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Caledonia Clean Energy Project Update

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Stephen Kerr - Introduction

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- **Over 25 years experience on renewable energy, oil & gas and construction projects - UK and international**
- **15 years working in renewable energy sector**
- **Most recently led Inch Cape Offshore Wind Farm development (up to 780MW east coast of Scotland) through concept, EIA, S36 consent and CfD application; 2009 - 2015**
- **Based in Edinburgh**

Summit Power Group

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- 25-year old U.S. developer of clean-energy power plants
- Founded by Donald Paul Hodel (former Secretary of Energy & Secretary of the Interior) and Earl Gjelde (No. 2 official at Energy & Interior)
- Traditional focus: wind, solar, and state-of-the-art combined cycle natural gas-fired power plants
- Focus now: power plants w/ CO_2 capture & sequestration
- Our new CEO Jason Crew headed GE's gasification unit
- Currently working on (1) two large gasification projects with 90+% CO_2 pre-combustion capture, and (2) retrofits of coal & gas-fired plants for post-combustion CO_2 capture

Two Summit CCS Projects: Texas & Scotland

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- Texas Clean Energy Project (TCEP) is in the financing stage and ready to start construction, once contracts are final
- Caledonia Clean Energy Project (CCEP): much earlier stage
- CCEP is a sister project to TCEP; this has many advantages
- These two gasification power projects have in common:
  - Commercial-scale power plants with 90+ percent CO_2 capture
  - No new technology – what's new is integrating proven systems
  - Siemens gasifiers & Siemens high-hydrogen combustion turbines
  - Lead EPC contractor is Chinese company with key experience
  - Export-Import Bank of China is the expected project lender
  - Both projects should be attractive to equity investors

TCEP Overview

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- 400+ MW “polygen” gasification plant to produce power, urea (fertilizer), and captured CO_2 (90+% from coal) for EOR
- Located atop Permian Basin oilfields: CO_2 pipeline will be ~1 km long, connecting to Kinder-Morgan pipeline system
- Largest award ($450M) in U.S. DOE’s Clean Coal Power Initiative, plus $100s of millions in special tax credits
- China Huanqiu Contracting & Engineering Corp. (HQC) is lead EPC contractor; China Ex-Im Bank will be lead lender
- Challenge through 2014/15 was to optimize plant / reduce cost
- Finalizing EPC contracts this month; financing commencing

TCEP Schematic Diagram

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Coal

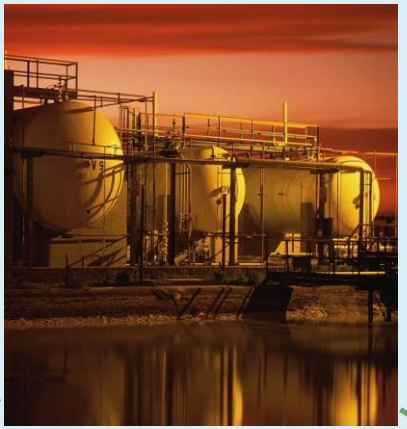
Coal Gasification, Gas Cleanup, and Gas Separation

Syngas

~195 MW ultra low carbon power to San Antonio from high-hydrogen combustion turbine in combined cycle

Brackish Water Purified via Reverse Osmosis

Water



Syngas

CO_2

Ammonia / Urea Complex

~750,000 tons/yr of urea delivered to major fertilizer company

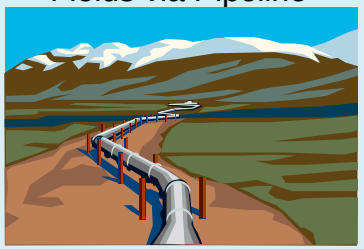
Oxygen

Air Separation Unit

Main Outputs "High Hydrogen" Syngas (~95% H_2 / 5% CO) & Pure CO_2

CO_2

CO_2 Delivered to Oil Fields via Pipeline



~2 mm tons per year delivered to Oil Producers

** Additional revenue from sales of sulfuric acid, argon gas, & minor products*

CCEP - Overview

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- 570MW gasification plant w ~ 94% CO_2 capture from coal
- Different balance to TCEP, optimized for power output
- Site is at Grangemouth, on Firth of Forth, near Edinburgh
- On- & off-shore CO_2 transport infrastructure largely exists
- One of four (4) finalist projects in UK's CCS Competition, but not one of the two (2) Competition projects chosen
- CCEP is a "Phase 2" project (per DECC Policy Scoping Document, Aug 2014) seeking clustered projects to help initiate CO_2/EOR sector
- With our debt structure, CCEP doesn't need a capital grant from DECC: just a Contract for Difference (CfD)

CCEP CO_2 Chain

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- Second of a kind IGCC Plant following Texas Clean Energy Project (TCEP)
- 570MW low carbon electricity for a million UK homes
- 3.8 Mt/yr CO2 Captured – Over 90%
- Re-use of existing pipeline systems
- Linking Central Scotland with the Central North Sea

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Feeder 10 pipeline

280km onshore

St Fergus CO2 Hub

Injection into proven saline formation under a depleted gas field

Atlantic pipeline

78km offshore

Captain Sandstone Fairway

Aberdeen

Dundee

Caledonia IGCC

Edinburgh

UK coal

Northern UK Emissions Cluster

Future CO2 Import to Peterhead Harbour

- Storage in proven offshore saline formation
- High security: subsea development (no platform)
- EOR Ready: Independent of Oil Company decision
- Emitter Cluster and Sink Cluster
- Development of St Fergus as a CO2 Hub

IGCC Plant Grangemouth

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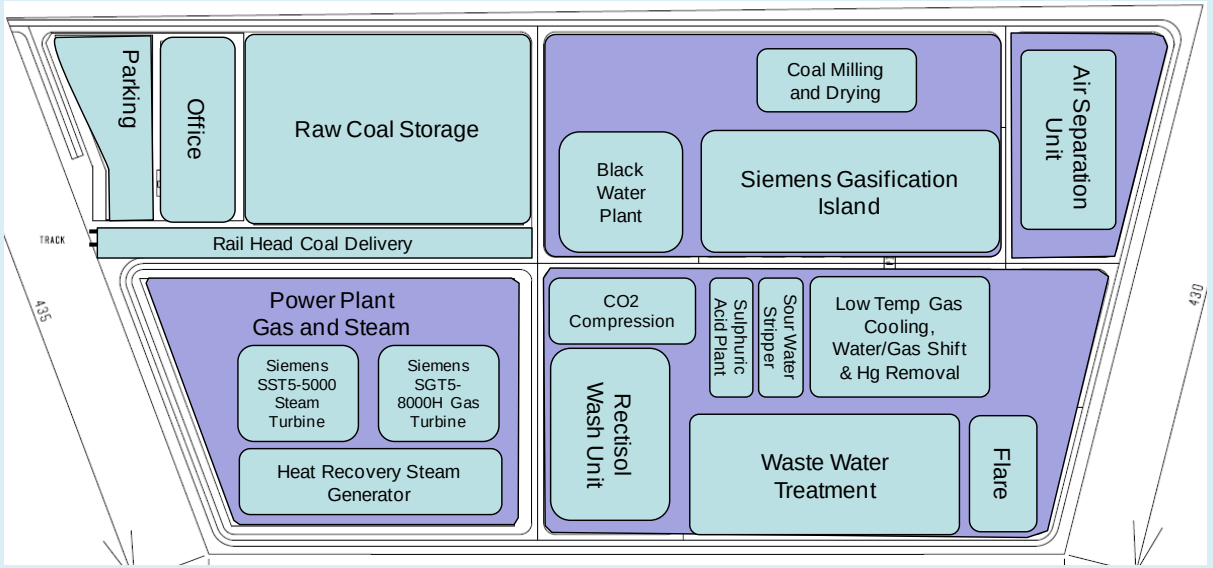
System	Equipment/Process	Manufacturer
Gasifiers	3no Siemens SFG-500 gasifier	Siemens
Combustion Turbine	1no Siemens SGT5-8000H	Siemens
Steam Turbine	1no Siemens SST5-3000RH	Siemens
Air Separation Unit	Air Compressors and Cold Box	Linde
H_2S Separation	Rectisol	Linde
CO_2 Separation	Rectisol	Linde
Heat Recovery Steam Generator	1no Triple Pressure with Duct Firing	Nooter/Eriksen or equivalent
Water-Gas Shift	Two-stage Sour Shift	Haldor Topsoe or equivalent
Sulfur Recovery	Sulfuric Acid Plant	Monsanto or equivalent
Mercury Control	Carbon Bed	Several



Onshore Transportion

- Onshore transport through connection to existing Feeder 10 Pipeline is planned (in talks w Nat'l Grid)
- Existing natural gas pipeline can be repurposed for CO_2 transport
- A FEED study was completed during DEMO 1 (Longannet) process
- Excess capacity may be used to transport other CO_2 eventually

Planned Work Programme

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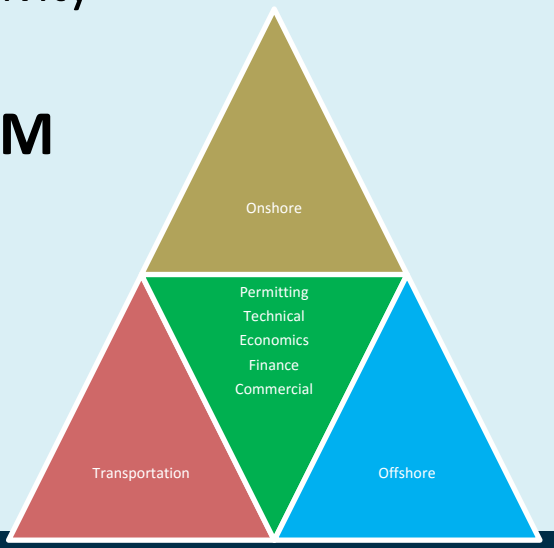
- **Currently finalising Grant Agreement, organisation and resources;**
  - Work Package 1: Industrial research and development, resulting in the preliminary design and notional pricing of CCEP.
  - Work Package 2: Feasibility study of requirements, constraints and mitigation including grid connection, planning and regulatory requirements, and financing considerations.
  - Work Package 3: Obtain required site options and/or exclusivity agreement(s) as project enablers
- **18 month programme, budget ≈ £6.0M, grant ≈ £4.2M**
- **Front loading important to de-risk project**



CCEP – What We Need

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- Policy stability, Development Risk, Phase 1 projects moving into Phase 2 projects, Investor Confidence

Continuity

- CO_2 chain physical interfaces, electrical grid connection, knowledge sharing, cost reduction, shared infrastructure, complex commercial interfaces

Collaboration

- Political, public & local community support, dedicated CfD budget and mechanism

Support

Long Term - Opportunity

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- **CCEP as anchor for sustained effort to develop an entire integrated system, consisting of:**
  - **Clustered CO_2 capture projects (not just one project),**
  - **Sharing a common CO_2 pipeline and offshore infrastructure,**
  - **To produce low-carbon electric power to replace the UK's coal plants (which are slated for closure within 15 years), and**
  - **To store carbon in depleted North Sea gas fields and saline formations, while also**
  - **Creating a CO_2 for enhanced oil recovery (EOR) sector in the North Sea, with its own secure geological storage of CO_2**

Long Term : Physical Components

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- **Sources of captured CO_2:**
  - **Peterhead Project: capture from natural gas, for 10 years or more**
  - **Caledonia #1 (a/k/a Grangemouth A): capture from gasified coal**
  - **Caledonia #2 (power plant) and/or capture from industrial sources**
  - **Possible marine terminal to receive added CO_2 from Europe by ship**
- **Onshore CO_2 transport: National Grid's Feeder No. 10 line**
  - **Caledonia #1 & #2 would leave room for industrial CCS sources as well, all using common infrastructure**
- **Offshore CO_2 transport: existing + some new pipelines**
- **Offshore CO_2 stores (providing the needed multiple sinks):**
  - **Goldeneye (depleted gas field, existing platform & infrastructure)**
  - **Suitable oilfields (with existing & new infrastructure for CO_2/EOR)**
  - **Saline formation underlying Goldeneye, if needed**

Long Term - Benefits

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- "Single source, single sink" should be avoided; multiple sources & sinks is the right way to do CCS where possible
- Use of a common CO_2 transport & storage infrastructure will significantly reduce costs of CCS (including from industrial sources)
- Environmental benefits: ~ 10 million tons/year of CO_2 sequestered, plus ≈ 1,500 MW of ultra low-carbon power if Central Scotland opportunity is fully developed
- Major employment & economic development benefits
- UK leadership potential in CCUS & cooperation with China

Thank you

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