R&D Director’s Dream

**Low Excess Air**
- Combustion with less combustion air
- Lower investment costs of new plants
- Improved energy efficiency
- Reduced emissions

**Boiler fouling mitigation**
- Longer campaign times for boilers
- Improved margins on new projects
- Improved guarantees; reduced guarantee costs

**DyNOR®**
- SNCR for low NOx emissions without catalyst
- <100 mg/m³ NOx with < 10 mg/m³ NH₃ slip

**New CCS**
- Upgrade of basic control module
- Add-on control features: Burn-out and fire end control (Riverside)
- Maximized throughput

**Inova Grate**
- Optimized grate construction, lower cost
- Lower maintenance costs
- Reduced building height

**Fabric Filter**

**Emissions**

**Additives**

**Filter Residues**

**Dream: Show Case Project**
Show the results of all ideas, development, modelling, trials and testing in a real plant
1) Inova Grate

Features of the Inova Grate

- Combines all positive aspects from cumulated years of experience
- In particular the Inova Grate is built to:
  - Accommodate a wide range of fuels → various configurations
    → air and water cooled
    → more grate movement controls
  - Further reduce burnout
  - Reduce plant building height (compared to Von Roll grate)
    → less inclination
  - Minimize investment costs
    → lower weight, fewer parts
  - Reduce maintenance costs
    → easy access
  - Improve plant availability
    → less and shorter outages
2) New Generation Combustion Control System (CCS)

Base CCS
PID-Controllers
Implemented on the DCS

Steam controller
O2 Controller
Combustion automatic

Base value calculation
Based on plant design

Primary air
Primary air temperature
Secondary air
Recirculated flue gas
Ram feeder speed
Grate speed

Supplementary controller
Fire position control
Burn-out control
Fuzzy-Hybrid Steam controller
Automatic heating value correction...

Setpoint
Steam production

Operator
Adaptation

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2) New Generation CCS Features

- **Fire Position Control**
  - Burnout Control
  - Ideal temperature distribution on grate
  - Early fire start
  - Late fire start

- **Early Detection of Fuel Property Changes**
  - Use existing or new data to calculate feed properties

- **Reduce Load Drops**
  - Determine reason for Load Drop
  - Live steam flow
  - Low fuel
  - Bad fuel
  - Variable setting A
  - Variable setting B

Ideal temperature distribution on grate:
- Fire Start
- Fire End
- Ideal positions:
  - 0-100 %
  - 350 - 550 nm

Temperature distribution plot:
- Fire Start
- Fire End
- Ideal positions

Fuel property changes:
- Use existing or new data to calculate feed properties

Load drop analysis:
- Variable setting A
- Variable setting B
- Live steam flow
- Low fuel
- Bad fuel
2) New Generation CCS Benefits

Sample calculation 2 x 500 tpd - 19 days:
- Steam production: 55,842 tons
- Lost steam production: 2,526 tons

Extrapolated to whole year (330 days):
- Lost steam production: 43,873 tons
  → Lost electric production: 7,239 MWh/y
  → Lost $ ($80/MWh): 579,119 $/y
3) Boiler Efficiency Analysis and Intelligent Boiler Cleaning

- Scaling almost instantly reduces boiler efficiency
- Efficiencies are calculated for individual boiler sections → cleaning efforts are optimized
- Shower cleaning
- Explosion cleaning
- Automated and monitored pneumatic rappers:

![Graph showing boiler section efficiencies over a 1 year period.](image-url)
4) DyNOR® - Dynamic NOx Reduction

- Virtual segmentation of the boiler
- Quick temperature measurement
- Dynamic, precise and quick responding reagent injection
4) DyNOR® performance (before other measures)

Results have been confirmed in other plants:

- Client: Westenergy OY
- Location: Vaasa, Finland
- Capacity: 1 x 520 tpd
  - 61 MW<sub>th</sub>
- Start-up: 2012
5) Energy Efficiency Improvement: minimize losses

- Stack losses are significant
- Roughly 10 – 15% of energy (LHV basis)
- Efficiency improvement by …
  - …lowering exhaust gas **temperature**
  - …lowering exhaust gas **flow rate**
5) Energy Efficiency: after lot of modelling

DEM Model (Discrete Elements Method)
(in cooperation with LEAT / U of Bochum)

- Objective:
  Numerical model of movement on grate and thermochemical processes within particles and gas phase

- Method:
  coupling of various modelling modules to account for:
  solid mechanics/ particle movement drying/gasification/pyrolysis of particles
  heat transfer to/within particles
  gas flow pattern and burn-out of gases
  radiant heat transfer

Example: content of volatiles in solid particles

Interface surface for data exchange to the CFD model
5) Energy Efficiency: ..and even more modelling

Results:

- Good agreement of modelled and measured temperature and oxygen profiles
- Identification of two extreme gas conditions:
  - Feed end
    - oxygen: 0 – 10 %
    - CO: 5 – 20 %
    - (varies greatly in time)
    - hydrogen: 2 – 5 %
  - Discharge end
    - oxygen: 20 %

end of flame zone
5) Energy Efficiency: the Solution

New Patented Premixing Solution

- With premixing on…
  - local \(O_2 = O_2\) at stack
  - local CO homogeneous and low
- Flue gas flow 20% lower (\(\lambda < 1.20\))
- Expected electricity prod. 4% higher
5) NOx generation

- NOx, uncontrolled, 1-minute averages

- NOx conc. (ppmv @ 7% O2 dry)
- NOx conc. (mg/m$^3$ i.N. 11%O$_2$ dry)

- O$_2$ concentration boiler (vol % dry)

- Germany 2004
- Norway 1999
- Germany 1998
- Switzerland 2002
- Switzerland 1990
- Netherlands 2004
- Netherlands 1996
- Switzerland 2003
- Germany 2005
- Germany 2005
- Norway 2007
- Switzerland 2010
And R&D Director’s Dream Came True: RENERGIA

- Location: Perlen, near Lucerne, Switzerland
- Capacity: 2 x 410 tpd 2 x 47 MW<sub>th</sub>
- Contract: 04/2012
- Start-up: 01/2015
- Many of the above described new developments will be included in this plant
Thank you for your attention

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