FIRING STRAW AND OTHER FUELS AT THE AVEDORE POWER PLANT UNIT 2.

BY
PREBEN MESSERSCHMIDT
PROJECT DIRECTOR

RAMBØLL

OVERVIEW

- **Ramboll in brief**
- Why replace fossil fuels?
- Straw & Wood – new fuels, new challenges
- Solutions & adaptation at Avedore
  - Configuration, Logistics, fuel preparation
- Reference project examples
- Summary

RAMBOLL IN BRIEF

- Founded 1945 in Denmark
- Owned by Ramboll Foundation and therefor a truly independent engineering and design consultant
- **> 13,000 experts**
- > 300 offices in 35 countries
- **EUR 1.5 billion revenue**

- Services across the markets:
  - Buildings
  - Transport
  - Environment & Health
  - Water
  - **Energy**
  - Oil & Gas
  - Management Consulting

RAMBOLL ENERGY'S COMPETENCE AREAS

Offshore wind

Waste-to-energy

Thermal power

District heating

More than 230 Thermal Power specialists provide clients a one-stop shop of consultancy services based on unique know-how and experience gained from a large number of projects and operational support work on thermal power stations

Firing straw and other fuels at the Avedore power plant Unit 2.
IEA CCT2017

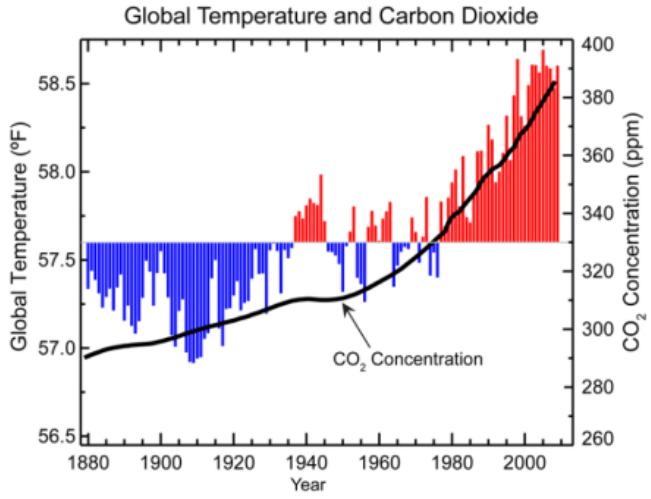
OVERVIEW

- Ramboll in brief
- **Why replace fossil fuels?**
- Straw & Wood – new fuels, new challenges
- Solutions & adaptation at Avedore
  - Configuration, Logistics, fuel preparation
- Reference project examples
- Summary

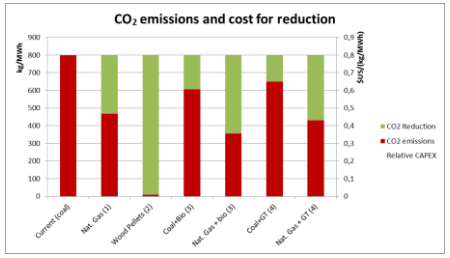
WHY REPLACE FOSSIL FUELS?

Why considering biomass as fuel?

- Regulatory or Environmental permit requirements
  - Decrease in CO_2 emissions
    1. Decommission of existing coal fired asset
    2. Substitute the fossil fuels used, i.e. Coal / Natural gas



Ref: US National Climatic Data Center – NOAA



Firing straw and other fuels at the Avedore power plant Unit 2.
IEA CCT2017

WHY REPLACE FOSSIL FUELS?

Fuel type considerations?

- Wood Pellet, as world market maturing fast, i.e. WP to be imported

- Why not utilise local / indigenous resources?:
  - Agricultural residues, i.e. straw, PKS, Olive husk etc
  - Forest residues, i.e. thinning, roots etc.
  - other by-products, i.e. sawmill cut-offs, waste wood etc.

RAMBØLL

Firing straw and other fuels at the Avedore power plant Unit 2.

OVERVIEW

- Ramboll in brief
- Why replace fossil fuels?
- **Straw & Wood – new fuels, new challenges**
- Solutions & adaptation at Avedore
  - Configuration, Logistics, fuel preparation
- Reference project examples
- Summary

BIOCONVERSION – NEW FUELS

White wood pellets) has different properties than coal:

- **Lower calorific value**
- **Lower ash melting point**
- **Hydroscopic**
- **Dusty**
- **Fire & explosion properties**
- **Health issues**

Straw properties:

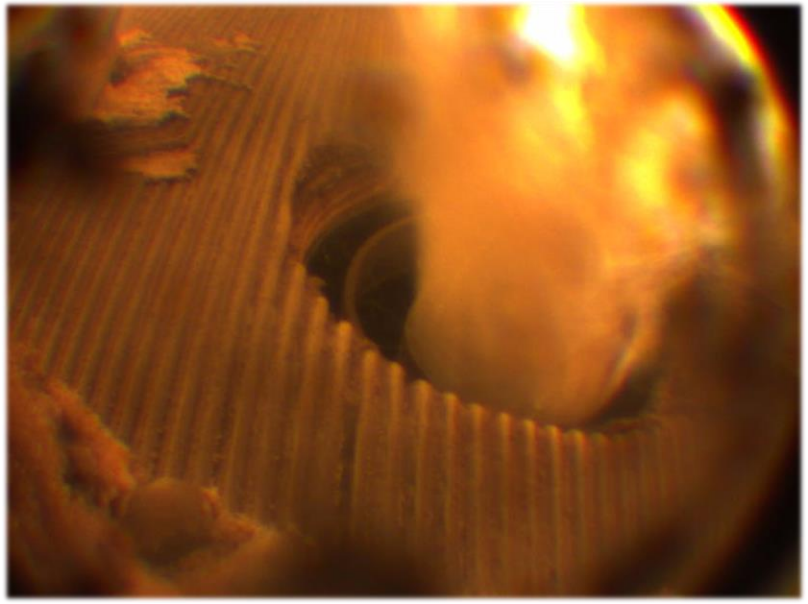
- **High on Chlorides**
- **Low calorific value**
- **Low ash melting point**
- **Hydroscopic**
- **Dusty**
- **Fire properties**
- **Health issues**

Firing straw and other fuels at the Avedore power plant Unit 2.

WOOD PELLETS: NEW FUEL, NEW CHALLENGES

Performance
- Milling throughput
- De-rating
- Slagging

Storage
- Stores (dry)
- Transportation (dry)
- Dust



Safety
- Dust explosion mitigations
- Fire control

Emissions
CO2, SO2, NOx

Firing straw and other fuels at the Avedore power plant Unit 2.

STRAW: NEW FUEL, NEW CHALLENGES

Performance
- Handling throughput
- Slagging
- Corrosion

Storage
- Stores (dry / semi-dry)
- Logistics (JIT)
- Transportation (Truck)
- Dust

Safety
- Fire control

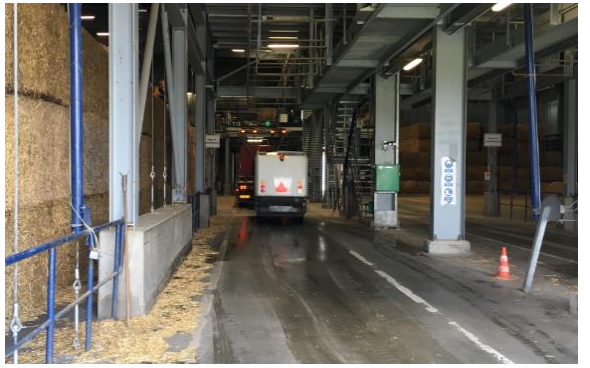
Emissions
CO_2, SO_2, NO_x

Firing straw and other fuels at the Avedore power plant Unit 2.

NEW FUELS, NEW CHALLENGES
DUST MANAGEMENT…..

"THE B….. DUST GETS EVERYWHERE!"

DUST MANAGEMENT IS IMPERATIVE!



…. AND MAY GENERATE AN EXPLOSION OR CATCH FIRE OUTSIDE THE BOILER

Firing straw and other fuels at the Avedore power plant Unit 2.

OVERVIEW

- Ramboll in brief
- Why replace fossil fuels?
- Straw & Wood – new fuels, new challenges
- **Solutions & adaptation at Avedore**
  - **Configuration, Logistics, fuel preparation**
- Reference project examples
- Summary

STRAW, WOOD CHIPS, OR WOOD PELLETS AS SUBSTITUTES FOR FOSSIL FUELS

Technical adaptation to existing plants?

1. Co-firing in existing pulverized fuelled boiler

	Straw	Wood
Pellets	5%	100%

2. Firing biomass in a separate boiler in parallel to the existing boiler

RAMBØLL

Firing straw and other fuels at the Avedore power plant Unit 2.

STRAW, WOOD CHIPS BOILER AS SUBSTITUTES FOR FOSSIL FUELS

Technical adaptation to existing plants?

- Firing biomass in a separate boiler in parallel to the existing boiler

  a) **Grate type of Boiler** (Limit to the thermal input, however robust solution)

  b) **CFB/BFB boiler** (can be very large and potentially replace the main boiler)

	Straw	Wood
Boiler	Grate	CFB/BFB
Size	<130 MW	Large

RAMBØLL

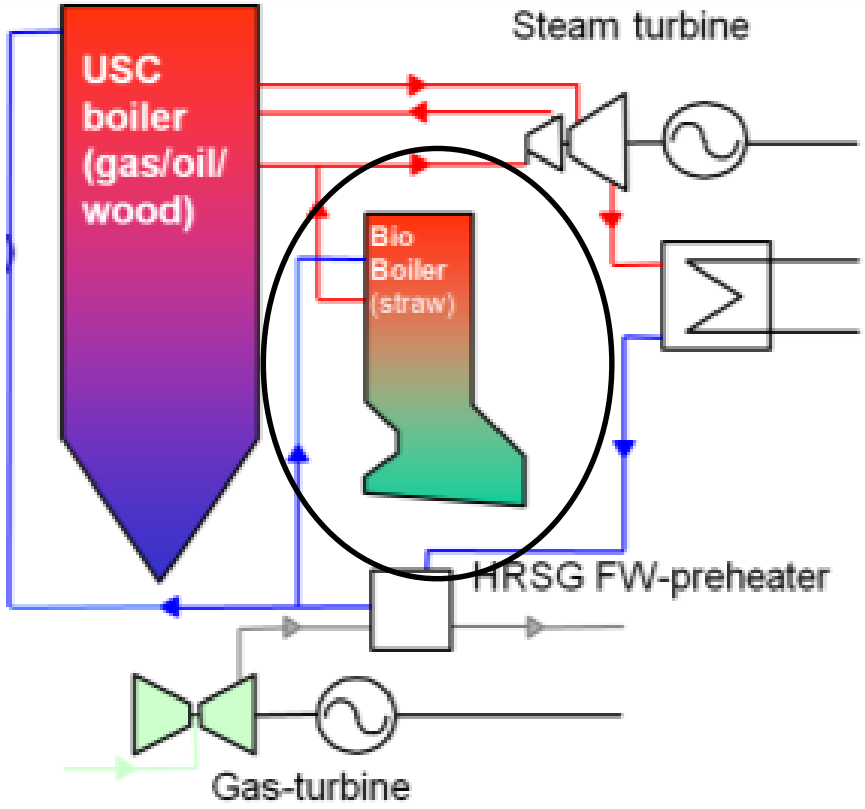
Firing straw and other fuels at the Avedore power plant Unit 2.

BIOCONVERSION - PLANT CONFIGURATION

Main Boiler:
- ***Tower boiler type***
- ***PC design – commissioned on Natural gas - now on Wood Pellets***

Straw fired boiler:
- ***Grate type***
- ***Live steam at 300 Bar, 580 C***
- ***100 MWth input – 40+ % efficiency***
- *Steam reheat in main boiler only*
- *CHP plant means high energy utilization (90+ %). Mainly used in heating season.*

Gas turbines:
- *2x50MW + HRSG*



Plant concept by DONG Energy, visited by delegations during COP15

Firing straw and other fuels at the Avedore power plant Unit 2.

STRAW, PROCUREMENT AND TRANSPORT LOGISTICS

Procurement :

- **Procured via annual auction from farmers** basis of farm storage, maximum humidity, no inert material, delivery on demand at farmers cost.
- **Heston bales** (0.6-0.7 tonnes per bale)

Transportation:

- **Delivery by truck** (24 Heston bales per load)
- **10 – 12 trucks / hour**
- **Transportation** within 100 km radius
- **Energy cost of transportation** is approx. 1% of heating value of the load

Firing straw and other fuels at the Avedore power plant Unit 2.

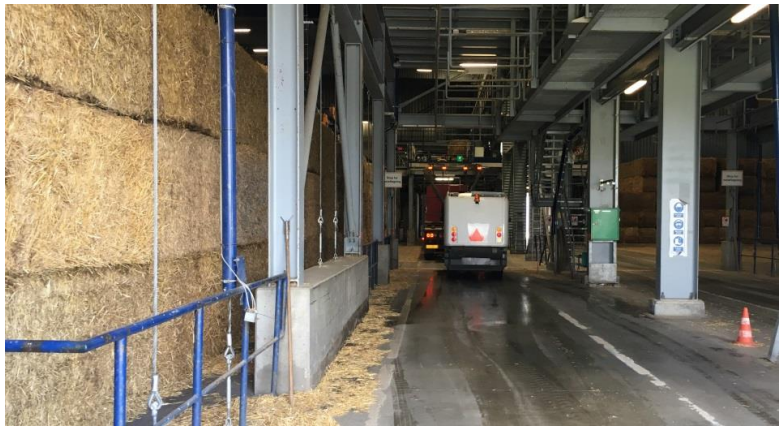
STRAW, STORAGE - DESIGN

- **Straw barn for 3,000 bales,** corresponding to approx. 2 days of operation
- Annual straw **volume: approx. 100,000 tonnes**
- **Humidity checked before unloading** – a rejection option
- **Automatic weighing and supplier registration for payment**
- **Automatic truck unloading, storage allocation, and reclaiming for combustion**

Firing straw and other fuels at the Avedore power plant Unit 2.

STRAW, STORAGE - DESIGN

- **Vacuum cleaning of truck by driver**
- **Floor cleaning a combination of vacuum cleaning and floor washing**
- **Automatic conveying from storage to boiler with fire barriers / dampers**



Firing straw and other fuels at the Avedore power plant Unit 2.

FUEL PREPARATION – PRE-CUTTING

Automatic conveying with pre-cutting and feeding

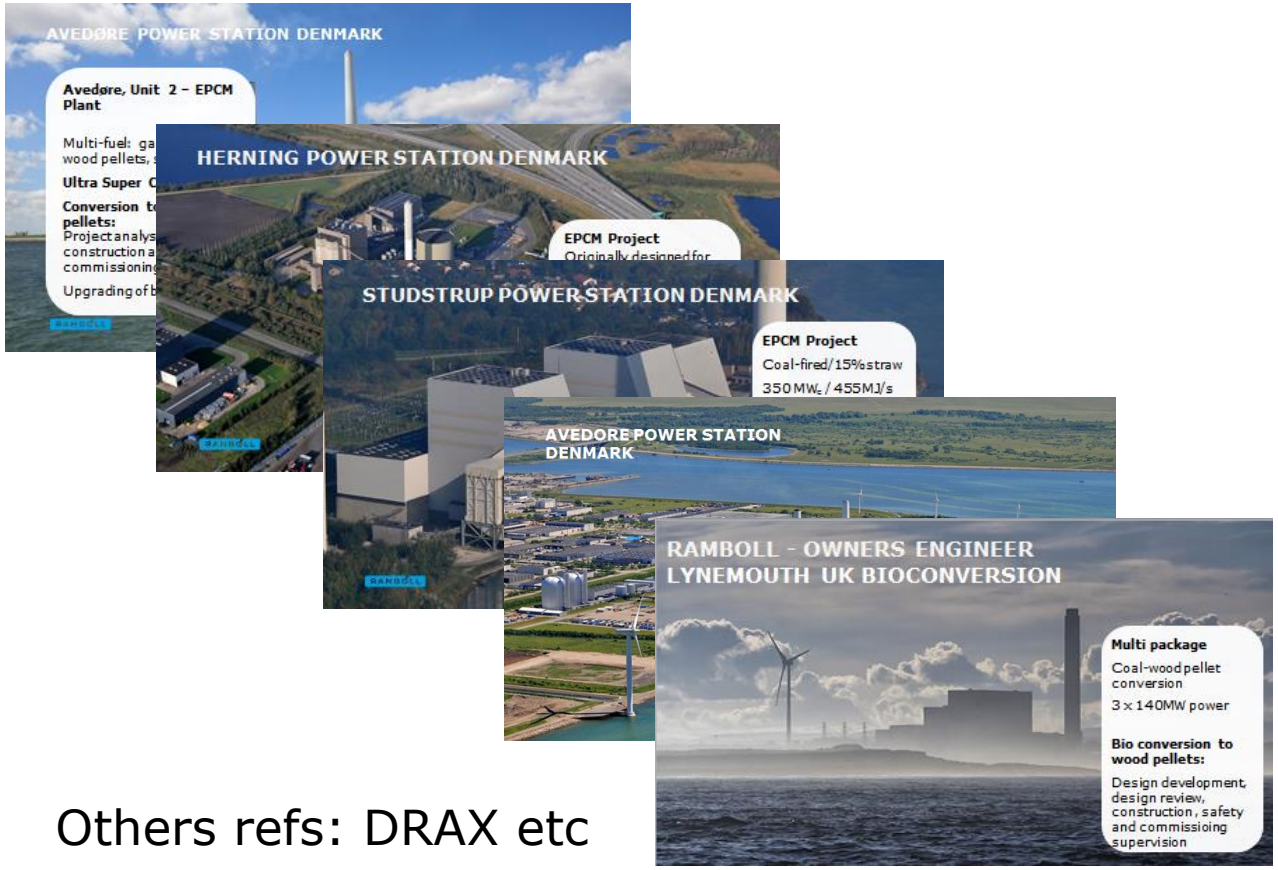
(Fixed grate principle)

Firing straw and other fuels at the Avedore power plant Unit 2.
IEA CCT2017

OVERVIEW

- Ramboll in brief
- Why replace fossil fuels?
- Straw & Wood – new fuels, new challenges
- Solutions & adaptation at Avedore
  - Configuration, Logistics, fuel preparation
- **Reference project examples**
- Summary

COAL TO BIOMASS CONVERSION – MAIN BOILER RESULTS



Others refs: DRAX etc

From 900MMBTU (270MWth) to 3,000MMBTU (880MWth)

Performance achievable:

85 – 100% MCR

Emissions:

CO_2 reduced by >90%

SO_2 significantly reduced

NO_x reduced by >50%

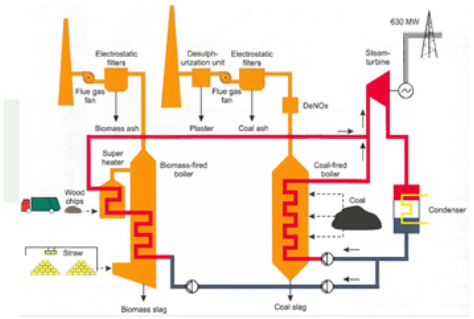
Firing straw and other fuels at the Avedore power plant Unit 2.
IEA CCT2017

COAL REPLACEMENT BY CO-FIRING IN PARALLEL BOILERS

ENSTED UNIT 3 - STRAW SOLUTIONS & ADAPTATIONS

For Ensted 3 (upgrade of existing plant) the technology selected is

- ***Grate fired boiler for straw***
- ***Grate fired wood chips boiler for super heating steam***
- ***Boiler at live steam pressure/ temperature (210 Bar, 540 C)***
- ***95 MJ/s thermal input – 40+ % efficiency***
- *Steam reheat in main boiler only*
- *CHP plant means high energy utilization (90+ %)*



RAMBØLL

Performance achievable:

130MWth replacement on straw

Potentially 100% replacement on other fuels

Emissions:

CO_2 reduced by >90%

SO_2 significantly reduced

NO_x reduced

RAMBØLL

Firing straw and other fuels at the Avedore power plant Unit 2.
IEA CCT2017

OVERVIEW

- Ramboll in brief
- Why replace fossil fuels?
- Straw & Wood – new fuels, new challenges
- Solutions & adaptation at Avedore
  - Configuration, Logistics, fuel preparation
- Reference project examples
- **Summary**

STRAW AND OTHER BIOMASS FUEL FIRING - SUMMARY OF KEY POINTS

- ✓It is **manageable and viable** to replace fossil fuels with biomass at existing plants.
- ✓Configuration differs, but can include use of **local fuels like straw**
- ✓**Good performance** achievable
- ✓Biomass offers significant **carbon savings**
- ✓**Careful consideration of fuel risks** required to develop safe design

- ✓ **But….Consistent policy support** is required to ensure the successful transformation of the thermal power generation business towards a renewable future

RAMBØLL

Firing straw and other fuels at the Avedore power plant Unit 2.

THANKS FOR YOUR ATTENTION

ANY QUESTIONS ?

Preben V. Messerschmidt
PNVM@ramboll.com
+45 51613363

Ramboll
Hannemanns Allé 53
2300 Copenhagen
Denmark