Vattenfall strategy and experiences on co-firing of biomass and coal

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Vattenfall Biomass Strategy and Implementation Plan

Main objective: Profitably increase the level of co-firing in the hard coal plants

→ Reduce fossil CO_2-emissions by 8-10 Mt/a through biomass co-firing (4-5 Mt biomass)

Biomass Utilization will involve three main biomass processing qualities:

- **Refined Wood Pellets:** preferred fuel for biomass use in pulverized fuel plants
- **White Pellets:** near-term fuel for first steps before ramp-up of refined wood pellets
- **Wood chips:** co-firing in fluidized bed boilers and in monocombustion plants

Uncertainties and challenges refined wood pellets/briquettes

- Uncertainties
  - Availability and price
  - Quality of refined pellets
- Technical impact on existing installations at heat and power plants
- Incentives

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Biomass Strategy: Refined Pellets as Preferred Fuel

Wood chips (residues)

Wood chips (logs)

White pellets/ briquettes

Refined pellets/ briquettes

- Steam explosion
- Torrefaction

Carbonization

- R&D stage

Vattenfall support development of pre-treatment methods for biomass with goal to

- **minimize the carbon footprint**
- **optimise the overall cost of production, transport and storage**
- **optimize critical fuel properties such as heat value, density, grindability, water resistance**

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Biomass Strategy: Refined Pellets as Preferred Fuel

Assumed Advantages of Refined Wood Pellets

- Utilization of existing coal logistics and downstream handling systems
  - Lower downstream CAPEX + OPEX
  - Optimized co-firing business case
  - High flexibility and fallback option
- Faster ramp-up and higher co-firing rates attainable

Vattenfall has the goal to verify the assumptions above.
For this purpose, the whole power plant process from ship unloader to chimney is subject to thorough investigations.

Large-scale tests of refined and densified woody biomass at coal combustion and gasification plants

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Fuel Property Overview

	Hard Coal	Wood Chips	Wood Pellets	Refined wood pellets
				
Moisture Content	<10%	35-45%	8-10%	1-7%
Lower Heating Value (LHV)	**25 MJ/kg**	**9-10 MJ/kg**	**17 MJ/kg**	**19 - 22 MJ/kg**
Bulk Density	850 kg/m³	300 kg/m³	650 kg/m³	690-740 kg/m³
Energy Density	**~ 21 GJ/m³**	**~ 3 GJ/m³**	**11 GJ/m³**	**13-15 GJ/m³**
Other properties / comments	Design fuel of existing plants	• Low energy density • Not grindable in coal mills at co-milling >3-5% cofiring rate	• Water Soluble • Grindability at co-milling (5-8%)	• Water Resistant (Steam Treated Pellets) • Grindable in coal mills at high rates

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Fuel properties of refined wood pellets tested at Vattenfall

Bulk density	**700 – 750 kg /m³**
Moisture content,	**6-8 %**
Ash content 550℃ as received	**0.4-0.5 %**
Volatile matter as received	**74-78 %**
Net calorific value	**17.9-18.8 [MJ/ kg]**

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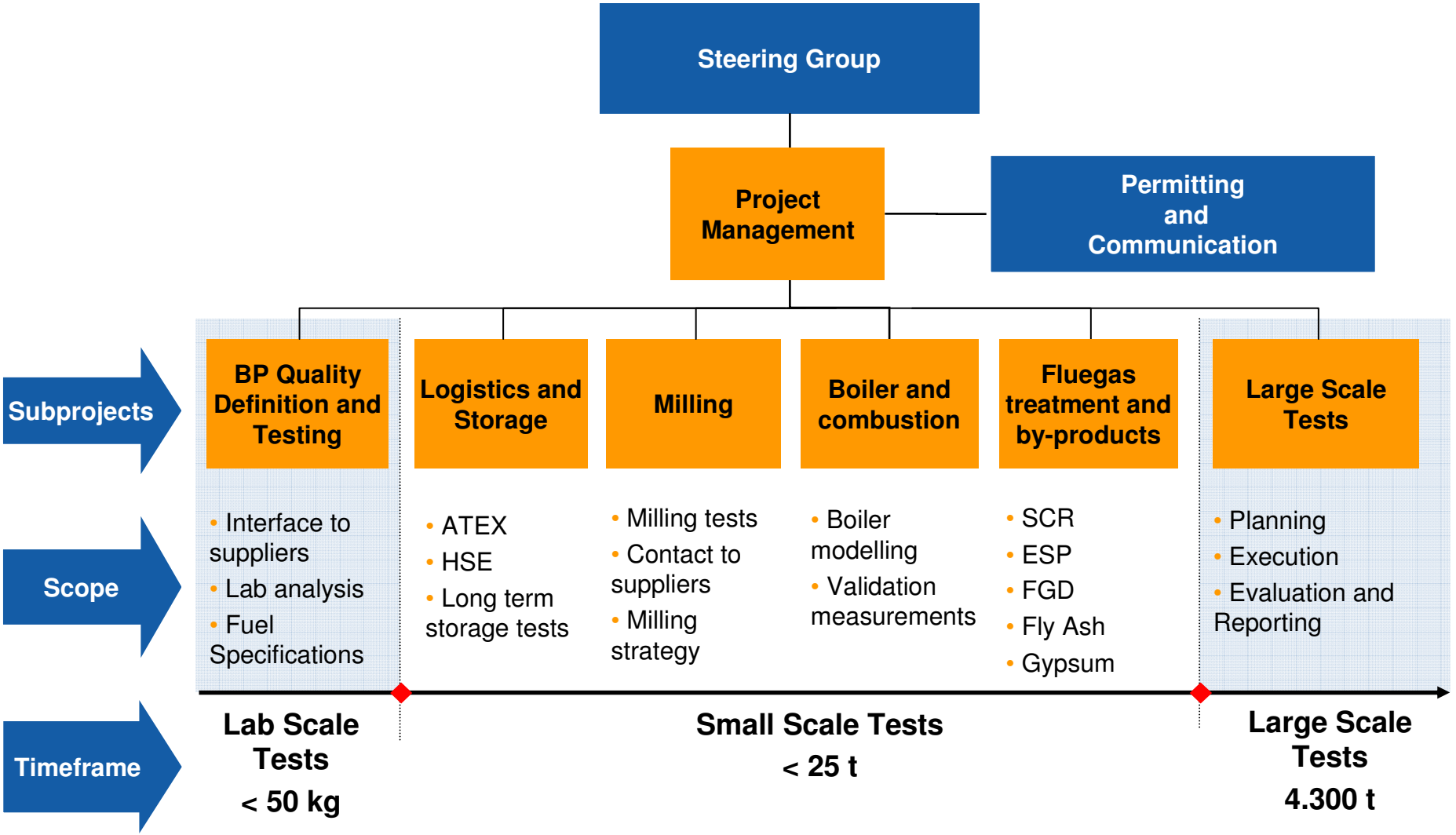
Refined wood Pellets Verification Program (2011)



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Basic Plant Data CHP Reuter West

Electrical Gross Power Capacity	2 x 300	MW_{el} (Cond.) (rated)
	2 x 255	MW_{el} (Full district heating)
Thermal Power Capacity	2 x 293	MW_{th} (district heating) (rated)
Coal consumption	1.1	Million tonnes/a
CO_2 emissions with 100% coal	2.8	Million tonnes/a
Coal yard storage capacity	220.000	tonnes hard coal

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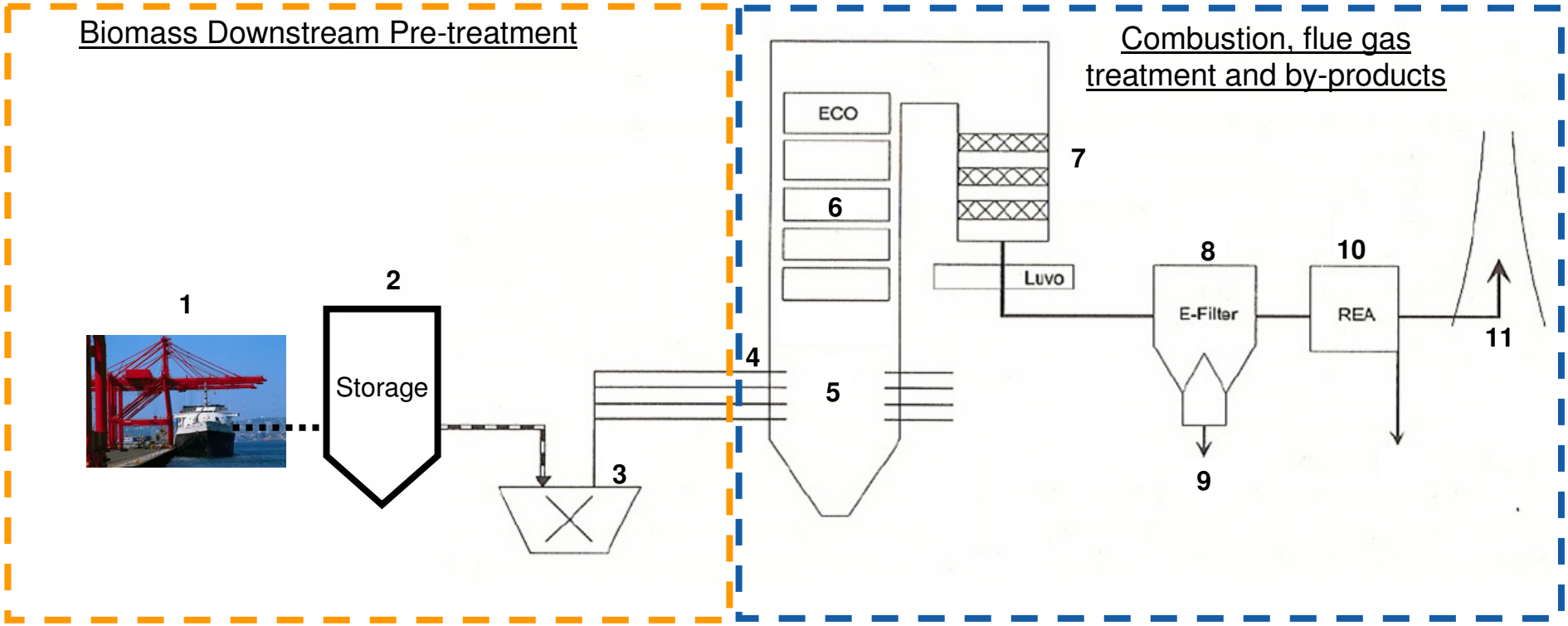
Relevant plant subsystems for biomass co-firing



1 Delivery and Unloading

2 Storage: Dust, smell, leaching

3 Mills (and drying): capacity decrease, mill operation

4 Dosing and Burners

5 Furnace walls: Corrosion, Slagging

6 Superheaters: Corrosion, Slagging

7 SCR: Catalyst Deactivation

8 ESP: Resistivity Increase

9 Fly Ash: Offtake

10 FGD: Capacity and gypsum quality

11 Exhaust gases: Emissions

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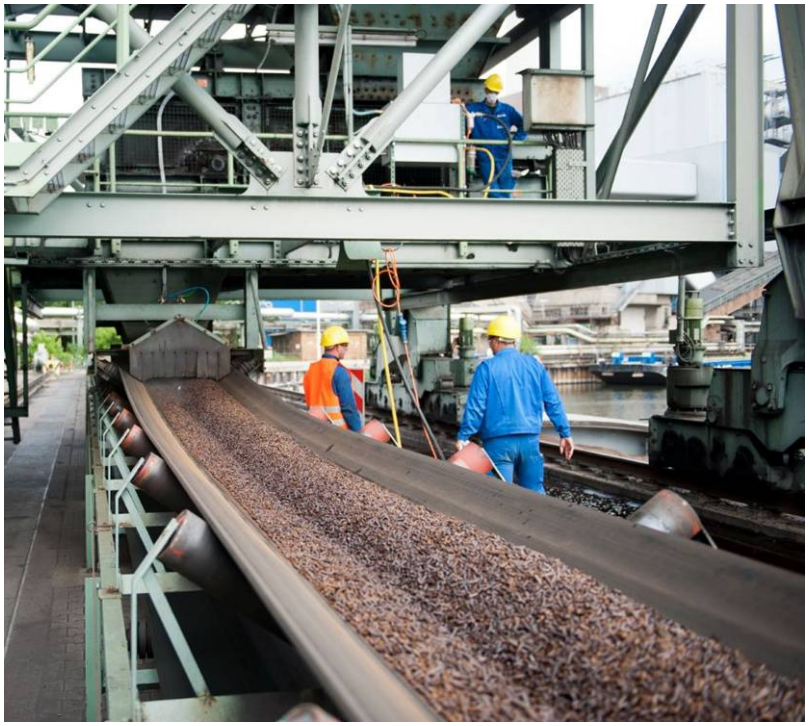
Large Scale Unloading Tests (2.400 t):
Unloading and transfer to conveyor

Unloading with water dispersion system in operation (top view)



Transfer point from ship unloader to conveyor belt with water dispersion system in operation

Dusting seems to be an issue

The dust suppression system resulted in minimal/irrelevant dust formation.

→ Conclusion:

Unloading of tested Black Pellets is possible with existing system, given adaptations in dust suppression systems and in the unloader grabs

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Conveying

Airborne dust measurements within at a.) converyor belt and b) transfer point at tower

- No critical/explosive airborne dust concentrations
- Total dustfall was at some points higher than in coal operation
- Some pellets slipped through the rubber fittings at the transfer points

→ Conclusion:

Conveying is possible with coal conveyors

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Storage at Reuter West hard coal yard

Stacker/Reclaimer in operation

Pellet pile from top of stacker/reclaimer

- Laboratory analysis resulted in high COD values of the leaching water, so that a ground insulation was installed

- From May – July, 4.318 t were stored and tested at Reuter West hard coal yard.

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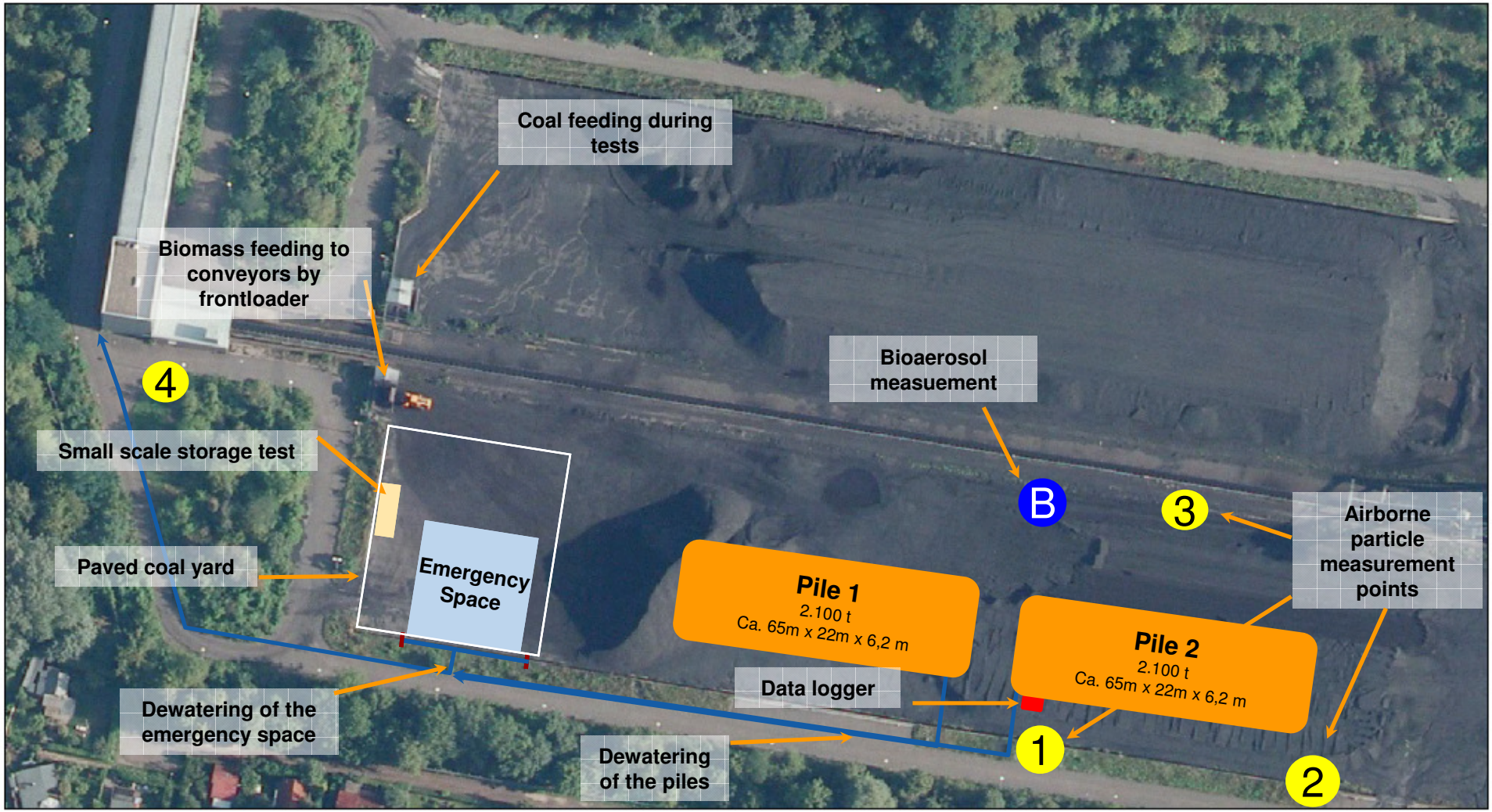
Storage: Large scale storage test setup



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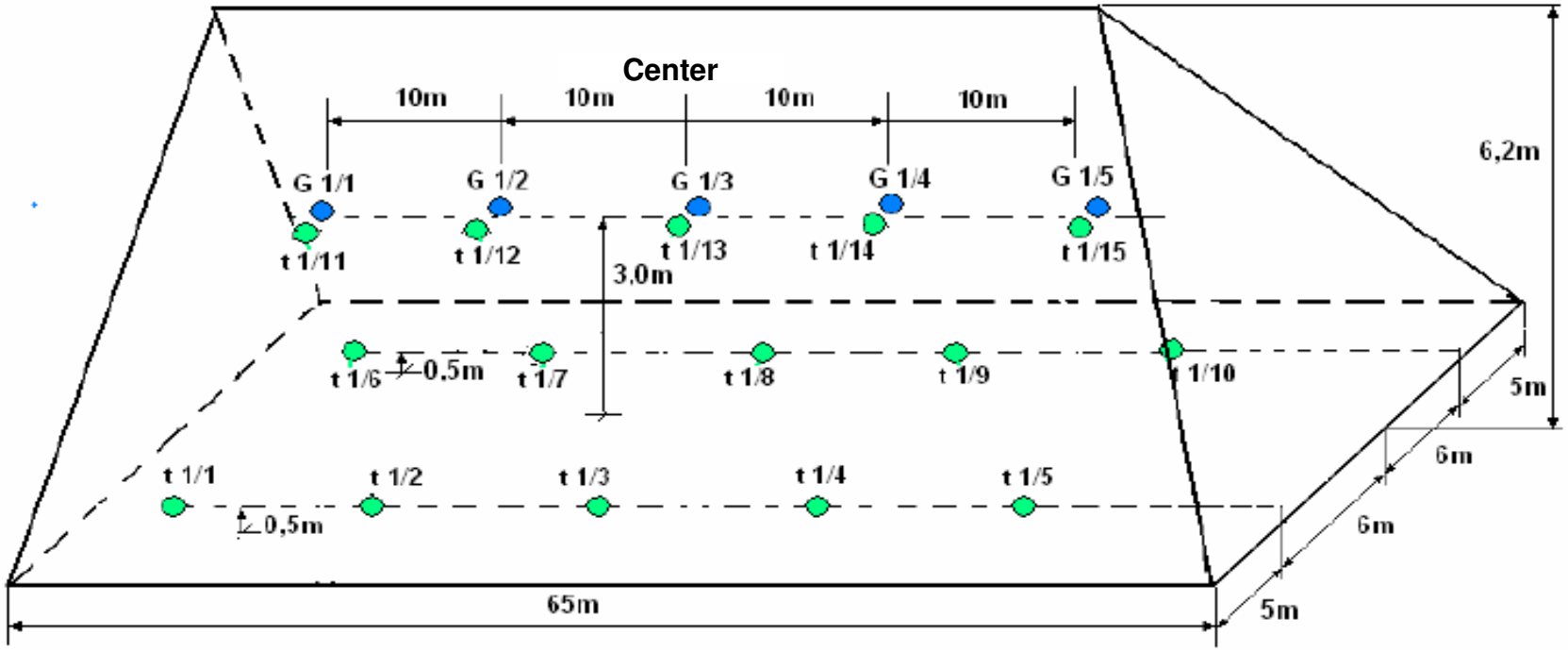
Measurement points inside refined pellets piles

Distribution of the temperature and gas measurement points in the large test piles



- Thermocouple with 50 m compensating cable
- Gas sampling PTFE hose with ceramic filters

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Fine dust measurement device

PM 10 and PM 2,5 fine dust measurement device at Reuter West coal yard

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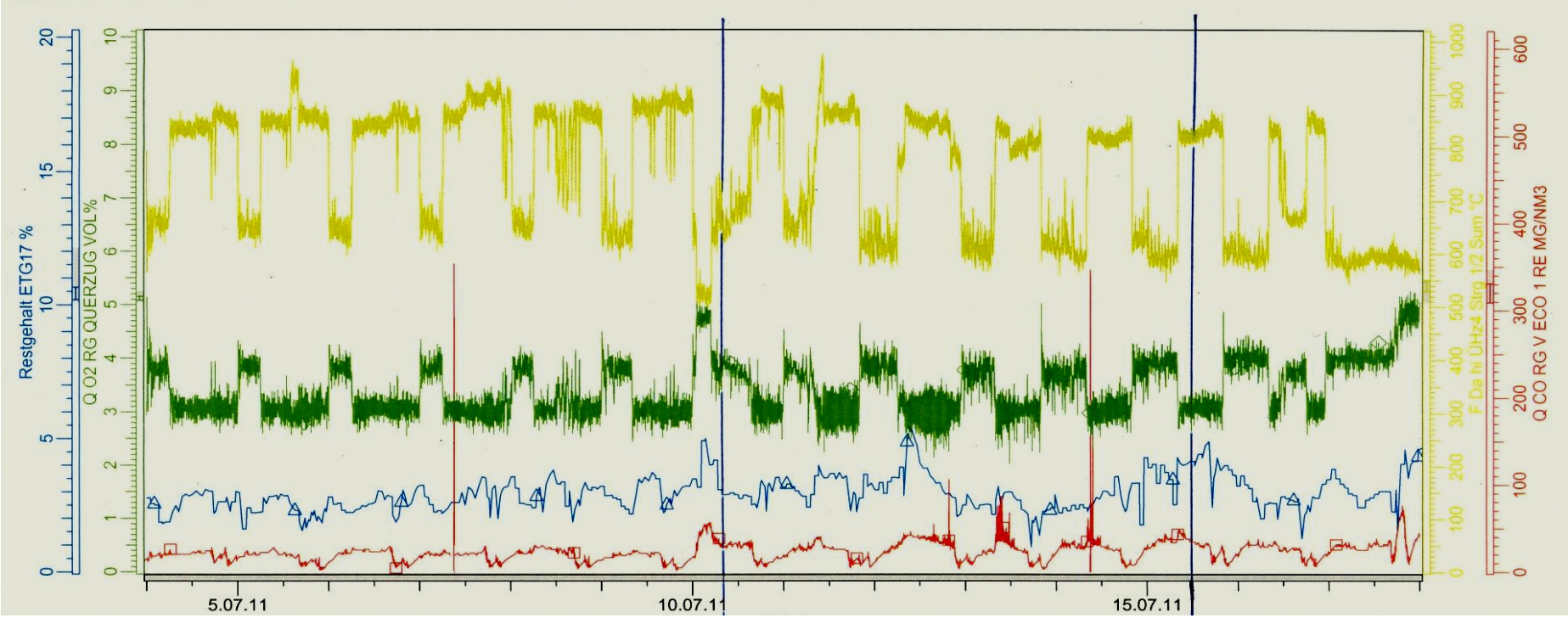
Boiler Operation during 20% (m/m) Test (16%th)



- Steam output (t/h)
- O2-concentration (%)
- Unburnt carbon (%)
- CO-Concentration (mg/m³)

- Highest boiler output during the last 6 months was achieved (987 t/h, 270 MWel net
- 5 days production of ~33-36 MWe green power

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Conclusions

- During the test campaign, Reuter West CHP operated at following co-firing rates ***without any modifications***:
  - 5 days at 20 ma-% (16%th) → 33-36 MWel green power
  - 2 days at 35 ma% (29%th) → > 53 MWel green power
  - 2 days at 50 ma% (43%th) → > 80 MWel green power

  → Such co-firing rates are unattainable with conventional biomass, unless significant investments are undertaken

- First test results indicate low cost feasibility of co-firing refined wood pellets

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Willem-Alexander Power Plant (WAC)

- Integrated Gasification Combined Cycle (240 MWe)
- Biomass Scale Up Project (50-70% e/e)
- CO_2 emission reduction: 550 kton/yr

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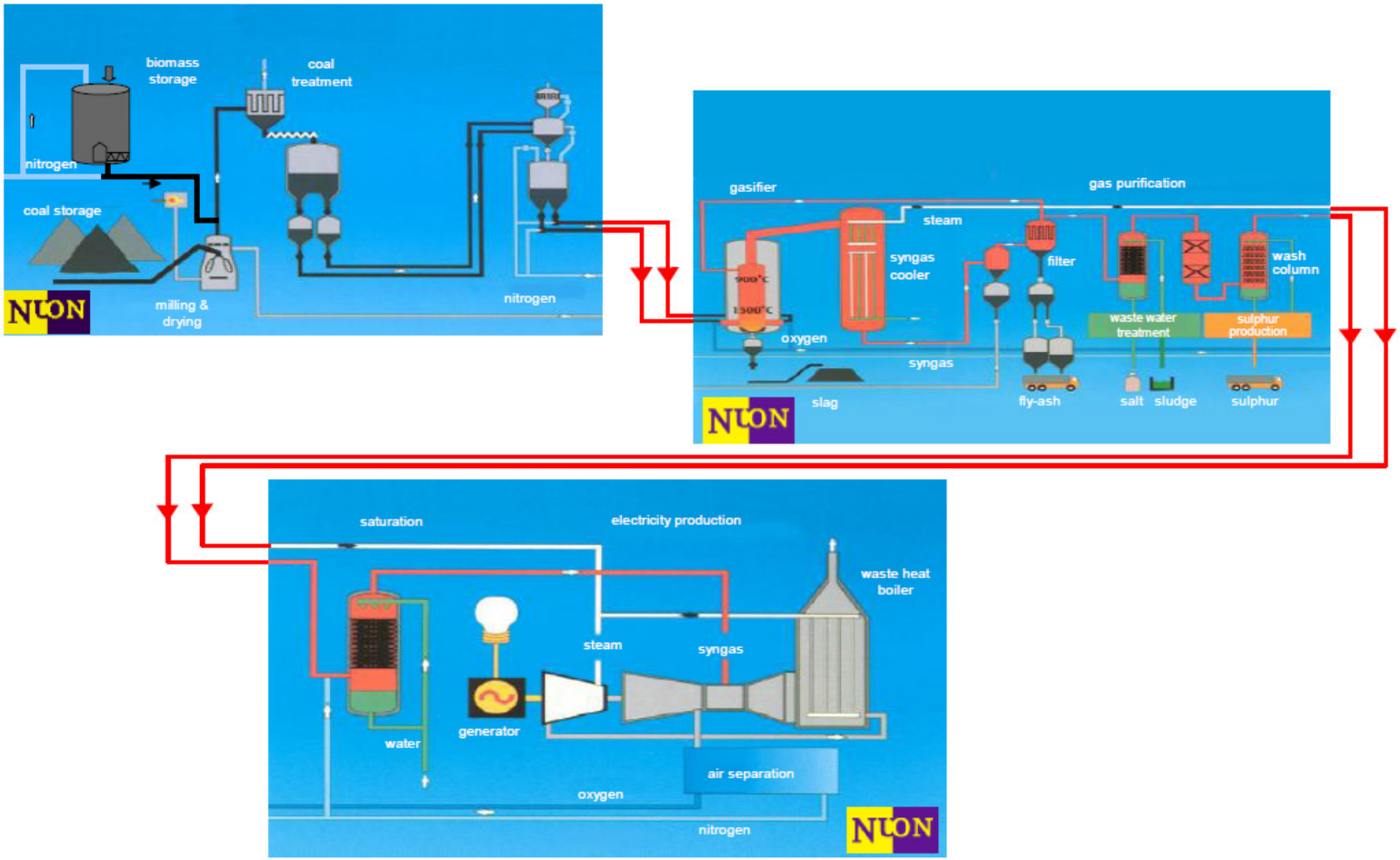
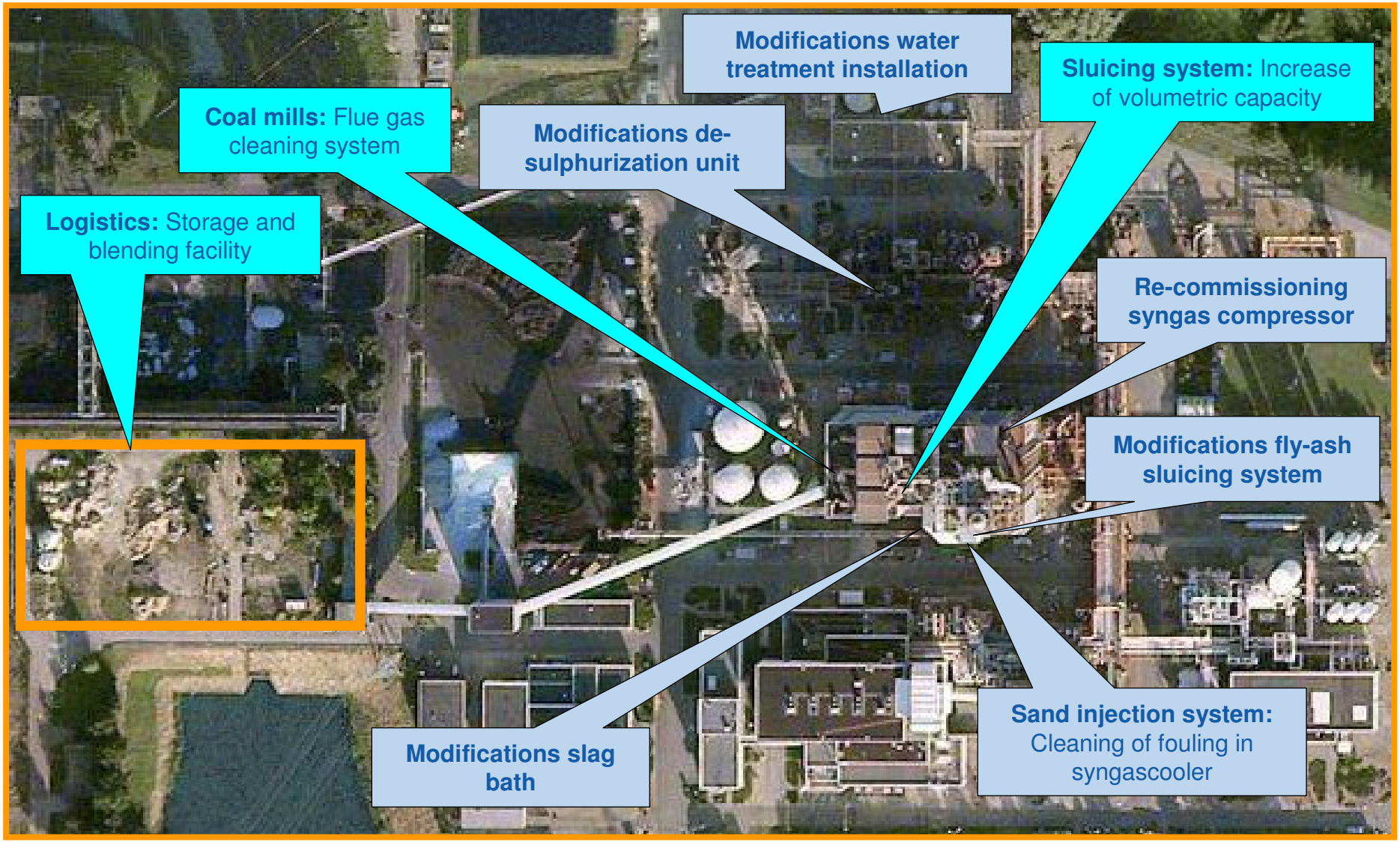
Process Scheme WAC

Process Willem-Alexander Power Plant



Technical modifications



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Willem-Alexander Power Plant

- Testing so far has been according to expectations
- Issues can partly be solved by hardware modifications and partly by increasing the quality of the refined pellets (upstream treatment)

Evaluating the solutions is an important part of upcoming phases of development work on biomass co-combustion at Buggenum

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