PROPOSED 2x350MW SUPERCritical COAL-FIRED POWER PLANT
Presentation Outline

- General Information
- Project Justification & Outcome
- Energy Sources & Drawbacks
- Clean Coal Technologies
- IEA Coal Power Plant Projections for 2015 - 2030
- Environmental Impacts & Mitigation – Local & Global
- Public Consultations
- General Discussion
General Information
### Project Overview – General Information

<table>
<thead>
<tr>
<th>Project Sponsors</th>
<th>Project Consultants</th>
</tr>
</thead>
</table>
| - SEC - Shenzhen Energy Corporation, China  
- VRA – Volta River Authority, Ghana | - SDEPCI: Power Plant  
- CCCC-FHDI: Coal Handling Terminal |

<table>
<thead>
<tr>
<th>Installed Plant Capacity</th>
<th>Coal Supply Sources</th>
</tr>
</thead>
</table>
| - Total Plant Capacity: 2,000MW  
- Phase I: 2X350 MW SC  
- April 2017 – Nov 2019/April 2020  
- Phase II: 4X350 MW SC or 2X600 MW USC  
- Project Cost - $1.5bn  
- Tariff - $0.1091 | - 1<sup>st</sup> Supplier: Glencore Xstrata of South Africa (30.2bn-Reserve)  
- 2<sup>nd</sup> Supplier: Anglo America from Columbia (6.2bn Reserve)  
- Annual Consumption for Phase I: 2MTons/year  
- Ash Storage Yard – 5yrs storage |

<table>
<thead>
<tr>
<th>Site Selection</th>
<th>Land Requirement</th>
</tr>
</thead>
</table>
| - Ekumfi Aboano (Central Region)  
- Komenda/Akwidaa /Domunli | - Land Requirement (270 hectares)  
Plant/Ash Yard/Access Road/Transmission RoW |
GENERAL INFORMATION - PROJECT OVERVIEW

Plant Layout

Coal Handling Terminal (Port)

Open Coal Storage yard

Totally Closed Coal Storage yard

15km Transmission Line
Energy Demand Projections (2015 – 2030)
- Annual Growth Rate - 7% & Installed capacity (2,574MW – 7,000MW)

Fuel Supply Risk
- Indigenous gas supply limitation (2036), pipeline challenges, unreliable supplier
- Light crude oil price volatility
- Poor hydrological years (period of insufficient rainfall)
- Intermittent nature of renewables energies and their impact on grid stability

Diversification of Energy Sources
- Most abundant fuel resource and widely distributed (860bn reserve worldwide)
- Challenges with Hydro - Thermal Complement / Akosombo Dam Management / low composite tariff
- Reducing the effect of stranded assets (2036)

Least Cost of Generation
Affordable source of electricity. Cheapest fuel in the long term invariable provides least economic cost of electricity (only next to large hydropower plants) for stainable development.
### Fuel Supply Risk

<table>
<thead>
<tr>
<th>Fuel Supply Sources (mmScfd)</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2036</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indigenous Gas/ mmScfd</td>
<td>127</td>
<td>313</td>
<td>242</td>
<td>211</td>
<td>51</td>
<td>Erratic &amp; Limited Supply</td>
</tr>
<tr>
<td>WAPCo / mmScfd</td>
<td>123</td>
<td>123</td>
<td>123</td>
<td>123</td>
<td>123</td>
<td>Unreliable Supply &amp; Pipeline Challenges</td>
</tr>
<tr>
<td>Total Supply/ mmScfd</td>
<td>250</td>
<td>436</td>
<td>365</td>
<td>334</td>
<td>174</td>
<td>Supply Shortfall</td>
</tr>
<tr>
<td>Total Demand/ mmScfd</td>
<td>450+</td>
<td>450+</td>
<td>450+</td>
<td>450+</td>
<td>450+</td>
<td>Increasing Demand</td>
</tr>
<tr>
<td>Deficit/ mmScfd</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LNG Augmentation</td>
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</tbody>
</table>

### GAS SUPPLY RISK

![Graph showing gas supply risk](image.png)
Energy Sources & Drawbacks
<table>
<thead>
<tr>
<th>Energy Sources</th>
<th>Drawbacks</th>
<th>Energy Sources</th>
<th>Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro</td>
<td>High CAPEX</td>
<td>Solar</td>
<td>Intermittent supply</td>
</tr>
<tr>
<td></td>
<td>Significant land requirement for large plants with dams/lakes</td>
<td>Grid connection challenges</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Public resistance due to relocation or micro climate effects</td>
<td>Use of toxic materials</td>
<td></td>
</tr>
<tr>
<td>Natural Gas/LCO</td>
<td>High upfront investment requirement for transport and distribution system</td>
<td>Reliance on subsidies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increasingly long supply routes and high cost of infrastructure</td>
<td>Land usage (2.5 Hectares/MW)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High price volatility</td>
<td>Tariff ($0.18/kWh - $0.22/kWh)</td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td>High emissions of CO₂, particulates and other pollutants</td>
<td>Wind</td>
<td>Transportation challenges</td>
</tr>
<tr>
<td></td>
<td>Not suitable for peaking generation units</td>
<td>Intermittent supply</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CCS have negative impact on thermal plant efficiency</td>
<td>Grid integration challenges</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reliance on subsidies</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tariff ($0.16/kWh)</td>
<td></td>
</tr>
<tr>
<td>Nuclear</td>
<td>High CAPEX and rising compliance costs</td>
<td>Nuclear</td>
<td>Long Public concerns about operation and final waste disposal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Liabilities in case of nuclear accident</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>High construction period</td>
</tr>
</tbody>
</table>
Clean Coal

Technology
COAL POWER GENERATION PROCESS

- Coal Bunker
- Coal Pile
- Coal Pulverizer
- Air
- Slag Disposal
- Water
- Steam
- Selective Catalytic Reduction (NOx Removal)
- Particulate Removal (Fly Ash)
- Scrubber (SO2 Removal)
- Exhaust Stack
- Generator
- Steam Turbine
- Warm Water
- Condenser
- Cooling Water

Low NOx
IEA COAL POWER PLANTS PROJECTIONS 2015 - 2030
Annex – country specific data

Table 2 Planned/announced coal capacities and estimated impact on CO2 emission. Source: Global Coal Plant Tracker (2015), IEA (2015) and Enerdata (2015).\textsuperscript{11}

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>Planned</th>
<th>2030 if all planned plants are built</th>
<th>Announced or pre-planned</th>
<th>Estimated new capacity in 2030 if announced and pre-planned are cancelled</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capacity (GW)</td>
<td>Capacity (GW)</td>
<td>Number of plants</td>
<td>Capacity (GW)</td>
<td>Number of plants</td>
</tr>
<tr>
<td>China</td>
<td>895</td>
<td>712</td>
<td>1171</td>
<td>1479</td>
<td>722</td>
</tr>
<tr>
<td>India</td>
<td>197</td>
<td>290</td>
<td>446</td>
<td>434</td>
<td>201</td>
</tr>
<tr>
<td>Indonesia</td>
<td>26</td>
<td>45</td>
<td>119</td>
<td>67</td>
<td>79</td>
</tr>
<tr>
<td>Japan</td>
<td>88</td>
<td>23</td>
<td>45</td>
<td>70</td>
<td>34</td>
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<tr>
<td>South Africa</td>
<td>41</td>
<td>13</td>
<td>24</td>
<td>35</td>
<td>9</td>
</tr>
<tr>
<td>South Korea</td>
<td>29</td>
<td>21</td>
<td>26</td>
<td>47</td>
<td>12</td>
</tr>
<tr>
<td>The Philippines</td>
<td>5.6</td>
<td>12</td>
<td>60</td>
<td>17</td>
<td>30</td>
</tr>
<tr>
<td>Turkey</td>
<td>15</td>
<td>71</td>
<td>93</td>
<td>80</td>
<td>73</td>
</tr>
<tr>
<td>EU28</td>
<td>185*</td>
<td>22</td>
<td>27</td>
<td>142</td>
<td>11</td>
</tr>
<tr>
<td>Total of countries analysed</td>
<td>1280</td>
<td>1210</td>
<td>2011</td>
<td>2372</td>
<td>775</td>
</tr>
<tr>
<td>World total*</td>
<td>1851</td>
<td>1428</td>
<td>2440</td>
<td>2703</td>
<td>923</td>
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</table>

*2013 (IEA, 2015).
Environmental Impact & Mitigations

Local & Global
<table>
<thead>
<tr>
<th>Pollutant(s)</th>
<th>Unit</th>
<th>Ghana (EPA) Standards</th>
<th>China Standards</th>
<th>World Bk. &amp; IFC Standards (New Plants)</th>
<th>European Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoke</td>
<td>Ringlemann</td>
<td>No.2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Solid Particles</td>
<td>mg/m³</td>
<td>200</td>
<td>30</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>SO₅</td>
<td>SO₂: mg/m³</td>
<td>None</td>
<td>New plants -100 (Proposed)</td>
<td>200</td>
<td>New -200 (Proposed)</td>
</tr>
<tr>
<td>SO₃</td>
<td>mg/m³</td>
<td>120</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>NO₅</td>
<td>mg/m³</td>
<td>1000</td>
<td>New – 100 (Proposed)</td>
<td>750</td>
<td>200</td>
</tr>
<tr>
<td>Mercury</td>
<td>mg/m³</td>
<td>NA</td>
<td>New - 0.03 (Proposed)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Aspects</td>
<td>Mitigation Measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
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</tr>
<tr>
<td>SO$_2$ &lt; 200mg/Nm$^3$</td>
<td>- Seawater Flue Gas Desulfurization (FGD) with efficiency of not less than 86%, without flue gas bypass and gas-gas heater (GGH).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO$_X$ &lt; 350mg/Nm$^3$</td>
<td>- Low NO$_X$ combustion: Boiler is designed with low NOx combustion, furthermore, SCR de-NOx equipment with efficiency of not less than 78% will be considered.</td>
<td></td>
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</tr>
</tbody>
</table>
| Flue Gas         | - Emitted through a common Stack of height 180m  
- Continuous emissions monitoring equipment will be installed on the stack.  
- On line emission levels to be available on site |
| Wastewater       | - Domestic sewage water, coal waste water and oil wastewater will be treated separately, and then reused.                                                                                                         
- Only circulating cooling sea water will be drained out of the plant.                                                                                                                        
- A thermal plume dispersion modeling is being undertaken to predict the permissible size of the mixing zone and the effect on sea,                                                 
- Effluent levels to be monitored as part of project monitoring plan                                                                                                                      |
<table>
<thead>
<tr>
<th>Aspects</th>
<th>Mitigation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust (Fly Ash) &lt; 50mg/Nm³</td>
<td>- Electrostatic Precipitator (ESP) of removal efficiency not less than 99.91%, dust can be controlled under 20mg/Nm³ at outlet of the ESP.</td>
</tr>
<tr>
<td></td>
<td>- Dust removal efficiency of desulfurization system can reach 50%, so total dust removal efficiency will be equal or more than 99.955%. Dust emission will be not more than 10mg/Nm³ at outlet of stack.</td>
</tr>
<tr>
<td></td>
<td>- Installation of geotextile membranes at ash storage yard to prevent ground water contamination</td>
</tr>
<tr>
<td></td>
<td>- Ash pit (first 5 years); alternate use</td>
</tr>
</tbody>
</table>
**Aspects** | **Mitigation Measures**
---|---
Noise | ▪ Conduct reasonable overall planning for the plant area. Arrange high-noise equipment far from the area which is sensitive to noise
▪ Reduce noise level by green belts planting. To plant arbor and shrub on roadsides, around the main powerhouse and nearby other sound sources as required, so as to reduce noise through the noise reduction function of plants.
▪ The proposed plant sites are far away from the nearby villages, it is predicted that the contribute value of plant noise to the residential areas will be low, so plant noise won’t disturb the local residents.
LOCAL ENV. IMPACT - FLY ASH UTILIZATION

Fly Ash

Ceramic Particles

Road Paving

Road Paving

Diagram 2. Fly Ash

Diagram 3. Boiler Slag

Diagram 5. Road paving

Fly Ash Unloading Bay

Hollow Blocks

Culverts

Pavement Blocks

Cement Production
Project’s Carbon Footprint.
- Expected annual project contribution is **3.69 million tons** of CO$_2$e

VRA CO$_2$ Reduction Measures
- Carbon sequestration potential of VRA Reforestation Programmes within Volta lake
- Offsets from VRA’s Combined Cycle Projects
- Offsets from VRA’s Renewable Energy Programmes (Solar/Wind)
- Carbon Accounting Programme beginning 2016
VRA’s Renewable Energy Development Programme Phase 1:

150 MW Wind Power Projects
✓ Planned 75MW Wind Power Project 1 (Anloga Extension) in the Volta Region (EIA / FEED ongoing )
✓ Planned 75MW Wind Power Project 2 (Wokumagbe and Goi) in the Ada West District (EIA / FEED ongoing)

14.5 MW Solar Power Projects
✓ 2.5 MW Navrongo Solar Power Plant (Operational)
✓ 8 MW Solar Power plant in Kaleo in the Upper West Region (Env. Permit issued / Financing stage)
✓ 4 MW Solar Power plant in Lawra in the Upper West Region (Env. Permit issued / Financing stage)
VRA CARBON SINKS

- Planted 3,193 hectares of forest cover as at close of 2015 and contributing between 300,000 – 730,000 tons of Carbon sink

- Planned sequestration value of 6,000 – 14,000 tons annually to the existing sink from 2016 – 2020

- Planned sequestration value of 96,000 – 230,000 tons by 2020 under the Forest Investment Program (VRA proposal completed for submission to the Forestry Commission)

Offsets from VRA Combine Cycle Projects

- Conversion of the 220 MW TICO Plant into a 330 MW CC Plant (Operational)

- Expansion of the existing 110 MW SC TT1PP into a 330 MW CC Plant (Env. Permit issued / Financing stage)

- Conversion of 220MW SC KTPP to 330 MW CC resulting in 400,000 tons CO2e. Savings (EIA / FEED ongoing)
As funding agency, China – Africa Development Fund (CAD Fund), is playing the following roles in line with the Green Credit guidelines:

- CAD Fund in July 2015, visited Ghana to confirm findings of pre-feasibility studies with Ghanaian stakeholders.

- CAD Fund in January 2016, met with SEC-VRA to review all aspects of the feasibility studies / Scoping Report and has made contributions for improvements.

- CAD Fund is to review the ESIA Report in order to identify, assess, monitor, control or mitigate associated Environmental & Social risks.

- CAD Fund is to ensure project sponsors are compliant with local environmental, land, health and safety laws and regulations in Ghana.
Public Consultations
Public Consultations & Disclosure Plan

1. Meeting to introduce project to key state agencies at Coconut Grove Hotel on April 13, 2015

2. Stakeholder workshop to present findings of prefeasibility study at GZ Plaza on July 15, 2015

3. Between April – December 2015, consultation meetings were held with relevant state agencies, namely GMA, GPHA, Energy Commission, GWC, GIPC

4. Stakeholder meeting with Energy Commission on Nov. 9, 2015

5. Registration of Project with EPA in Sept. 2015 and presentation of project mitigation strategies to the EPA in November 16, 2015
6. Community consultations between Nov – Dec 2015 culminating in visit to thermal power plant at Aboadze by 31 Community members from Ekumfi on Dec. 23, 2015

7. Submission of Scoping Report in December 2015


10. District level public forum on March 31, 2016


12. Planned National level public forum in May/July 2016