Lifecycle Energy Modeling
Input into Upstream Design Process

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# Agenda

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upstream conceptual design process  
typical conceptual design case generation |
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CO₂ emissions vs. production  
availability model output |
| Conclusion   | Net savings achieved – life cycle  
net savings achieved – totals  
questions |
Background
Energy usage profile of upstream industry

Top Energy Intensive Industries (worldwide, 2005)

- Upstream and Midstream: 25.28
- Iron and Steel: 20.32
- Refining: 17.23
- Petrochem and Chemicals: 14.25
- Cement: 7.78

Oil and gas is top industrial energy user

Upstream use primarily in pumping/compression
Stage gate process
method of capital appropriation

Assess phase (0.1% of project capital)
develop concept design cases
generate high level definition
target +/-50% cost estimate

Select phase (1% of project capital)
refine and select base case
front end engineering work
target +/-30% cost estimate

Define phase (10% of project capital)
detailed engineering
target +/-10% cost estimate
Background
Typical concept design case generation

Base process requirements

- 2 stage separation with OTU
- 3 stage separation

- Sales gas let down from terminal stage
- Separate lift gas compressor

Air cooling

Indirect seawater cooling

Seawater $T_{max}$ 85°F

Seawater $T_{max}$ 65°F

Centralized electric plant with motors

Discrete turbine drives

- All GoM construction
- Subs constructed in Europe

- 4 leg full size TLP
- 4 leg mini TLP
- 4 leg mid size TLP
- 4 leg Semisub
- FPDSO
- Truss Spar

Candidate for further study
Rejected

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Design input
Production profile

Production Profile

- Oil Production
- Produced Water
- Injected Water
- Gas Production

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### Design input

#### Valuation methods

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel usage</td>
<td>Cost avoidance of fines associated with flaring. Discounted NPV assuming future local gas market average pricing for recent gas sales or fraction thereof. 2009 average wellhead gas price $3.71/kscf.</td>
</tr>
<tr>
<td>CO₂ emissions</td>
<td>Primarily cost avoidance of emissions taxes. Possible offsets market for international companies. Discounted NPV for countries with future requirements. EUA December 2010 contract was €15.10/ton CO₂.</td>
</tr>
<tr>
<td>Availability</td>
<td>Calculate actual production time out of service. Use production pricing and profile for value. Compare NPV for base output and for increased availability. NPV difference is value of deferred production. Brent spot was $72.40/bbl.</td>
</tr>
<tr>
<td>Inflation</td>
<td>2.5% annually.</td>
</tr>
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Comparison
Energy intensity vs. production

Annual Average Energy Intensity vs. Production

- GT
- VSD
- Production

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Comparison
CO₂ emissions vs. production

CO₂ Emissions vs. Production

- Production Year
- tonn CO₂ / year

GT
VSD
Production

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Comparison
Availability model
Conclusion
Net savings achieved, life cycle

Constituent Values of Life Cycle NPV Savings (VSD vs. GT)

<table>
<thead>
<tr>
<th>Production Year</th>
<th>Present Value (mil)</th>
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<tbody>
<tr>
<td>1</td>
<td>6.8</td>
</tr>
<tr>
<td>2</td>
<td>7.9</td>
</tr>
<tr>
<td>3</td>
<td>8.5</td>
</tr>
<tr>
<td>4</td>
<td>9.2</td>
</tr>
<tr>
<td>5</td>
<td>8.7</td>
</tr>
<tr>
<td>6</td>
<td>7.9</td>
</tr>
<tr>
<td>7</td>
<td>7.1</td>
</tr>
<tr>
<td>8</td>
<td>6.4</td>
</tr>
<tr>
<td>9</td>
<td>5.8</td>
</tr>
<tr>
<td>10</td>
<td>4.8</td>
</tr>
<tr>
<td>11</td>
<td>3.7</td>
</tr>
<tr>
<td>12</td>
<td>2.8</td>
</tr>
<tr>
<td>13</td>
<td>2.0</td>
</tr>
<tr>
<td>14</td>
<td>1.4</td>
</tr>
<tr>
<td>15</td>
<td>0.9</td>
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</tbody>
</table>

- Availability Increase
- CO2 Emission Reduction
- Fuel Usage Reduction
**Conclusion**

**Net savings achieved, totals**

<table>
<thead>
<tr>
<th></th>
<th>GT</th>
<th>VSD</th>
</tr>
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<tbody>
<tr>
<td>CAPEX (total platform installed cost)</td>
<td>1,149,163,400</td>
<td>1,183,251,600</td>
</tr>
<tr>
<td></td>
<td>(34,088,200)</td>
<td></td>
</tr>
<tr>
<td>NPV OPEX savings for fuel gas</td>
<td></td>
<td>9,304,509</td>
</tr>
<tr>
<td>NPV OPEX savings for emissions</td>
<td></td>
<td>1,925,837</td>
</tr>
<tr>
<td>NPV OPEX savings for uptime</td>
<td></td>
<td>62,315,457</td>
</tr>
<tr>
<td>Total NPV savings</td>
<td></td>
<td>73,545,804</td>
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<tr>
<td>Overall savings</td>
<td></td>
<td>39,457,604</td>
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Questions?