WoodRoll® - breakthrough technology for cleanest energy gas from biomass!

Small-scale gasification for CHP

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Cortus Energy × Forest Energy

- 2016年5月にフォレストエナジーとコルタスエナジーは戦略的事業提携
  A strategic joint agreement was made between Forest Energy and Cortus Energy in May 2016
- 目的是バイオマスのガス化による1.9MWの熱電併給設備を日本で展開すること
  Partnership to develop, build and operate 1.9MWel gasification biomass power plant in Japan
- 日本向けの使用は2016年12月に完成
  Basic engineering for Japan model of WoodRoll completed in December 2016

- Gasification technology
- Engineering
- Investment

- Development
- Project finance & Investment
- Operation
2. 2MWel biomass business in Japan
Forest Energy

- We develop, project finance, own and operate wood fired biomass power plants.

- We develop, project finance, own and operate wood fired biomass power plants.

- 5MW +
  - Domestic wood as main fuel
  - BTG power plant using local wood as fuel

- 2MW
  - Cortus Energy's WoodRoll gasification technology
  - Cortus Energy’s WoodRoll gasification technology

- 20.5MW, Akita, Operation 2016 -
  - 5.75MW, Miyazaki, Operation 2015 -

- CHP
  - 1.9 MW el
  - 2.4 MW th

- FC
  - H2
燃料調達の現実
Lessons learnt – Fuel collection

1. 持ち込まれる木材の含水率は45%～60%のレンジでばらつきも大きい
   Moisture content of wood delivered is 45 to 60%, with wide variance

2. 異物混入（ワイヤ、鉄片、小石等々）
   Wires, stakes and stones found in wood

3. 燃料は買取価格が高いところに行き、運搬圏内は100km〜200km
   Fuel goes to highest buyer and will travel 100 – 200 km away from power plant

4. 木の伐採・搬出コストは地域・地形によって差が大きい
   Large variance in cost to cut down trees, depending on area, steepness and accessibility

5. ペレットは割高かつ品質にバラつきがある
   Pellet is still small business, and price is high, quality is variable
小規模バイオマス発電の事業設計

Implication to business and design

現実： 燃料は買取価格が高いところに行き、100km〜200kmも集材圏内

Reality: Fuel goes to highest buyer, and will travel 100 – 200 km away from power plant

意味合い： 発電所間の棲み分けは曖昧で価格競争に晒される。また、地域によって値段差がある。

Implication: Need flexibility in fuel type and high power generation efficiency to have control over fuel price competition. Each area will have its unique characteristics
小規模バイオマス事業の戦略
Forest Energy approach to small biomass energy in Japan

1. 燃料種類に対してフレキシブルなシステム
   Fuel flexibility. No single fuel solution

2. ウッドチップを主燃料とするシステム
   Woodchip as main fuel source. Not pellets

3. ウッドチップ含水率の上限が高く、ばらつきを許容できるシステム
   Tolerance to high moisture rate and variance in moisture rate

4. 発電効率 ≒ 30%
   Power generation efficiency ≒ 30%

5. 熱電併給ができる設備
   CHP capability a must

6. 電力事業のみで成立する全体の経済性。熱利業は時間をかけて取り組む
   Project economics need to be good just on electricity. Heat usage need time to develop
小規模バイオマス・エネルギーシステム
2MW el biomass system

地元木材を
地産地消
Fuel = local biomass

ガス化設備で
木からガスを生成
Gasification

3つの用途
3 applications

燃料電池（FC）
発電 1.9MWel
熱供給 2.4MWth

21年目以降
Post FIT

Cortus Enegy “WoodRoll”

- ウッドチップ、バーク、竹チップ、稈殻
  Woodchips, barks, bamboo chips, rice hulls
- 含水率 moisture rate: 〜60%
- 含水率50%のチップを75 ton/日（day）

- 売電で成立する事業モデル
  Power (electricity) based business model
- 熱供給は売電後、時間をかけて地域
  Take time to coordinate heat usage
3. The WoodRoll® technology
Cortus Energy

- Founded in 2006 to develop and commercialize the patented gasification process WoodRoll®.
- WoodRoll® is a gasification process for biomass, producing clean energy gas with a high energy value.
- The purity and high energy value of the energy gas makes it suitable for replacing fossil fuels.
- Listed on Nasdaq OMX First North since February 2013.
- The company has 12 employees and 10 consultants.

- WWF climate solver (2009)
- Top 25 Nordic Cleantech Open (2010)
- Top 25 Cleantech Summit Geneva (2011)
- Classified as “Beyond state of the art” by German consulting company (2010) and Chicago Gas Technology Institute (2011)
- Stockholm Cleantech hotlist (2013-)
- Seal of excellence, EU (2016)
WoodRoll® is a unique technology that replaces fossil energy by efficient gasification of biomass that produces green energy for vehicles, industry and power generation.

**Feedstock**
- Forest-based feedstock such as forest residues and energy crops.
- Waste from industry such as fiber sludge and construction waste.
- Agricultural waste such as animal manure and crop residues.

**Applications**
- Biogas
- Renewable power
- Hydrogen
- Industry

**Fuel flexibility**
- 35 tons of biomass (equivalent to a lorry with trailer)
- One-day operation of a WoodRoll® = 100 oil barrels

1. The biomass is heated and dried (100°C).
2. During the pyrolysis the biomass is converted into pyrolysis gas and char (400°C).
3. The pyrolysis gas is burned and heats gasification, waste heat goes to pyrolysis and drying.
4. In the gasifier finely ground char reacts with steam (1-100°C) and form a clean energy gas.
5. The energy gas is cooled with water that becomes steam, which is feed to the gasifier.

**Tar incineration!**
WoodRoll® – development until today!

- **2007**: Collaboration with KTH for biofuels - Thermo Gravimetric Analysis (TGA)
- **2008**: 150 kW gas pilot tests
- **2009**: New TGA - Close to 300 samples of biofuels made (Mar. -2017)
- **2010**: Engineering of 5 MW WoodRoll®
- **2011**: 500 kW\textsubscript{thermal} Installation integrated WoodRoll® in Köping
- **2012**: WoodRoll® Test plant
- **2013**: DemoSNG Methanation tested in Köping
- **2014**: New 6 MW\textsubscript{th} modular WoodRoll® plant
- **2015**: Projects 6 MW\textsubscript{th} modular WoodRoll® plant
- **2016**
- **2017-**

Tests of:
- Fuels
- Gascleaning
- Crackning
WoodRoll® – Fundamentals

Biofuels
- Reactivity
- Ashes

Drying
- Dusting
- Condensation
- Single percentage humidity

Pyrolysis
- Pyrolysis gas
- Combustion of pyrolysis gas
- Char yield

Gasification
- Conversion rate
- Ash control
WoodRoll® – Achievements

Biofuels
- 20 biofuels verified

Drying
- Controlled dusting and condensate
- Single percentage humidity in operation

Pyrolysis
- Pyrolysis gas cracked after hot filter
- Combustion stable
- Char yield $[T, X_i]$ 35% +/-10%

Gasification
- >99% Conversion rate reached
- Ash melting only for chemical sludge
- Ultra clean syngas
WoodRoll® – gas composition

Syngas analysis example 2016
Pyrolysis at 360°C

Vol%:
- Forest residuals
- Wood chips

- H2
- CO
- CO2
- CH4
4. Business projects

1. Höganäs AB
2. Forest Energy
3. Mariposa
4.1 Probiostål project
Höganäs AB
4.1.1 WoodRoll® in Höganäs

Höganäs AB and Cortus AB collaborate for renewable energy under a 20 years renewable energy supply contract

- Höganäs wants to be the first steel manufacturer to replace fossil such as natural gas and coke with renewable energy to stay ahead of the competition
- Cortus has an excellent first commercial and industrial plant to operate in 2018
- A cooperation has been running since 2012 within Jernkontoret (Swedish Iron and Steel Society).
4.1.2 WoodRoll® in Höganäs - background

• A pre-design (Basic engineering) has been completed for Höganäs in 2015/16 at a cost of 8.5 MSEK, where industry, institutes and academy together have developed a basis for the introduction of renewable energy in the production facilities at Högnäs.

• The pre-design includes:
  • Manufacturing, installation, commissioning of a WoodRoll®- plant (Cortus/Höganäs)
  • Environmental impact study as a life cycle analysis (Swerea)
  • Modeling, simulation and analysis of heating process impact in Höganäs (KTH)
  • Energy optimization of the system – gasification and furnace (KTH)

• The parties are finalizing a 20 year supply contract.
4.1.3 Project partners

ABB  
Calderys®
Höganäs  
Cortus Energy
Outokumpu  
SSAB
Sveaskog  
Södra
4.1.4 Project plan

- **2017**
  - Q1: Start of detailed engineering Probiostål
  - Q2: Höganäs 20 years supply agreement
  - Q3: Start of procurement of process equipment
  - Q4: Höganäs 20 years supply agreement

- **2018**
  - Q1: Höganäs 20 years supply agreement
  - Q2: Module manufacturing and installation
  - Q3: Factory acceptance test in Emtunga Höganäs
  - Q4: Höganäs 20 years supply agreement

- **2019**
  - Q1: Höganäs 20 years supply agreement
  - Q2: Site installation and checkout Höganäs
  - Q3: Höganäs 20 years supply agreement
  - Q4: Höganäs 20 years supply agreement

- **2020**
  - Q1: Höganäs 20 years supply agreement
  - Q2: Site acceptance test in Höganäs
  - Q3: Höganäs 20 years supply agreement
  - Q4: Höganäs 20 years supply agreement

- **2021**
  - Q1: Höganäs 20 years supply agreement
  - Q2: Höganäs 20 years supply agreement
  - Q3: Höganäs 20 years supply agreement
  - Q4: Höganäs 20 years supply agreement

- **2022**
  - Q1: Höganäs 20 years supply agreement
  - Q2: Höganäs 20 years supply agreement
  - Q3: Höganäs 20 years supply agreement
  - Q4: Höganäs 20 years supply agreement

- **2023**
  - Q1: Höganäs 20 years supply agreement
  - Q2: Höganäs 20 years supply agreement
  - Q3: Höganäs 20 years supply agreement
  - Q4: Höganäs 20 years supply agreement

- **2024**
  - Q1: Höganäs 20 years supply agreement
  - Q2: Höganäs 20 years supply agreement
  - Q3: Höganäs 20 years supply agreement
  - Q4: Höganäs 20 years supply agreement
4.1.5 Modular 6 MW WoodRoll®

**Engineering**
- The plant is sectioned into function blocks
- Cortus is responsible for process engineering
- Design support from ÅF, WSP (AutoCAD Inventor)
- The engineering is based on the pilot plant in Köping
- Process equipment is bought from established suppliers
- The modules are manufactured in Emtunga

**Modules**
- The plant consist of 14 modules
- The basic module size is 4.45 m * 13.35 m * 4.00 m
- Each module will have its own electrical cabinet
- The process modules have integrated electrical and control cabinets
- Power and network connections to the modules
4.1.6 Planned structure for modular plant at site 2018
4.2 Forest Energy, Japan
4.2.1 First WoodRoll® plant in Japan
4.2.2 First WoodRoll® plant in Japan
4.3 Mariposa, California
4.3.1 Mariposa biomass project

• An **EPIC grant of 5 MUSD** has been granted by California Energy Commission on the 24th of March 2017 for this project
• The project group has been working for nearly two years for a joint heat and power project in Mariposa (California) based on a modular 6 MW WoodRoll® with double gas engines and heat recovery
• In 2016 MBP received support from the state for a pre-design study of a biomass heat and power plant based on a modular 6 MW WoodRoll®
• Environmental permit application has been sent in (March 2017)
• For a realization phase of the project, possibilities for further collaborations with other parties in California are necessary and under investigation. This is a prerequisite for implementation of the project.
• Basic engineering will be started in the second half of 2017.
• A plant order is expected early 2018.
4.3.2 Mariposa biomass project
5. Next step
Power

Industry

WoodRoll MARKET

Hydrogen

Synthetic fuels and chemicals
Thank you