Development of a high-efficiency power generation system integrated with pressurized biomass gasification

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• The WHY: biopower and company outline
• The WHAT: BTC Basics
• The HOW: Development program & Outlook
1.5 °C
URBANISATION AND ELECTRIFICATION
ELECTRIFICATION OF INDUSTRY
THE ENERGY TRANSITION: 1.5°C scenario

Electricity Generation. Source, IRENA 2019, REMap 2050

- 24% Renewables 2016
- 86% Renewables 2050

1000 TWh/år growth
SOLAR & WIND?

- Increased volatility in supply & prices
- Capacity & grid issues
- Enormous investments in grid, storage, etc
RENEWABLE POWER ON DEMAND

PHOENIX BIOPOWER
TRANSFORMING BIOPOWER FOR THE FUTURE
RENEWABLE POWER ON DEMAND

- **PLANNABLE**: Power and heat on-demand.
- **SCALABLE**: Cost-effective and highly efficient.
- **SUSTAINABLE**: Consume half the biomass.
TRADITIONAL STEAM CYCLE

BIOMASS RESIDUES

BURN FUEL,
MAKE STEAM,
DRIVE A GENERATOR

25-30% ELECTRICAL EFFICIENCY
BTC TECHNOLOGY

BTC: Biomass-fired Top Cycle

GASIFY FUEL, USE IN TOPCYCLE GAS TURBINE, DRIVE THE GENERATOR

BIOMASS RESIDUES

50-60% ELECTRICAL EFFICIENCY

2X
ECONOMIC ADVANTAGE

LEVELISED COST AS WIND POWER

BUT HARVESTING HIGHER MARKET PRICES

Germany electricity price predicted have standard deviation of 70 €/MWh by 2030
ANNUAL GROWTH RATE FOR BIOPower IN CHINA

- 600 Mton residues per year available
- Up to 1800 TWh electricity

KEY MARKETS

- NREAP plans: 40% of CHP will be biomass-fired by 2050
- 400 TWh of electricity
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Project Management, R&D  
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Chairman  
(Industrifonden)

CATHARINA LAGERSTAM  
Board member  
(S.E.C Lux, ICA Bank)

BIRGITTA RESVIK  
Board member  
(Fortum, Svenskt Näringsliv)

OLA JOHANSSON  
Board member  
(Siemens, Epishine)
BUILDING FROM A SOLID IP AND KNOW-HOW FOUNDATION

- **Internal**
  - Personell and know-how from projects with Vattenfall, Alstom, others

- **Leveraged R&D**
  - 3M€ Wet Combustion R&D at TUB
  - 3M€ Vattenfall TopCycle R&D at KTH
  - 3M€ Biomass gasification R&D

- **6 Patent Groups**
  - 19 Granted
  - 3 Pending
THE BTC CONCEPT
BTC: A NEW POWER CYCLE

- Steam-injected, high pressure gas turbine
- Near-stoichiometric combustion
- 50% steam in turbine
- Biomass pressurisation, gasifier, cooler all utilise steam
- Water recovered in flue gas condenser
BIGCC: VÄRNAMEO DEMO PLANT

- Pilot to develop technology
- SFW, E.On
- 18 MW fuel
- Pressurised CFB gasifier
- Hot gas clean-up
- 8500 hours gasifier
- 3500h BIGCC
- Fulfilled design spec
- BIGCC abandoned as nuclear fleet kept
--- BIOMASS TO POWER PATHWAYS ---

- Steam Rankine 200 MWf: 10% LHV el. efficiency
- BioNG-CCGT 800 MWf: 30% LHV el. efficiency
- BIGCC 200 MWf: 40% LHV el. efficiency
- BTC 200 MWf: 50% LHV el. efficiency
BTC: ROLE IN THE ENERGY SYSTEM

- 40% lower operating costs than steam cycle
- 3 times as much power with CHP than steam cycle
- Local production: grid, security of supply,
- Dispatchable renewables
- Extra services: biochar, BECCS, fast start on natural gas
**TOP CYCLE: A PLATFORM TECHNOLOGY**

**Advantage vs Combined Cycle**

- Halve the costs of CO₂ capture, 70% lower power penalty
- -30 % capital costs. Low NOx, no flashback
- +15% pt total efficiency in district heat
- +10-15 % pts electrical efficiency
DEVELOPMENT
BTC ROADMAP

2018
- Feasibility

2020
- Components
- Concept
- Pilot: 5 MW fuel

2025
- Industrialisation
- BTC1: 20-30 MW, 50-55%

2030
- Expansion
- BTC2: 100 MW, 60+%
AGGRESSIVE DEVELOPMENT UNDERWAY

Invested: 2.5 M€

Reference Group

Site

Competence

PRIVATE INVESTORS
BTC: CURRENT DEVELOPMENT WORK

- Reliable fuel conversion
  - Biomass pressurisation and pretreatment
  - Gasification in fluidised bed
  - Gas cooling
  - Hot gas filter
  - Combustion near-stoichiometric

- Materials in new environment

- Initial gas turbine design

- Plant integration and control
# PROGRESS

<table>
<thead>
<tr>
<th>WORK PACKAGE</th>
<th>SCALE</th>
<th>HIGHLIGHTS / COMMENT</th>
<th>FORECAST</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM</td>
<td>-</td>
<td>New IP identified, Reference Groups meetings</td>
<td></td>
</tr>
<tr>
<td>Plant</td>
<td>-</td>
<td>Optimisations and basic engineering ongoing.</td>
<td>Case studies end Q3</td>
</tr>
<tr>
<td>Gas turbine materials</td>
<td>Coupons</td>
<td>Steam environment effects on TBC, bond coat</td>
<td>Lifetime tests finalised Q4.</td>
</tr>
<tr>
<td>Feed System</td>
<td>100 kW 45 bar steam</td>
<td>Concept chosen, initial 40 bar tests</td>
<td>Continuous 40 bar tests by Q4</td>
</tr>
<tr>
<td>Gasification</td>
<td>50 kW_f</td>
<td>First gasifier tests over 20 bars</td>
<td>40 bar results by Q4</td>
</tr>
<tr>
<td>Combustion</td>
<td>100 kW</td>
<td>First 50 kW tests very successful</td>
<td>Atmospheric, 100kW operating window by Q4</td>
</tr>
</tbody>
</table>
COMING WORK:

PHASE 2
4 MW PILOT PLANT

- 2 site candidates
- Operation 2022
- Fuel conversion, can combustor and sector test
- 1 t/h fuel
EXPANDING OUR PARTNERSHIP
Renewable Power On Demand

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