



SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE

Suomen Soodakattilayhdistys ry

Soodakattilapäivä 2023

**Helsinki Congress Paasitorni
2.11.2023**

Raportti 8/2023

(16A0913-E0229)

SOODAKATTILAPÄIVÄ 2.11.2023 OHJELMA

Helsinki Congress Paasitorni, Paasivuorenkatu 5 A, 00530 Helsinki

09.00-09.25	Ilmoittautuminen ja aamukahvi <i>Kokoustila Sirkus, Helsinki Congress Paasitorni</i>
09.25-09.30	Tilaisuuden avaus
09.30-10.00	Suomen Soodakattilayhdistys, vuosikatsaus / Sisaryhdistysten kuulumisia <i>Emma Kärkkäinen, Suomen Soodakattilayhdistys ry</i>
10.00-10.30	CCUS (Carbon Capture and Utilization or Storage) sellutehtaalla <i>Esa Vakkilainen, LUT-yliopisto</i>
10.30-11.00	Kahvitauko
11.00-11.30	Tulistimien maksimipintalämpötilalisän muutos kattilan koon funktiona <i>Jussi Saari, LUT-yliopisto</i>
11.30-12.00	Ligniinin talteenotto, käyttö ja näkymät <i>Jarno Peltonen, SciTech Service Oy</i>
12.00-13.00	Lounas <i>Paasiravintola</i>
13.00-13.30	Maximizing safety and performance: Roadmap to autonomous ANDRITZ HERB™ recovery boiler <i>Niki Lankila, ANDRITZ</i>
13.30-14.00	Uusia soodakattiloita Kiinaan – energia- ja päästöratkaisut <i>Markku Isoniemi, Valmet Technologies Oy</i>
14.00-14.30	Sootblow more, with less steam – Sustainable sootblowing <i>Johan Holmér, Wave Impact Heat Management AB</i>
14.30-15.00	Kahvitauko
15.00-15.30	Tulevaisuuden näkymät selluteollisuudessa <i>Salla-Mari Järvinen, AFRY Management Consulting Oy</i>
15.30-16.00	Sodahuskommittén - Ruotsalais-norjalainen soodakattilakomitea, vuosikatsaus <i>Kristian Rosenqvist, The Swedish Norwegian Recovery Boiler Committee (SNRBC)</i>
16.00-16.30	Yhdistyksen opinnäytetyöpalkinnon esittely: Effect of recovery boiler plant electricity production increase on sustainability <i>Aleksi Sivonen, Tampereen yliopisto</i>
17.00-18.30	Cocktailtilaisuus <i>Sirkus-lämpö</i>
19.30-	Illallinen <i>Ravintola Meripaviljonki</i>

SUOMEN SOODAKATTILAYHDISTYS, VUOSIKATSAUS

Emma Kärkkäinen
Suomen Soodakattilayhdistys ry



Katsaus Soodakattilayhdistyksen toimintaan 2022-2023

Soodakattilapäivä 2023

2.11.2023

Emma Kärkkäinen

Soodakattilapäivä 2023



Sisältö

- Soodakattilayhdistyksen esittely ja kuulumiset
- Suomen soodakattilat
- Projektikatsaus

Soodakattilapäivä 2023



Soodakattilayhdistys

- Suomen Soodakattilayhdistys ry on edistänyt soodakattiloiden ja kemikaalien talteenottoprosessien **turvallista, tehokasta** ja **ympäristöystävällistä** käyttöä jo vuodesta 1964.
- Soodakattilayhdistys
 - kerää tietoa kattilavaurioista ja –onnettomuuksista, ja jakaa näistä tietoa jäsenistölleen
 - julkaisee ohjeistuksia ja suosituksia sekä järjestää seminaareja ja kokouksia
 - tukee ja teettää talteenottoprosesseihin keskittyvää tutkimusta, joka edistää yhdistyksen tarkoitusta

Soodakattilapäivä 2023



Yhdistyksen jäsenet

- Soodakattilayhdistyksen jäsenistöön kuuluu mm. suomalaisia sellutehtaita, kattilavalmistajia, vakuutusyhtiöitä, tarkastuslaitoksia sekä yliopistoja
- Yhteensä 32 jäsentä, joista 13 on sellutehtaita
 - Yhdistyksessä äänivaltaa käyttää 28 äänioikeutettua jäsentä
 - Kolme yliopistoa ulkojäsenenä



ANDRITZ



MetsäFibre

kiwa



Replico



SINTROL



A''
Auto-ylöpisto



CLYDE
INDUSTRIES



STORA ENSO



KOTKAMILLS



FM Eläval



Valmet
FORWARD



IND-INSPECTION
& CONSULTING OY



AFRY



AFRY



OUUN
YLIOPISTO



ÅA

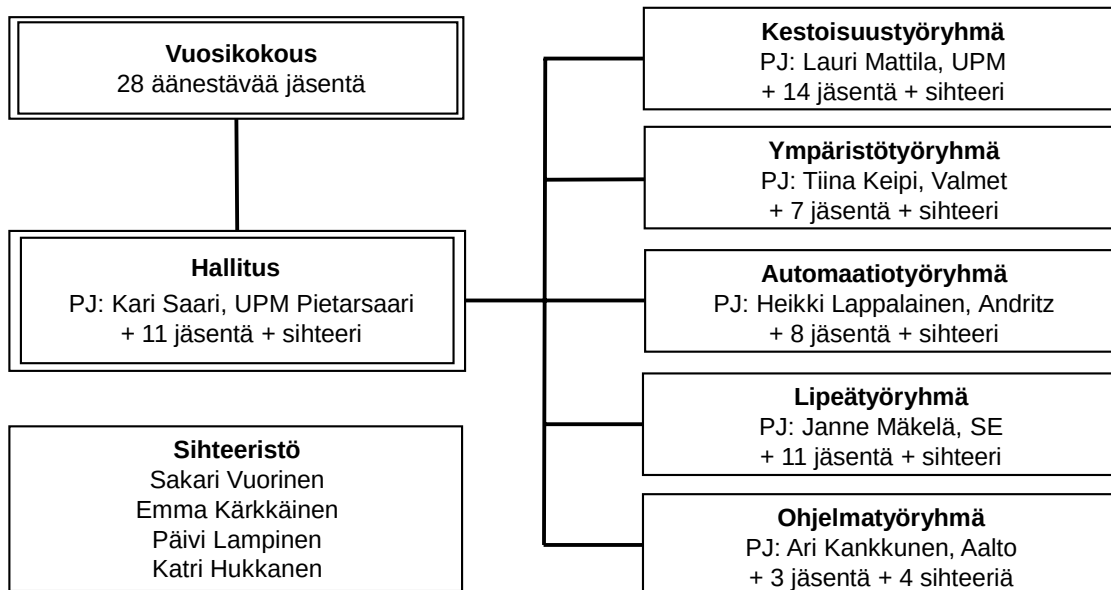


tukes

Soodakattilapäivä 2023



SKY organisaatio 2023



Soodakattilapäivä 2023



Toiminta viime aikoina

- Eilen kokoonnuttiin kaikkien työryhmien ja hallituksen kesken Helsingissä työpajojen merkeissä.
- Vuosikokous järjestettiin hybridimuotoisena huhtikuussa Tampereella.
- Konemestaripäivät järjestettiin huhtikuun alussa Kotkassa ja perinteinen tehdasvierailu tehtiin MM Kotkamillsille.
- 60-vuotisjuhlaseminaarin järjestelyt ovat edenneet ja save the date –kutsu lähetetty (5.-7.6.2024).



Soodakattilapäivä 2023

Tulevia tapahtumia



- Konemestaripäivä
 - To 25.1.2024
 - Varkaus / SE Varkaus
- Soodakattilaoperaattoreiden kokemustenvaihtopäivä
 - Helsingissä maaliskuussa 2024
 - Kohderyhmänä soodakattilan operaattoritason henkilöt
 - Käytännön esimerkkien avulla soodakattiloissa tapahtuneita vaurioita sekä ajossa syntyneitä ongelmatilanteita

Soodakattilapäivä 2023

Opinnäytetyöpalkinto

- Jaetaan vuosittain parhaasta maisterivaiheen opinnäytetyöstä (laajuus 30 op) sulfaattisellutehtaan talteenottoalueella
- Palkinto jaettiin ensimmäisen kerran vuonna 2009
- Palkinnon arvo on 2.000 €
- Palkintoa voi hakea Suomessa korkeakoulussa tai yliopistossa tutkintonsa suorittavat opiskelijat, joiden opinnäytetyö liittyy sulfaattisellutehtaan kemikaalien talteenottoon
- Tarkemmat tiedot yhdistyksen nettisivuilta
 - <http://www.soodakattilayhdistys.fi/yhdistys/opinnaytetyopalkinto>

Soodakattilapäivä 2023



Suomen soodakattilat

Soodakattilapäivä 2023

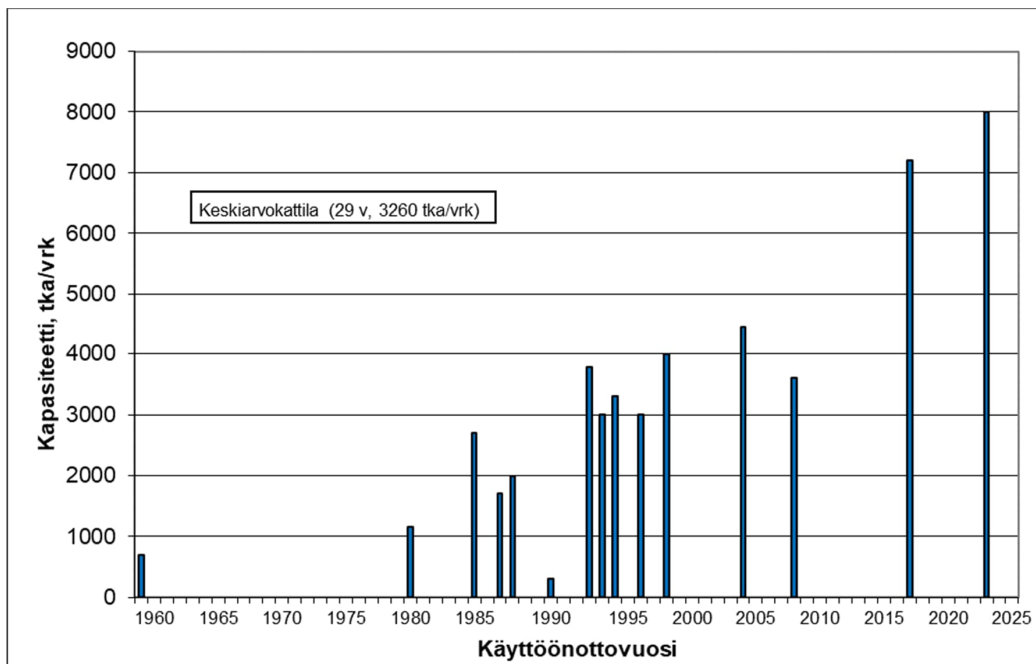


Suomen soodakattilat

- Kattiloita 15 kappaletta
 - Vanhin vuodelta 1959 (63 vuotta - Kotka)
 - Uusin vuodelta 2023 (0 vuotta - Kemi)
 - Suurin 8000 tka/vrk (Kemi)
 - Pienin 300 tka/vrk (Heinola)
- Tehtaita 13 kappaletta
- Keskimääräinen kattilan ikä 29 vuotta (1994)
- Keskimääräinen kapasiteetti 3 260 tka/vrk
- Yhdistetty kapasiteetti 48 880 tka/vrk

Soodakattilapäivä 2023

Suomen soodakattilat



Soodakattilapäivä 2023

Vauriotietokanta

- Kestoisuustyöryhmä ylläpitää vauriotietokantaa raportoiduista soodakattilavaurioista
- Jäsenet ilmoittavat vauriosta tai onnettomuudesta vapaaehtoisesti yhdistykselle.
- Kestoisuustyöryhmä käsittelee kokouksessa ilmoituksen ja laatii tapahtuneesta lausunnon.
- Lausunnoilla pyritään jakamaan tietoa hyvistä käytännöistä ja edistämään yleistä turvallisuutta

Kattilan käyttötilanne, jossa vaurio havaittiin

- ☒ Kaikki
- ☐ alasajo
- ☐ muu tuotantokatkos
- ☐ normaalikäyttö
- ☐ vesipainekoe
- ☐ vuosihuolto
- ☐ ylösajo

Vaurioitunut osa

- ☐ ekonomaiseri
- ☐ konvektio-osa
- ☐ lieriö
- ☐ muu osa
- ☐ tulipesä
- ☐ tulistin
- ☐ verhoputkisto

Huom! Vaurioita ja häiriöitä voi ilmoittaa tietokantaan myös jälkikäteen.

Soodakattilapäivä 2023

Häiriötietokanta

- Sama periaate kuin vaurioiden ilmoittamisessa
- Automaatiotyöryhmä käsittelee kokouksessa ilmoituksen ja laatii tapahtuneesta lausunnon.
- ”Häiriöksi voidaan määritellä tilanne, jossa soodakattilaa ei ole pystytty käyttämään odotetulla tavalla, koska joku laite tai järjestelmä ei ole toiminut oikein. Tilanteesta voi olla seurauksena esimerkiksi kattilan alasajo. Esimerkkinä primääri- ja sekundääri-ilman paineiden äkillinen heilahdus voi aiheuttaa häiriön ja kattilan alasajon.”

Häiriön aiheutti

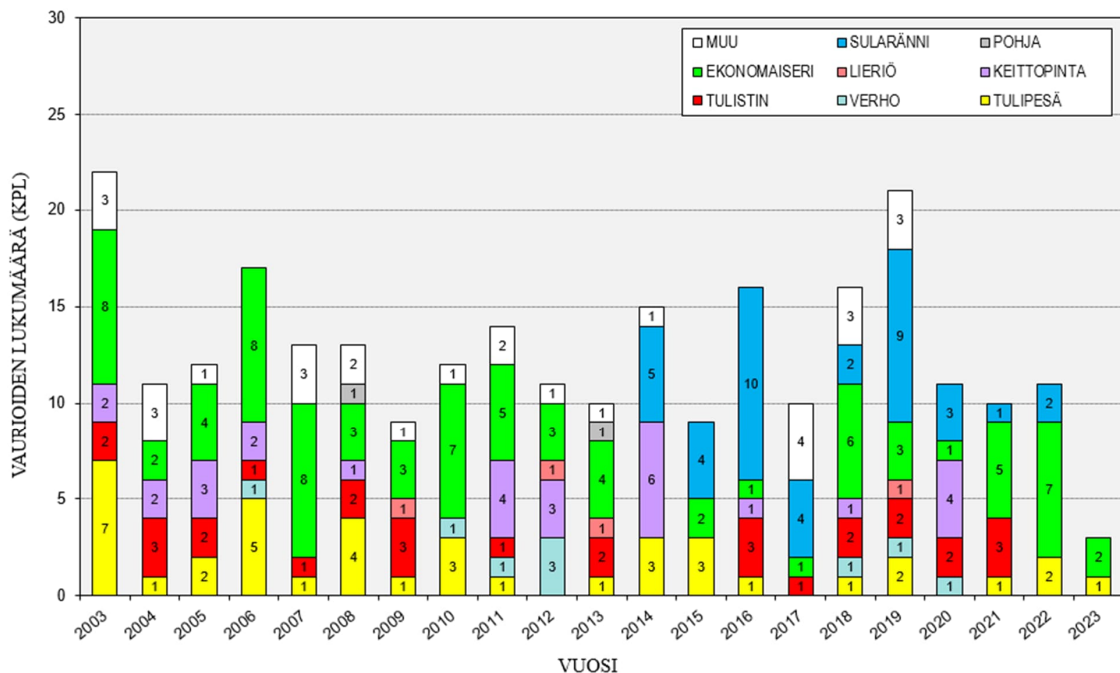
- ☒ Kaikki
- ☐ 1 sähköhäiriö
- ☐ 2A vika pääjärjestelmässä
- ☐ 2B vika turvajärjestelmässä
- ☐ 3A vika pääjärjestelmän asennuksessa
- ☐ 3B vika turvajärjestelmän asennuksessa
- ☐ 4 kunnossapidollinen toimenpide

Häiriön aiheuttaneen turvajärjestelmän tyyppi

- ☒ Kaikki
- ☐ 1 relelogiikka
- ☐ 2 langoitettu logiikka
- ☐ 3 ohjelmoitava logiikka
- ☐ 4 automaatiojärjestelmä

Soodakattilapäivä 2023

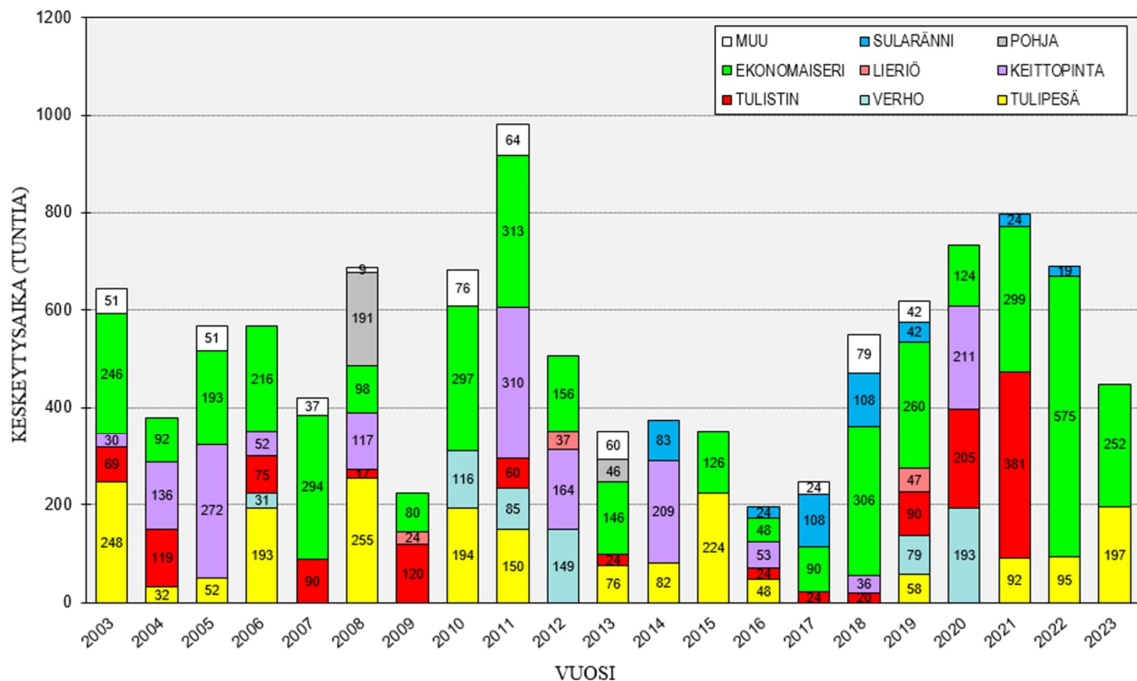
RAPORTOITUIJEN VAURIOIDEN LUKUMÄÄRÄ VAURIOTYYPEITTÄIN VUOSINA 2003-2023



Soodakattilapäivä 2023



LIPEÄN POLTON KESKEYTYSAIKA VAURIOTYYPEITTÄIN VUOSINA 2003-2023



Soodakattilapäivä 2023



VAURIOT ja SEISAKKIAIKA 3-vuotinen keskiarvo



Soodakattilapäivä 2023



Yhdistyksen projektit

Soodakattilapäivä 2023



Projekteja 2022-2023

- Kestoisuustyöryhmä
 - Materiaalisuosituksen päivitys: Putken kuorinta ja S0-linjaus
 - Soodakattilatyöntekijän suojavaatetuksen kehittäminen
 - Selvitys soodakattiloiden keraamisista rakenteista
 - S0-suosituksen käänös englanniksi
 - Compound-putkien säröily ja vauriomekanismit
 - Soodakattiloiden käytettävyyden ja luotettavuuden arviointi
- Lipeätyöryhmä
 - Tulistimien maksimipintalämpötilan muutos kattilan koon funktiona osat I-II
 - Korkean kappaluvoon vaikutus mustalipeän ominaisuuksiin

Soodakattilapäivä 2023



Projekteja 2022-2023

- Ympäristötyöryhmä
 - Hajukaasusuosituksen päivityksen käännös englanniksi
 - CCUS (hiilidioksidin talteenotto, hyötykäyttö ja varastointi) sellutehtailla
 - Opinnäytetyötietokanta
 - Viherlipeäsakan POP-yhdisteet
 - Soodakattilan tuhkan hyötykäyttömahdollisuudet
- Automaatiotyöryhmä
 - Kyberturvallisuuden perusteet soodakattilalla
 - Kattilalaitoksen sähkötekniset turvajärjestelmät (päivitys)
 - Järjestelmien välinen tiedonsiirto soodakattilalla – esimerkkinä OPC UA
 - Lipeäkierron jatkuvatoimisten mittalaitteiden luotettavuus

Soodakattilapäivä 2023



Opinnäytetyötietokanta

- Työn tavoitteena oli kerätä soodakattilaan läheisesti liittyvien 2000-luvusta alkaen tehtyjen opinnäytetöiden/diplomitöiden tiedot yhteen paikkaan Soodakattilayhdistyksen sivuille
- Opinnäytetyötietokanta filttareineen löytyy jäsensivuilta kohdasta Tutkimusraportit -> Opinnäytetyöt

Etsi

Vuosi

Oppilaitos

Saatavilla sähköisesti

Cooling procedure of the modern kraft recovery boiler

Tekijä: Wahlman, Toni

Aihe: Soodakattilaan liittyvät työt

Laajuus: Diplomityö

Vuosi: 2022

Oppilaitos: LUT

Saatavilla sähköisesti: Ei

Pysyvä linkki: <https://urn.fi/URN:NBN:fi-fe2022111065088>

Soodakattilapäivä 2023

Viherlipeäsakan POP-yhdisteet

- Pysyvät orgaaniset yhdisteet (Persistent organic pollutants) eli POP-yhdisteet ovat joukko myrkyllisiä ja hitaasti hajoavia halogenoituja hiilivetyjä
- POP-jätteen käsittelystä säädetään EU:n POP-asetuksessa (EU 2019/1021) sekä Suomen kansallisessa jätelainsäädännössä.
- Jätteenkäsittelymenetelmästä viherlipeäsakasta tehtiin perusanalyysit sekä kartoitettiin dioksiinien, furaanien ja PAH-yhdisteiden pitoisuudet



Soodakattilapäivä 2023

Viherlipeäsakan POP-yhdisteet

- 10 suomalaista tehdasta osallistui projektiin
 - Valkaistu massa: 3 tehdasta
 - Ruskea massa: 3 tehdasta
 - Molempia: 2 tehdasta
- Dioksiinien ja furaanien pitoisuudet alittivat POP-jätteen rajat selkeästi
- Myös PAH-yhdisteiden pitoisuudet olivat hyvin pieniä
- Materiaalia:
 - POP-jätteen tunnistusopas, Ympäristöministeriö, 2023
 - POP-asetus, EU, 2019
 - Päivitys POP-asetuksen liitteisiin IV ja V, EU 2022

Analysed by Eurofins Nab Labs Oy, Titaantie

MILL	Dry matter, %	Carbonate CO ₃	Sulphate SO ₄ , water soluble	Chloride Cl ₂ , water soluble	Unburned coal	Unit
	SCAN-N 22	SCAN-N 32	SCAN-N 6	SCAN-N 4	Gravimetric, internal method	
A	46.4	18.6	0.02	<0,01	4.5	% dw
B	36.3	16.9	0.07	0.14	2.3	% dw
C	56.0	36.1	0.08	0.04	1.4	% dw
D	43.3	31.1	<0,01	<0,01	1.8	% dw
E	74.0	22.7	0.08	<0,01	6.7	% dw
F	44.4	23.3	0.08	<0,01	9.2	% dw
G	30.1	32.4	0.15	<0,01	14	% dw
H	54.2	44.3	0.02	<0,01	0.48	% dw
I	42.3	34.3	0.1	<0,01	3.2	% dw
J	49.3	19.4	0.02	<0,01	0.95	% dw
AVG	47.6	27.9	0.1	0.1	4.5	% dw
MIN	30.1	16.9	0.02	0.04	0.48	% dw
MAX	74.0	44.3	0.2	0.1	14.0	% dw

"<" = Result is under the quantification limit of the analysis method
ND = not detected; dw = dry weight

Soodakattilapäivä 2023



Lisätietoa toiminnasta yhdistyksen nettisivuilta

www.soodakattilayhdistys.fi

sakari.vuorinen@afry.com
emma.karkkainen@afry.com
paivi.lampinen@afry.com
katri.hukkanen@afry.com



Soodakattilapäivä 2023

**CCUS (CARBON CAPTURE AND UTILIZATION OR STORAGE)
SELLUTEHTAALLA**

***Esa Vakkilainen
LUT-yliopisto***

LAND OF THE CURIOUS

 Soodakattilapäivä 2.11.2023

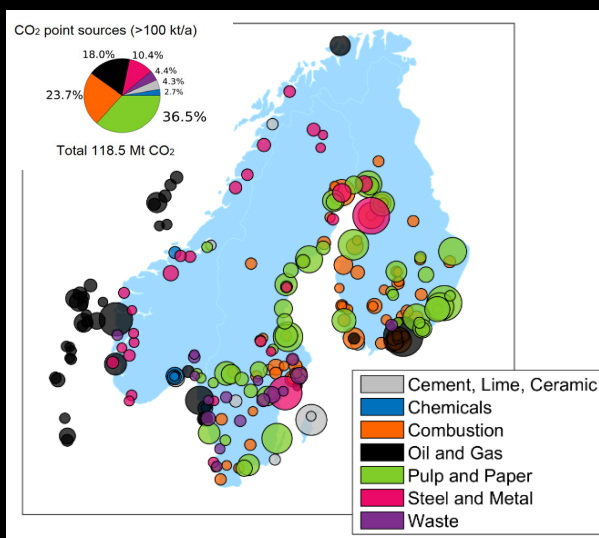
CCUS (CARBON CAPTURE AND UTILIZATION OR STORAGE) SELLUTEHTAALLA

LUT-yliopisto, Esa Vakkilainen

TAVOITTEET

- » Työssä kartoitetaan hiilidioksidin talteenoton menetelmiä sellutehtaan näkökulmasta
- » Arvoidaan niiden vaikutusta sellutehtaan toimintaan
- » Arvoidaan talteenoton kustannuksia
- » Arvoidaan politiikkatoimia, joilla käyttöönottomahdollisuuksiin sellutehdasympäristössä voidaan vaikuttaa

SUOMEN METSÄTEOLLISUUS TUOTTAA CO₂

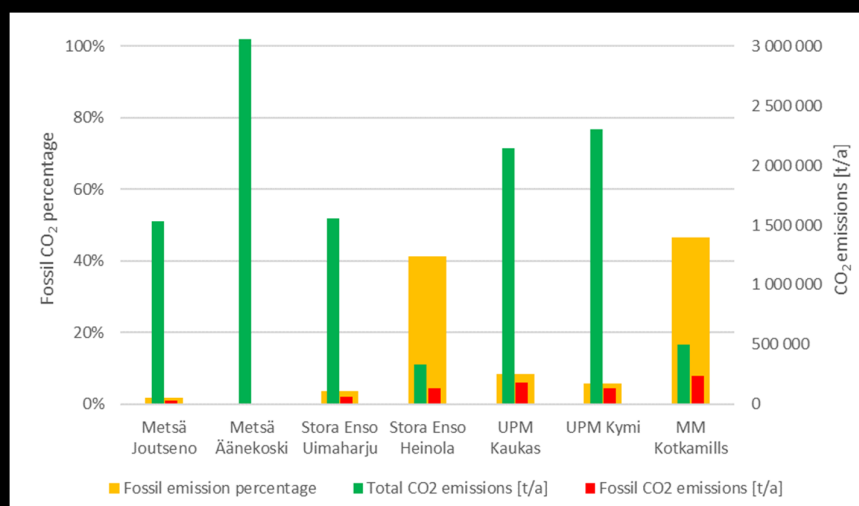


- » Fossiilinen CO₂ ei käy
- » Metsäteollisuudesta saatavissa >20 MtCO₂/a
- » Jos 10 MtCO₂/a metanoliksi
 - Tarvitaan 9000 MW sähköä
 - Tuotetaan 7.5 MtMeOH
 - ~12 % meriliikenteen polttoaineesta
 - Hinta 800-1000 €/t
- » Liikevaihtoa 7-8 miljardia €

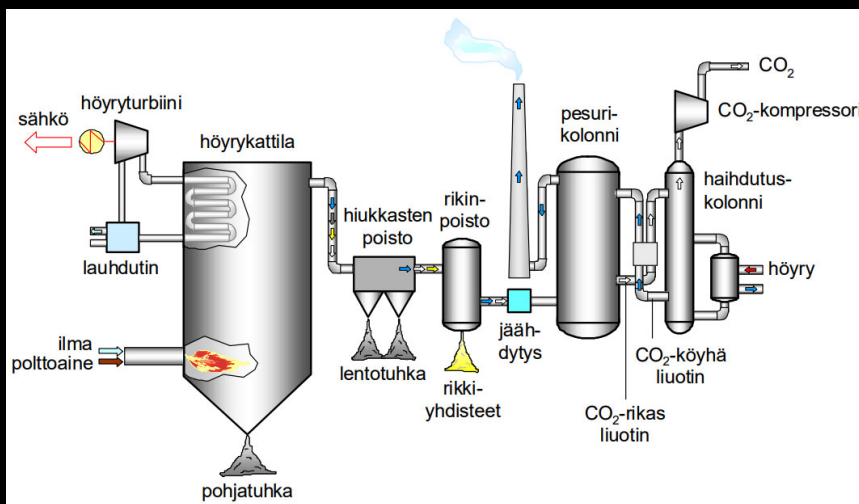
SAVUKAASUT ESIMERKKITEHTAALLA

	Osuus CO ₂ päästöistä, %	CO ₂ , mol-%(kostea)	H ₂ O, mol-%	Määrä, tCO ₂ /ADt
Soodakattila	68.0	15.7	22.9	2.25
Kuorikattila				
Märkä kuori	23.4	12.2	23.1	0.77
Puristettu kuori	23.4	13.5	14.9	0.77
Meesauuni	8.6	20.4	30.9	0.28

SUOMALAISTEN TEHTAIDEN CO2



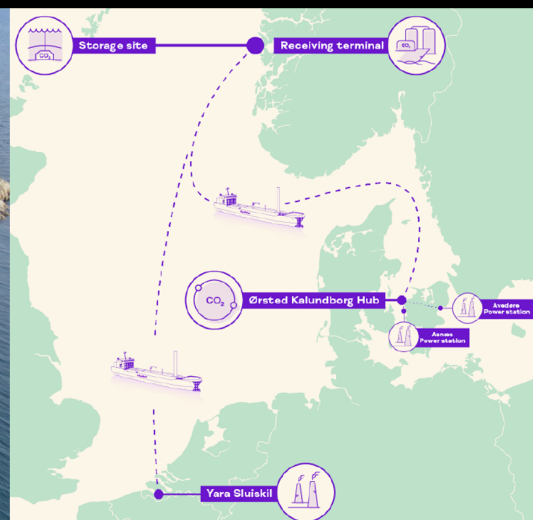
CO₂ TALTEENOTTO SAVUKAASUISTA



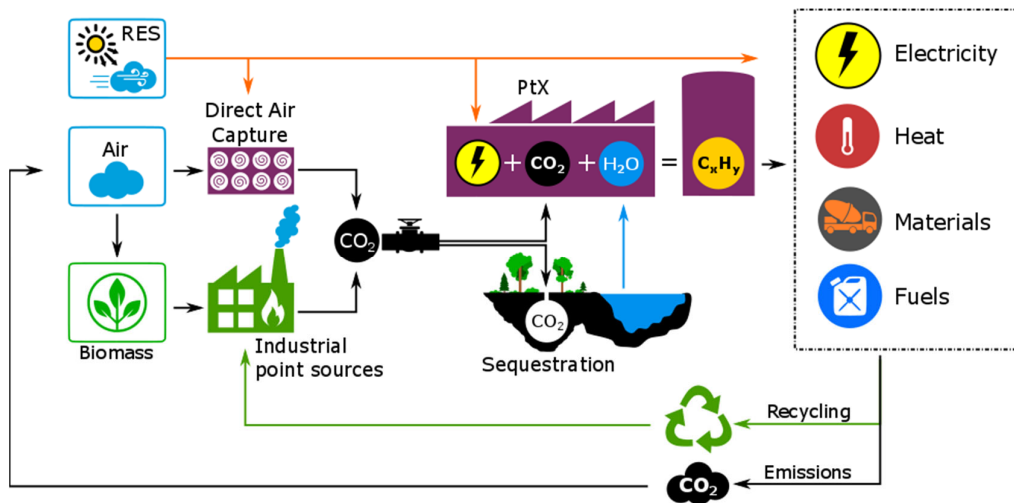
Lähde: VTT

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NORTHERN LIGHTS VOI VASTAANOTTAA CO₂



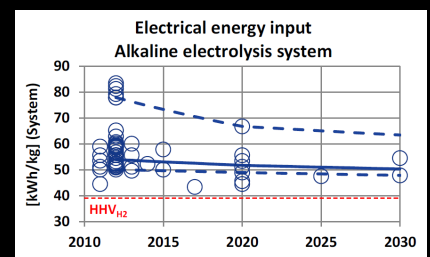
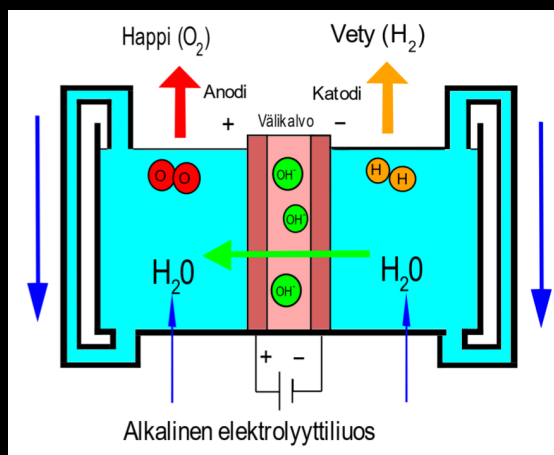
TIE NEGATIIVISIIN PÄÄSTÖIHIN - HIILEN KIIERRÄTYS



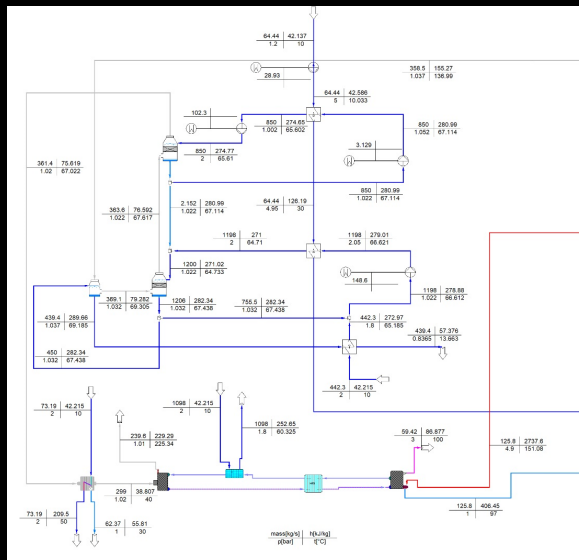
Kestävä järjestelmä

Lopulta ainoa kestävä järjestelmä on suljettu kierto, jossa materiaalit kierrätetään ja prosessien vaatima energia otetaan uusiutuvista lähteistä. Esiteollisen ajan CO_2 pitoisuus voidaan saavuttaa CCS:n avulla.

ELEKTROLYYSERILLÄ VETYÄ



MALLI CO2 TALTEENOTOLLE

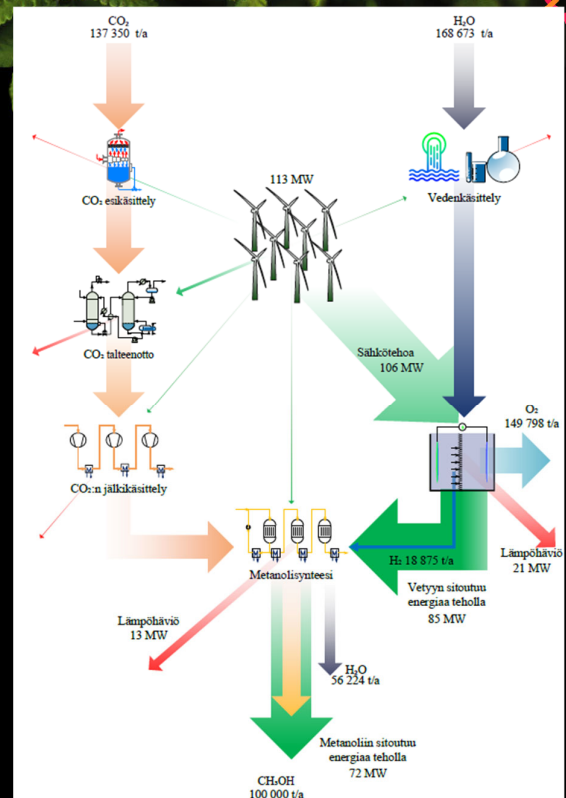


TASEET CO2 TALTEENOTOLLE

Osuus savuk. [%]	20	30	40	50	60	66
Talteenotto [tCO ₂]	544 700	817 000	1 089 400	1 361 700	1 634 100	1 797 500
Lämpöä [MW]	88.9	133.4	177.8	222.3	266.7	293.4
Sähköä [MW]	199.1	197.9	187.6	175.2	164.2	158.2
Lauhdemäärä [MW]	164.4	126.4	97.7	70.8	43.5	22.8

METANOLITASE (JATKUVA)

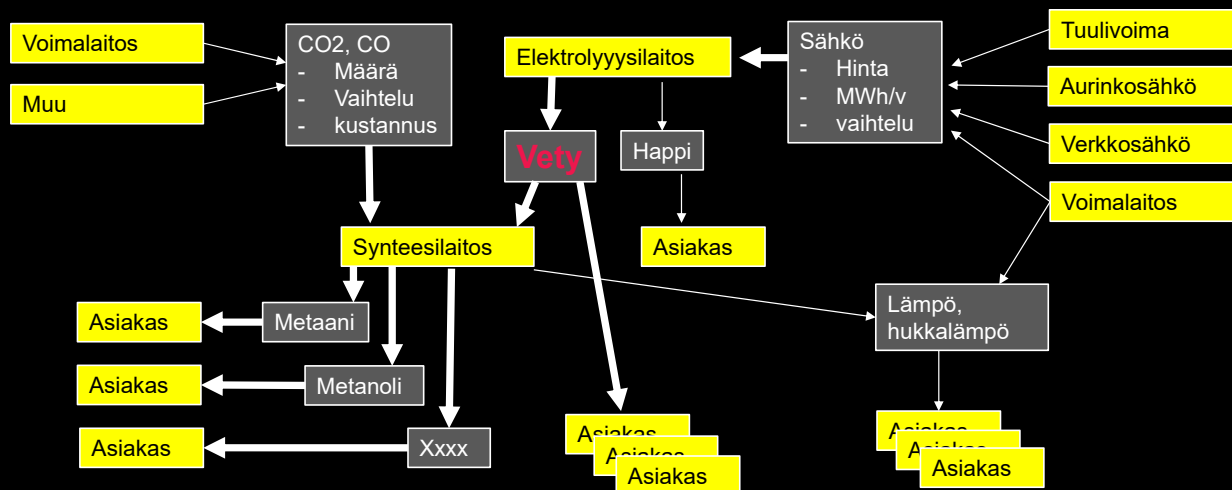
- » CO₂ 137350 t/a
- » Sähkö **106 MW**
- » Vettä 168673 t/a
- » Happea 149798 t/a
- » Vetyä 18875 t/a
- 85 MW**
- » Metanoli 100000 t/a
- » Liikevaihtoa ~60 M€/a



YHTEENVETO

- » Näyttää siltä että 100 000 tCO₂ talteenotto olisi mahdollista useammallakin suomalaisella sellutehtaalla
- » Energiatase tai hiilidioksidin talteenottojärjestelmä ei rajoita kapasiteettia
- » Suurin rajoite tulee ainakin alussa ostosähkön rajallisesta kapasiteetista
- » EU regulation kehitys vaikuttaa P2X markkinoihin

KUN KEHITÄMME VETYTALOUTTA – MITÄ SE ON?



**TULISTIMIEN MAKSIMIPINTALÄMPÖTILALISÄN MUUTOS KATTILAN
KOON FUNKTIONA**

Jussi Saari
LUT-yliopisto

LAND OF THE CURIOUS

 SOODAKATTILAPÄIVÄ 2.11.2023

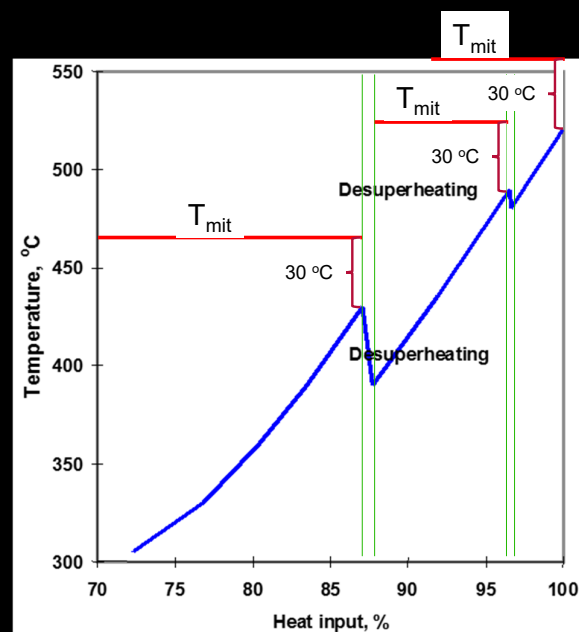
TULISTINTUTKIMUS

LUT-Yliopisto

Jussi Saari, Esa Vakkilainen

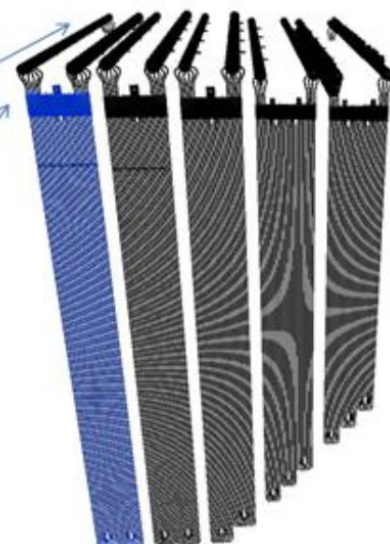
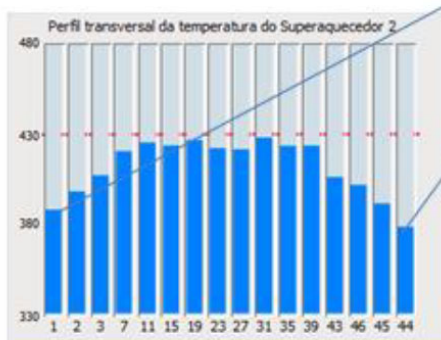
LÄMPÖTILALISÄ TULISTIMISSA

- » Kattilateollisuudessa perinteisesti käytetään mitoituskeskilämpötilaan $+30\text{ °C}$ tulistimen ulostulon keskilämpötilaan
- » Jos toimintalämpötila $>$ mitoituslämpötila, putket viruvat nopeammin
- » Onko $+30\text{ °C}$ oikea mitoitus kaiken kokoisille kattiloille?
 - Uusilla isoilla kattiloilla varsinkin ensimmäinen tulistin savukaasun suunnassa nostaa paljon lämpötilaa - tarvitseeko isomman arvon?
- » Onko saman jakotukin rinnakkaisille putkille sama:
 - Villaroel 2018: yhden tulistinpaneelin reunimmainen putki tulistaa jo 30 °C enemmän



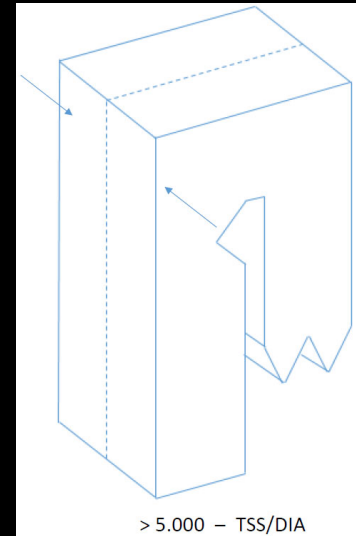
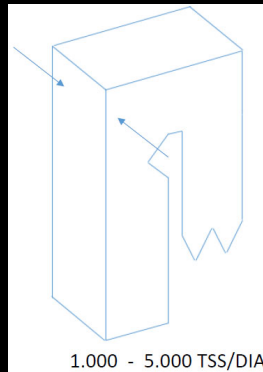
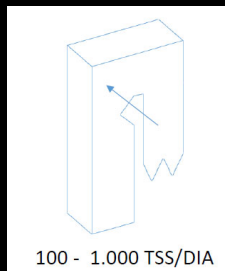
TULISTIMEN KESKELLÄ PUTKET KUUMEMPIA KUIN REUNOISSA

- » Kattilan keskellä kuumimmat savukaasut



30 °C PERÄISIN AJALTA KUN KATTILAT ALLE 1000 T_{KA}/D

- »Etuseinän leveys kasvanut kolminkertaiseksi
- »Onko lämpötilaero reunat – keskellä myös noussut
- »Onko pienellä kattilalla (7 m) sama ero kuin isolla (18 m)



TULISTINPROJEKTI

- »Vaihe I – datan keräys suomalaisista kattiloista
 - 2-3 esimerkkitehdasta; ensimmäinen ja viimeinen tulistin
- »Vaihe II – rinnakkaisten putkien koon ja lukumäärän vaikutus
- »Vaihe III – CFD mallinnus: pieni ja iso kattila
 - Virtausmallinnus eri kokoisilla kattiloilla
 - Lämpövirrat keskellä ja reunoilla
- »Vaihe IV – miten tuloksia hyödynnetään
 - Lämpötilajakauma – miten muutamalla mittauksella arvioida jakaumaa
 - Miten eri ajo- ja ilmamallit voi aiheuttaa eroja materiaalilämpöihin
 - Nuohous- ja ruiskutus yhteistoiminta

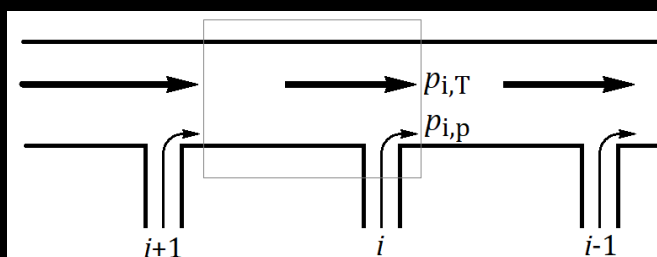
TARKASTELEVAT KATTILAT

	KATTILA A	KATTILA B	KATTILA C
Nimelliskapasiteetti [t_{ka}/d]	7200	3600	700
Tuorehöyryvirta [kg/s]	363	168	34.5
Paine [bar]	115	102	84
Lämpötila [$^{\circ}C$]	515	505	460

LASKENTAPERIAATE

1. Ensimmäinen arvaus = ideaalinen tasajakaumatilanne, kaikissa putkissa sama massavirta
2. Lasketaan painehäviöt jakotukissa, putkissa, ja keräystukissa
 - Kokonaispainehäviöt ei samat jokaiselle putkelle (lähtöoletus sama massavirta)
3. Saadaan paine-ero (virhetermi) Δp_i jokaisen tulistinputken i sisääntulossa keräystukkiin, keräystukin paineen $p_{i,T}$ ja putkesta tulevan höyryn paineen $p_{i,p}$ välille:

$$\Delta p_i = p_{i,T} - p_{i,p}$$
4. Säädetään massavirtoja kussakin putkessa i , kunnes $\Delta p_i \approx 0$

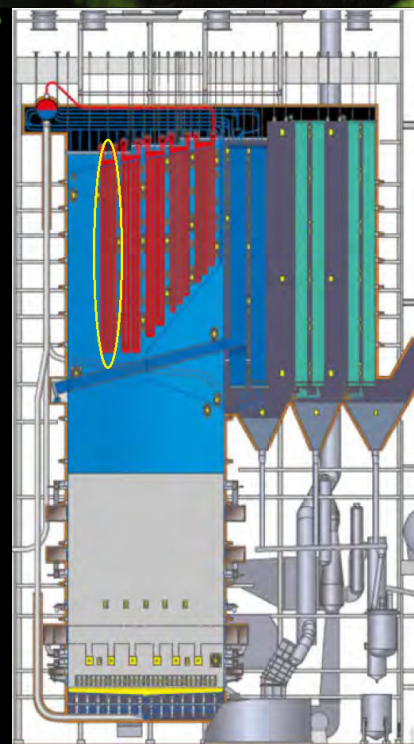


KATTILA A, TULISTIN II

» Tulistin II, ensimmäinen savukaasun virtaussuunnassa

- 5 putkea/paneeli, 63 mm OD (6.3 mm seinämä)
- 4 läpikulkua
- Mittausdata 23 putken pintalämpötilasta ulostuloissa.
- Oletus: mitattu joka toiselta panelilta → yhteensä 47 paneelia

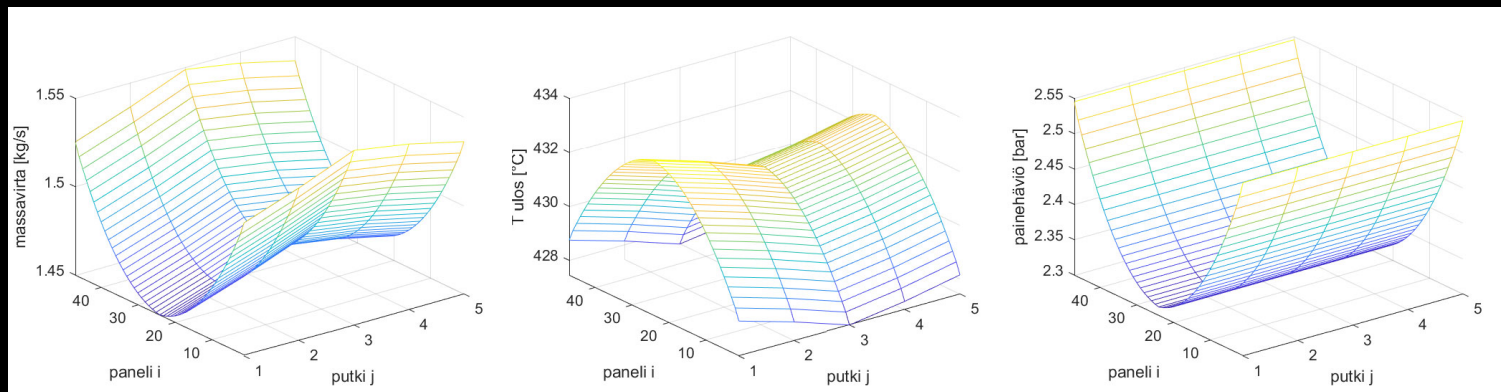
- Mittaukset 2 vuorokaudelta
- Kuva: keskimääräinen T_{ulos}
- Mittauksista puolet keskimmaisessa, puolet reunimmaisessa putkessa



KÄYTETYT OLETUKSET: KATTILA A

- » Höryvirta sisään 350 kg/s (mittausjakso: keskimääräinen kuorma 7300 t_{ka}/d)
- » Tila sisääntulossa:
 - 125 bar
 - 360 °C
- » Suurin virtausnopeus jako- ja keräystukeissa: noin 20 ja 25 m/s (halkaisija 440 mm)
- » Tulistinpaneelin korkeus: 21.5 m
- » Lämpövirran tiheys:
 - 25 kW/m²
 - Säädetty manuaalisesti tuottamaan likimain mitattu loppulämpötila

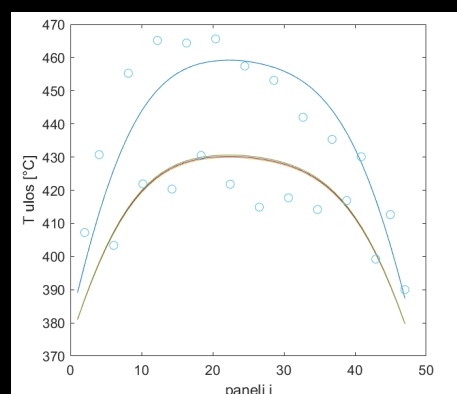
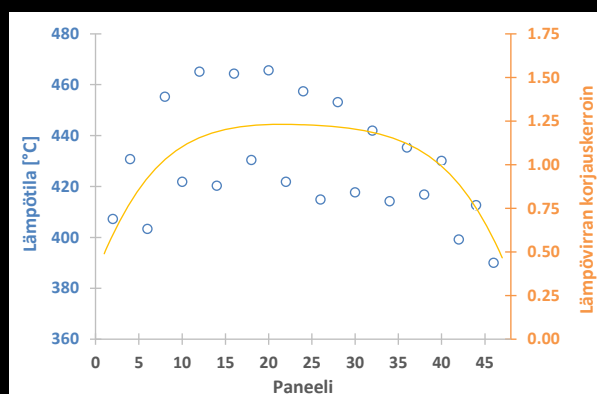
TULOKSET VAKIOLÄMPÖVIRRALLA, KATTILA A



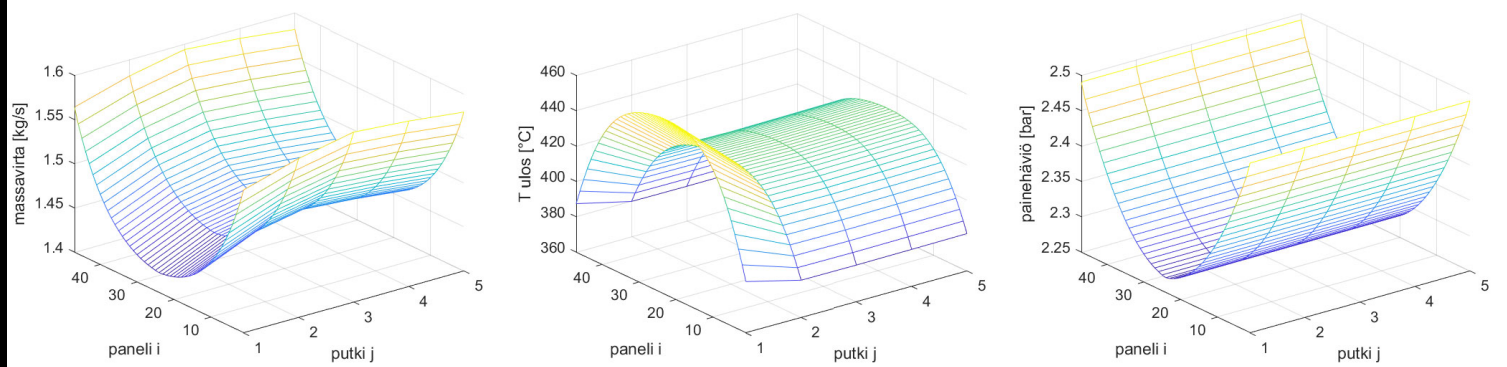
- » Virtausjakauma melko tasainen paneelien ja putkien välillä
- » Virtauksen jakautuminen selittää pienen osan mittaustulosten lämpötilaeroista,
 - Mittausdatassa paljon suurempi ero: $T_{kuumin} - T_{kylmin} \approx 75\text{ °C}$

LÄMPÖVIRРАН SOVITUS MITTAUKSIIN, KATTILA A

- » Lämpövirran korjauskertoimen sivusuunnassa:
 - Keskellä laajalti +10...20%
 - Reunojen minimi - 50%
- » Suuret korjauskertoimet savukaasun virtaussuunnassa:
 - Paneelien etu- ja alareunoille +80%
 - Paneelin takareunalle +10%



TULOKSET KORJATUIN LÄMPÖVIRROIN, KATTILA A

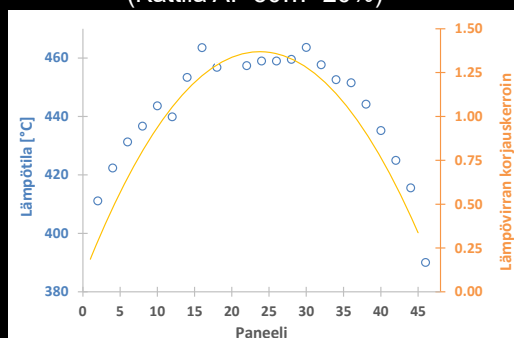


- » Lämpövirtakorjaus tuo lämpötilajakauman mittaustuloksia vastaavaksi
- » Seurauksena virtausjakauman epätasaisuus kasvaa vain melko vähän

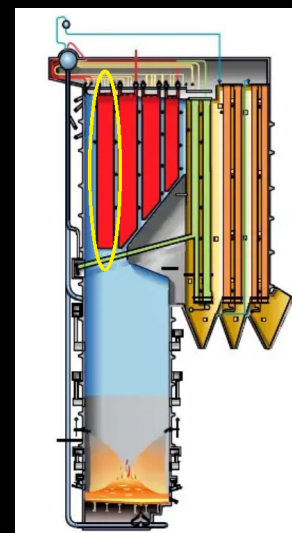
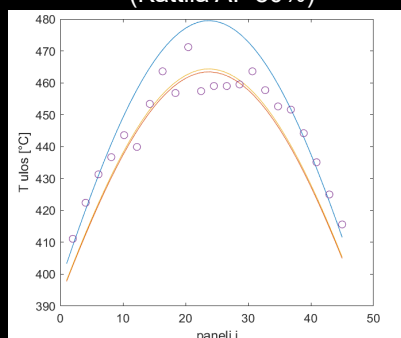
KATTILA B, TULISTIN II

- » Kattila A:n kaltainen; nimelliskapasiteetti n.puolet tästä ($7200 \rightarrow 3600 \text{ t}_{\text{ka}}/\text{d}$)
 - 3 63 x 6.3 mm putkea/paneeli, 45 paneelia, 4 läpikulkua (kattila A: 5 putkea, 47 paneelia)
 - Lämpövirta korjattu poikki- ja pituussuunnissa samalla periaatteella kuin A.

Poikkisuuntainen korjaus suurempi
(Kattila A: -50...+20%)

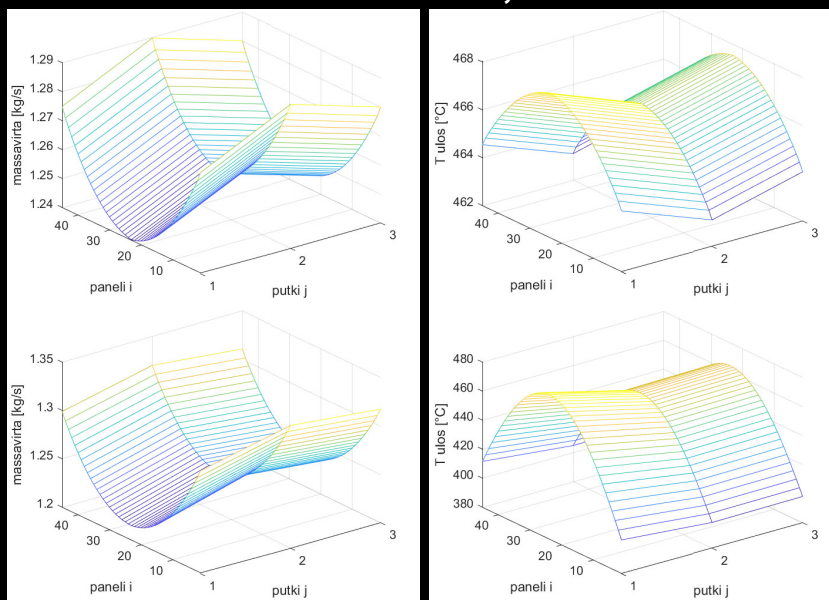


Etu- ja alareunan korjaus +50%
(Kattila A: +80%)



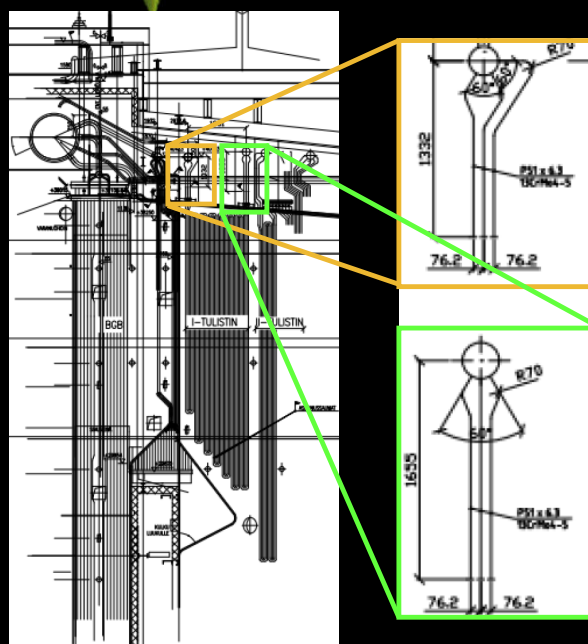
TULOKSET KORJATUIN JA VAKIOLÄMPÖVIRROIN, KATTILA B

- Ylemmissä kuvissa vakiolämpövirta
- Alla korjatuilla lämpövirroilla saadut tulokset
- Tulokset saman suuntaiset kuin Kattilalle A: poistuvan lämpötilan korjaaminen likimain mitattua vastaavaksi lämpövirran avulla muuttaa virtausjakaumaa vähän.



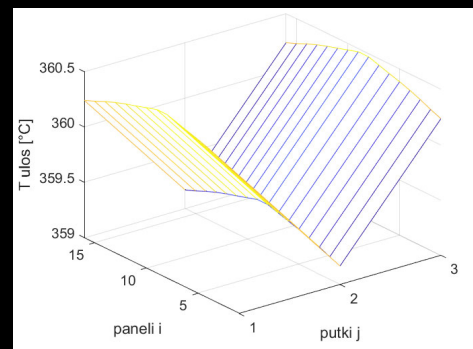
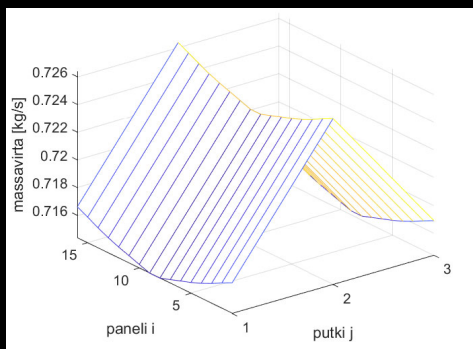
KATTILA C, TULISTIN I

- Merkittävästi pienempi kattila, kapasiteetti <10% Kattilasta A
- Mallinnettu tulistin I:
 - 14 putkiläpikulkua
 - 16 paneelia, 3 putkea/paneeli, 51.0 × 6.3 mm
- Putkikohtaisen ulostulolämpötiladatan puuttuessa tehtiin vain teoreettinen mallinnus tasaisella lämpövuon tiheydellä



TULOKSET VAKIOLÄMPÖVIRROIN, KATTILA C I-TULISTIN

- » Pieni määrä paneeleita ja suuri määrä läpikulkuja tuottaa tasaisen virtausjakauman
- » Vain n. 0,2°C ero ulostulolämpötiloissa keskimmäisten ja reunimmaisten paneelien välillä
- » Keskimäinen putki jonkin verran lyhyempi → suurempi massavirta ja pienempi lämpövirta
→ keskimmäisten putkien ulostulolämpötila n.1°C pienempi kuin reunimmaisissa



YHTEENVETO

- » Höryvirran jakautuminen tulistinputkiin kaikissa kattiloissa melko tasainen
- » Suurissa kattiloissa vaihtelu suurempaa; selittää silti vain muutaman prosentin lämpötilan vaihtelusta.
- » Kattiloiden A ja B II-tulistimien mitatut ulostulolämpötilat pienenevät reunoja kohti selvästi
- » Em. lämpötilavaihtelun selitykseksi jää lähes täysin savukaasupuolen lämmönsiirto- ja virtausilmiöt, joita tutkitaan vaiheessa III.

YHTEENVETO

- C-kattilan I-tulistimessa virtausjakauma kattiloiden A ja B II-tulistimia tasaisempi. Tätä selitti:
 - pienempi virtausnopeus jako- ja keräystukeissa
 - suurempi painehäviö lämpöpintaputkissa (14 läpikulkua).
- Kattilan suuri koko lisää virtauksen epätasaista jakautumista rinnakkaisten paneelien määrän kasvaessa
 - Vaikutus kuitenkin pienehkö, ja kohdistuu lähtökohtaisesti vaikutukseltaan vähäiseen ilmiöön.
 - Kompensoitavissa pienemmillä virtausnopeuksilla jakotukissa (suuremmat halkaisijat)
- Lämpötilajakauman parempi ymmärrys vaatii savukaasupuolen CFD-mallinnuksen.

LIGNIININ TALTEENOTTO, KÄYTTÖ JA NÄKYMÄT

Jarno Peltonen
SciTech Service Oy

SciTech Service

“Technology is the application of science for business objectives”

Lignin Separation

Recovery Boiler Day 2023
02.11.2023

Jarno Peltonen

SciTech-Service facts

- Established in 1983
- Year 2022 key figures:
 - ✓ **2.0 M€** turnover
 - ✓ 28 customers served in Europe, South America, Africa and Asia

HELSINKI TEAM:

11 experts (7 Dr., 1 Lic.Sc., 3 M.Sc.)

RAUMA LABORATORY:

1 M.Sc., 4 specialist technicians

(100% owned subsidiary, Experimentis Oy Inc)

- Global network of world leading experts
- Independent subsidiary of Andritz Oy since 7.7.2023

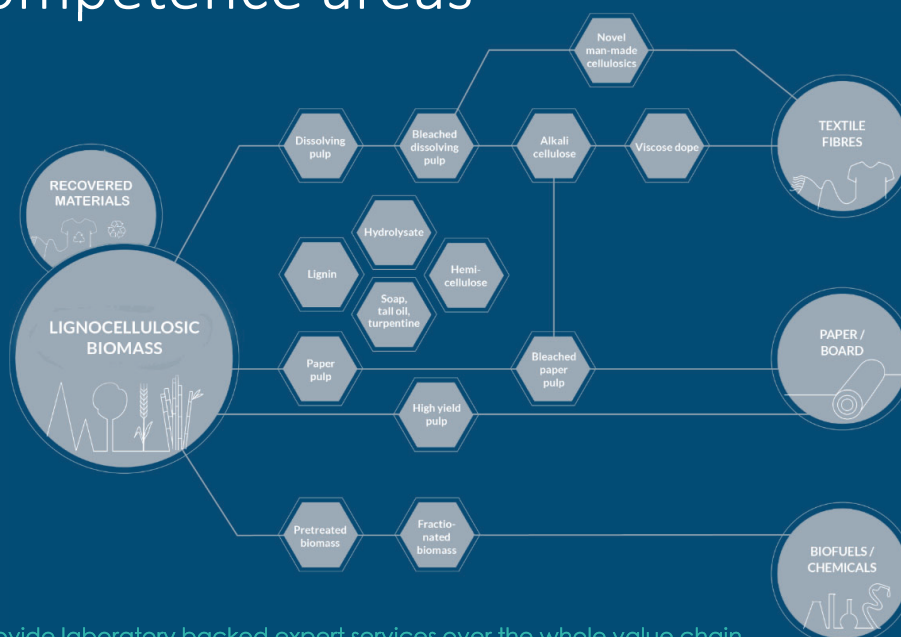


SciTech
Service

02/11/2023

3

Our competence areas



We provide laboratory backed expert services over the whole value chain

SciTech
Service

02/11/2023

4

Lignin Properties

- Typical lignin content of different wood species (% of OD wood):
 - Pine: 27 %
 - Spruce: 27 %
 - Birch: 20 %
 - Eucalyptus: 22 – 28 %
 - Acacia: 27 – 28 %
- Lignin content in kraft black liquor:
 - SW: 500 – 600 kg/ADt
 - HW: 350 – 450 kg/ADt
- Carbon content of lignin: 62 – 63 %
- Heating value (HHV) of lignin: 25 – 26.5 MJ/kgDS (BL appr. 14)
- Sulphur content of kraft lignin: 1.5 – 2.5 %
- Dried lignin powder has high dust explosion risk (higher than other biofuels)

Reasons for Lignin Separation and Lignin Utilization

Why?

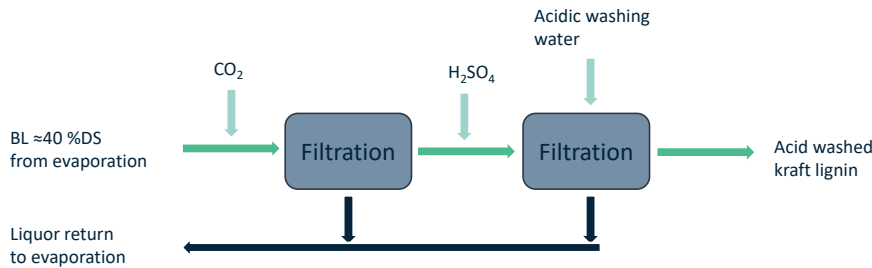
- Originally lignin was separated for debottlenecking recovery boiler → pulp capacity increase
- Pulp mill surplus energy recovery in other format than electric power → lignin as fuel in lime kiln or sold as fuel outside the mill etc.
- Additional bioproduct and revenue to pulp mill

Lignin Utilization

- Fuel
- Raw material:
 - Phenolic resins, binders
 - Active carbon
 - Composites
 - Batteries
 - Etc.

Lignin Separation – Commercial Processes

- Even 70 % lignin recovery from black liquor can be technically achieved, but in practice maximum feasible recovery rate is < 30 %.
- Commercial scale lignin separation technologies exist (acid washed lignin):
 - Andritz – LignaRec
 - Valmet – LignoBoost



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Lignin Separation – Impacts 1/2

- Evaporation:
 - Evaporation need increases due to liquors added for lignin separation are returned to evaporation
- Recovery Boiler:
 - Minimum boiler load is achieved typically with 30 – 40 % lignin removal rate. With higher rates flue gas temperature before the superheaters decreases and the HHRR decreases under boiler design level.
 - Lower furnace starts to be problematic already with 30 % lignin removal rate (TRS, SO₂ reduction). When removal rate approaches 40 % steam superheating starts to be affected.
 - ➔ Typically 25 - 30 % lignin removal rate is kept as practical maximum due to RB operation
- Lignin removal's impacts on black liquor:
 - Viscosity reduced when long lignin molecules are removed
 - BPR not significantly affected
 - Proportion of inorganics increases

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Lignin Separation – Impacts 2/2

- Na/S balance:
 - H_2SO_4 usage will have significant impact on Na/S balance, since in many case there is already excess of S due to ClO_2 by-product mixing to BL
 - Utilization of ClO_2 by-product maybe needs to be reduced
 - Due to sulphidity rise more RB fly ash maybe needs to be dumped
 - Other methods for Na/S balance controls needs to be considered
 - Sodium bisulphite sales
 - H_2SO_4 production from NCGs
 - Amount of lignin separated needs to be optimized
- Costs:
 - Most of lignin separation costs (acid wash lignin) come from chemicals:
 - CO_2 cost: $\approx 30\%$ of total
 - NaOH make-up cost: $> 40\%$ of total
 - H_2SO_4 cost: $> 10\%$ of total
 - Rest: increased evaporation need, power, maintenance etc.

Other Lignin Separation Alternatives 1/3

- LignoForce – Black liquor oxidation before lignin separation
 - Black liquor oxidated with O_2
 - Less H_2S than without oxidation
 - Better filterability than non-oxidized lignin
 - Process steps:
 - Oxidation with O_2
 - Acidification with CO_2
 - Coagulation
 - Filtration and washing with acid water
 - Drying

Other Lignin Separation Alternatives 2/3

Tailored lignin separation alternatives have been developed / are under development – All lignin doesn't need to be acid washed and dried

- LigniOx – Lignin dispersants at kraft pulp mill and at organosolv biorefinery
 - The LigniOx oxidation process uses O_2 under alkaline conditions to solubilize water-insoluble lignin
 - Oxidised lignin is used e.g. as concrete plasticizer and dispersants
 - Process steps:
 - CO_2 precipitation
 - Oxidation with O_2 (alkaline conditions)
 - Membrane concentration

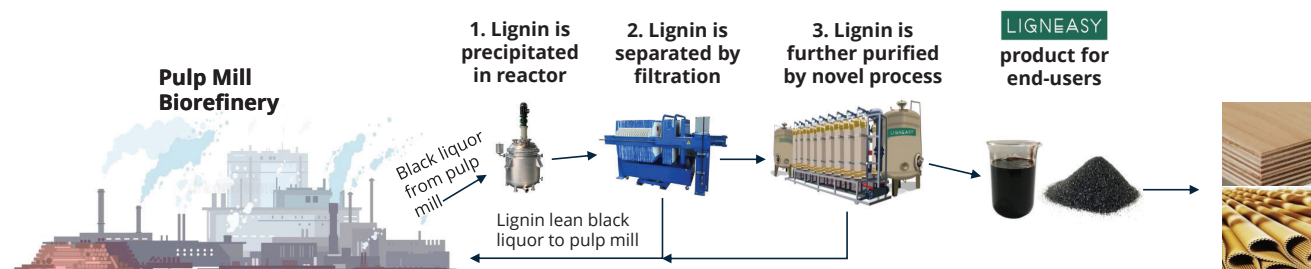
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Other Lignin Separation Alternatives 3/3

- LingEasy – sulfuric acid free, low impact lignin separation for kraft pulp mills for phenolic resins (plywood glue)
 - Lignin separation from black liquor based with precipitation with CO_2 and filtration
 - Lignin purification with novel process
 - Product for end users (either liquid or spray dried)
 - Sulfuric acid not used → Na/S balance not impacted



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12

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Future

- Development of the lignin market
- New innovations
- Higher value usages of lignin
- Tailored separation methods for different end uses
- Lignin separation as part of state-of-the-art pulp mill

SciTech
Service

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**MAXIMIZING SAFETY AND PERFORMANCE: ROADMAP TO
AUTONOMOUS ANDRITZ HERB™ RECOVERY BOILER**

Niki Lankila
ANDRITZ



PULP & PAPER AUTOMATION AND DIGITALIZATION

MAXIMIZING SAFETY AND PERFORMANCE

ROADMAP TO AUTONOMOUS ANDRITZ HERB RECOVERY BOILER

NIKI LANKILA
NOVEMBER 2, 2023

ANDRITZ
ENGINEERED SUCCESS

AGENDA

01 DEFINITION OF AUTONOMY

02 AUTONOMOUS PULP MILL

03 AUTONOMOUS RECOVERY BOILER

04 ANDRITZ PRODUCTS AND SOLUTIONS

05 RECOVERY BOILER CAPACITY EVOLUTION

06 CLIENT REFERENCES



Autos = self

Autos - nomos = self-law
Originates from Greek language

Capability of control systems to react to changes without human intervention



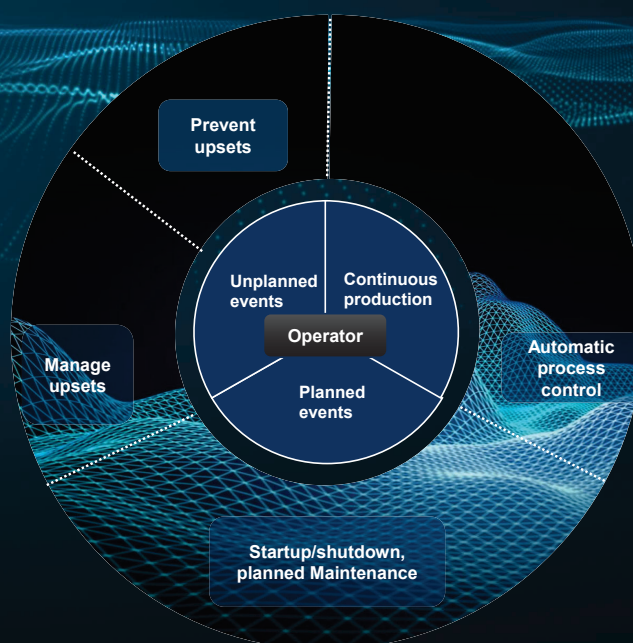
Autonomous pulp mill

Control tasks include complicated tasks, such as: reasoning, planning, problem solving, categorizing, adapting & learning from past scenarios

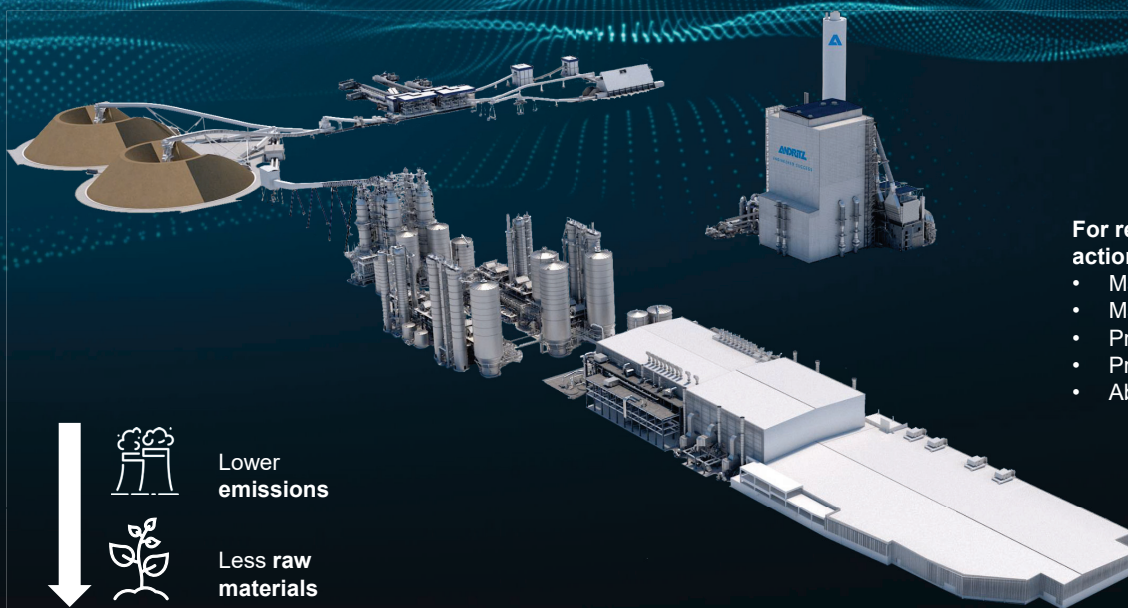
Autonomous decision-making system time space extends into future

Soma, R., Bratteteig, T., Saplaçan, D., Schimmer, R., Campano, E. & Verne, G.B. 2022. Strengthening Human Autonomy In the Era of Autonomous Technology
Formosa, P. 2021. Robot Autonomy vs. Human Autonomy: Social Robots, Artificial Intelligence (AI), and the Nature of Autonomy.
Tavallaey, S.S. & Ganz, C. 2019. Automation to Autonomy.

AUTONOMOUS PULP MILL

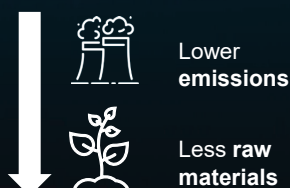


MULTIPLE PLANTS ACT JOINTLY AUTONOMOUSLY IN AN AUTONOMOUS MILL



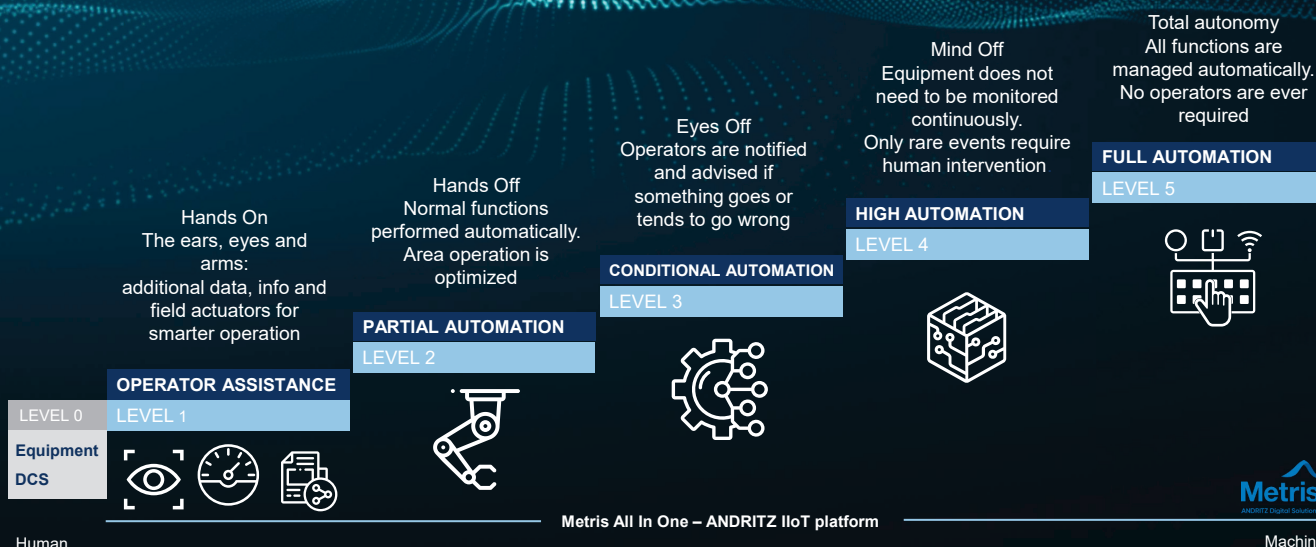
For reaching autonomy, following actions will be automated:

- Manual inspections
- Manual cleaning
- Process optimizing
- Production optimizing
- Abnormal situation management



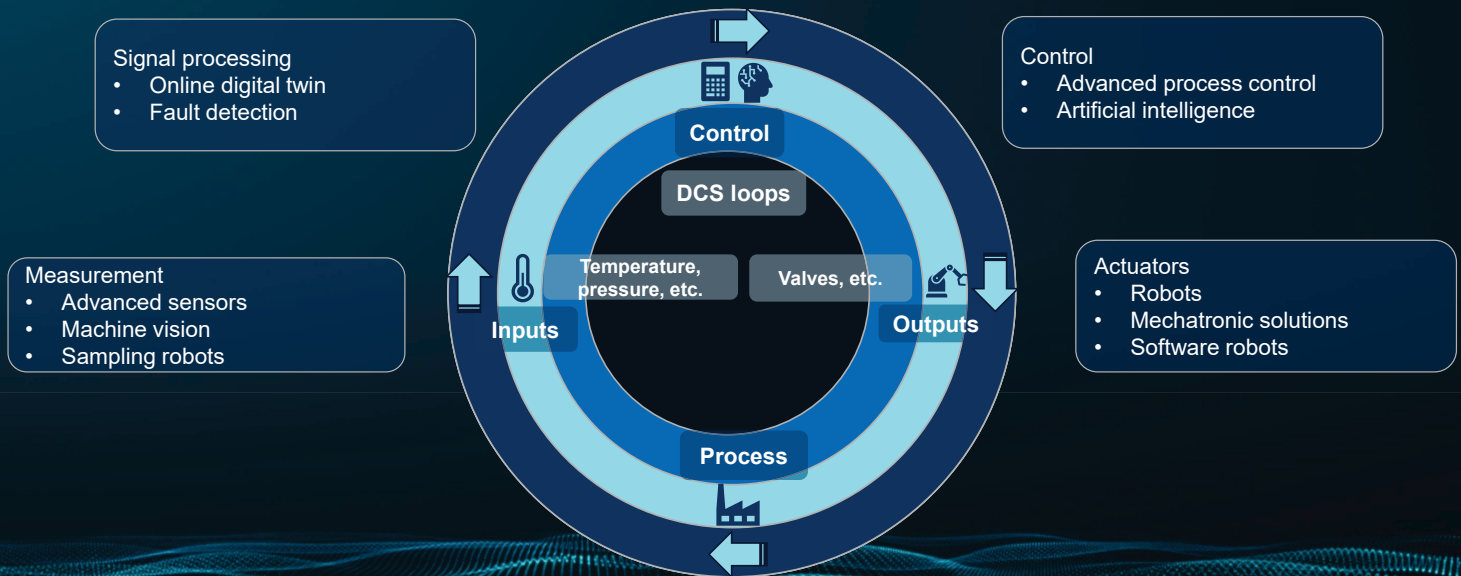
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LEVELS OF AUTONOMY IN PULP MILL



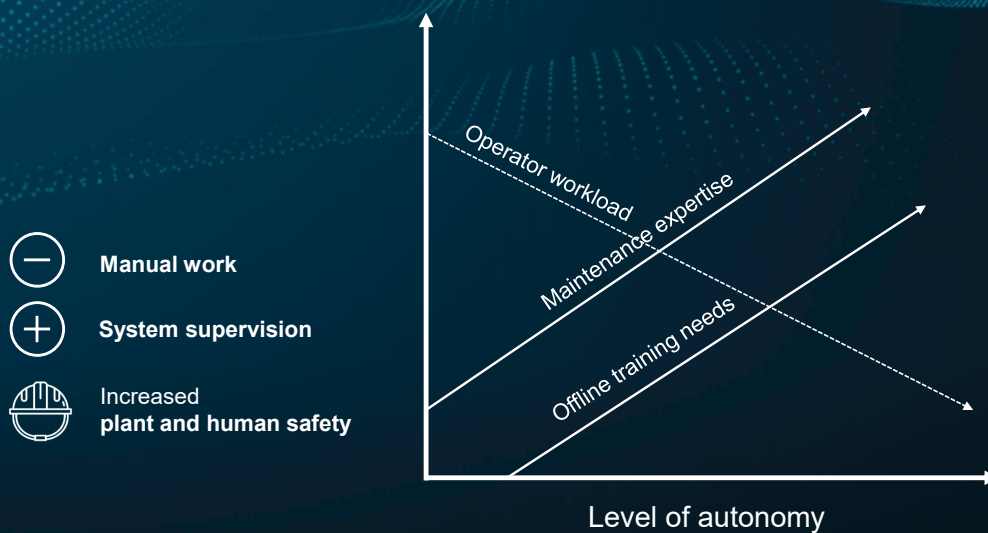
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AUTONOMOUS RECOVERY BOILER



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AUTONOMOUS RECOVERY BOILER



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AUTONOMOUS RECOVERY BOILER

- Normal production autonomy hierarchy:
 1. Control loops in DCS as backbone and back-up
 2. Advanced process controls for optimizing plant operation
 3. Online digital twins for future prediction & scenario studies
- Automatic start-up & shutdown sequences
 - With additional instrumentation & actuators
- Ongoing future developments:
 - Recovering from abnormal situations
 - Working within boundaries set by equipment malfunctions, limitations and abnormal situations



Target:
95% of plant on
automatic control

DIGITAL PRODUCTS AND SOLUTIONS

PURPOSE

PRODUCTS

PROCESS OPTIMIZATION

Maximize Process Performance

- Metris ACEs (Advanced Process Control)
- Metris Digital Twins
- Metris Autonomous Manager
- Metris Mill-wide Management
- Metris AVA (Computer Vision)

PLANT OPERATIONS AND MANAGEMENT

Maximize Operations Efficiency

- Metris X
- Metris SCADA
- Metris Plant InSights

ASSET OPTIMIZATION

Maximize Productivity and Asset Availability

- Metris Asset Management
- Metris Digital Twin

ADDITIONAL INSTRUMENTS AND ROBOTICS



- Advanced Visual Analysis
- Smart Sensors
- Digital Adviser
- Robotics



PURPOSE
PRODUCTS

Visual analysis for difficult, expensive or impossible process measurements

- AVA Carryover
- AVA Spray Orientation Tool
- AVA Char bed Tool
- AVA Smelt Reduction Tool

Complimentary instruments for improved pulp & paper process optimization

- HEWI: Weight Indication System

Digital & AI advisors for improving operators situational awareness

- Water Leakage Advisor
- Decision Support Wall

Robotized and mechatronic solutions for safe & optimized field operation

- Smelt Spout Robot
- Automatic Carryover Measurement
- SMART Liquor Burning

ADVANCED VISUAL ANALYSIS

SMART SENSOR

DIGITAL ADVISER

ROBOTICS

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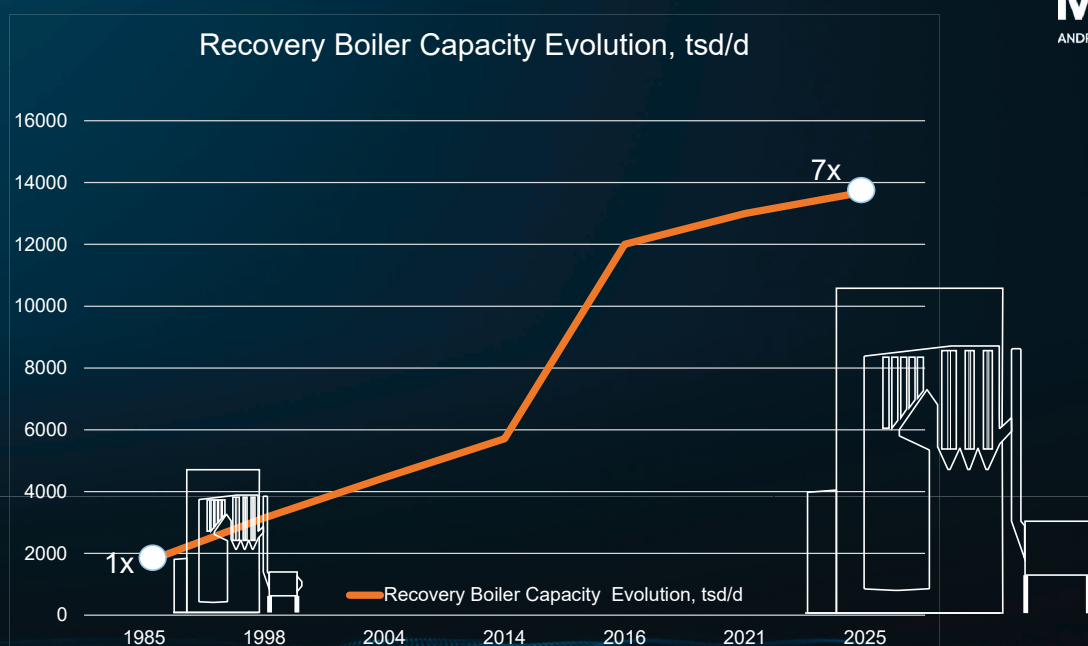


AUTONOMY IN MAGNUM BOILERS

RECOVERY BOILER CAPACITY EVOLUTION IN 1985-2021

ANDRITZ

ENGINEERED SUCCESS



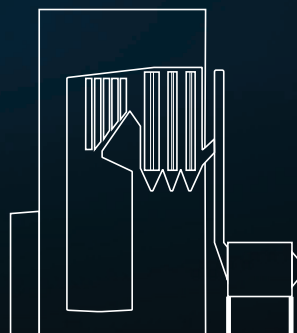
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AUTONOMY IN MAGNUM BOILERS

Due to the increased size of recovery boilers, both manpower and automation solutions are required when maintaining one.

- Boiler sizes continue to grow and > 10 000 tds/d boilers are becoming normal
 - Daily operation alone is challenging in such boilers, not to mention the temporary equipment malfunctions

- ✓ < 10 liquor sprays to be cleaned every hour
- ✓ < 5 smelt spouts to be cleaned every hour



- ✓ +30 liquor sprays to be cleaned every hour
- ✓ +10 smelt spouts to be cleaned every hour



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CASE: SMELT SPOUT CLEANING SYSTEM



Mondi Frantschach mill, Austria, 2021



Safety risk
reduction
92%



"By using a robot, we have substantially reduced the physical and also mental strain in this exposed area."

Gottfried Joham,
Managing Director at Mondi Frantschach

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CASE: WATER LEAKAGE DETECTION



Smurfit Kappa's Nettingsdorf mill, Austria, 2023



Increased
plant and
human
safety



"To bring the ANDRITZ WLA experts together with the recovery boiler team was an excellent idea. These experts listened to all our needs and put into place almost all of the suggestions we had to enable the solution to give us all the information we needed."

Walter Marchgraber,
Pulp Mill Manager, Smurfit Kappa Nettingsdorf

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**UUSIA SOODAKATTILOITA KIINAAN –
ENERGIA- JA PÄÄSTÖRATKAISUT**

Markku Isoniemi
Valmet Technologies Oy



New recovery boilers to China –
energy and emission solutions

Uusia soodakattiloita Kiinaan –
energia- ja päästöratkaisut

Soodakattilapäivä 2023

Markku Isoniemi

New pulp mills to China

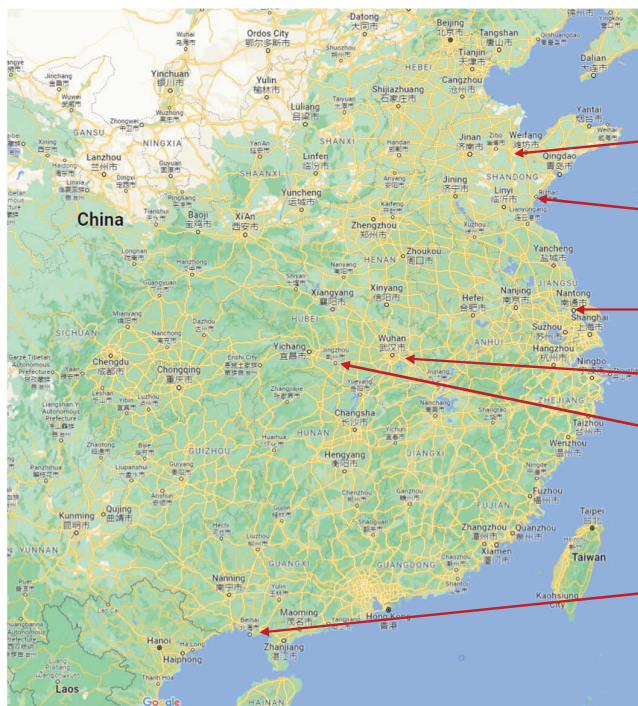
Background

- China has been worlds biggest importer of recycled paper and board (e.g. OCC). Between 2017 and 2020 waste paper imports to China practically stopped. This caused lack of fiber to Chinese paper industry.
- Many major Chinese paper companies decided to invest in new pulping capacity. Most of the new chemical pulp capacity is unbleached / high kappa. A lot of BCTMP pulp capacity is also added.
- Main reason for these pulp grades are higher grade packaging materials like FBB (folding box board). Total new capacity planned 5 years ago was about 10 million ADt/a
- China does not have wood resources for this new capacity so mainly they plan to import chips
- New pulp mills have also new paper machines. Main steam systems are normally separate. Typically coal fired power boilers have back pressure turbines for paper mill and recovery boiler a condensing turbine for pulp mill. Excess power from recovery boiler can be used in paper mill but not sold to external grid.

Recovery boiler projects in China

- New recovery boilers are often bigger than local boiler suppliers are used to. Chinese customers also want high electricity and steam generation. These factors have favored European RB suppliers.
- Scope of delivery is most often supply of “core machinery” only + engineering of layout, boiler building, piping and ducting
- Emissions: dust limit strict (10 mg/Nm³); NO_x limit is typically required 50 or 100 mg/Nm³
- Manufacturing and equipment mainly from China
- Customers involve a Chinese design institute who provides engineering for equipment and materials in customer scope
- Customers handle erection and site works, only small advisor team from boiler supplier
- Changes happen in project schedule
- Lots of travel restrictions / quarantines during Covid period

Recent recovery boiler projects in China



Shandong Huatai (2025)	3200 tds/d	105 barg	515°C
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ASSD Rizhao RB2 (2010)	7500 tds/d	83 barg	480°C
ASSD Rizhao RB11 (2023)	3500 tds/d	100 barg	505°C

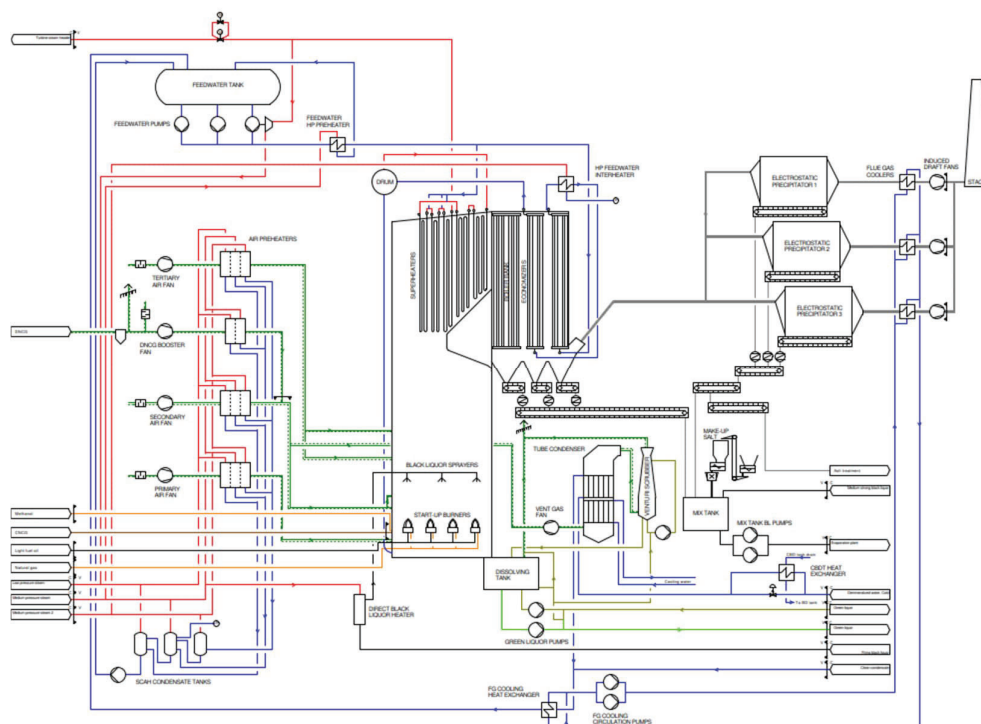
Oji Nantong (2014/2021)	3400 tds/d	78 barg	500°C
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Huanggang Chenming (2017)	4800 tds/d	105 barg	515°C
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Nine Dragons Jingzhou (2022)	2300 tds/d	99 barg	510°C
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Sun Paper Beihai (2021)	4600 tds/d	105 barg	515°C
Nine Dragons CP5 Beihai (2023)	2300 tds/d	99 barg	510°C
Nine Dragons CP10 Beihai (2023)	4600 tds/d	105 barg	515°C

High Power solutions



High Power features

- Feedwater interheater + interheater
- 3-stage air preheaters
- Flue gas coolers
- Vent gas condenser

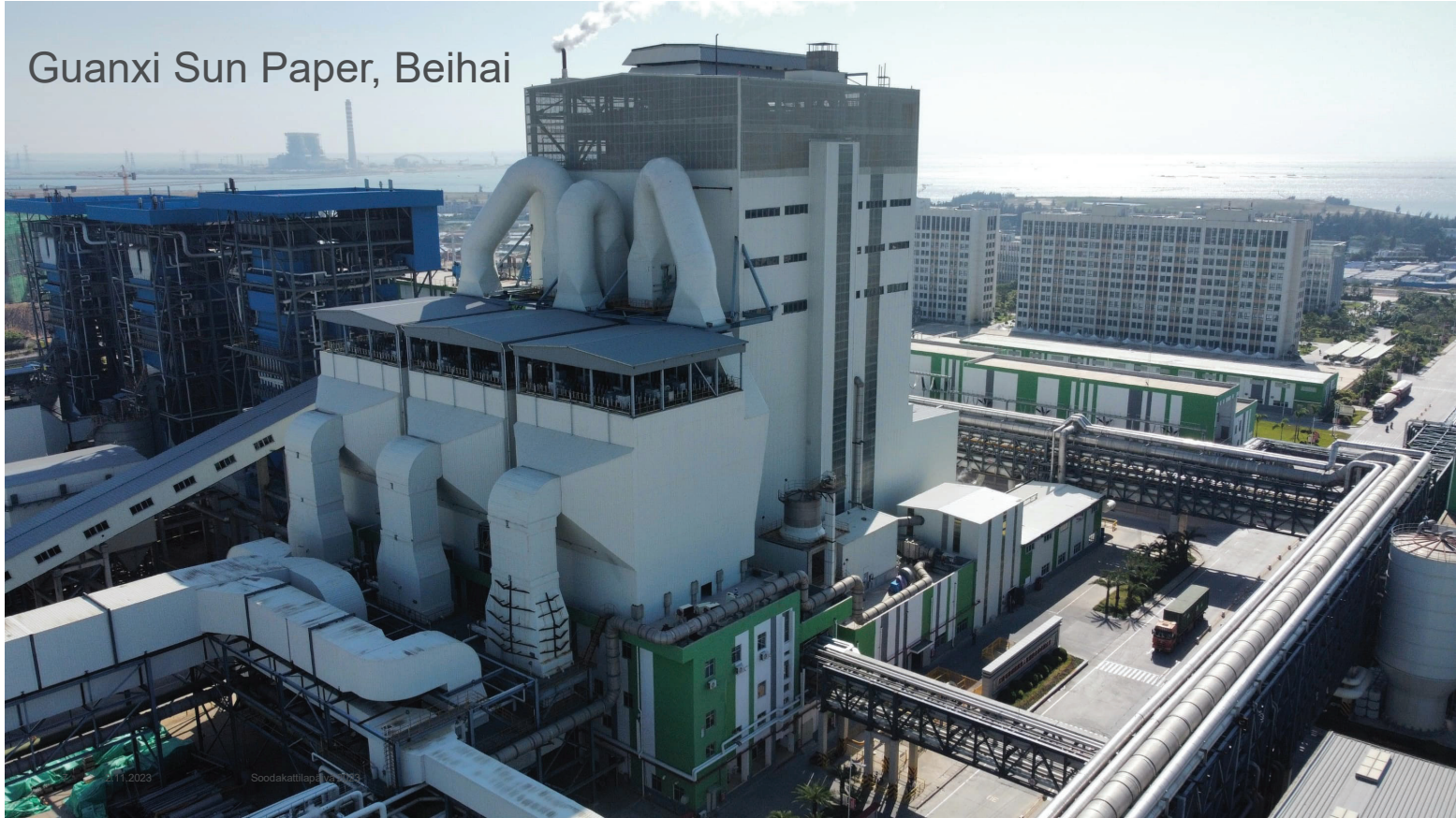
NOx reduction solutions

Chinese recovery boilers

Project	Quaternary air	SNCR	De-NOx scrubber	SCR
Huatai Dongying	X	-	X	-
Nine Dragons Beihai CP5	X	-	X	-
Nine Dragons Beihai CP10	X	-	X	-
ASSD Rizhao RB11	X	(X)	-	X
Nine Dragons Jingzhou	X	-	X	-
Guanxi Sun Paper	X	-	-	-
Huanggang Chenming	-	(X)	-	-
Jiangsu Oji Paper	X	X	-	X*
ASSD Rizhao RB2	X	X	X*	-

*) upgrade

Guanxi Sun Paper, Beihai



Nine Dragons, Jingzhou



Asia Symbol Rizhao RB11

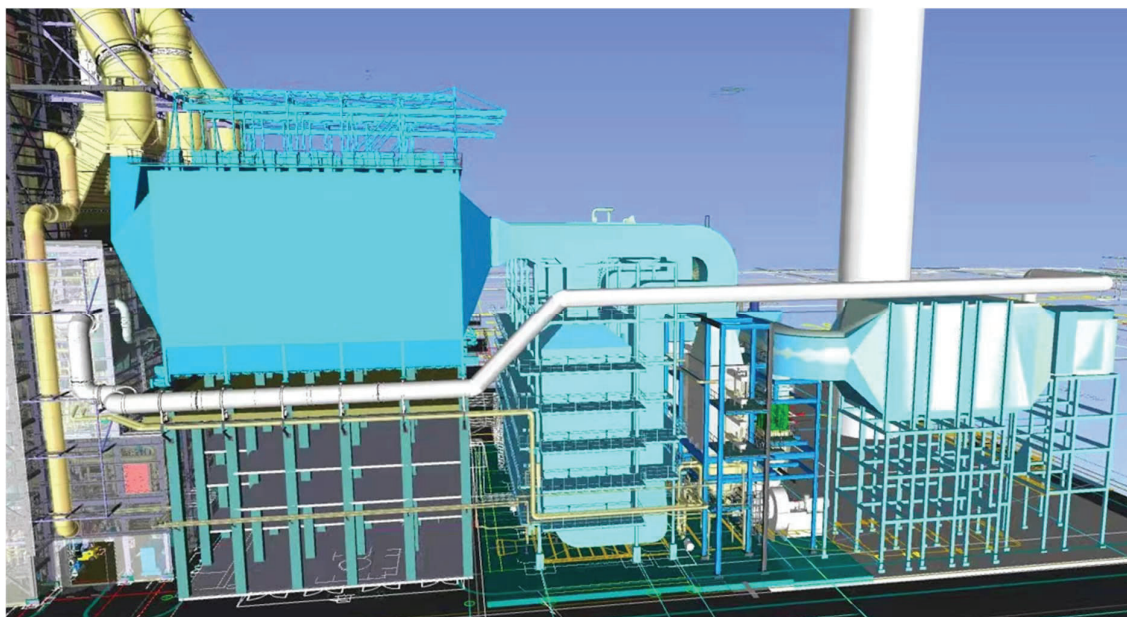


9 2.11.2023

Soodakattilapäivä 2023

Valmet

SCR at Rizhao



10 2.11.2023

Soodakattilapäivä 2023

Valmet



Valmet ESP Technology in the Chinese Market

- Today, the typical dust emission limit for all new recovery boilers and lime kilns is less than 10 mg/Nm³ in China
- Case: Huatai - The first Valmet ESPs for recovery boiler in China
 - **Power Optimizer** - Guarantee requirement (one chamber out of operation) enables significant **Energy Savings** during normal operation, approx. 30%

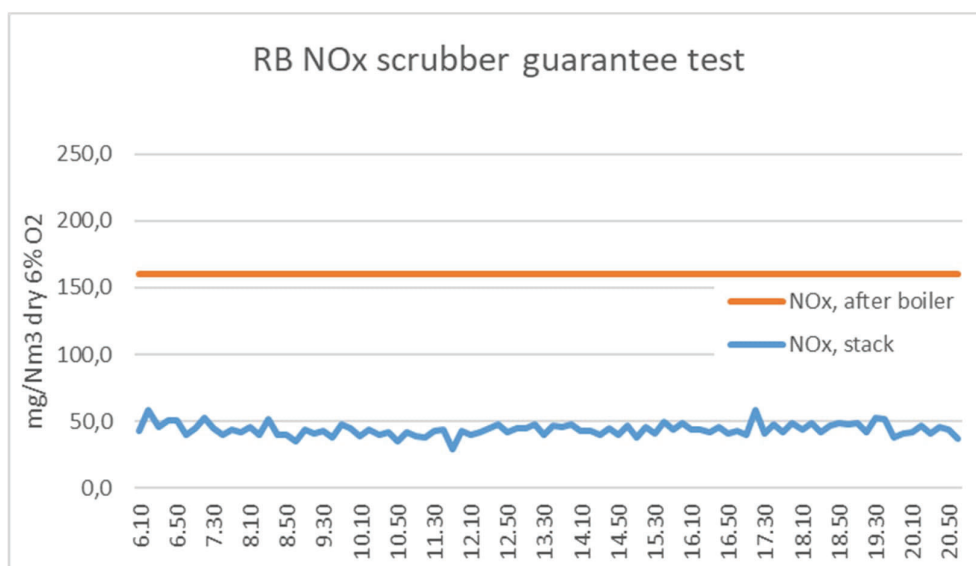
Huatai RB ESP Dust emission guarantees	Value
3 chambers in operation – 100% MCR	10 mg / Nm ³
2 chambers in operation – 100% MCR	10 mg / Nm ³

Valmet ESP references Dust emission guarantee after ESPs, less than 10 mg / Nm ³	Country	Units	Delivery year
Huatai, Recovery boiler	China	3	2025
DS Smith Paper Viana, Recovery boiler	Portugal	2	2025
Smurfit Kappa Nervion, Lime kiln	Spain	1	2023
Metsä Fibre Oy Kemi, Recovery boiler	Finland	4	2023
Metsä Fibre Oy Kemi, Lime kiln	Finland	2 (Dry and Wet ESP)	2023

Soodakattilapäivä 2023



De-NO_x scrubber performance test, project in China



Valmet NOx scrubber references

Customer	Application	Flue gas flow Nm ³ /h	Startup	NOx limit
Sun Paper Yanzhou	Recovery boiler 450 tds, ClO ₂ NOx scrubber	144,000	2017	100 mg/Nm ³
Sun Paper Yanzhou	Recovery boiler 1000 tds, ClO ₂ NOx scrubber	288,000	2018	100 mg/Nm ³
Sun Paper Yanzhou	Recovery boiler 900 tds, ClO ₂ NOx scrubber	270,000	2019	100 mg/Nm ³
Asia Symbol (Shandong) Pulp and Paper Co. Rizhao	NCG Incinerator, O ₃ NOx scrubber	108,000	2019	100 mg/Nm ³
Asia Symbol (Shandong) Pulp and Paper Co. Rizhao	Recovery boiler 7500 tds, ClO ₂ NOx scrubber	1,440,000	2019	100 mg/Nm ³
Asia Symbol (Shandong) Pulp and Paper Co. Rizhao	Lime Kiln, ClO ₂ NOx scrubber	144,000	2019	100 mg/Nm ³
Moorim P&P Korea	Recovery boiler 1 & 2, ClO ₂ NOx scrubber	432,000	2020	27 ppm
Nine Dragons Paper, Jingzhou	Recovery boiler 2300 tds/d, ClO ₂ NOx scrubber	452,880	2022	50 mg/Nm ³
Nine Dragons Paper, Jingzhou	Lime kiln 420 tds/d, ClO ₂ NOx scrubber	65,160	2022	100 mg/Nm ³
Nine Dragons Paper, Beihai	Recovery boiler 4600 tds/d, ClO ₂ NOx scrubber	910,800	2023	50 mg/Nm ³
Nine Dragons Paper, Beihai	Recovery boiler 2300 tds/d, ClO ₂ NOx scrubber	452,880	2023	50 mg/Nm ³
Nine Dragons Paper, Beihai	Lime kiln 950 tds/d, ClO ₂ NOx scrubber	151,200	2023	100 mg/Nm ³
Nine Dragons Paper, Beihai	Lime kiln 420 tds/d, ClO ₂ NOx scrubber	65,160	2023	100 mg/Nm ³

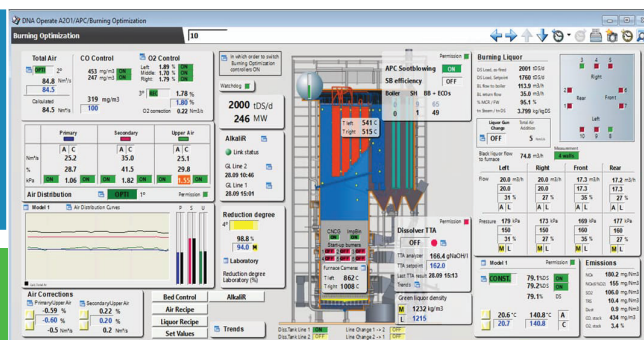
Confidential customer tackle NOx emissions with Valmet Recovery Boiler Optimizer

Goals

- Meet NOx limit of 160 mg/Nm³
- Maximize green liquor TTA and Reduction efficiency

Benefits

- To reach low NOx limit residual oxygen needs to be 1.5...2.0 % when recovery boiler is operating at full capacity
- Maximum TTA without pirssonite scaling
- Optimal reduction degree



Our solution

- Valmet High Power Recovery Boiler
- Valmet Recovery Boiler Optimizer
- Valmet Recovery Liquor Analyzer with ABC titration and Reduction Efficiency

“Reaching tight environmental targets was a challenge in manual operating mode. Valmet Recovery Boiler Optimizer freed operators from continuous monitoring of CO and O₂ levels enabling higher production. Several air curves for different liquor compositions help us when wood material is constantly changing”



**SOOTBLOW MORE, WITH LESS STEAM – SUSTAINABLE
SOOTBLOWING**

Johan Holmér
Wave Impact Heat Management AB

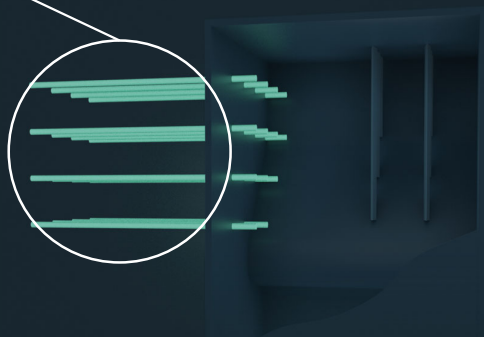
Half of the steam and
half of the time,
used for steam sootblowing
in black liquor recovery boilers,
is wasted.

SOOTBLOW MORE, WITH LESS STEAM



WHY DO WE DO THIS?

HIGH IMPACT
SOOTBLOWING SYSTEM
(HISS)



HALF THE STEAM AND HALF THE TIME
USED FOR SOOTBLOWING, IS WASTED.

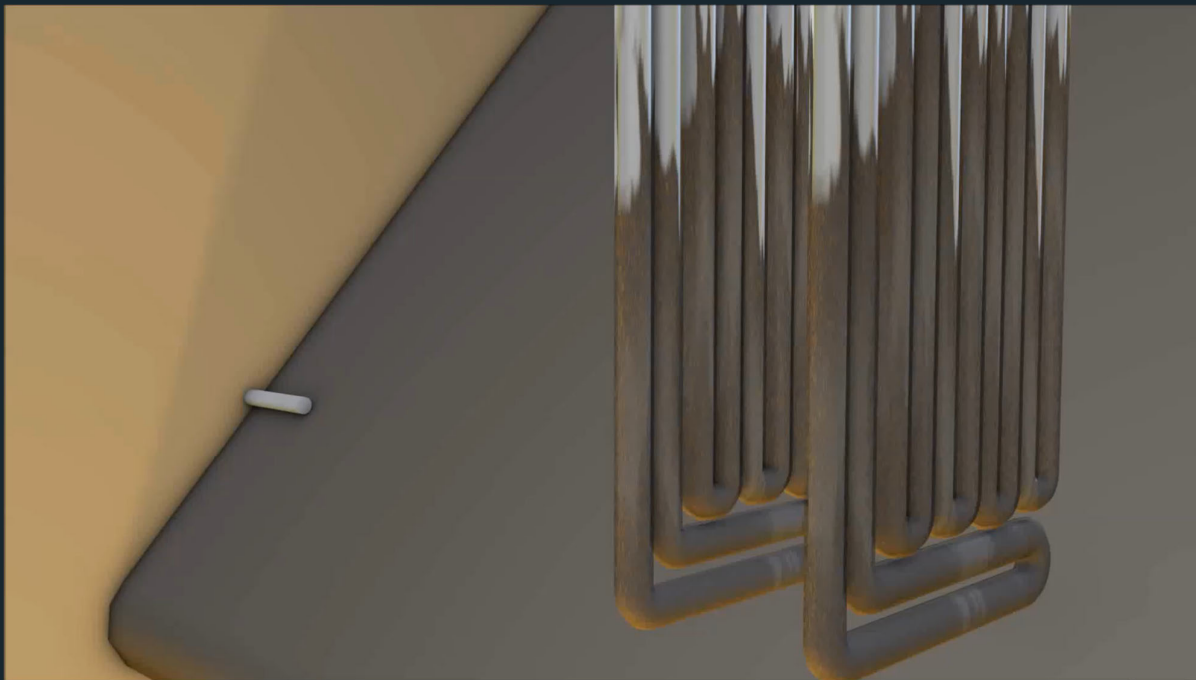
ALL PULP MILLS CARRY **US\$ 2 MILLION IN ENERGY LOSSES** EACH YEAR BECAUSE "THIS IS HOW WE HAVE ALWAYS DONE SOOTBLOWING"

ALL PULP MILLS CARRY **> US\$ 2 MILLION IN PRODUCTION LOSSES** FROM INEFFICIENT AND WASTEFUL SOOTBLOWING

HEAT MANAGEMENT -
BEYOND TECHNICAL SPECIFICATION



TRADITIONAL SOOTBLOWING



ALL CLEANING AT FIRST
IMPACT OF STEAM JET

CLEANING EFFECT FROM FIRST IMPACT – POWER BOILER



CLEANING EFFECT FROM FIRST IMPACT – RECOVERY BOILER



1

HOW DOES SOOTBLOWING WORK?

Heat Management

WHAT AM I BUYING?

GUARANTEES FOR HISS™

HIGH IMPACT SOOTBLOWING SYSTEM™

For a black liquor recovery boiler sootblowing system equipped with HISS™,
Heat Management guarantees below benefits

- Same or better boiler availability, at comparable process situation as reference period
- A minimum of 30 % steam consumption reduction, compared to today
(Theoretical maximum 50 %)
- 100 % more sootblowing starts per day possible

Heat Management

HISSTM SOOTBLOWING IN SUSTAINABILITY CONTEXT

PULP MILL, 2 500 tDS/day RB (1995)
Sootblowing steam 7 % of boiler main steam

The Customer and Heat Management develops a tailor-made solution, where the Customer will increase efficiency of the chemical and energy recovery process, while reducing sootblowing steam by 30 % (8 t/h).

This means reducing mill water consumption by 0,1 %

This means reduce annual energy consumption by more than 45 GWh (electricity and heat)

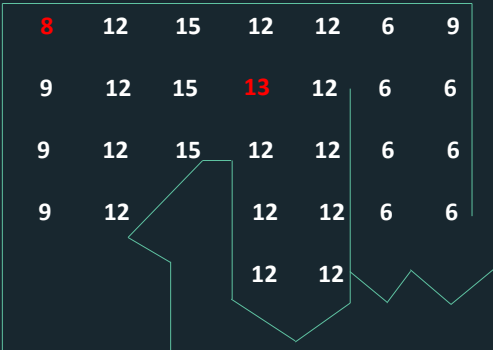
This is equivalent to 0,15 % of the annual energy consumption of all Customer sites combined and harmonizes well with Customer sustainability goal of 0,8 % reduction in annual energy consumption (MWh saved/MWh total energy used, electricity and heat).



EXTRA CAPACITY

WITHOUT SACRIFICING "CLEAN" AREAS

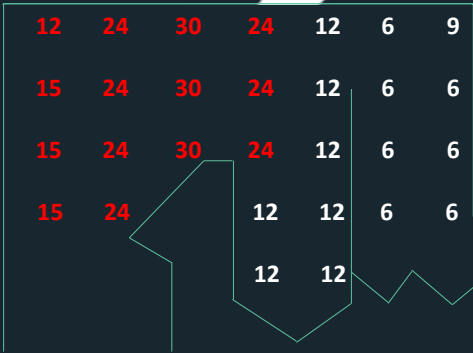
Traditional Steam Soot Blowing



Base soot blowing = 300 starts/day

To increase sootblowing in one area,
necessary to decrease in other area

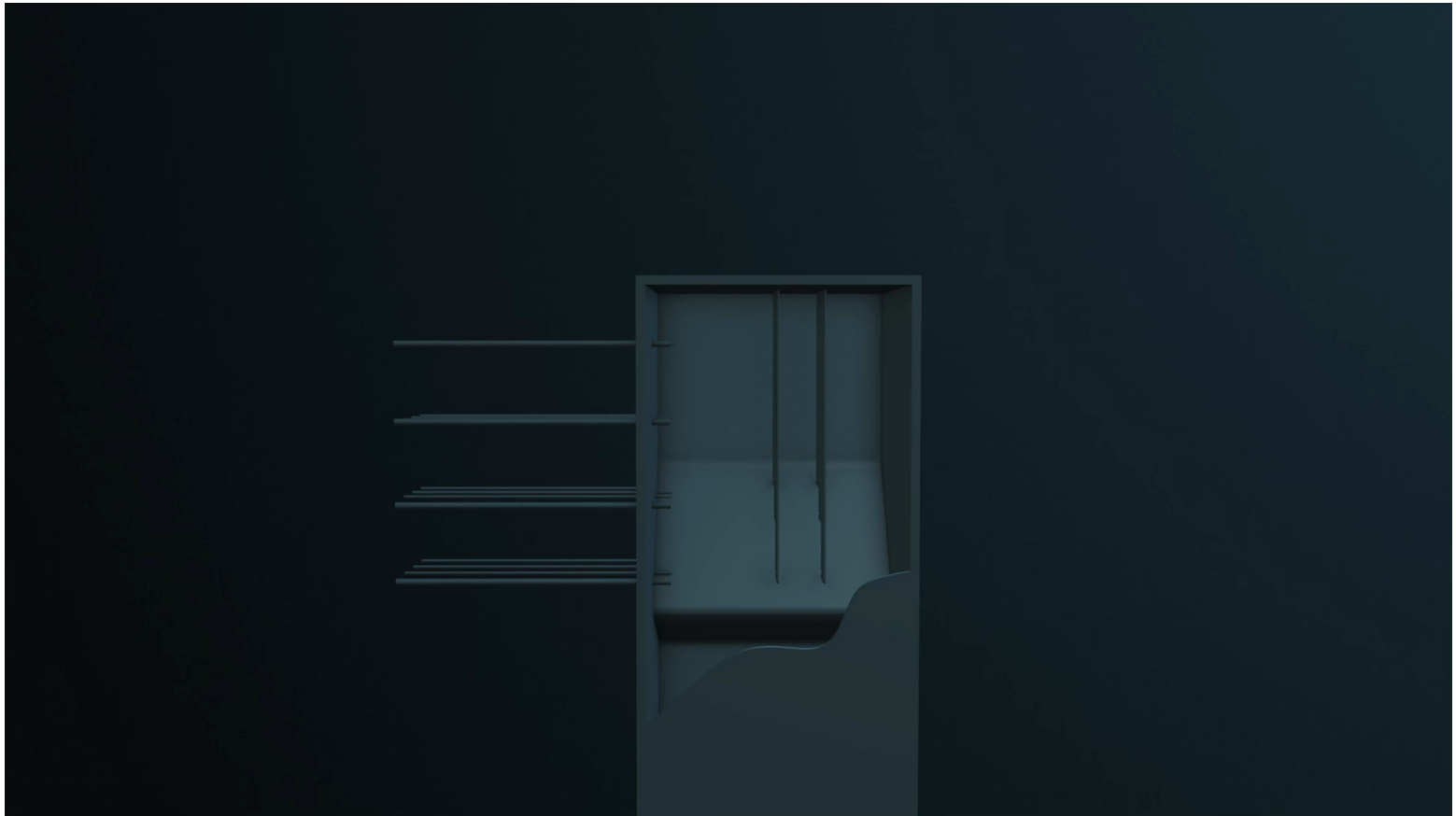
HISSTM Cleanability Control



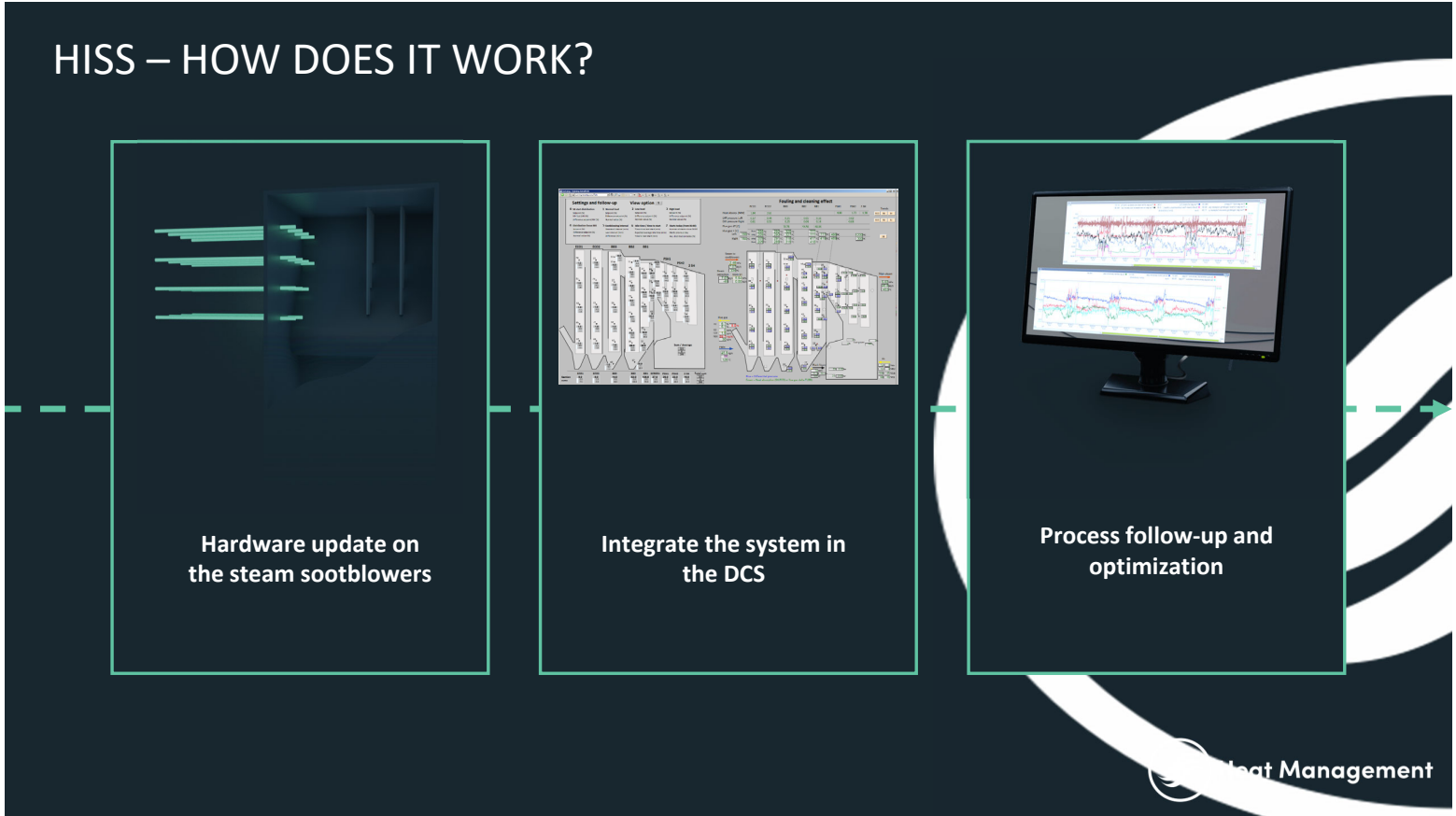
New base soot blowing = 600 starts/day

Possibility to increase sootblowing without decreasing
cleaning effect in other





HISS – HOW DOES IT WORK?



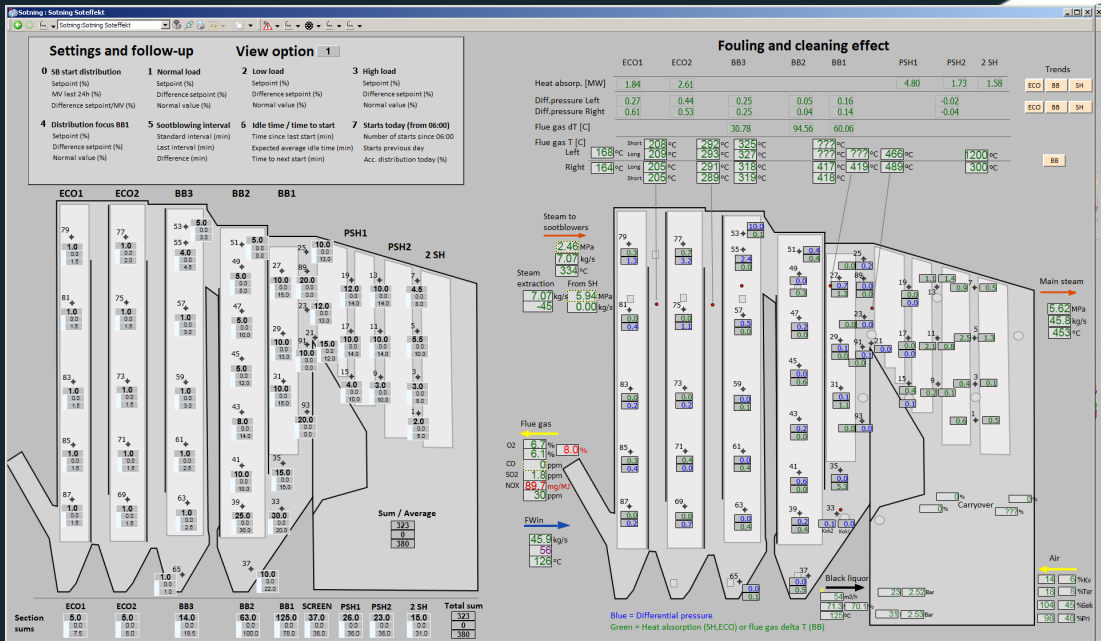
INNOVATIVE PATENTED SOOTBLOWER OPERATION



HISS™ Actuators

3 SOOTBLOW MORE WITH LESS STEAM

HISS™ CLEANABILITY CONTROL OPERATOR-STATION SOOTBLOWING INTERFACE



3 SOOTBLOW MORE WITH LESS STEAM

HISSTM SOOTBLOWING IN SUSTAINABILITY REPORTS

AUSTRIAN MILL

ZELLSTOFF PÖLS

GO ZERO: PÖLS ON TRACK FOR CARBON-NEUTRAL PRODUCTION

Some 90% of all CO₂ emissions from the production process in Pöls comes from biogenic CO₂, meaning that these are not fossil-based, thanks to wood being used both for its material and for bioenergetic properties. The optimization measures being implemented on an ongoing basis will make it possible for the site to achieve carbon-neutral production as early as 2040, putting Zellstoff Pöls AG at the very forefront of efforts here, both within HEINZEL GROUP and on the international stage.

NEW HYDROELECTRIC POWER PLANT SAVES 300 METRIC TONS OF CO₂E ANNUALLY

Work on the new hydroelectric power plant at the Zellstoff Pöls AG mill started in July 2021, with EUR 3.9 million being invested in a new run-of-river power plant here to replace the 100-year-old hydroelectric power plant, which had to be shut down due to damage. The new plant will also optimize the process by which water is removed from the river for the mill. Being designed as a run-of-river power plant and having a fish ladder integrated into the system will also help improve the ecological balance of the river Pölsbach, while also providing protection against flooding for the entire region. Once commissioned in July 2022, the plant is expected to generate around 1,200,000 kWh of electricity and save 300 metric tons of fossil-based CO₂e every year.

HISS – HIGH IMPACT SOOT BLOWING SYSTEM

The pulp and paper mill gets most of its energy from the burning of thickened black liquor. The boiler system is steam-cleaned to remove any dirt accumulating during the process so as to ensure the facility runs as it should. The newly developed HISS system makes it possible to reduce the amount of steam required for cleaning by up to 30%. The steam saved here can be used to generate additional energy, which is expected to translate into annual savings of 1,000 metric tons of CO₂e.

DEVAP – PRE-EVAPORATION AFTER COOKING

Live steam has been used up to now to provide heating in the pulp cooking process. The new DEVap system involves generating steam from cooking liquor via a heat exchanger to replace the use of live steam, enabling a considerable amount of energy and around 2,500 metric tons of CO₂e to be saved every year.



«Launched in 2021, our sustainability project 'Caring for Tomorrow' encompasses all the measures planned to reduce our carbon footprint on our journey to becoming CO₂-neutral. Zellstoff Pöls has set itself the goal of reducing its fossil-based CO₂ emissions by around 50% by 2030.»
Ingrid Gruber, CFO, Zellstoff Pöls AG

HISS – HIGH IMPACT SOOT BLOWING SYSTEM

The pulp and paper mill gets most of its energy from the burning of thickened black liquor. The boiler system is steam-cleaned to remove any dirt accumulating during the process so as to ensure the facility runs as it should. The newly developed HISS system makes it possible to reduce the amount of steam required for cleaning by up to 30%. The steam saved here can be used to generate additional energy, which is expected to translate into annual savings of 1,000 metric tons of CO₂e.

Link to the report, published April, 2021:

<https://www.heinzelnz.com/en/downloads/annual-report-2021/>



REFERENCES AND RESULTS

Pulp Mill	Country	Year	Boiler size (MMlbs DS/day)	Number of sootblowers	Manufacturer	Steam Saving (%)	Increased sootblowing (%)	Results
Swedish Pulp Mill	SE	2023	2 700	70	Valmet (Götaverken)	TBD	TBD	Start-up H1, 2024. Guaranteed minimum saving 30 % (8 t/h) -> 7 GWh power & 40 GWh LP steam, meaning less 1 950 tCO2e/year.
Bulgarian Pulp Mill	BU	2022	500	17	B&W	TBD	TBD	Start-up H2, 2023
Swedish Pulp Mill	SE	2022	1 200	76	Valmet (Götaverken)	30	30	Sootblowing more, with less steam since May-2023. From 20 kpph to 14 kpph.
Swedish Pulp Mill	SE	2022	1 000	16	Götaverken	45	0	Immediate steam savings of 42 %.
Brazilian Pulp Mill	BR	2022	5 200	96	Valmet (Kvaerner)	20	66	Sootblow more, with less steam since March-2023. Goal to eliminate chill & blow during 15 month campaign while saving 10 t/h steam.
Swedish Pulp Mill	SE	2022	1 500	64	Valmet (Kvaerner)	TBD	TBD	Start-up H1-2023 (upgrade after rebuild)
Indonesian Pulp Mill	ID	2021	4 100	94	Valmet (Kvaerner)	20	66	Start-up Oct-2021. Sootblowing more, with less steam.
Swedish Pulp Mill	SE	2021	2 000	74	Valmet (Tampella)	40	5	Guaranteed minimum steam savings of 6 kpph. Achieved 9 kpph. Improved cleanability.
Swedish Pulp Mill	SE	2021	4 600	108	Andritz	0	100	Increased production from 4 200 to 4 950 tDS/day. Sootblowing twice as much, without consuming more steam.
Swedish Pulp Mill	SE	2021	1 400	60	Valmet (Götaverken)	37	10	Increased boiler black liquor throughput by 15 %, now operating at 1 300 tDS/day. Steam savings 6 t/h. Improved process (smelt) stability.
Swedish Pulp Mill	SE	2020	2 400	92	Andritz	25	0	Eliminated one water wash. Steam savings 25 %.
Austrian Pulp Mill	AT	2020	2 600	80	Andritz	30	15	30% saved steam -> +1,5 MW increased electricity production -> More 12,75 GWh/year and less 1 000 tCO2e/year.
Swedish Pulp Mill	SE	2016	2 700	80	Valmet (Metso)	35	25	Increased load by 7 %. Steam savings 8 t/h. April 2018 – Sept 2019 completed 18 months season for first time. Improved cleanability.
Swedish Pulp Mill	SE	2011	2 400	100	Valmet (Tampella)	25	50	Increased production with remained boiler up-time in combination with saving steam. Improved cleanability.
Swedish Pulp Mill	SE	2011	800	24	Valmet (Götaverken)	0	100	Prolonged time between water washes and increased production. Improved cleanability.
Swedish Pulp Mill	SE	2010	1 050	23	Valmet (Götaverken)	0	100	Elimination of outages for manual cleaning between revision stops. Improved cleanability.
Swedish Pulp Mill	SE	2009	1 500	64	Valmet (Kvaerner)	35	25	Production increase 5 %, while saving 3 t/h, Improved cleanability.

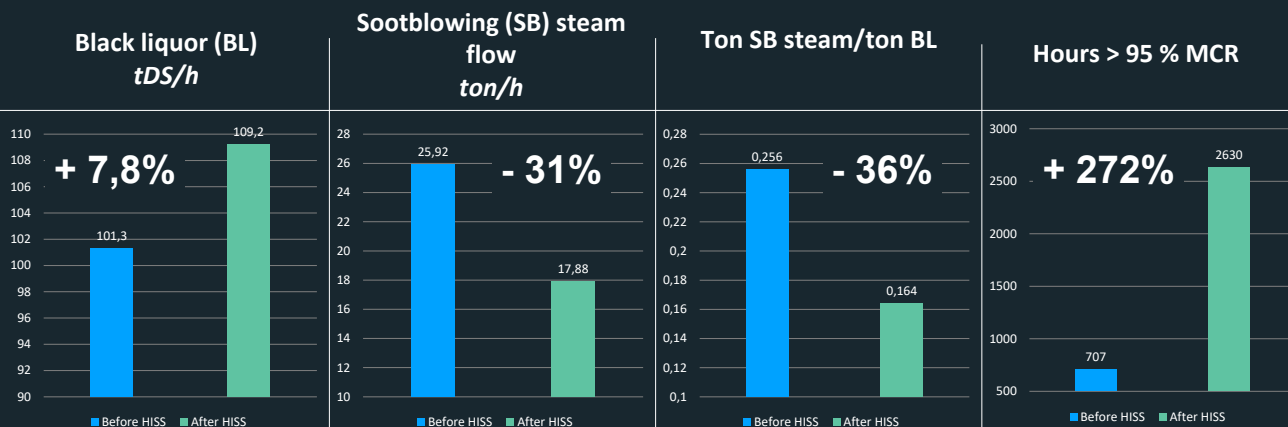




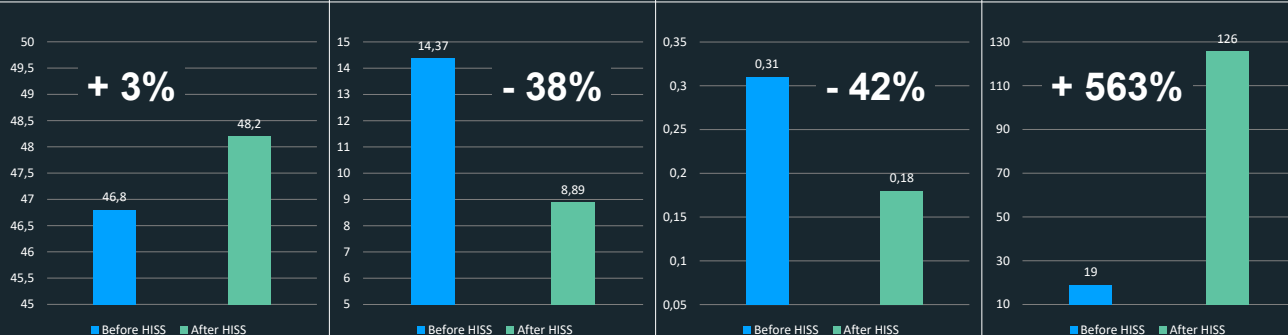
MILL RESULTS

Heat Management

Mill 1

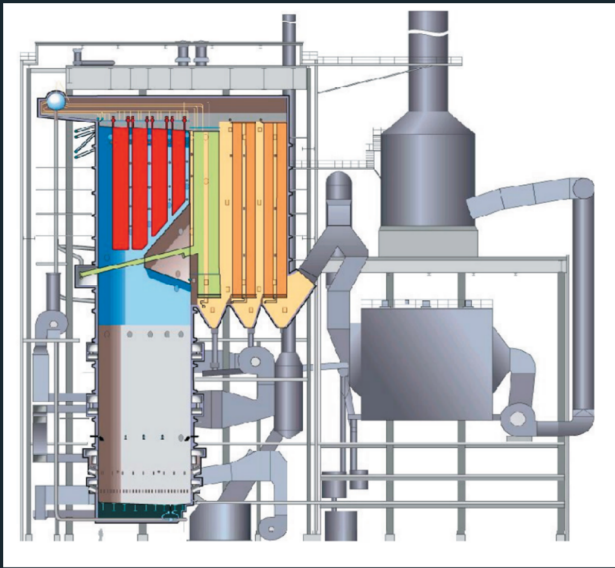


Mill 2



MILL RESULTS

MILL #1 EXPERIENCE

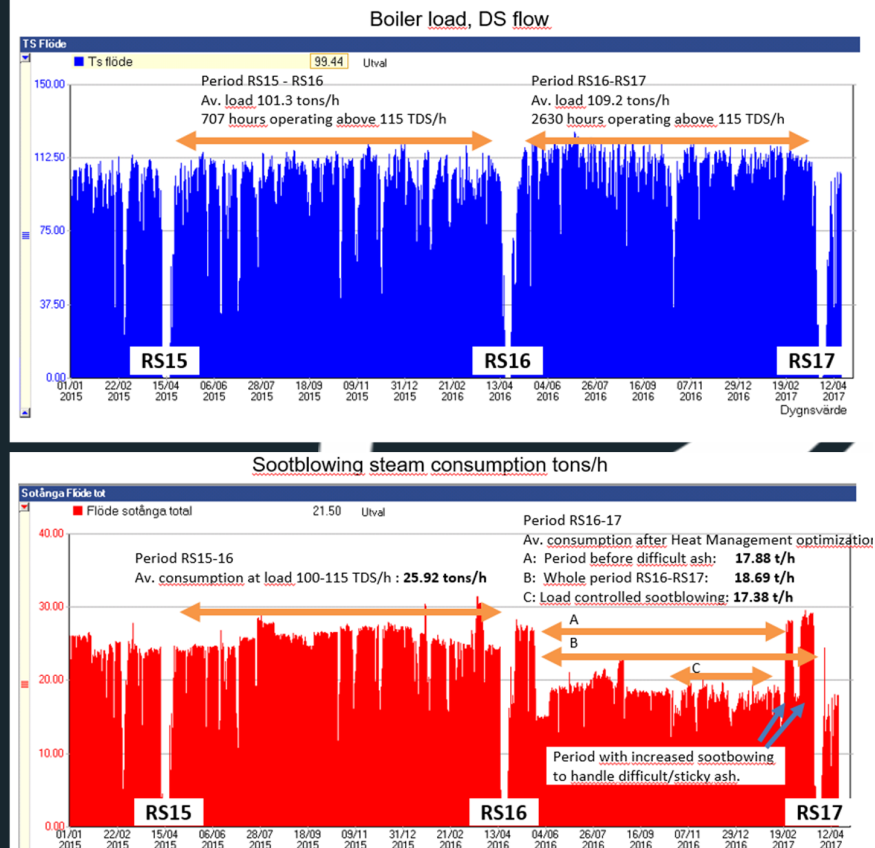


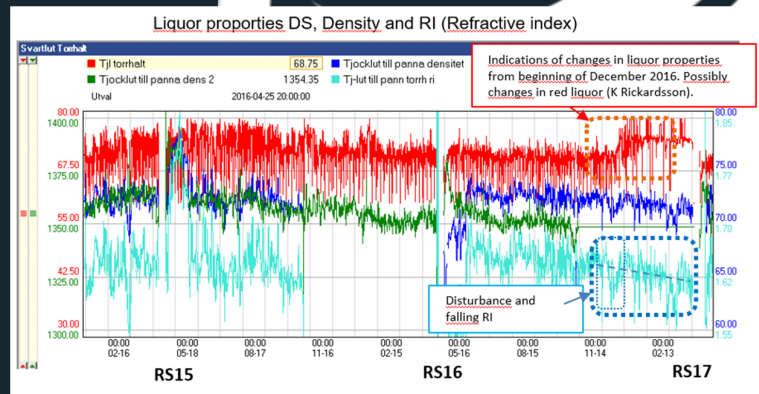
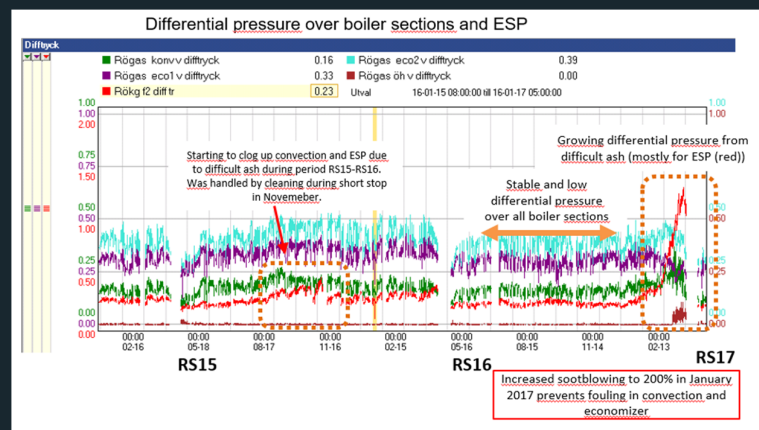
Guarantees with HISS™:

- ✓ 100 % extra sootblowing starts
 - ✓ 30 % steam saving
- ✓ Same or better cleanability
- ✓ 12-month process follow-up

Load	2700 DS/day
Manufacturer	Kvaerner (Valmet) 1999
No of Sootblowers	80 fully retractable
No of Headers	2
Start-up HISS™	April 2016

Mill #1 experience



MILL RESULTS

- ✓ 100 % extra sootblowing starts
- ✓ 30 % steam saving
- ✓ Same or better cleanability
- ✓ 12-month process follow

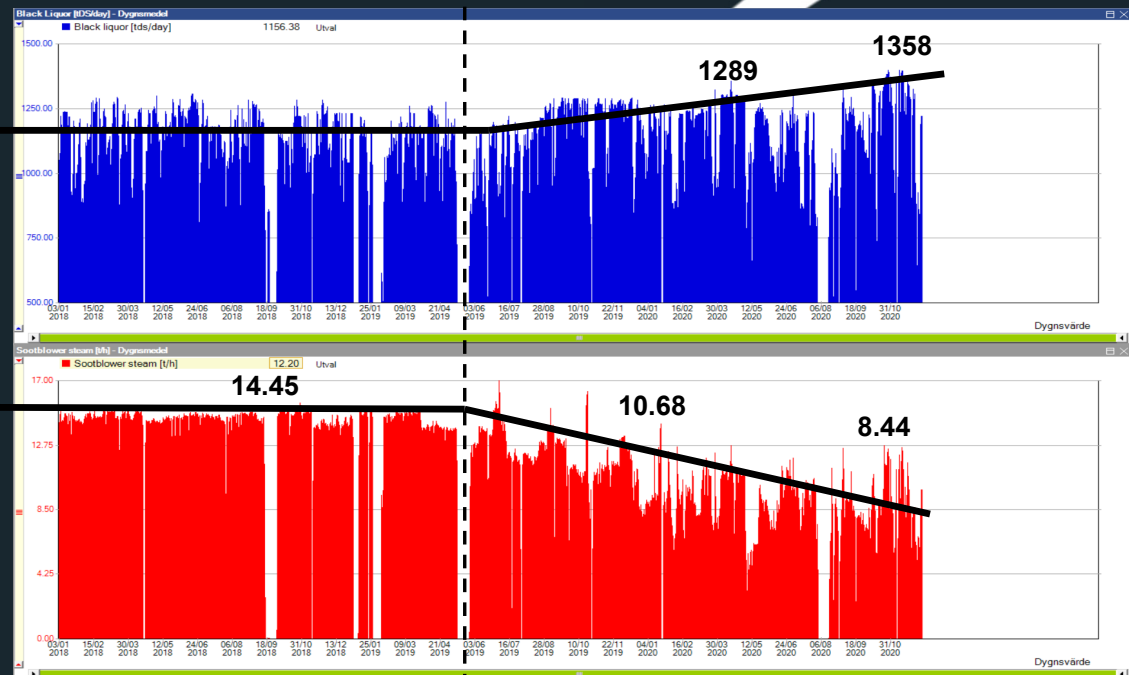
LOAD	1400 DS/day
MANUFACTURER	Götaverken 1968
No of Sootblowers	60 fully retractable
No of Headers	1
Start-up HISS™	October - 2018

MILL #2 EXPERIENCE

HISS INSTALLATION

INCREASE LOAD

REDUCE STEAM



MILL RESULTS

CONTACT INFORMATION



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Heat Management

A cleantech company



TULEVAISUUDEN NÄKYMÄT SELLUTEOLLISUUDESSA

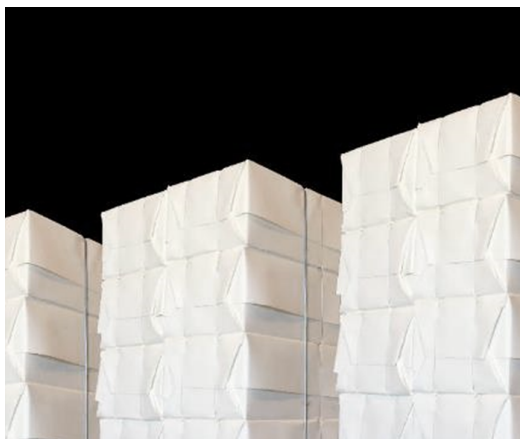
Salla-Mari Järvinen
AFRY Management Consulting O



Future prospects of the global pulp industry

Salla-Mari Järvinen, AFRY Management Consulting Oy

FINNISH RECOVERY BOILER COMMITTEE – NOVEMBER 2ND, 2023



How will the new capacity shape the global pulp supply structure?

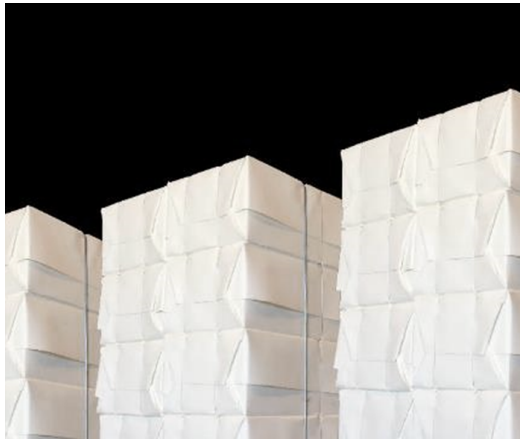


What is the future of the pulp industry – will the growth continue?



What will be Finland's role moving forward?





How will the new capacity shape the global pulp supply structure?



What is the future of the pulp industry – will the growth continue?

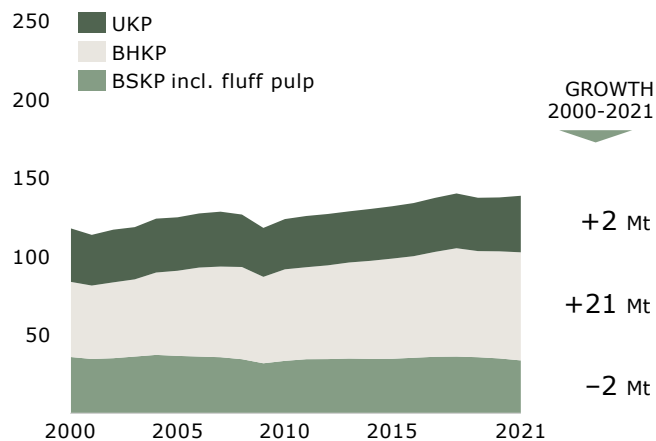


What will be Finland's role moving forward?

During the past 20 years, demand for kraft pulp has steadily increased (+21 Mt), with China driving the strongest growth

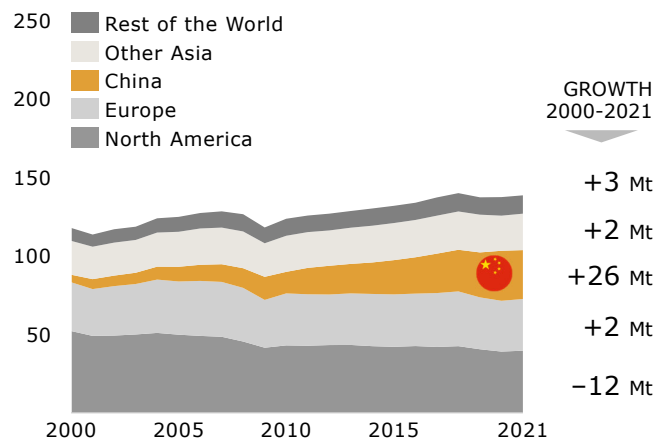
TOTAL KRAFT PULP CONSUMPTION BY GRADE

Million tonnes



TOTAL KRAFT PULP CONSUMPTION BY REGION

Million tonnes



Tissue, hygiene and packaging sectors are the primary drivers for kraft pulps; also tightening white RCP supply is foreseen to boost BKP demand

KEY DEMAND DRIVERS

-  Stable long-term GDP growth
-  Growing population, middle class and urbanization
-  High demand growth in tissue and hygiene products
-  Limited availability of white recycled paper
-  Booming e-commerce and growing premium packaging sector; deteriorating RCP quality

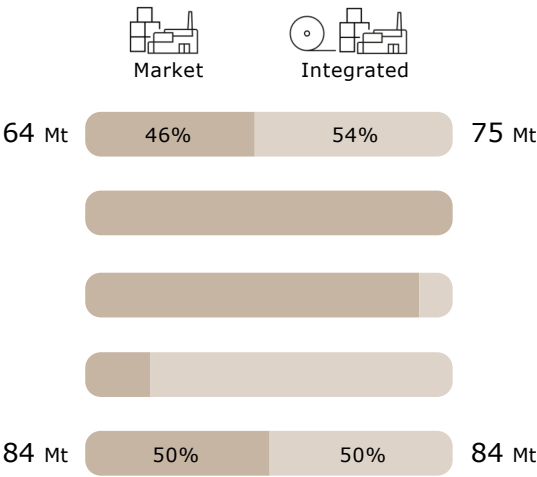
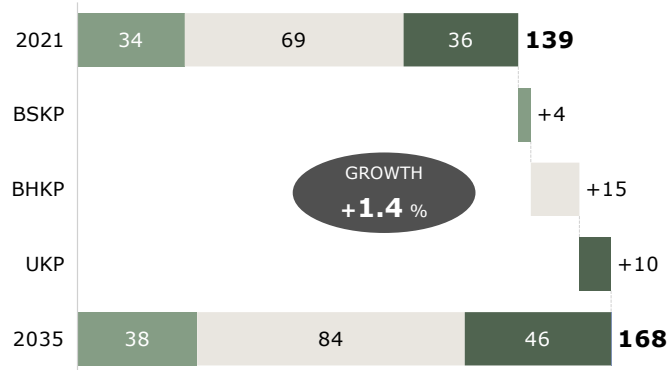
BSKP	BHKP	UKP
⊕	⊕	⊕
⊕	⊕ ⊕ ⊕	⊕ ⊕
⊕ ⊕	⊕ ⊕ ⊕	
⊕ ⊕	⊕ ⊕ ⊕	
⊕ ⊕	⊕	⊕ ⊕ ⊕

Total kraft pulp demand is expected to reach almost 170 Mt by 2035; share of market pulp will continue to increase driven by market BHKP

TOTAL KRAFT PULP CONSUMPTION OUTLOOK BY GRADE

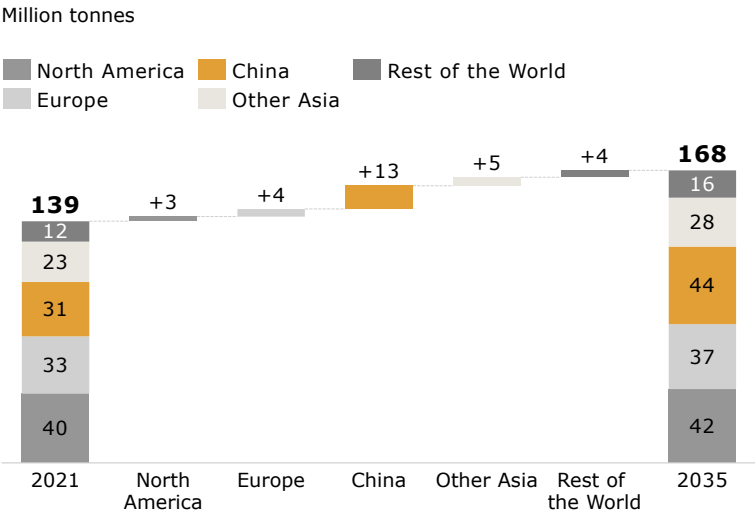
Million tonnes

■ BSKP incl. fluff pulp ■ BHKP ■ UKP

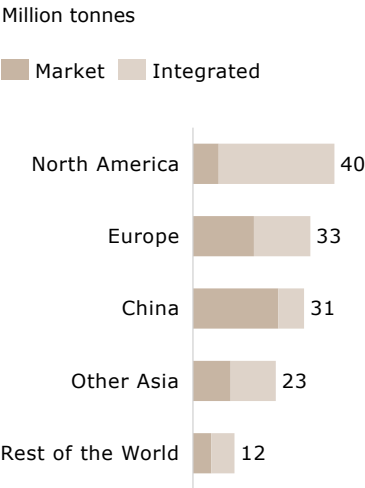


China continues to be the main global demand engine for fibre, but structural problems in China’s economy will pose significant risks to future growth

TOTAL KRAFT PULP CONSUMPTION OUTLOOK BY REGION



2021 KRAFT PULP CONSUMPTION



Global kraft pulp consumption continues to grow at 1.4%/a through 2035 primarily driven by market BHKP and China

How will the new capacity shape the global pulp supply structure?



What is the future of the pulp industry – will the growth continue?



What will be Finland’s role moving forward?

Global kraft pulp market continues to grow with 1.4%/a through 2035 primarily driven by market BHKP

How will the new capacity shape the global pulp supply structure?

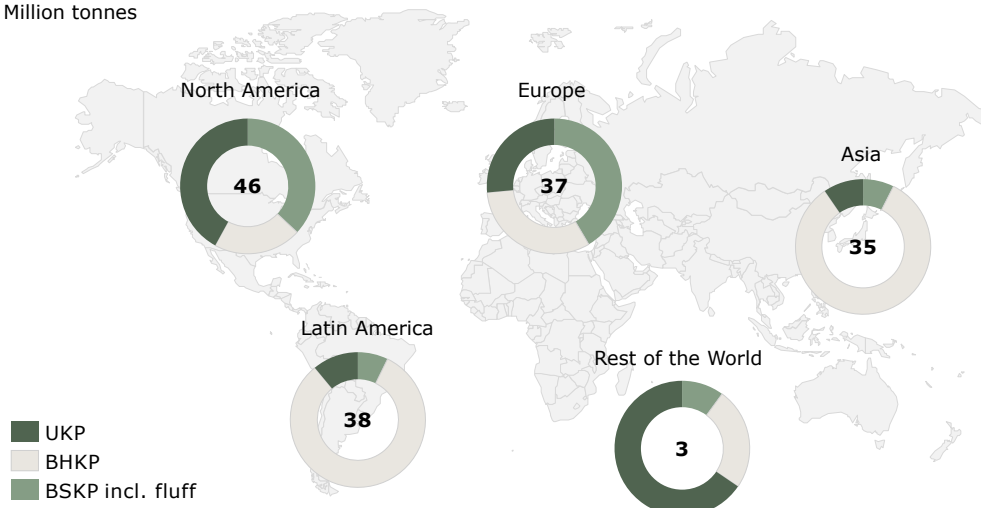
What is the future of the pulp industry – will the growth continue?

What will be Finland's role moving forward?

Current distribution of kraft pulp capacity (159 Mt) is fairly balanced across the regions

CURRENT TOTAL KRAFT PULP CAPACITY Q4/2023

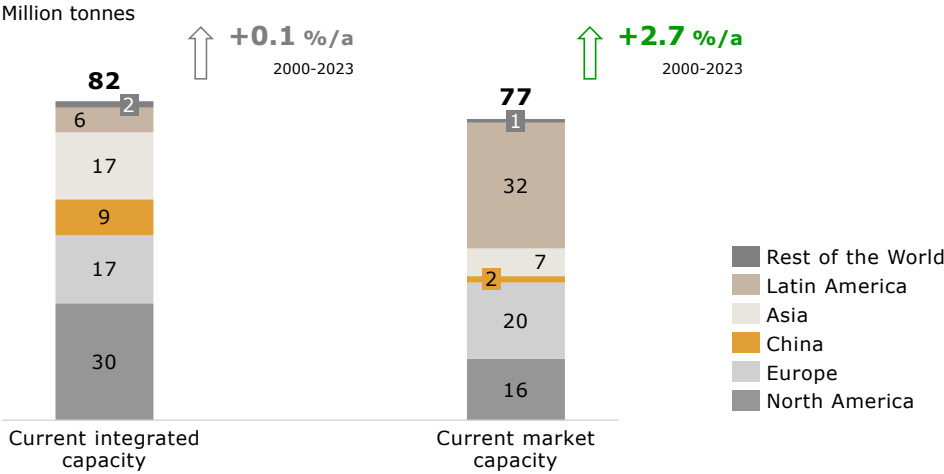
Million tonnes





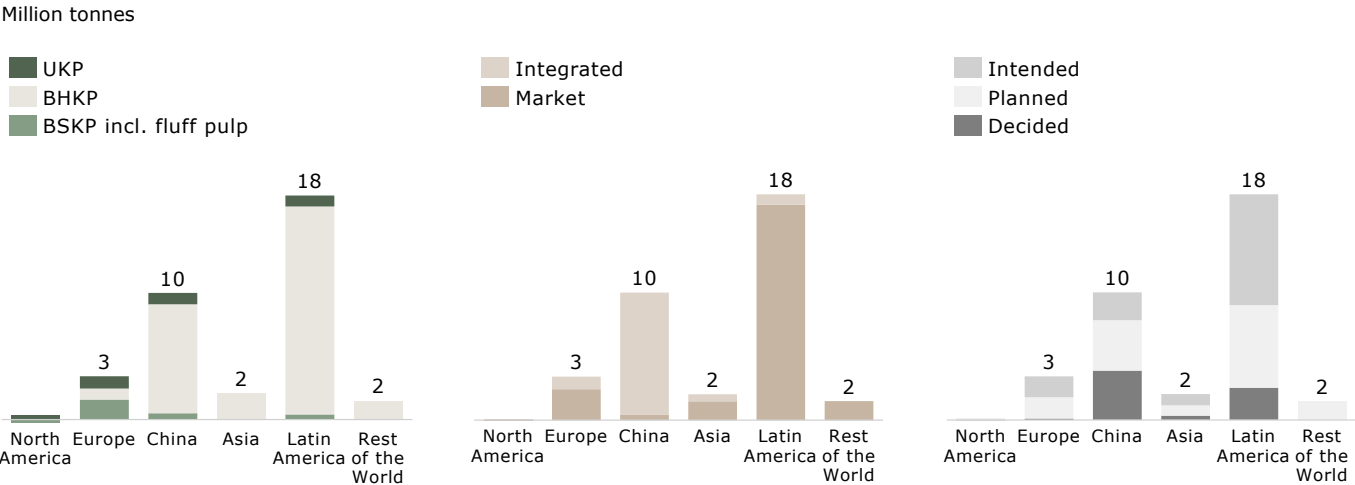
And so far, market pulp has been gaining market share from integrated pulps

INTEGRATED VS. MARKET KRAFT PULP CAPACITY Q4/2023



But will this situation change as sizeable investments in Latin America and China dominate the project pipeline?

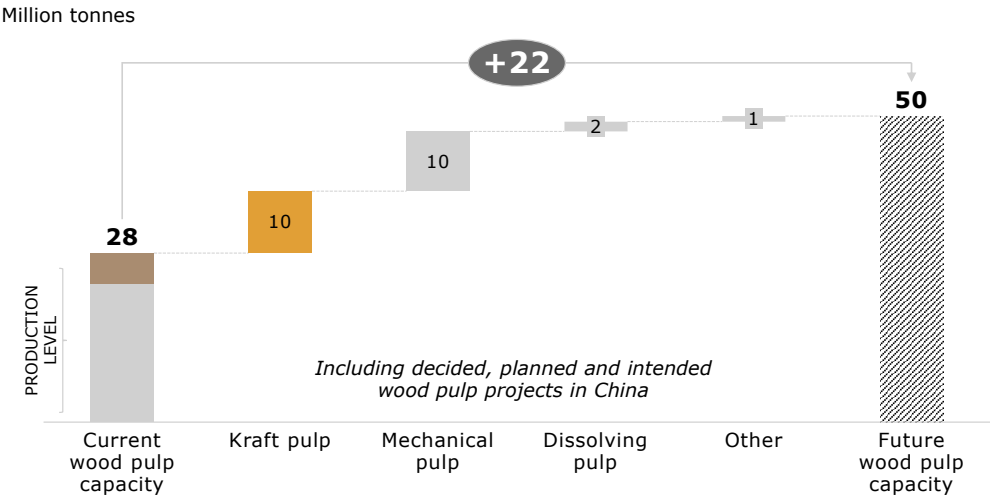
TOTAL KRAFT PULP INVESTMENT ACTIVITY BY 2030



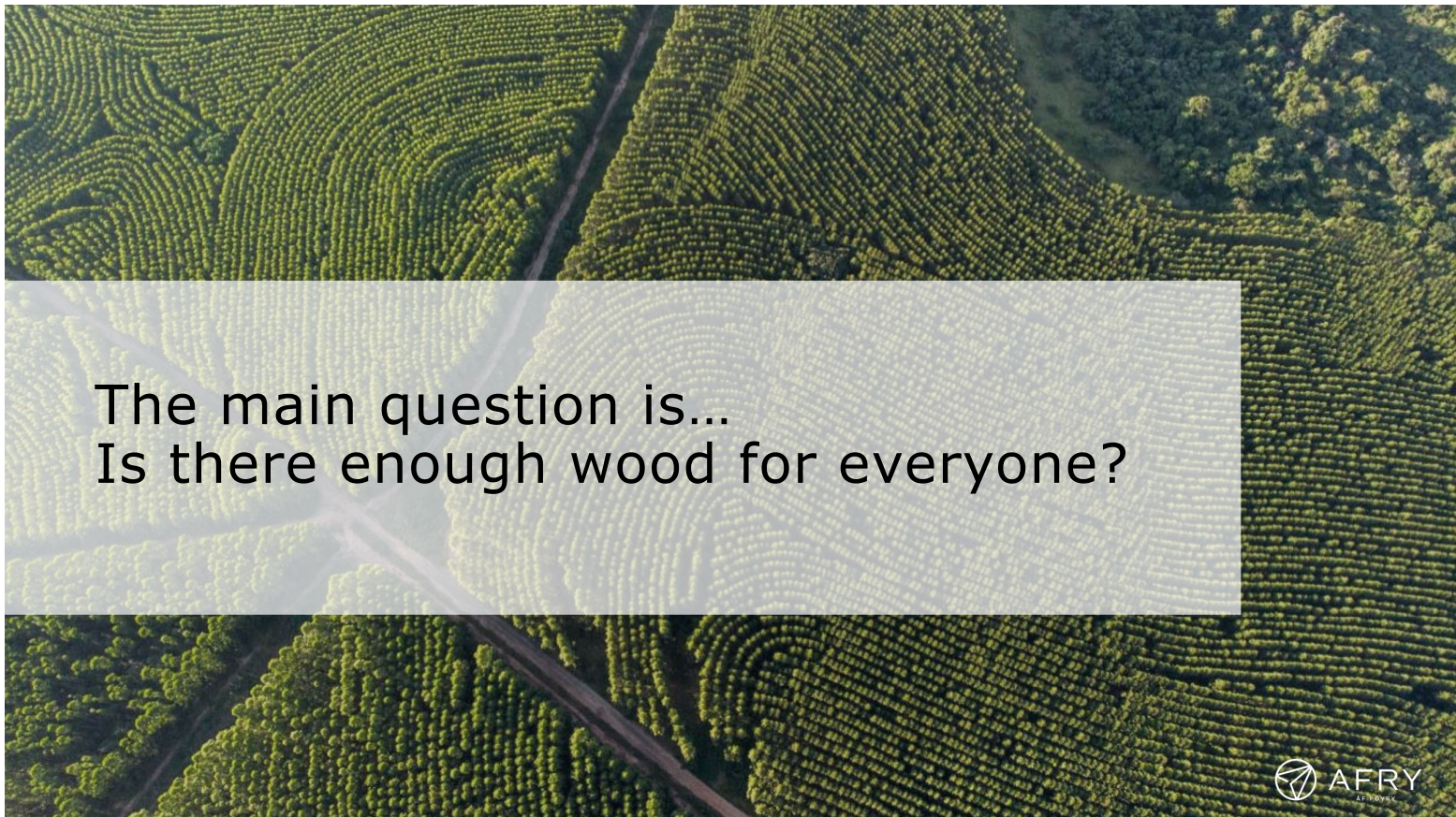


Substantial Chinese (integrated) pulp production is under construction, with 22 Mt projects in the pipeline

ANNOUNCED TOTAL PULP CAPACITY CHANGES IN CHINA



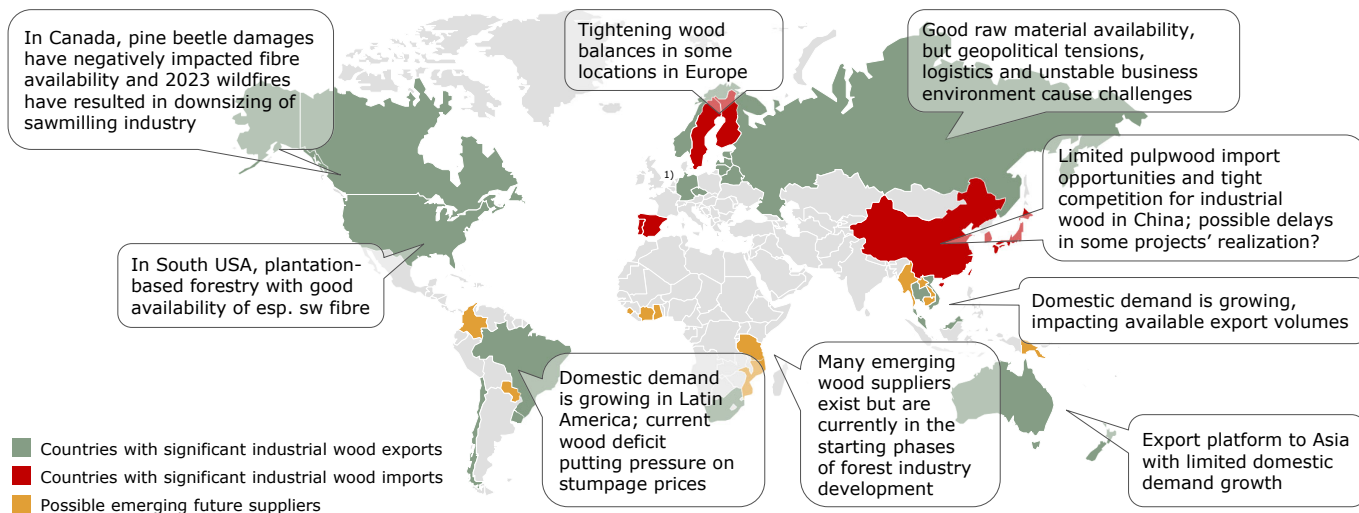
Is this phenomenon going to change the structure of global pulp markets?



The main question is...
Is there enough wood for everyone?

The availability of fibre clearly affects the implementation of new pulp projects, but also impact the competitiveness of existing mills

GLOBAL FIBRE AVAILABILITY



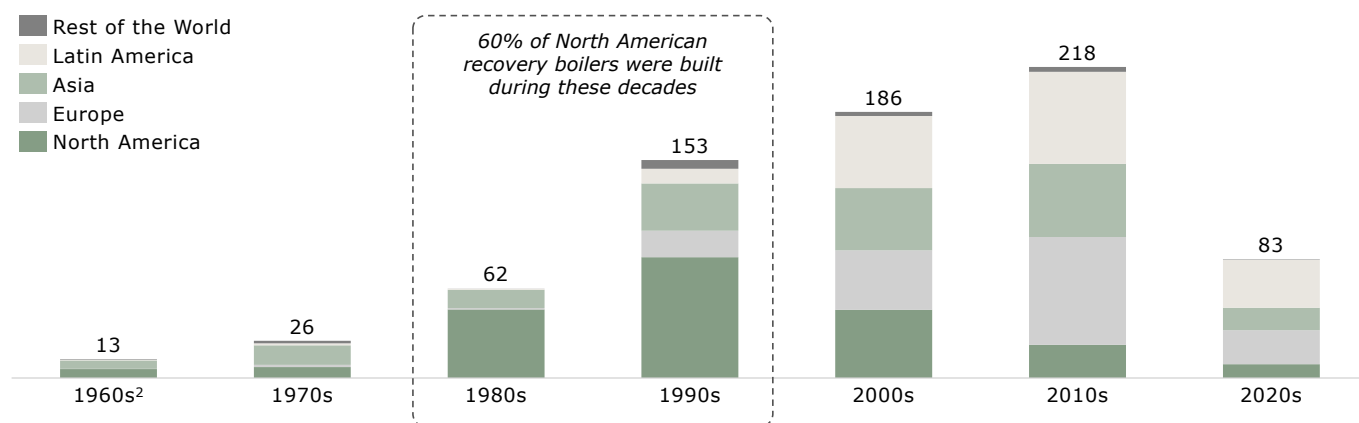
¹ Exports from Germany and Czech Republic are due to oversupply from large-scale forest calamities

15 2023-11-02 | FUTURE PROSPECTS OF THE GLOBAL PULP INDUSTRY

Increasing competition and new supply can lead to closing down of non-competitive pulp capacity in the upcoming years

RECOVERY BOILER BREAKDOWN BY START/REBUILD DECADE¹

TDs/day



¹ Recovery boilers used for BSKP, BHKP and/or UKP; can be used to produce other grades as well. Decade according to start or rebuild year. ² 1960s and earlier.

16 2023-11-02 | FUTURE PROSPECTS OF THE GLOBAL PULP INDUSTRY

Global kraft pulp market continues to grow with 1.4%/a through 2035 primarily driven by market BHKP

How will the new capacity shape the global pulp supply structure?



What is the future of the pulp industry – will the growth continue?

Kraft pulp supply will be more concentrated in Latin America and Asia in the future – fibre availability is the key question mark

What will be Finland's role moving forward?

Global kraft pulp market continues to grow with 1.4%/a through 2035 primarily driven by market BHKP

How will the new capacity shape the global pulp supply structure?



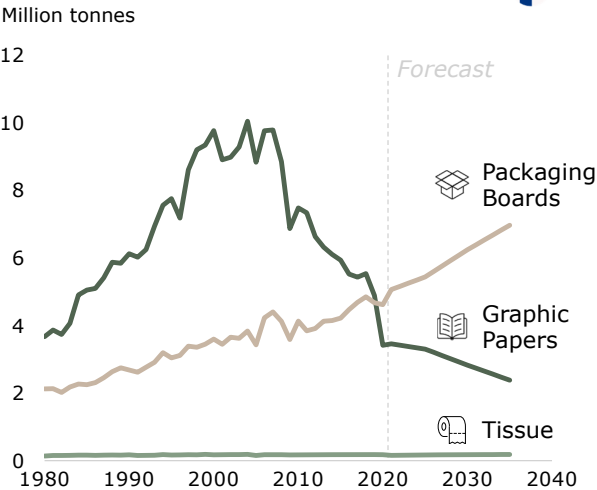
What is the future of the pulp industry – will the growth continue?

Kraft pulp supply will be more concentrated in Latin America and Asia – fibre availability is the key question mark

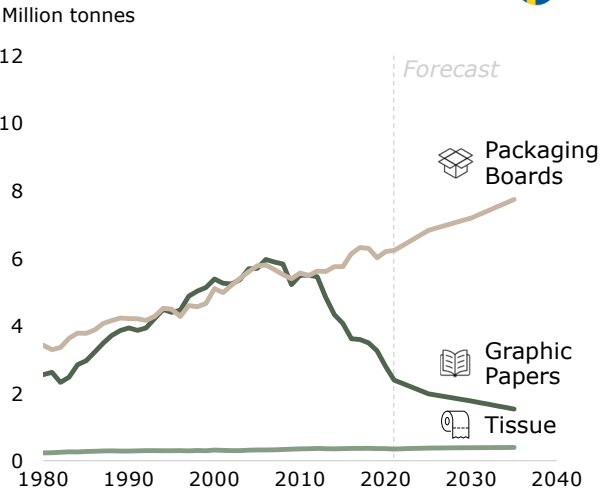
What will be Finland's role moving forward?

Production of packaging materials is steadily growing while graphic papers continue to decline

P&B PRODUCTION IN FINLAND

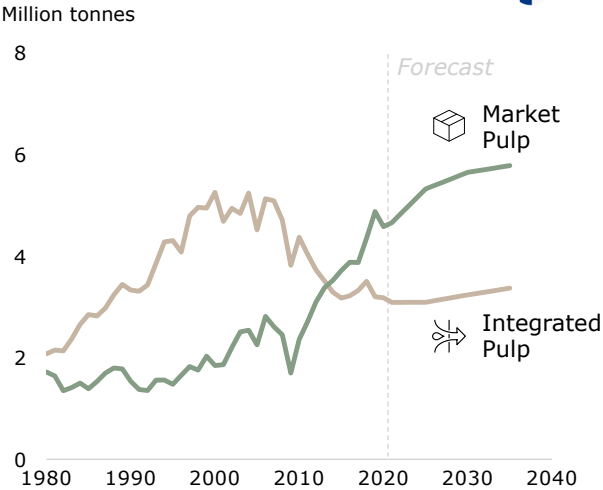


P&B PRODUCTION IN SWEDEN

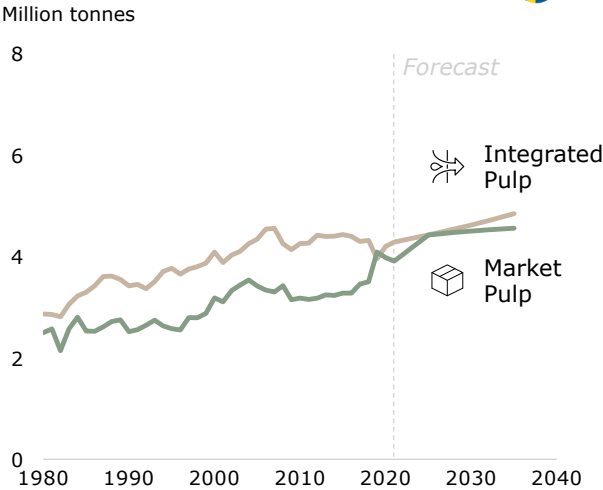


Role and importance of market pulp is growing, also in the Nordics

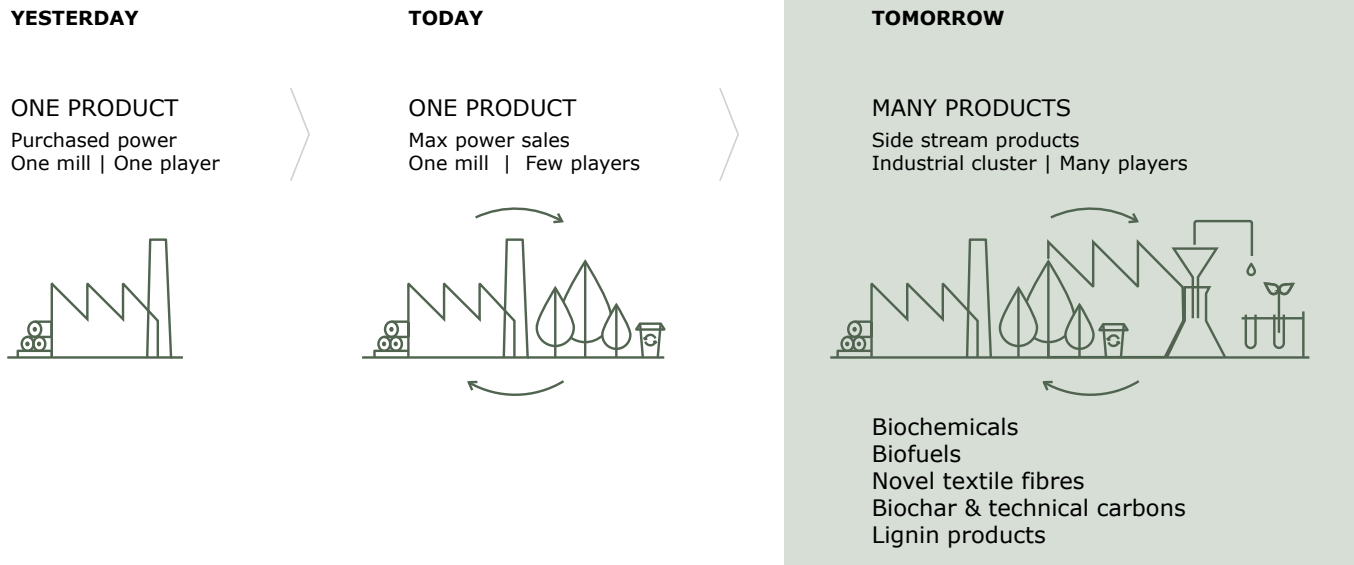
KRAFT PULP PRODUCTION IN FINLAND



KRAFT PULP PRODUCTION IN SWEDEN



Besides pulp and electricity, future pulp mills will get revenues from other value-adding bio-based products



Global kraft pulp market continues to grow with 1.4%/a through 2035 primarily driven by market BHKP

How will the new capacity shape the global pulp supply structure?

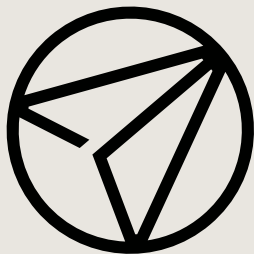
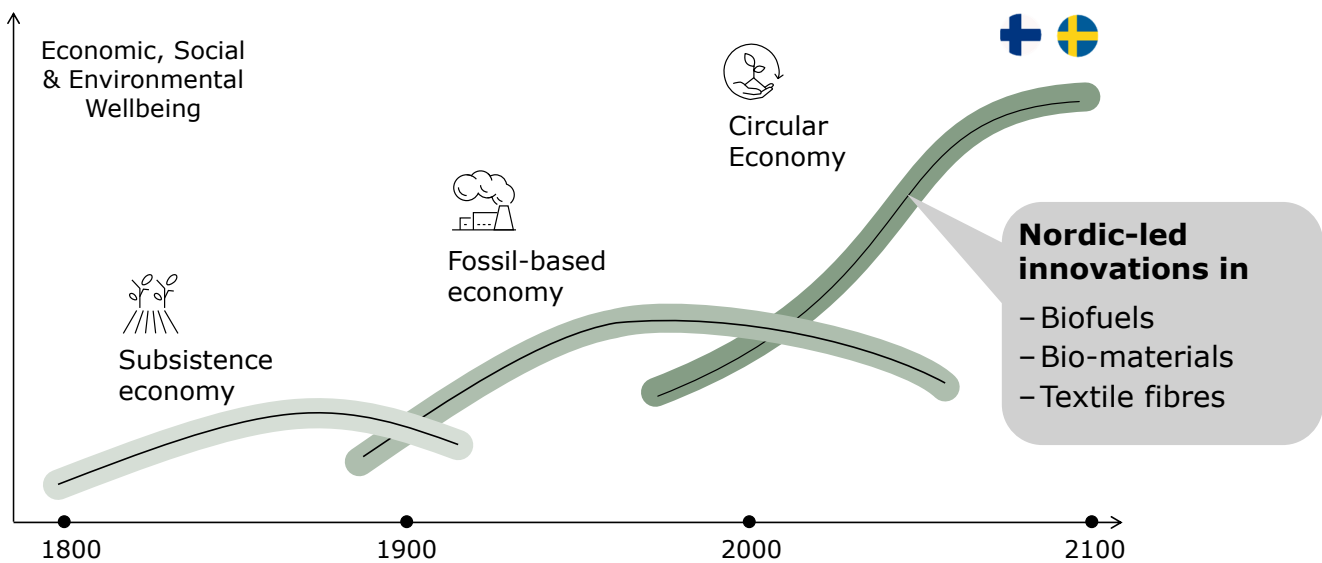
Nordics are in the forefront of developing novel products from pulp mills

What is the future of the pulp industry – will the growth continue?

Kraft pulp supply will be more concentrated in Latin America and Asia – fibre availability is the key question mark

What will be Finland’s role moving forward?

A new era for innovations and sustainable growth!



AFRY

ÅF PÖYRY

**SODAHUSKOMMITTÉN - RUOTSALAIS-NORJALAINEN
SOODAKATTILAKOMITEA, VUOSIKATSAUS**

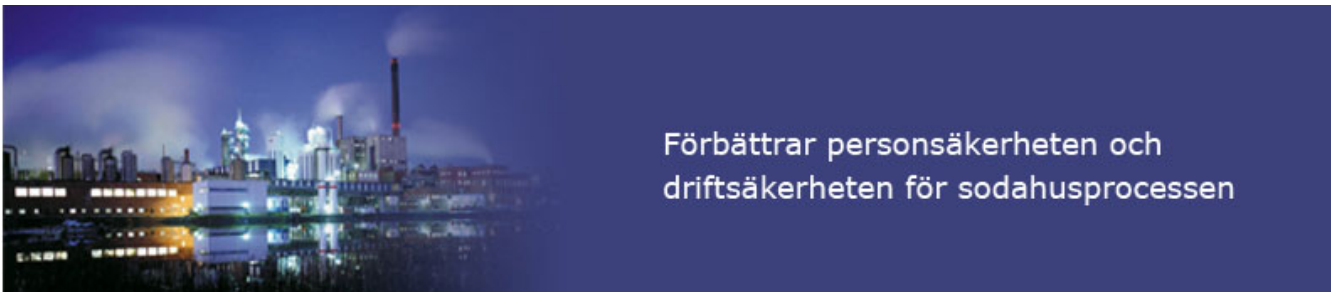
Kristian Rosenqvist
The Swedish Norwegian Recovery Boiler Committee (SNRBC)

Report from the Swedish-Norwegian Recovery Boiler Committee

Soodakattilapäivään 2/11 2023

Kristian Rosenqvist, AFRY

Secretary of the Swedish-Norwegian Recovery Boiler Committee (SNRBC)



Topics

- Members and organization
- Recovery Boilers in Sweden and Norway
- Reported incidents
- Standardization
- Recommendations and standardization
- Certification of operators
- Experience sharing day
- Recovery Boiler meeting
- Prioritized projects

Members

- All mills producing kraft pulp and Domsjö in Sweden (22 mills), and Borregaard in Norway
- Recovery boiler manufacturers (Andritz and Valmet)
- 3rd party (Dekra, Force and Kiwa)
- Swedish Paper Industry Workers' Union

Organization

The Board of the SNRBC
Chairman: Anders Fransson, Valmet
Secretary: Kristian Rosenqvist, AFRY
18 members (11 voting)

Recommendations Subcommittee
Secretary: Lars Andersson, AFRY
Additional 4 members

Incidents Subcommittee
Secretary: David Good, Dekra
Additional 13 members

Education Subcommittee
Secretary: Björn Lundgren, Kiwa
Additional 5 members

EIA Subcommittee
(Electricity, Instrumentation, Automation)
Secretary: Kristian Rosenqvist, AFRY
Additional 8 members

Recovery Boilers in Sweden and Norway

Fall 2023

- New recovery boiler at Frövi mill starting up

Fall 2022

- New recovery boiler at Metsä board Husum starting up

Spring 2019

- Increased capacity Smurfit Kappa Piteå

Autumn 2018

- Increased capacity recovery boiler SCA Östrand

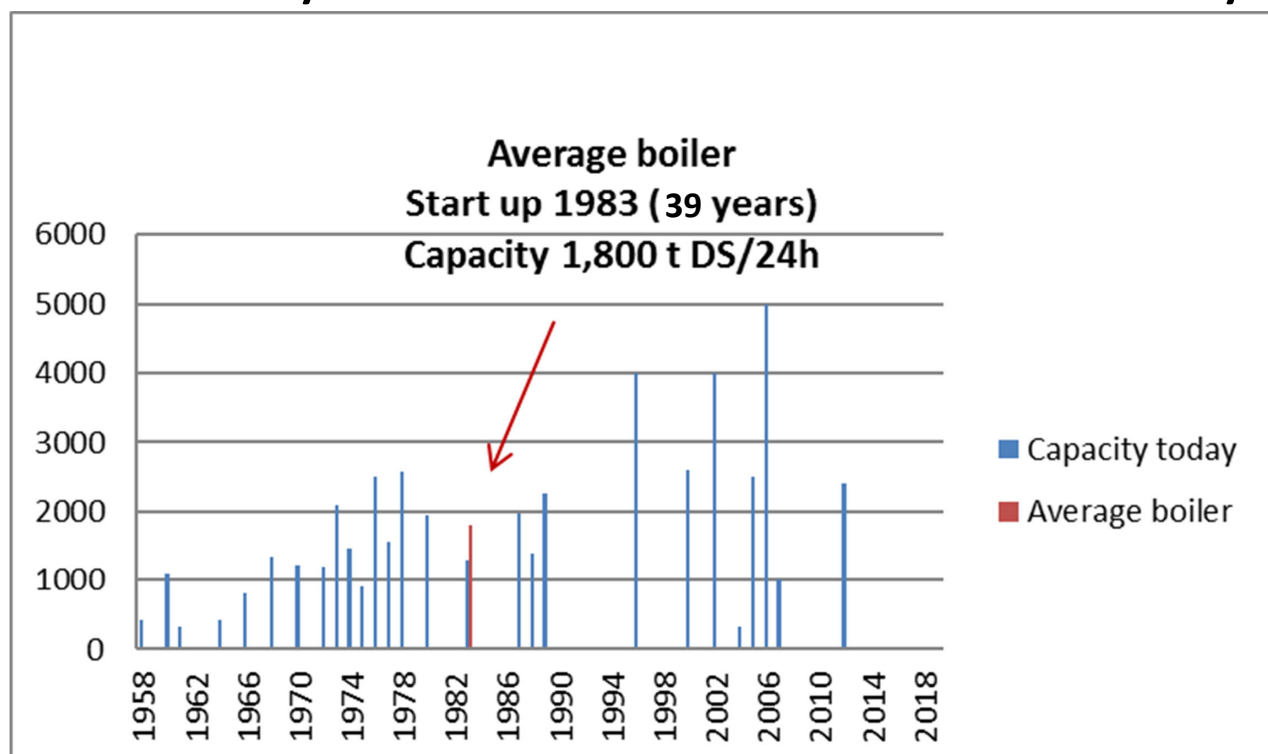
Autumn 2016

- Increased capacity recovery boiler Södra Cell Värö

Autumn 2013

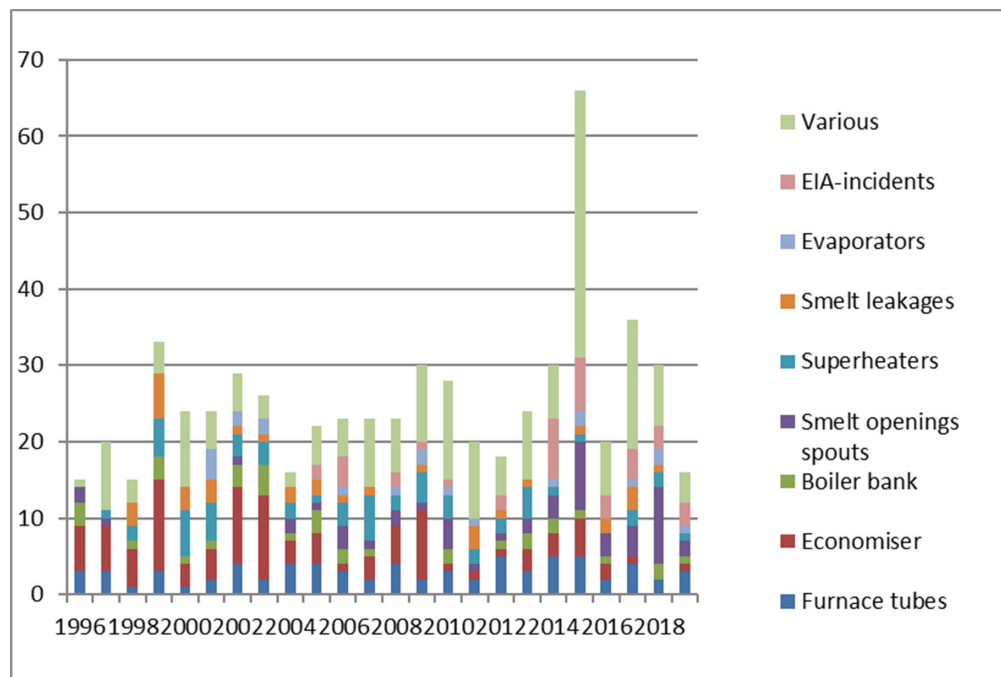
- The boiler in SCA Munksund was converted to single drum
- New evaporator line in BillerudKorsnäs Skärblacka

Recovery Boilers in Sweden and Norway



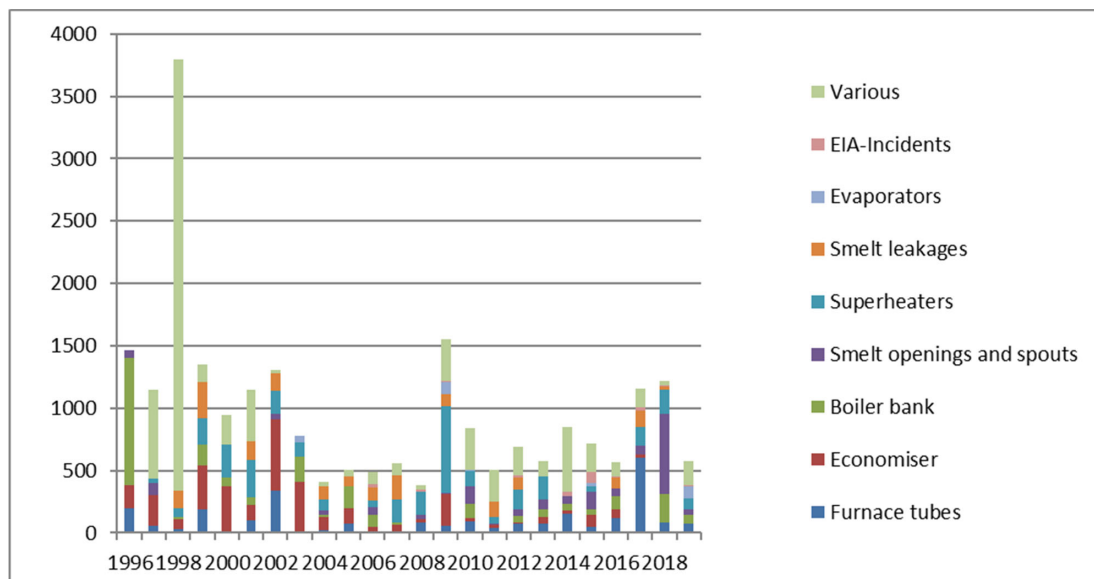
Reported incidents

- Amount of incidents



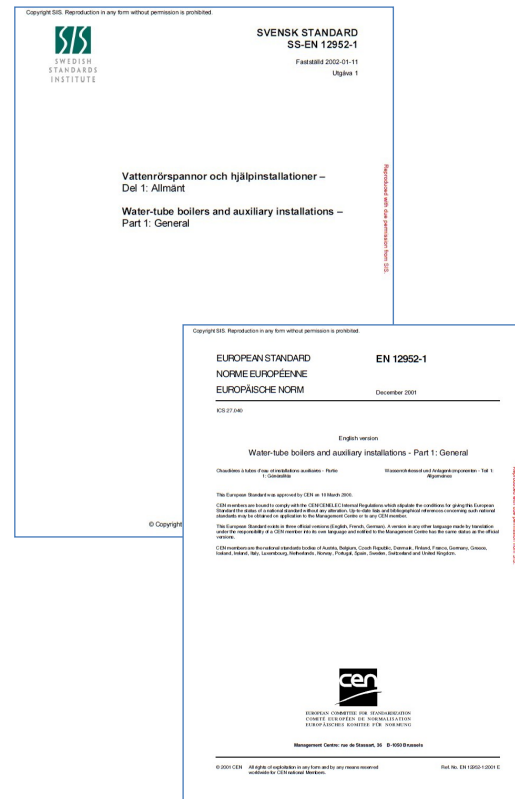
Reported incidents

- Down time [h]



Standardization

- We are members in the Swedish Standardization, SIS
- We are represented in the Swedish Working Group TK285, Boilers
- We take part in the CEN Standardization work for the boiler standard: EN 12952, "Water tube boilers"

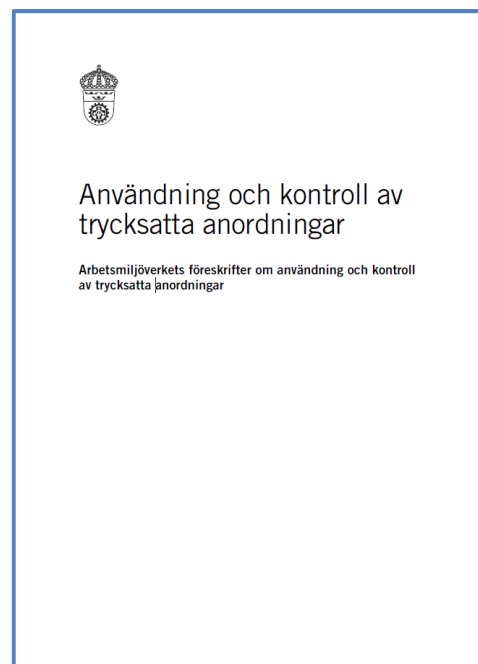


Standardization

Since november 2017 Sweden has a new regulation för pressurized devices (AFS 2017:3)

Important changes, relevant to recovery boilers are:

- Inspection of boilers
- Assessment of remaining lifetime, routines, journal keeping
- Certification of boiler operators



Recommendations

The SNRBC has 40 recommendations, divided in areas like:

B: Construction and equipment

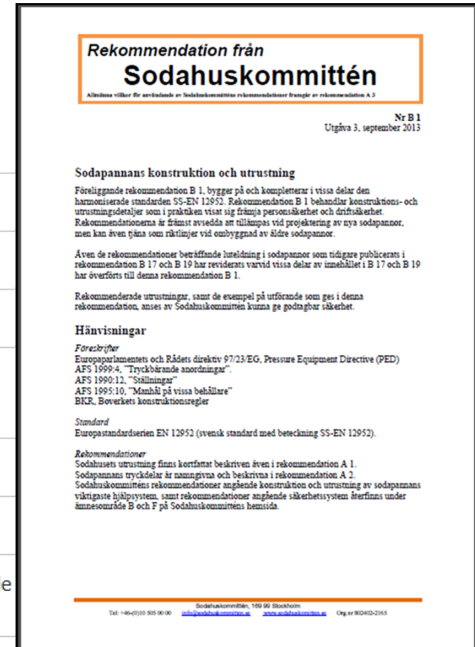
C: Operation and operational disturbances

B: Konstruktion och utrustning

Nr.	Titel
B1	Sodapannors konstruktion och utrustning
B2	Säkerhet i sodahusbyggnader

C: Drift och driftstörningar

Nr.	Titel
C1	Information om kritiska tillstånd och händelser i sodahuset.
C2	Information om sodapannedrift samt förebyggande och åtgärdande av driftstörningar.



Updating of the recommendations every third year

Recommendations approved 2021-2022

- B4 Construction and design of dissolving tank (2022)
- B22 Recovery boiler air systems
- B17 Evaporation black liquor systems (2022)
- B5 Safety equipment around recovery boilers (2022)
- D4 Repair and maintenance welding of recovery boilers (2022)
- B2 Safety in boiler houses (2021)
- B8 Emergency shutdown and rapid drainage of recovery boiler (2021)
- C4 Quality of makeup water, condensate, feed water, boiler water and steam (2021)
- C12 Chemical cleaning of water-side scaling (2021)
- B13 Combustion of oil and gas in recovery boilers - equipment and safety systems (2020)

Certification of recovery boiler operators

The minimum accepted recovery boiler experience until examination and certification is 2 years

All certificates need to be updated/renewed each 7th year

The “re-examination test” is web-based and divided into three main parts:

- Recovery boiler design
- Combustion optimization
- Safety

Education adopted to also suit the knowledge requirements for boiler operators in the renewed Swedish regulation of pressurized devices

Certification of recovery boiler operators

Knowledge requirements in the renewed Swedish regulation of pressurized devices (AFS 2017:3):

- Knowledge of the regulation for pressurized devices
- Boiler principles: thermodynamics, superheated steam, phase transitions
- Boiler construction
- Risks during start and stop of boiler
- Monitoring and safety system of boiler
- Emergency situations and how the operator should act
- Properties of steam, water and oil at temperatures exceeding 110°C
- Special risks in boilers where heat can be accumulated and how to prevent these risks
- Boiler control system
- Boiler alarms related to safety and critical to safety

Färdighet eller kunskap	Kategori			
	1	2	3	4
Ha kunskaper om kraven för pannor i dessa föreskrifter:	X	X	X	X
- Fortlöpande tillsyn				
- Pannans livslängd				
- Kontroll				
- Övervakning				
Känna till de grundläggande principerna bakom pannor: termodynamik, överhettning och fasomvandling.	X	X	X	X
Kunna ISO-standardenheter för temperatur, tryck, massa, densitet och energi.	X	X	X	X
Kunna beskriva hur pannan och de huvudkomponenter som är förbundna med pannan fungerar.	X	X	X	X
Ha grundläggande kunskaper om de risker som finns vid start och stopp av en panna.	X	X	X	X
Ha grundläggande kunskaper om de risker som finns med eldning av olika bränslen.	X	X	X	X
Kunna beskriva och förstå en pannas övervaknings- och säkerhetsutrustning, varför de finns, hur de fungerar och vilka åtgärder som ska vidtas när de aktiveras.	X	X	X	X
Ha kunskaper om de nödsituationer som kan uppkomma vid användning av pannor och hur en [pannoperator] ska agera vid dessa nödsituationer.	X	X	X	X
Känna till krav vid ständigt och periodisk övervakning.	X	X	X	X
Ha kunskaper om egenskaper hos ånga samt vatten och olja som hanteras över 110°C.	X		X	
Veta vilka särskilda risker som finns vid eldning av pannor där restvärme kan ackumuleras i farlig mängd och hur dessa risker förebyggs.	X	X		
Veta hur de styr- och regler-system som säkerställer att pannan hålls inom tillåtna värden fungerar.	X	X		
Känna till vad som skiljer säkerhetsrelaterade och säkerhetsskritiska larm från övriga larm.	X	X		

Certification of recovery boiler operators

Phase 1, 4 days	Phase 2, 4 days	Phase 3, 4 days	Phase 4, 4 days
Introduction	Process control, phase 1	Process control, phase 2	Process control, phase 3
Introduction to pulp production and chemical recovery	Energy technology	Regulations	Critical conditions
Environmental technologies	Feed- and boiler water	Safety systems	Operation and operational disturbances
Process- and production economy	Boiler circulation and steam formation	Fuel, hot water and hot oil boilers	Safety aspects of operation, case study
Project	Combustion technology	Material and damages	Final presentation of project
Homework	Presentation of project, part	Site visit Presentation of project, part	

Experience sharing day

Operators and other persons from member companies meet and discuss important topics.

2023 the topic was

” Incidence handling and emergency shut downs”

- 30 operators from swedish mills got the opportunity to work discuss incidents reported to the committee, with presentations on how they would have handled similar situations at their mills.
- Regulations, norms, recommendations
- Discussions

The topic for 2024 is still being planned.

Prioritized projects 2023

Risk Analysis Recovery Boiler (continuation) – SIL classification

Guidelines on risk analysis of recovery boiler incl

- required safety functions in a recovery boiler
- by SNRBC recommended SIL-level (Safety Integrity Level) for each safety function
- Added chapters on what should be included in boiler testing

Smelt run-offs

- Bench marking study based on data from many swedish mills, to analyze the effects of different mill-parameters on the smelt run-off phenomena. This study is in its data analysis phase.

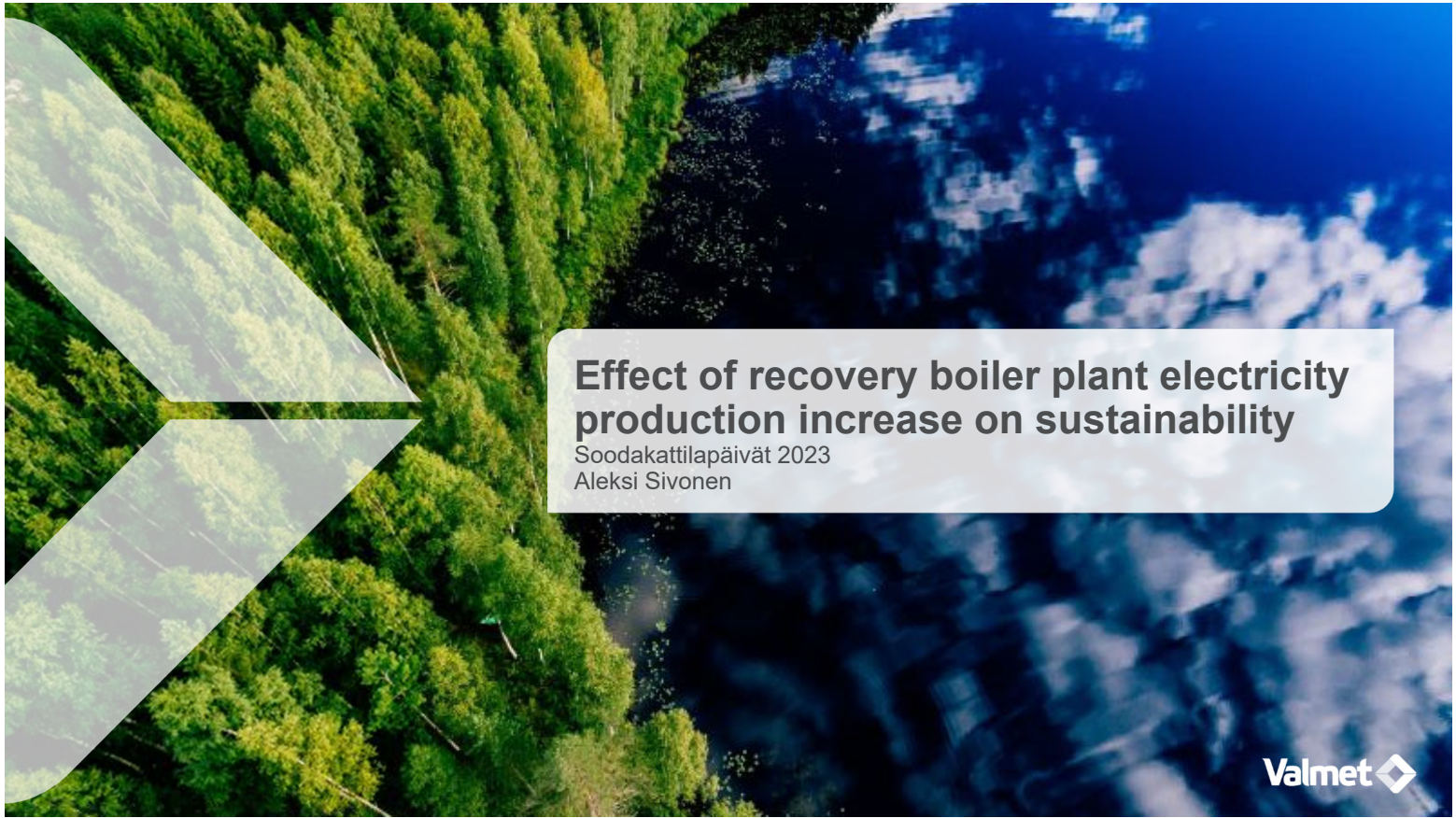
Thank You!



Förbättrar personsäkerheten och
driftsäkerheten för sodahusprocessen

YHDISTYKSEN OPINNÄYTETYÖPALKINNON ESITTELY:
EFFECT OF RECOVERY BOILER PLANT ELECTRICITY PRODUCTION
INCREASE ON SUSTAINABILITY

Alexi Sivonen
Tampereen yliopisto



Effect of recovery boiler plant electricity production increase on sustainability

Soodakattilapäivät 2023

Aleksi Sivonen



Background and starting point

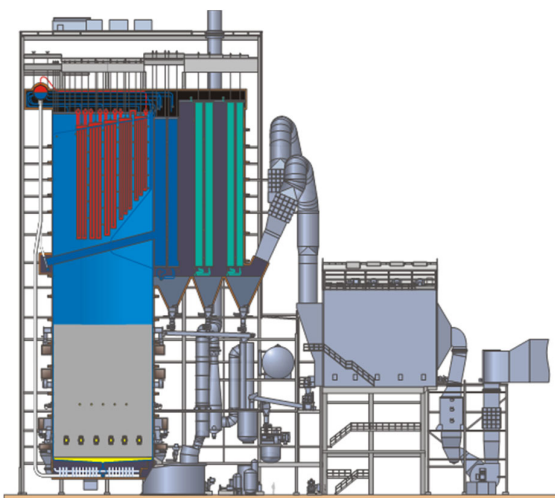
- Motivation for the thesis was created by Valmet's sustainability target for recovery boilers.
- The main idea was to examine possibilities to increase the electricity production and evaluate its effect of sustainability.
 - Increased main steam parameters and partial reheating were examined in terms of electricity production increase.
- During the process, different challenges in electricity production increase were examined.
- Boiler dimensions and furnace energy balance calculated with internal boiler design software were used as initial data in the modelling of boiler and boiler plant.
- Calculations were made according to EN 12952

Master's thesis

Research questions

1. What kind of methods can be used to increase electricity production in thermal power plants and which of them are applicable to recovery boiler environment?
2. What kind of indicators can be used to evaluate the effect of increasing recovery boiler plant electricity production on sustainability?
3. What properties do the existing modelling tools have, and can they be connected to be used in recovery boiler electricity production optimization?
4. How large a potential each of the studied technologies has in terms of electricity production increase?
5. What is the optimal combination of the studied technologies for maximizing the electricity production while still considering the selected sustainability indicators?

Base case - reference



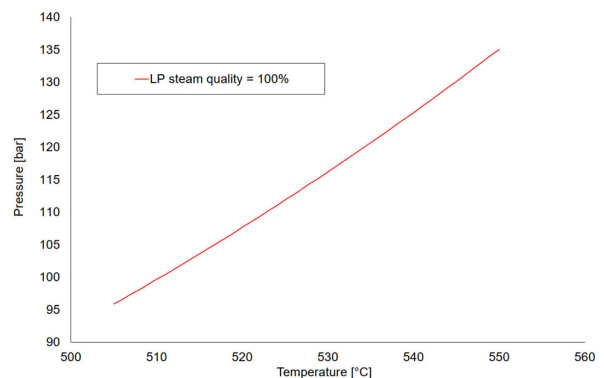
- Main steam temperature 505°C.
- Main steam pressure 105 bar.
- Materials used in superheaters:
 - 16Mo3
 - 10CrMo9-10
 - 7CrMoVTiB10-10
 - TP309 L.
- Electricity production of 255 MW.
- Ash is treated with a crystallizer.

Finding the maximum main steam parameters

- Corrosion (Ash quality) and wall thickness in superheaters were the limiting factors for main steam temperature.
- Lowest potassium and chlorine were reached with 100% ash treatment duty cycle.
- When considering process availability the maximum duty cycle of 90% was selected for further calculations.
 - Based on the duty cycle, it was also possible to determine operational cost for ash treatment.
- Lowest practical potassium and chlorine contents were used to determine first melting temperature (FMT) of the ash.
- FMT was used along with some corrosion margins to calculate the **maximum main steam temperature of 550°C** for the boiler under examination.

Finding the maximum main steam parameters

- The maximum pressure of main steam was determined based on low pressure extraction steam quality.
 - To prevent excess condensate flow into low pressure steam network the low pressure extraction steam must have steam quality of 100%.
- Extraction steam quality was examined with electricity production model.
- Corresponding **maximum main steam pressure was determined to be 135 bar.**



Effect of main steam pressure on lower furnace

- Increase in main steam pressure subsequently increases the pressure also in furnace walls.
 - Higher pressure raises the saturation temperature of the water and further increases the fireside wall temperature.
 - Change in pressure affects also wall tube thicknesses. **High pressure restricts usage of compound tubing.**
 - Pressure carrying carbon steel tube wall thickness options are limited. **Use of overlay welded tubes is required.**
- Lower furnace corrosion and materials needs to be considered in areas of high thermal loading.
- Importance of boiler water chemistry increases since the internal deposit significantly affects the fireside wall temperatures.
 - The main point of interest is in compound area.

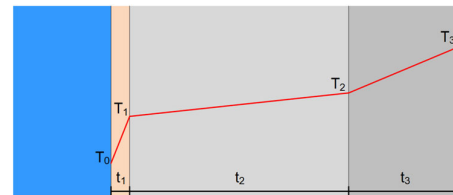
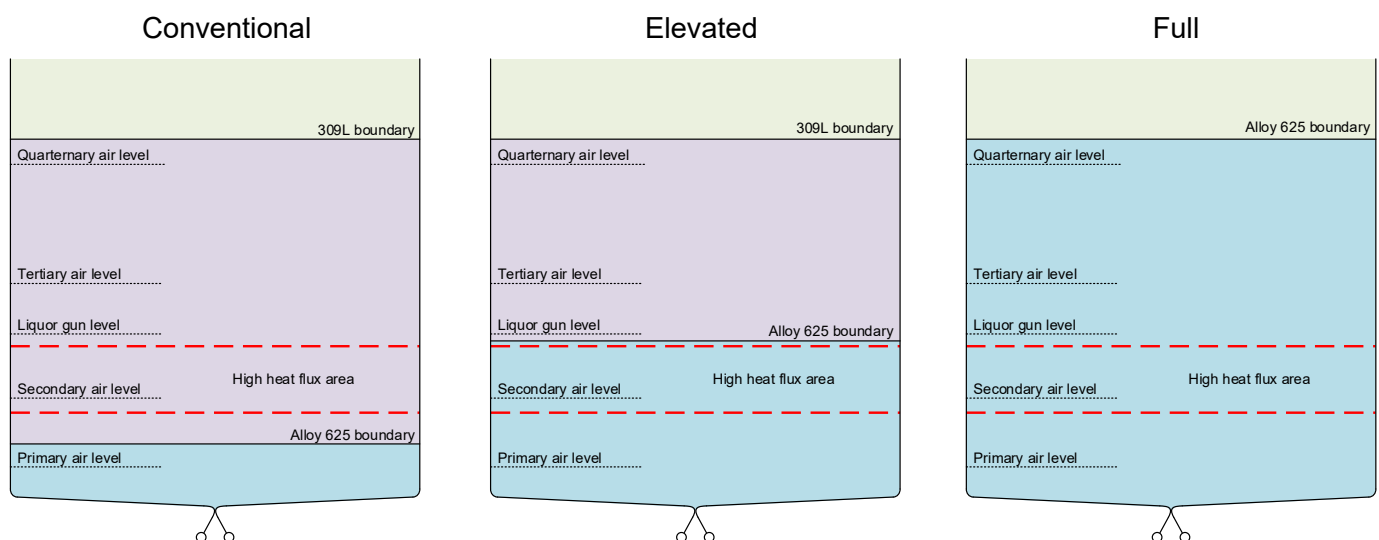


Figure 5.8. Structure of the multi-layered tube wall used in surface temperature calculations. Internal deposit thickness t_1 , carbon steel wall thickness t_2 and cladding layer thickness t_3 varies between examined tubes. Temperature profile is presented with the red line.

Wall temperatures and corrosion in lower furnace

Three compound area options were defined to consider lower furnace corrosion.



The base case has an elevated 625 boundary.

Reheat

- Can the process efficiency be increased by adding a reheater to the boiler?
 - 50% reheat mass flow from total main steam flow
 - 505°C reheat temperature
- Due to partial reheat massflow, low pressure steam moisture on the primary turbine extraction cannot be decoupled from the main steam parameters.
- Created electricity production model was combined with an optimization algorithm and it was used to find a combination of reheat temperature and reheat mass flow to maximize the electricity production.
- With examined reheat configuration, no feasible options were found when compared to examined cases without reheater.

Cases defined and examined in the thesis

- Base case
- High steam parameter case
 - Maximum realizable main steam parameters with four stage superheating limited by requirements in steam attemperation.
 - Four stage superheating
 - Main steam 540°C and 125 bar
- Maximum steam parameter case
 - Maximum parameters defined based on superheater corrosion and materials.
 - Four or five stage superheating
 - Main steam 550°C and 135 bar
- Reheater case
 - 50% of main steam flow into reheating.
 - Four stage superheating and reheater
 - Main steam 530°C and 110 bar, 505°C reheating temperature.

Sustainability evaluation

- In sustainability assessment part of the thesis the environmental and economical sustainability were examined by using multiple indicators defined in literature.
- All indicators were normalized against electricity production (MW)

Indicator	Data source
Electricity production	Electricity production model
Low alloyed steel usage	Pressure part mass calculations
Stainless steel usage	Pressure part and superheater mass calculations
Capital cost	Cost evaluations based on pressure part material usage
Chemical usage	Make-up chemicals due to ash treatment losses
Liquid waste	Ash treatment rejects
TRS	Air emissions data from the company
NOx	
SO ₂	
CO	
CO ₂	From combustion calculation

Sustainability evaluation

- Sustainability indicators were used to define an **overall impact factor** that was considering all indicator values without emphasizing single indicators.
- This was done by weighted summation where the weights were defined so that the standard deviations of the weighted values were equal.
- Overall impact value was used to evaluate the sustainability of the examined boiler configurations
 - The lower the value, the better for the environment

Table 6.9. Overall impact indicator determined for the examined cases.

Case	Overall impact	
Base case	1,668	(505°C and 105 bar)
High steam parameters Elevated alloy 625	1,639	(540°C and 125 bar)
High steam parameters Full alloy 625	1,641	(540°C and 125 bar)
Max steam parameters Full alloy 625	1,653	(550°C and 135 bar)

Conclusions

- Cost evaluation was done to each examined cases and payback time was calculated based on operational costs of ash treatment and capital costs from boiler pressure part and other equipments.

(540°C and 125 bar)

Table 6.2. Cost increment for the high steam parameter case from the base case with two lower furnace options.

	Component	Cost change [%]
Elevated alloy 625	Carbon steel and compound area	3.9
	Superheaters	82.4
	Auxiliary equipment	25.5
	Total	25.5
Full alloy 625	Carbon steel and compound area	13.0
	Superheaters	82.4
	Auxiliary equipment	25.5
	Total	31.5

(550°C and 135 bar)

Table 6.3. Cost increment for the maximum steam parameter case from the base case.

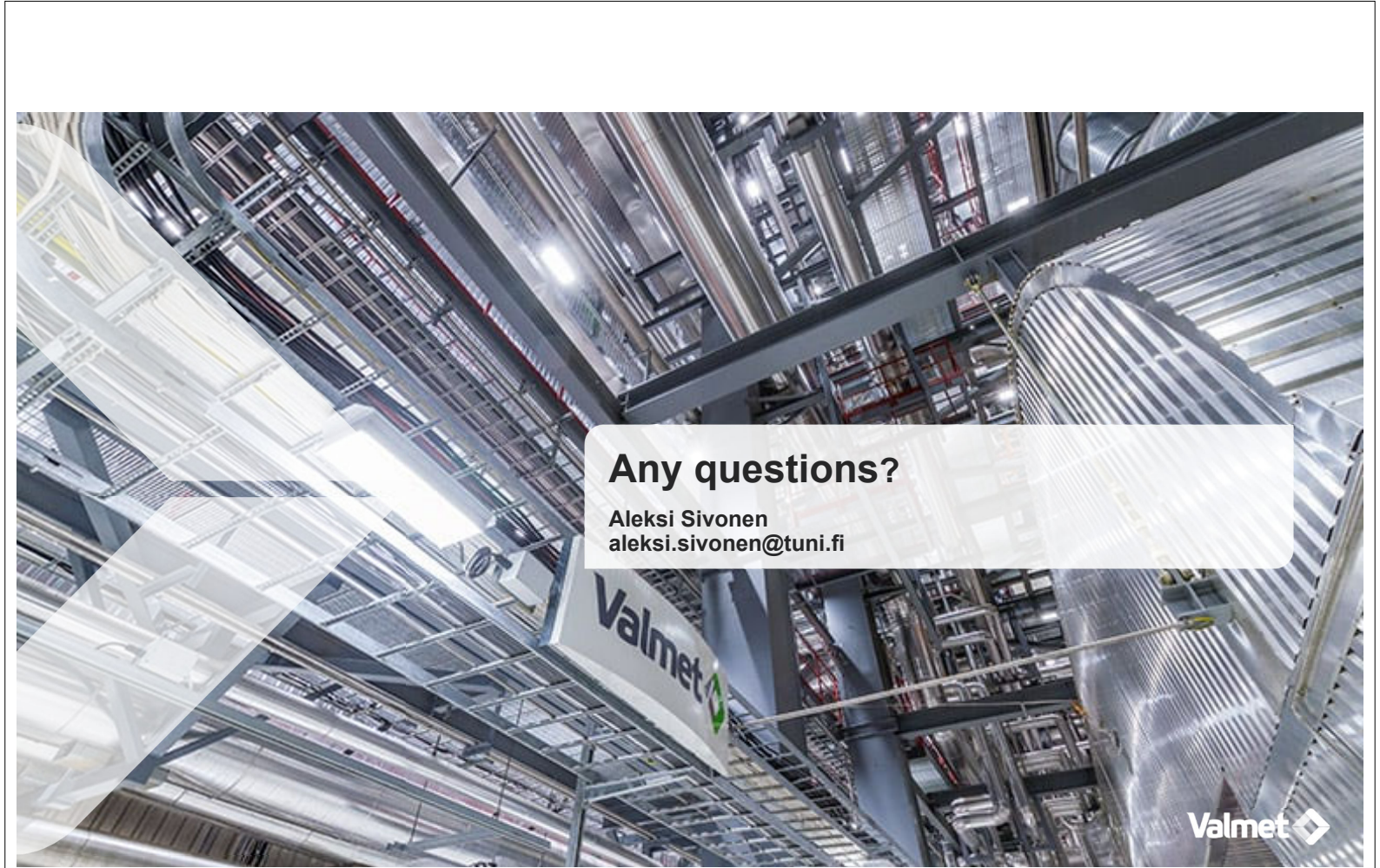
	Component	Cost change [%]
Full alloy 625	Carbon steel and compound area	14.6
	Superheaters	98.7
	Auxiliary equipment	37.9
	Total	37.9

Conclusions

- With the maximum steam parameter case (550°C and 135 bar) the increase in electricity was 5%
 - However, chemical losses are very high due to maximum ash treatment duty cycle → higher environmental impact
- The high steam parameter case with elevated alloy 625 lower furnace was selected as the optimal combination of parameters based on the payback time and overall impact factor.
 - Main steam temperature 540 °C, main steam pressure 125 bar
 - 5 stage superheating, lower furnace with overlay welded tubes
 - 4% increase in electricity production
- The examination of the sustainability indicators states clearly that maximizing the electricity production is not always the best way to increase the sustainability.
- To increase the sustainability the optimization should be done based on the electricity production and the overall impact in sustainability.

Table 7.1. Payback times, overall impact indicators and electricity production values for the selected cases.

Case	Payback time [a]	Overall impact	Electricity output [MW]
Reference	-	1,668	255.3
High steam parameters Elevated alloy 625	2.8	1,639	264.9
High steam parameters Full alloy 625	3.4	1,641	264.9
Max steam parameters Full alloy 625	5.3	1,653	268.7



Any questions?

Aleksi Sivonen
aleksi.sivonen@tuni.fi

Valmet 

Valmet 
FORWARD

SUOMEN SOODAKATTILAYHDISTYS RY, RAPORTTISARJA

- 1/2022 Suomen Soodakattilayhdistys ry
Konemestaripäivä 7.4.2022, esitelmät
Sokos hotelli Kaarle, Kokkola, UPM-Kymmene Oyj, Pietarsaaren tehtaat
(16A0913-E0215) 7.4.2022
- 2/2022 Suomen Soodakattilayhdistys ry
Soodakattila-alan yhteistoiminta
Toimintakertomus 2021
(16A0913-E0216) 26.4.2022
- 3/2022 Suomen Soodakattilayhdistys ry
Soodakattilapäivä 27.10.2022
Lapland hotels Arena, Tampere
(16A0913-E0217) 27.10.2022
- 4/2022 Suomen Soodakattilayhdistys ry
Kyberturvallisuuden perusteet soodakattiloiden automaatiojärjestelmissä
Suvi Kaartinen ja Henry Haverinen, Insta Advance Oy
(16A0913-E0218) 7.11.2022
- 5/2022 Suomen Soodakattilayhdistys ry
Suositus soodakattilan tulipesän seinien ja pohjan compoundputkien pinnoitehitsin tunkeumalle
Andritz Oy, Inspecta Tarkastus Oy, Replico Oy, Valmet Technologies Oy, Kestoisuustyöryhmä
(16A0913-E0219) 26.10.2022
- 6/2022 Suomen Soodakattilayhdistys ry
Selvitys soodakattiloiden keraamisista rakenteista
Saara Söyrinki, Pekka Pohjanne, Pertti Lintunen, Teknologian tutkimuskeskus VTT Oy
(16A0913-E0220) 9.11.2022
- 7/2022 Suomen Soodakattilayhdistys ry
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Susanna Mäki ja Kirsi Jussila, Työterveyslaitos
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SUOMEN SOODAKATTILAYHDISTYS RY, RAPORTTISARJA

- 1/2023 Suomen Soodakattilayhdistys ry
Konemestaripäivä 9.2.2023, esitelmät
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(16A0913-E0222) 9.2.2023
- 2/2023 Suomen Soodakattilayhdistys ry
Soodakattila-alan yhteistoiminta
Toimintakertomus 2022
(16A0913-E0223) 20.4.2023
- 3/2023 Suomen Soodakattilayhdistys ry
Kattilalaitoksen sähkötekniset turvajärjestelmät
Riku Kilpivuori ja Otto Laakkonen
Savonia Ammattikorkeakoulu
(16A0913-E0224) 4.5.2023
- 4/2023 Finnish Recovery Boiler Committee
Recommendation for glad welding penetration of wall and floor composite tubes in black liquor
recovery boiler furnace
Andritz Oy, Inspecta Tarkastus Oy, Replico Oy, Valmet Technologies Oy, Durability sub-committee
(16A0913-E0225) 8.6.2023
- 5/2023 Suomen Soodakattilayhdistys ry
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(16A0913-E0226) 19.6.2023
- 6/2023 Suomen Soodakattilayhdistys ry
Towards carbon-negative future of the pulp and paper industry
Kasper Heikkilä, LUT-yliopisto
(16A0913-E0227) 19.6.2023
- 7/2023 Suomen Soodakattilayhdistys ry
Tulistimien maksimipintalämpötilalisän muutos kattilan koon funktiona
Tulistinprojekti Osat I & II
Jussi Saari, Esa Vakkilainen, LUT-yliopisto
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