls on existing generating units
  - SO2 Controls
  - NOx Controls
  - HG Reduction

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## Existing Plant Emissions Reductions

### SO2 Controls

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
<th>In-Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit #1</td>
<td>In-Duct Injection</td>
<td>2009</td>
</tr>
<tr>
<td>Unit #2</td>
<td>In-Duct Injection</td>
<td>2009</td>
</tr>
<tr>
<td>Unit #3</td>
<td>In-Duct Injection</td>
<td>2009</td>
</tr>
<tr>
<td>Unit #4</td>
<td>Wet Scrubber</td>
<td>2012</td>
</tr>
</tbody>
</table>
### Existing Plant Emissions Reductions

**NOx Controls**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
<th>In-Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit #1</td>
<td>Low NOx Burners Selective Non-Catalytic Reduction (SNCR)</td>
<td>2009</td>
</tr>
<tr>
<td>Unit #2</td>
<td>Low NOx Burners Selective Non-Catalytic Reduction (SNCR)</td>
<td>2009</td>
</tr>
<tr>
<td>Unit #3</td>
<td>Low NOx Burners Selective Non-Catalytic Reduction (SNCR)</td>
<td>2009</td>
</tr>
<tr>
<td>Unit #4</td>
<td>Low NOx Burners Selective Catalytic Reduction (SCR)</td>
<td>2011</td>
</tr>
</tbody>
</table>
## Existing Plant Emissions Reductions

### Hg Controls

<table>
<thead>
<tr>
<th>Unit</th>
<th>In-Service Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit #1</td>
<td>Activated Carbon Injection/Fabric Filter 2009/2011</td>
</tr>
<tr>
<td>Unit #2</td>
<td>Activated Carbon Injection/Fabric Filter 2009/2011</td>
</tr>
<tr>
<td>Unit #3</td>
<td>Activated Carbon Injection/Fabric Filter 2009/2011</td>
</tr>
<tr>
<td>Unit #4</td>
<td>Wet Scrubber/SCR 2012/2011</td>
</tr>
</tbody>
</table>

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Impact on Delaware

- **Reliability**
  - Retention of existing units provides for continued reliable electricity supply
  - Installation of IGCC increases the local generating capacity by 630MW and allows for added load growth
Impact on Delaware

- **Price Stability**
  - Redevelopment plan is based on continued use of lower cost coal as the primary fuel source
  - Allows for continued fuel diversity within Delaware and avoids over reliance on natural gas
  - Long-term Power Purchase Agreement (PPA) contracts result in much desired rate stability for Delaware consumers

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Impact on Delaware

- **Environmentally Responsible**
  - IGCC emissions are comparable to a natural gas combined cycle power plant
  - IGCC is able to capture CO2
  - Emissions on existing units are significantly reduced
  - Overall emissions rates significantly reduced for the entire site and exceed CAIR and CAMR requirements and are needed to meet Delaware’s eventual regulations
Economic Benefits

- Indian River Generating Station currently employs 170 full-time employees from the local area.
- Many additional contract employees are employed during maintenance outages.
- IGCC construction would bring approximately 400 - 900 additional jobs during the construction period.
- IGCC facility would add an additional 85 - 100 permanent full-time jobs.
- IGCC is economically beneficial to the state as a capital investment of approximately $1.5 billion will be invested in Delaware.
- Emission reduction projects investments are approximately $330 million.

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Why IGCC?

- Coal generation preferred
  - US retains ample coal supply (the “Saudi Arabia of coal”).
  - Coal is the cheapest generation resource option – assures lower energy cost to consumers
  - Other fuels options are scarce and subject to technology or infrastructure limitations.
  - Using domestic fuel reserves reduces dependency on foreign oil and gas imports – reduces exposure to world events

- Environmental regulations
  - require major coal plant investments and/or retirements
  - limitations on new technology
  - IGCC is “Clean Coal Technology”

- IGCC preferred over pulverized coal options

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Why Coal?

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What Is IGCC?

- IGCC turns coal into a clean synthetic gas which fuels a gas turbine instead of using natural gas.

**NGCC**: Natural Gas Combined Cycle

**IGCC**: Integrated Gasification Combined Cycle

**Combined Cycle**: Gas turbine cycle plus a steam turbine cycle
630 IGCC MW Configuration

Dual Train Gasification System (pre-combustion clean-up)

Coal Prep & Feed → Gasifier → Gas Cooling → Acid Gas Recovery → Mercury Capture → Reheat / Humidify → CO2 Capture (optional) → CO2 Capture (optional) → Carbon Sequestration (Future) → Sulfur Production → Slag & Sulfur Sales → Slag Recovery → Slag & Sulfur Sales → Coal Prep & Feed

Combined Cycle Power Block 630 MW Net Output

Gas Turbine Generator → Steam Generator → Power Out

Steam Turbine Generator → Heat Sink Condenser → Power Out

Gas Turbine Generator → Steam Generator → Power Out

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IGCC Plant Emissions

- SO2 0.05 #/MBTU
- NOx 0.016 #/MBTU
- Hg 90+% reduction
- CO2 Installed with equipment that will enable the capture of approximately 66% of the CO2 and be comparable to a natural gas combined cycle plant
Overall Emissions Rate Reductions

- The expected emissions reductions (including the IGCC and emissions controls projects) are shown below:
  - SO2  90% reduction
  - NOx  80% reduction
  - Hg   75%-90% reduction
IGCC has ability to capture carbon

- $\text{CO}_2$ capture costs based on available technology
- $\text{CO}_2$ capture adds 15% to 30% $/\text{MWH}$ in market
- Cost = $14$ to $24$ per ton
- Cost does not include sequestration
- Sequestration limited to geological configuration
Advantages of IGCC vs. Best PC

- More fuel efficient – 4-5% lower heat rate
- Fuel flexibility – optimize sources & cost
  - Most coals, petcoke & even biomass
- 20-30% less water consumption
- 40-60% less solid waste
  - Saleable “slag” & sulfur
- Lower emissions – NOx, SO2, PM, & VOCs
- 90%+ Hg removal
- Carbon capture capable – much lower cost
- Broad stakeholder support for IGCC

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Notes:
1. Based on recent PC environmental permit filings
2. Limestone to gypsum releases CO2
3. Amount of limestone is proportional to coal sulfur

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IGCC Overview

BACT IGCC...

Air Separation Unit → Gasification (Coal to syngas) → Low Temp Gas Cooling

Coal → O₂ → Syngas → Slag

Cooled Syngas

COS & Acid Gas Removal

Solvent (make-up) → Sulfur

Mercury Removal

Clean Syngas → GT

N₂ → Back-up fuel

ST → Electricity

HRSG

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Notes:
1. Based on IGCC environmental permit filing
2. Limestone is not required
3. Minimum sulfur removal level is 98%
4. NOX from GT is ~15 ppm
Gasification - Is it well established?

Cumulative Worldwide Gasification Capacity and Growth

MWth Syngas

- Planned
- Operating
Phase II Development
Indian River
Where are we in the project?
IGCC Phases Of Development

Four Project Phases

- **Phase I - Assess Opportunity 3 Months**
  - Is IGCC an option
  - Location

- **Phase II - Project Definition 6 Months**
  - Preliminary Engineering
  - Cost Estimation
  - Environmental Assessment

- **Phase III – Detailed Development 18 to 24 Months**
  - Agreements
  - Contracts
  - Engineering
  - Permitting

- **Phase IV – Construction 40 to 46 Months**
  - Actual Construction
  - Tie Ins
  - Start Up

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## Indian River Capacity with IGCC

<table>
<thead>
<tr>
<th>UNIT ID</th>
<th>CAPACITY MW</th>
<th>FUEL</th>
<th>START</th>
<th>RETIRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>80</td>
<td>Coal</td>
<td>1957</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>80</td>
<td>Coal</td>
<td>1959</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>150</td>
<td>Coal</td>
<td>1970</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>410</td>
<td>Coal</td>
<td>1980</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>17</td>
<td>#2 FO</td>
<td>1967</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total Current</strong></td>
<td><strong>737</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IGCC</td>
<td>630</td>
<td>Coal/Petcoke</td>
<td>2011-12</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total w/ IGCC</strong></td>
<td><strong>1367</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Phase II – Site Assessments

<table>
<thead>
<tr>
<th>Assessments</th>
<th>Indian River</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available Space (acres)</td>
<td>1100</td>
</tr>
<tr>
<td>Net Capacity (MW)</td>
<td>633</td>
</tr>
<tr>
<td>Steam Turbine</td>
<td>New</td>
</tr>
<tr>
<td>Cooling System</td>
<td>New Tower</td>
</tr>
<tr>
<td>Water Source</td>
<td>Existing Indian River &amp; Wells</td>
</tr>
<tr>
<td>Fuel Delivery</td>
<td>Existing Rail</td>
</tr>
<tr>
<td>Fuel Storage</td>
<td>Existing or new Yard</td>
</tr>
<tr>
<td>Slag/Sulfur Transport</td>
<td>Existing Rail/Truck</td>
</tr>
<tr>
<td>Grid Interconnection</td>
<td>Existing 230 kV</td>
</tr>
<tr>
<td>Startup/Backup Fuel</td>
<td>Existing Oil</td>
</tr>
</tbody>
</table>

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SCGP – Membrane wall gasifier manufacturing

1. Membrane wall during manufacturing in the workshop

   Courtesy of Babcock Borsig Espana, Bilbao, Spain

2. Erection of membrane wall into the gasifier pressure vessel at site (or in the workshop)

   Courtesy of Elcogas, Puertollano, Spain

3. Ready assembled gasifier
Syngas Cooler Being Delivered via Barge.
Syngas Cooler Being Erected
Permitting Roadmap

- 14-24+ months – potential critical path

Figure 3  CSC CERTIFICATION AND PERMIT PROCESS OVERVIEW FOR MONTVILLE, CONNECTICUT

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## Indian River Permits Required

<table>
<thead>
<tr>
<th>Permit or Approval</th>
<th>Agency</th>
<th>Expected Agency Review Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FEDERAL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acid Rain Permit</td>
<td>USEPA</td>
<td>6 months</td>
</tr>
<tr>
<td>Army Corps of Engineers (USACE) Construction Permit</td>
<td>USACE</td>
<td>3 - 18 months</td>
</tr>
<tr>
<td>Federal Endangered Species Consultation</td>
<td>US Fish and Wildlife Service</td>
<td>2 – 6 months</td>
</tr>
<tr>
<td>Notice of Proposed Construction or Alteration</td>
<td>FAA</td>
<td>1-2 months</td>
</tr>
<tr>
<td><strong>STATE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction, Installation, Alteration and Operation Air Permit</td>
<td>DNREC</td>
<td>6 – 12 months</td>
</tr>
<tr>
<td>Title V - State Operating Permit</td>
<td>DNREC</td>
<td>6 – 12 months</td>
</tr>
<tr>
<td>Coastal Zone Permit</td>
<td>DNREC</td>
<td>6 months</td>
</tr>
<tr>
<td>Solid Waste Permit</td>
<td>DNREC</td>
<td>1-2 months</td>
</tr>
<tr>
<td>NPDES Surface Water Discharge Permit</td>
<td>DNREC</td>
<td>6 - 12 months</td>
</tr>
<tr>
<td>NPDES Industrial Storm Water Discharge Permit</td>
<td>DNREC</td>
<td>1-2 months</td>
</tr>
<tr>
<td>NPDES Storm Water Permit for Construction Activity</td>
<td>DNREC</td>
<td>2 - 4 months</td>
</tr>
<tr>
<td>Water Allocation Permit</td>
<td>DNREC</td>
<td>3-6 months</td>
</tr>
<tr>
<td>Subaqueous Land / Wetlands Permit</td>
<td>DNREC</td>
<td>3-5 months</td>
</tr>
<tr>
<td>401 Water Quality Certification</td>
<td>DNREC</td>
<td>3-5 months</td>
</tr>
<tr>
<td>Wastewater Treatment Plant License</td>
<td>DNREC</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>RCRA Hazardous Waste Identification Number</td>
<td>DNREC</td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>

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OBJECTIVES

- OVERVIEW OF PLANT
- NPDES PERMIT HISTORY
- 316(a) THERMAL VARIANCE
- 316(b) IMPINGEMENT & ENTRAINMENT
<table>
<thead>
<tr>
<th>Unit</th>
<th>Year</th>
<th>Cooling Water</th>
<th>MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1957</td>
<td>Once-Through</td>
<td>108</td>
</tr>
<tr>
<td>2</td>
<td>1958</td>
<td>Once-Through</td>
<td>108</td>
</tr>
<tr>
<td>3</td>
<td>1970</td>
<td>Once-Through</td>
<td>162</td>
</tr>
<tr>
<td>4</td>
<td>1980</td>
<td>Cooling Tower</td>
<td>26</td>
</tr>
</tbody>
</table>
Aquatic Studies

- **316(a) Thermal Impact Assessment**
  - Study plan developed in cooperation w/ DNREC, others
  - Field studies conducted: April ‘98 – Nov ’99
  - Report submitted to DNREC: Jan ’01

- **316(b) Impingement & Entrainment**
  - Study plan developed in cooperation w/ DNREC, others
  - Field studies conducted: Dec ‘99 – Nov ’01
  - Report submitted to DNREC: Aug ’03

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316(a) THERMAL IMPACT STUDIES

PURPOSE

- Delineate thermal plume
- Evaluate potential effects of temperature on biological communities
- Evaluate interaction between temperature, dissolved oxygen, and nutrients
- ERES Resource Assessment

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316(a) THERMAL IMPACT STUDIES

SCOPE

- Water quality assessment
  - Temperature, dissolved oxygen, nutrients, other

- Thermal plume delineation
  - Extent of thermal plume under various tidal & meteorological conditions

- Fisheries assessment
  - Risk assessment (thermal tolerance)
  - Weight of evidence (population trends)

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316(a) THERMAL IMPACT STUDIES
SAMPLING PLAN

- Sampling period
  - April 1998 - October 1999

- Data collection programs
  - Instantaneous water quality (grab)
  - Temperature plume mapping
  - Datasonde monitoring
  - Ancillary parameters
  - Plant data
  - Meteorological data

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Temperature Delineation Transects

- **A**: (11.7) 1 2 3
- **B**: (10.6) 1 2 3
- **C**: (10) 1 2 3
- **D**: (9.0) 1 2 3
- **E**: (8.6) 1 2 3
- **F**: (8.0) 1 2 3
- **G**: (7.7) 1 2 3
- **H**: (6.9) 1 2 3
- **I**: (6.5) 1 2 3
- **J**: (5.5) 1 2 3
- **K**: (4.9) 1 2 3
- **L**: (4.0) 1 2 3
- **M**: (2.8) 1 2 3
- **N**: (2.0) 1 2 3

- **#** = River Miles (from IR Inlet)
- **O** = Transect Station

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Water Quality Sampling Locations

Sampling Station

1 (RM 11.6)  2 (RM 9.9)  3 (RM 8.0)  4 (RM 9.2)  5 (RM 7.5)  6 (RM 6.9)  7 (RM 6.0)  8 (RM 4.8)
CONCLUSIONS

- No appreciable harm has occurred to the fish and shellfish populations in the Indian River Estuary from the IRGS discharge
- No blockage to migration results from the IRGS discharge
- Viability of the fish and shellfish populations in the Indian River Estuary is unaffected by the IRGS discharge
COOLING WATER INTAKE
316(b) IMPINGEMENT & ENTRAINMENT STUDIES PURPOSE

- Collect current data on I/E of representative important species (RIS) of fish and shellfish

- Evaluate potential effects of the CWIS on RIS populations of the Indian River Estuary and Rehoboth Bay

- Evaluate whether operation of the CWIS is resulting in an Adverse Environmental Impact

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Assessment of I/E of six RIS:
- Bay anchovy, Atlantic Menhaden, Spot, Atlantic Croaker, Winter Flounder, Blue Crab

Population studies
- Finfish trawls (monthly)
- Ichthyoplankton tows (weekly)

Plant studies
- Impingement sampling (biweekly Dec-Apr; weekly May-Nov)
- Entrainment sampling (weekly)
Sampling period
- December 1999 – November 2001

Data collection
- Finfish trawls (coord w/ DNREC program)
- Ichthyoplankton tows (near/far field)
- Impingement sampling (traveling screens)
- Entrainment sampling (intake canal)

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Ecological Risk Assessment Framework

Impact Assessment Models
  – Empirical Transport Model
  – Equivalent Adult Model
  – Equivalent Yield Model
  – Production Foregone Model

Weight of Evidence Analysis

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Low risk of Adverse Environmental Impact to all Representative Important Species populations

Operation of the Cooling Water Intake Structure is protective of a balanced indigenous community and long-term sustainability of fish and blue crab populations
SUMMARY / STATUS

- **316(a) Thermal Impacts**
  - Recent studies completed
  - Report submitted to DNREC
  - Formal request submitted for renewal of thermal variance

- **316(b) Intake Impacts**
  - Recent studies completed
  - Report submitted to DNREC
  - Preparing plan to achieve compliance with EPA Phase II reg