

Biomass gasification in Norway

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Gasification in Norway

- Biomass gasification has not got a long history in Norway
- Fundamental research at Universities
- Applied research
- Small scale waste-to-energy applications
- No large scale gasification facilities
- Some interested larger companies

Small-scale waste gasification

Energos
EnviroArc
Organic Power

ENERGOS Gasification Technology

Proven Small-scale, Energy from Waste



Petter Lundstrøm



Development History



Developed in Norway during the 1990's. The design remit was to deliver:

- A small-scale energy from waste plant which could provide;
- Communities with a cost effective alternative to mass-burn incineration with
- Minimal emissions to atmosphere
- High flexibility in handling different waste types and CVs

The result was:

- A two-stage thermal process which enabled extremely good combustion control, eliminating the need for complicated and expensive flue gas treatments

Development History

- 1990/97** Technology developed by SINTEF in Trondheim, Norway with support from the Ministry of the Environment
- 1997** **Ranheim**; 10,000 tonnes per annum
- 2000** **Averøy**; 30,000 tpa
- 2001** **Hurum** and **Minden**; each 38,000 tpa
- 2002** **Forus**; 39,000 tpa and **Sarpsborg I**; 78,000 tpa
- 2004** ENER·G Holdings plc acquires business and assets of ENERGOS ASA
- 2006** Ranheim plant purchased and re-commissioned
Averøy plant purchased (90%)
- 2007/08** Retrofit of a conventional EfW plant on **Isle of Wight**; 30,000 tpa

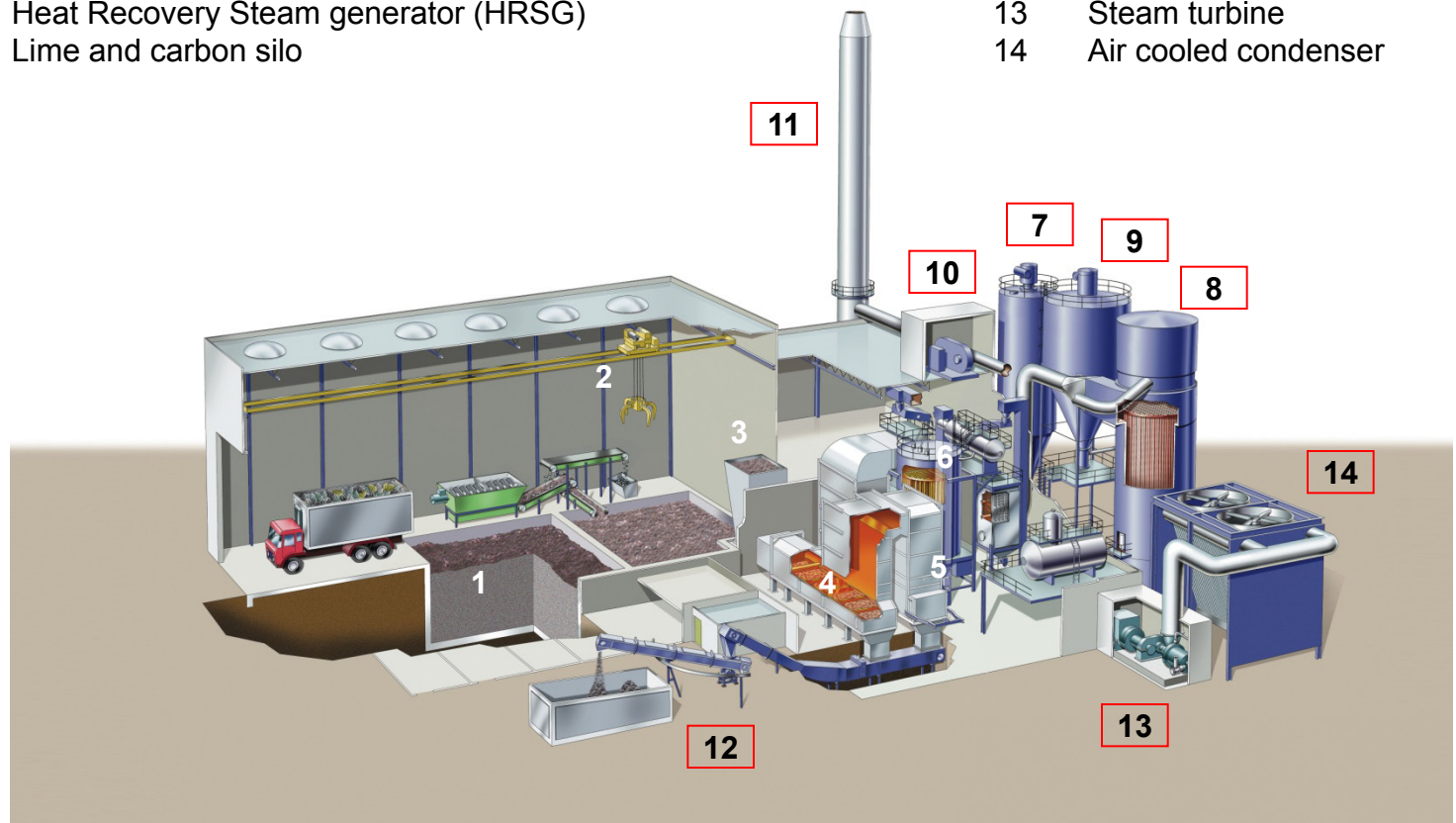
Development History



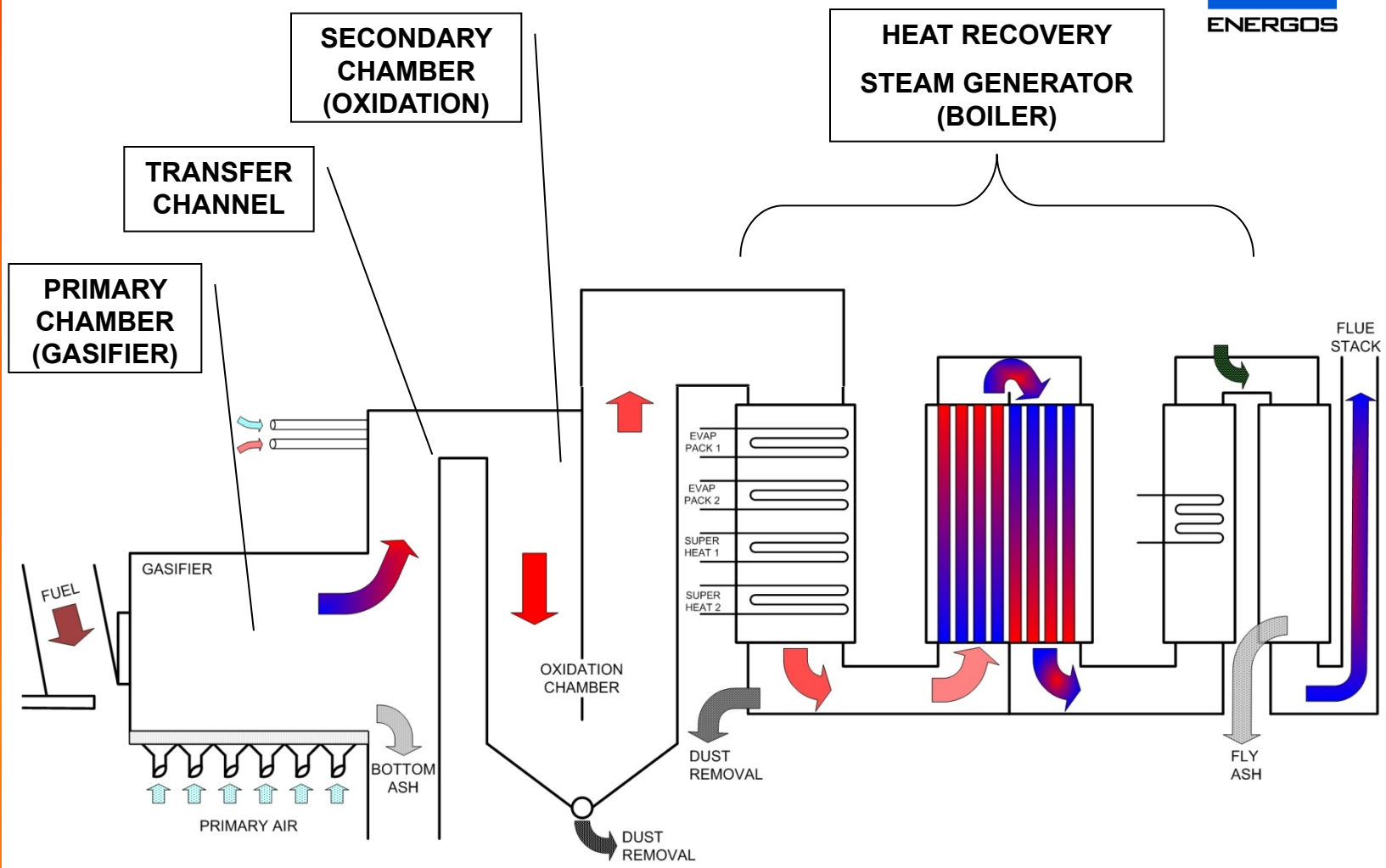
- 2008** First new order received for 80,000 tonne 2-line plant at **Sarpsborg II**, Norway
Irvine site acquired (with planning permission)
Installation work for Sarpsborg II commenced.
Preferred Bidder Status awarded to UU/Interserve for **Derby/Derbyshire** PFI project
- 2009** **Isle of Wight** plant commissioned
Planning consent granted for **Knowsley**
Planning consents granted (to a partner company) for sites at **Doncaster, Newport** and **Barry**
New offices opened in Trondheim and Warrington to facilitate growth
- 2010** **Sarpsborg II** plant commissioned

ENERGOS Energy From Waste Plant

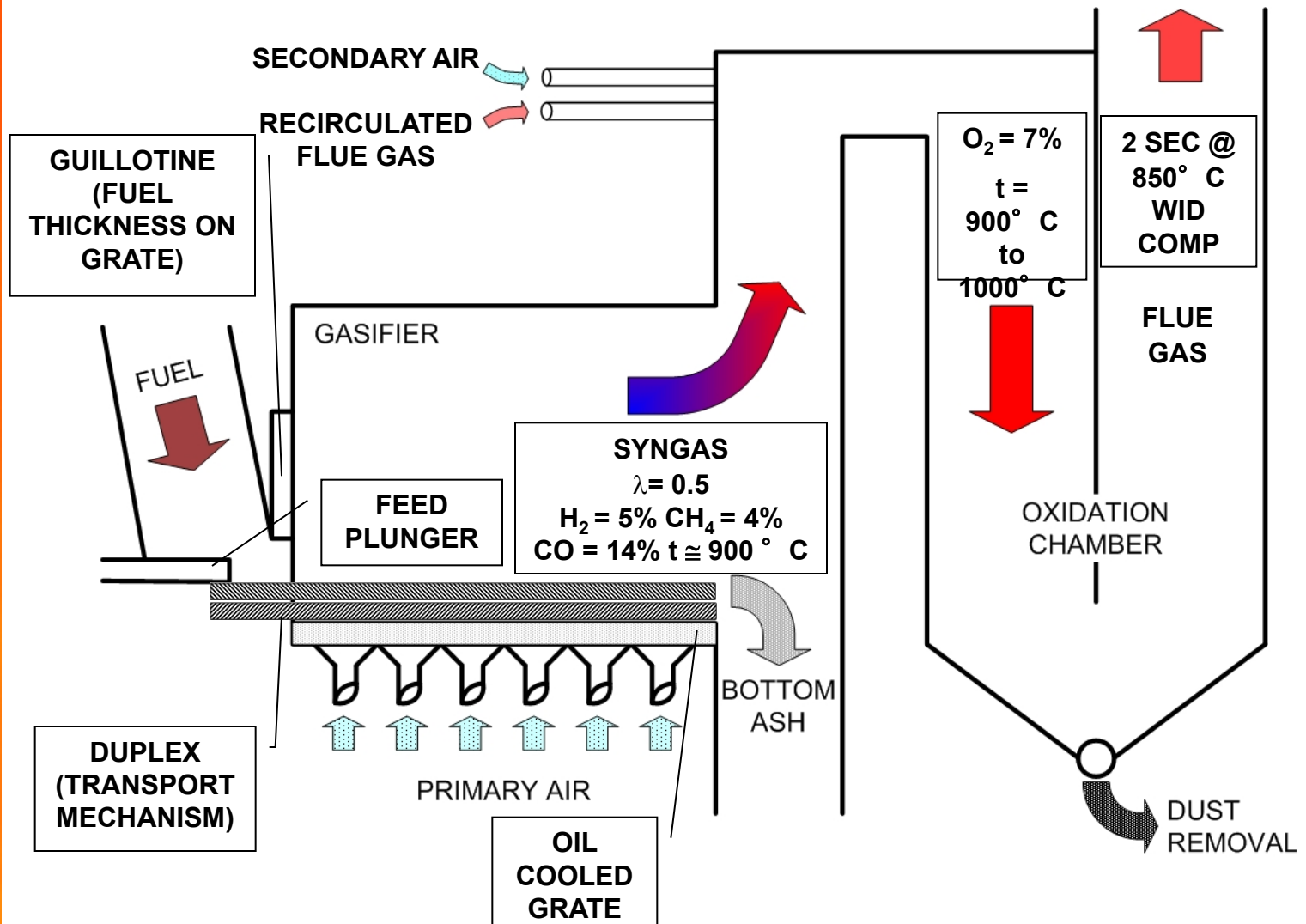
- | | | | |
|---|--|----|-----------------------|
| 1 | Fuel bunker | 8 | Bag house filter |
| 2 | Fuel crane | 9 | Filter residue silo |
| 3 | Hopper | 10 | Flue gas fan |
| 4 | Primary chamber (Gasification) | 11 | Chimney |
| 5 | Secondary chamber (High temperature oxidation) | 12 | Bottom ash extraction |
| 6 | Heat Recovery Steam generator (HRSG) | 13 | Steam turbine |
| 7 | Lime and carbon silo | 14 | Air cooled condenser |



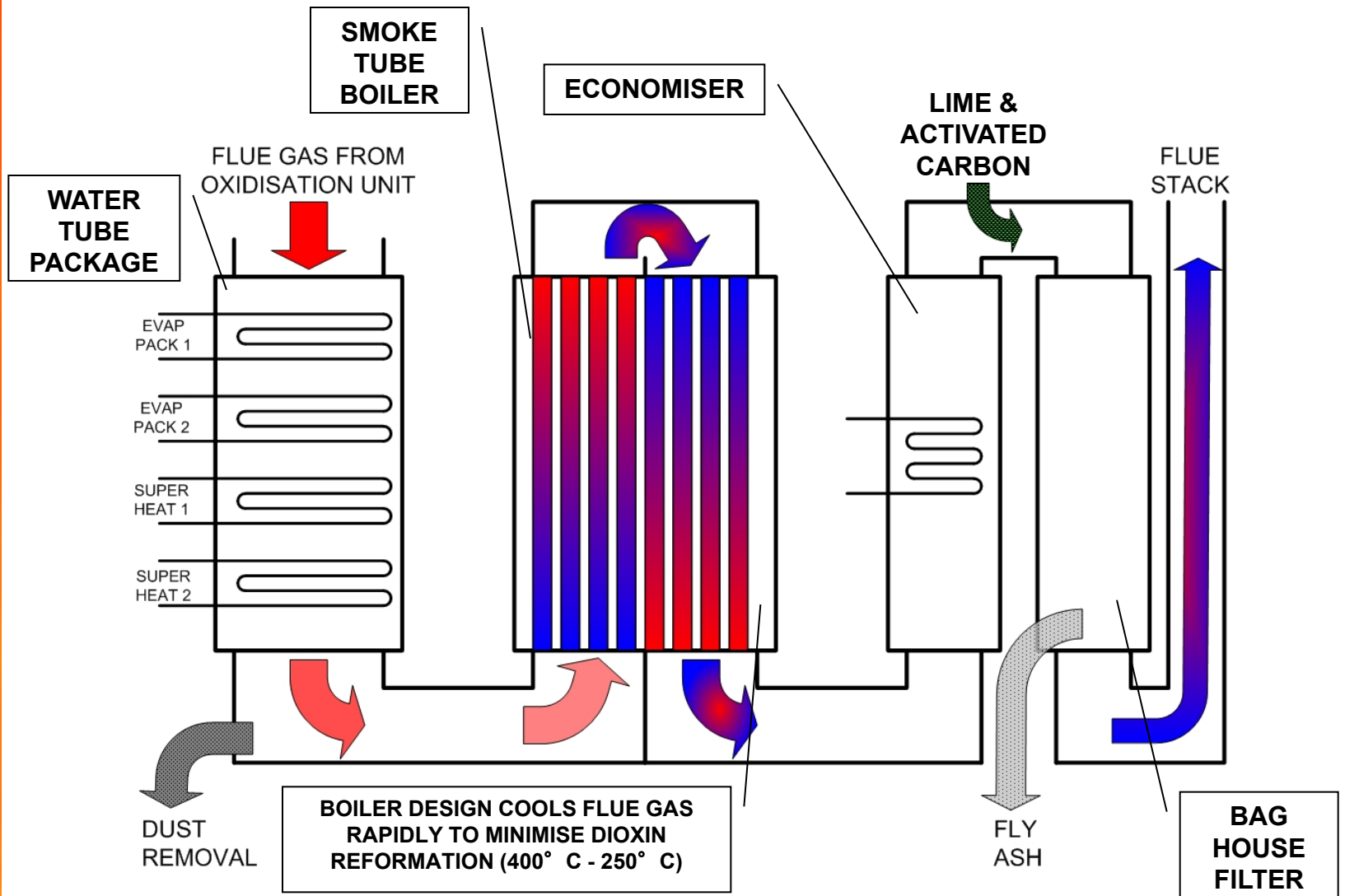
The ENERGOS Process



The Gasifier & Thermal Oxidiser



Heat Recovery & Steam Generation

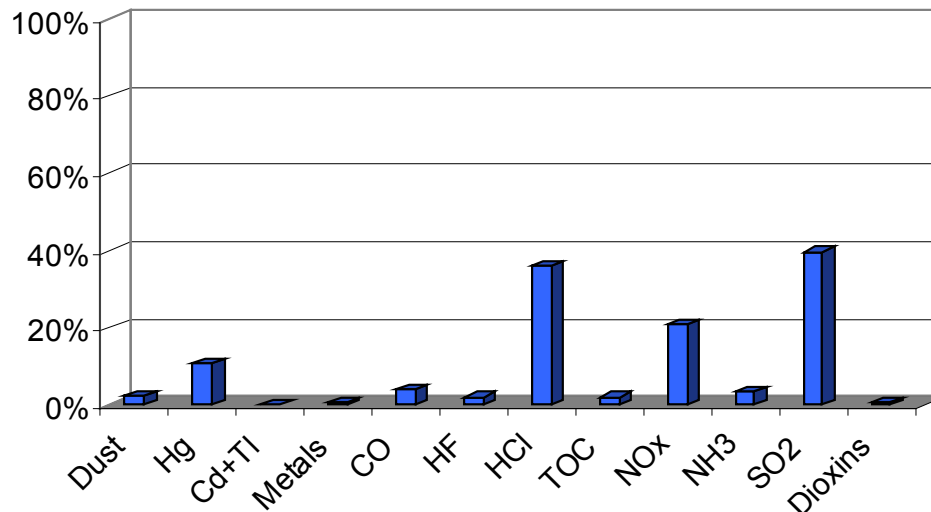


Emissions

The ENERGOS plant was designed to minimise emissions.

Its provides:

- Low carbon content in bottom ash (less than 3% TOC)
- Simultaneously low and stable Carbon Monoxide (CO) and Nitrogen Oxides (NOx) emissions



	EU Limits	Energos
Dust	10.00	0.24
Hg	0.0300	0.00327
Cd+Tl	0.050	0.00002
Metals	0.500	0.00256
CO	50	2
HF	1.000	0.020
HCl	10.0	3.6
TOC	10	0.2
NOx	200	42
NH3	10.0	0.3
SO2	50	19.8
Dioxins	0.100	0.001

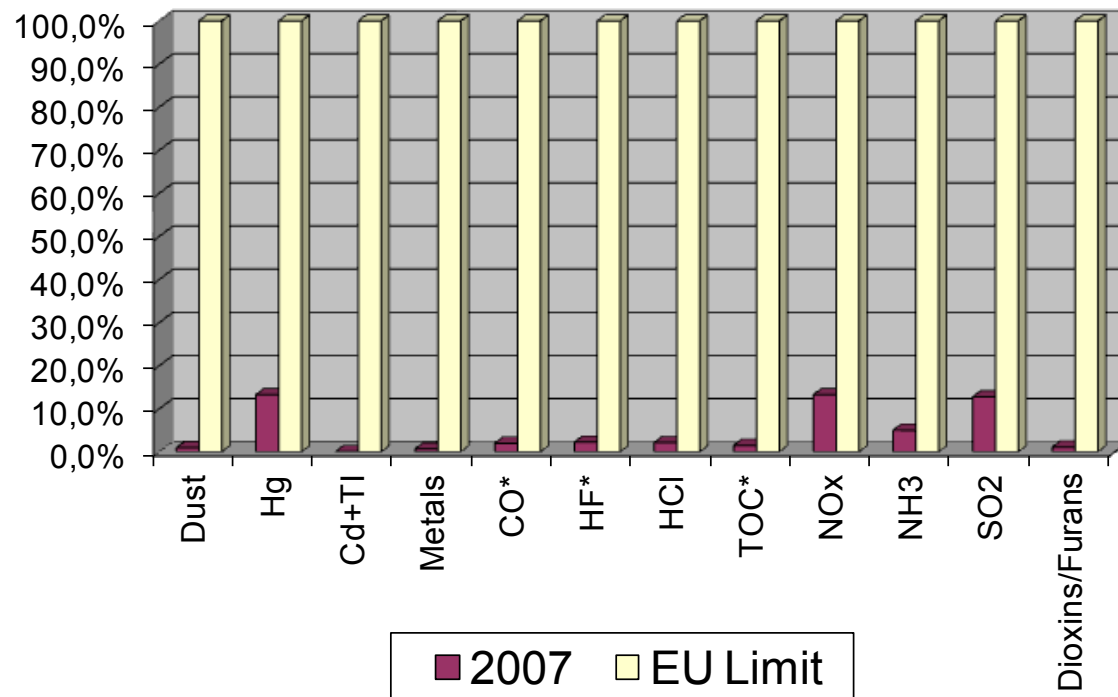
Stable Emissions



- The ENERGOS process offers significantly lower emissions compared with EU WID
- Its stability is demonstrated by its performance against half hour average peaks
- The following table shows the maximum emissions recorded during the independent tests undertaken at Averoy in May 07.
- These tests are carried out over a 4 day testing period
- The plant processes MSW and C&I waste

Averoy Plant - Half Hourly Peaks Emissions 7th year of operation

Averoy 1/2 Hourly Emissions May 07



Measurements taken at ENERGOS Averoy plant May 07 by independent agency, TUV NORD Umweltschutz, and submitted to Norwegian Environmental Agency for regulation purposes. All measurements at 11% Oxygen. Limits are mg/Nm³, except Dioxin / Furans at ng/Nm³.
*NOTE: CO, HF and TOC: Measurements show less than (being the lower limit of detection reliability for the measurement instruments).

Operational Energos plants



Ranheim Plant
 Location: Norway
 Commissioned: 1997
 Fuel capacity: 10,000 tonnes/year
 Energy production:
 25 GWh (thermal)/year



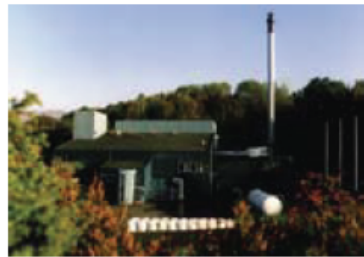
Forus Plant
 Location: Norway
 Commissioned: 2002
 Fuel capacity: 39,000 tonnes/year
 Energy production: CHP
 105 GWh (thermal)/year



Hurum Plant
 Location: Norway
 Commissioned: 2001
 Fuel capacity: 39,000 tonnes/year
 Energy production:
 105 GWh (thermal)/year



Isle of Wight Plant
 Location: United Kingdom
 Commissioned: January 2009
 Fuel capacity: 30,000 tonnes/year
 Energy production:
 (electrical) 1.8MW



Averøy Plant
 Location: Norway
 Commissioned: 2000
 Fuel capacity: 30,000 tonnes/year
 Energy production: CHP
 69 GWh (thermal)/year



Sarpsborg1 Plant
 Location: Norway
 Commissioned: 2002
 Fuel capacity: 78,000 tonnes/year
 Energy production:
 210 GWh (thermal)/year

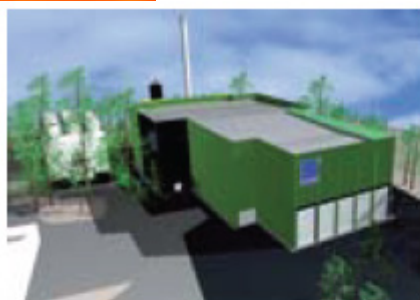


Minden Plant
 Location: Germany
 Commissioned: 2001
 Fuel capacity: 39,000 tonnes/year
 Energy production:
 105 GWh (thermal)/year



Sarpsborg 2 Plant
 Location: Norway
 Commissioned 2010
 Fuel capacity: 78,000 tonnes/year
 Energy production:
 256 GWh (thermal)/year

Energos plants under development



Irvine Plant

Fuel capacity: 78,000 tonnes/year



Newport Plant

Fuel capacity: 120,000 tonnes/year



Barry Plant

Fuel capacity: 80,000 tonnes/year



Knowsley Plant

Fuel capacity: 78,000 tonnes/year



Doncaster Plant

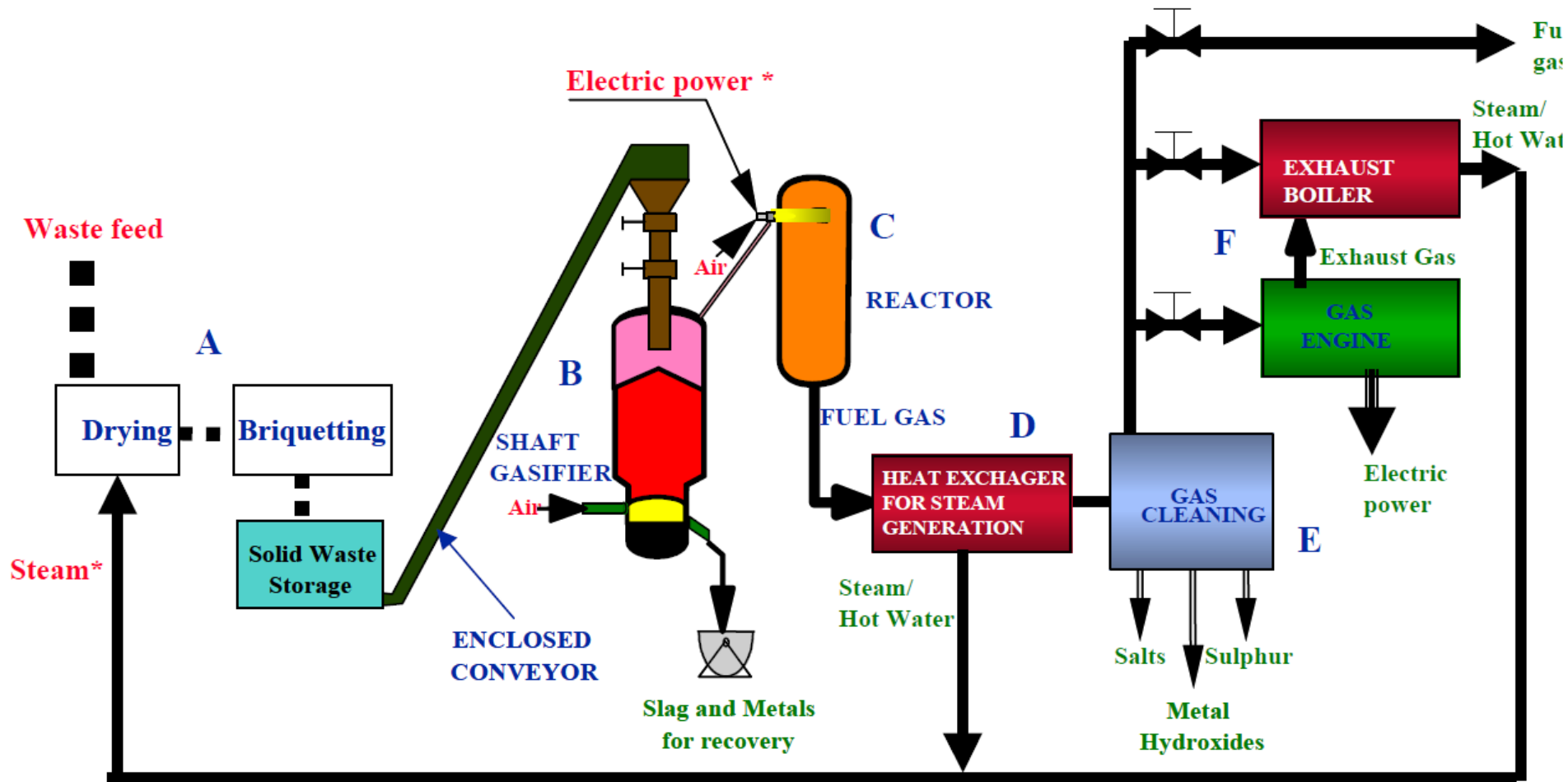
Fuel capacity: 120,000 tonnes/year



Bradford Plant

Fuel capacity: 160,000 tonnes/year

EnviroArc PyroArc process



<http://www.enviroarc.com>

Plans

Fiborgtangen Biokraft

Investment presentation
(in,parts, with confidential info removed)

Kristian Lien

Introduction

- Development of a renewable energy plant founded on local waste streams
- Linked to existing industry, new development providing off take arrangements and new business opportunities.
- Economic development employment protection and generation

What?

- Gasification plant producing a pure syngas
- CHP plant producing electric power and heat from pure syngas
 - ~ 100 GWh / yr electric power
 - ~ 200-250 GWh / yr of steam
- Linked to existing boiler house at Norske Skog Skogn
 - Operational synergies, lower heat production costs
 - Extended boiler house lifetime and reduced maintenance costs
- Provisions for future renewable materials / chemicals / fuels.

WHO?

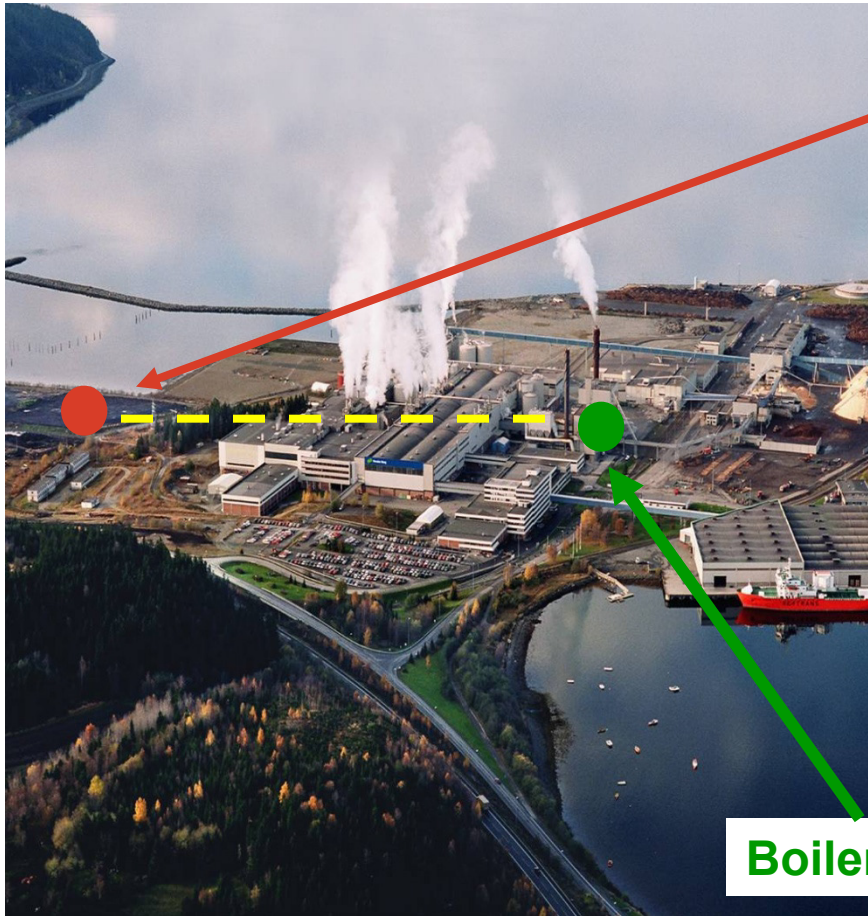
- Fiborgtangen Vekst: Project developer
- Norske Skog: Heat customer,
renewable materials
producer.
- NTE: Electric power customer,
energy entrepreneur.
- APP: Technology provider.
- LGE: Investor,
financial facilitator.
- Allskog: Future raw materials
stakeholder

WHY?

- Environmental recycling of materials and energy
- High net electricity production
- Less expensive heat
- Syngas – The gateway to a variety of renewable materials production:
 - Plastics
 - Chemicals
 - Composites
 - Biofuels
- Future off take and value creation from forestry and used end-of-life biomass resources
- The next generation of industrial and district heating plants

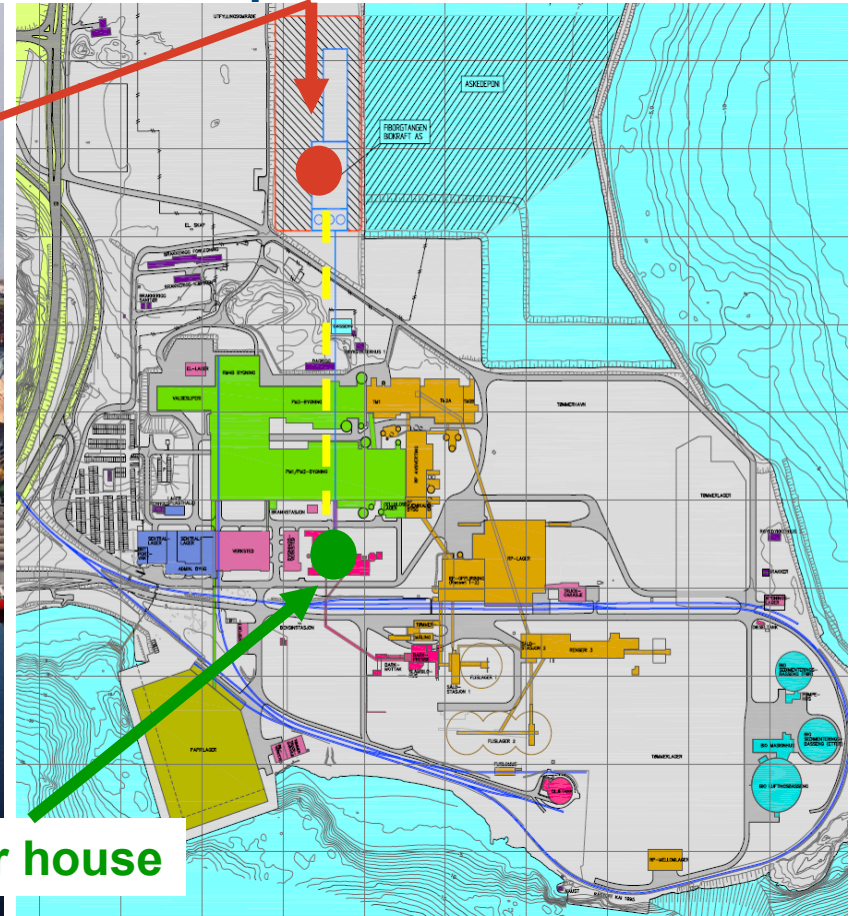
Where?

- Mill site



Boiler house

- Gasplasma site



When?

- Feasibility study: Spring 2010
- Pre study: Fall 2010
- Investor search /
risk mitigation: Spring 2011

- Main study: Fall 2011
- Permit, contract and
financial closure: Spring 2012
- Point of no return: Fall 2012
- Production: Spring 2014

Partners

- Investment
 - NSI
 - NTE
 - LGE / APP
 - FVAS / Allskog
- Strategic
 - Rekom, Retura, Fiber Nor
 - Local and national authorities
 - Fiborgtangen Industrial Park
 - Impello (investor search)

Research

Project financed through public funding – Norwegian Reserach Council

- Norwegian Research Council RENERGI programme:
 - The objective of RENERGI is to develop knowledge and solutions as a basis for ensuring environment-friendly, economically efficient and effective management of the country's energy resources, a highly reliable energy supply and internationally competitive industrial development.
- Knowledge-building Project with User Involvement (KMB)
 - **Objective:**
To contribute to long-term industry-oriented researcher training and competence building in Norwegian research communities, within topics that are crucial to the development of business and industry in Norway.

Gasbio – key data

- New project within thermochemical biofuel production
- **Project type:** KMB
- **Budget:**
 - Norwegian Research Council: 5000 kNOK/a
 - Industry: 1338 kNOK/a**Total: 6338 kNOK/a**
- **Duration:** 4 years
- **Partners:**
 - Coordinator – project owner: SINTEF Energy Research
 - Industry: Norske Skog, Metso, Statoil, Avinor
 - Other: NTNU – Education

Gasbio – objectives

Overall objective: to establish an internationally oriented solid Norwegian competence base within biomass gasification to produce biofuels.

- **Educate** PhD and MSc candidates. **Train** qualified researchers.
- **Publish** research results
- **Cooperate** closely with industry within personnel training and research.
- **Establish** formal links to research groups in Sweden, Denmark and Finland. **Establish** personnel exchange program.
- **Establish** advanced laboratory facilities
- **Develop** theories and computational models. **Scaling-up** from lab. scale to full scale.
- **Develop** new gasification concepts
- **Perform** case studies in close cooperation with industry

Thank you for your attention!

Questions?

