

Sumitomo SHI FW "SFW"

Powering a decarbonized
world for everyone

Advanced gasification for producing multi-
purpose syngas from solid feedstocks for FT-SAF

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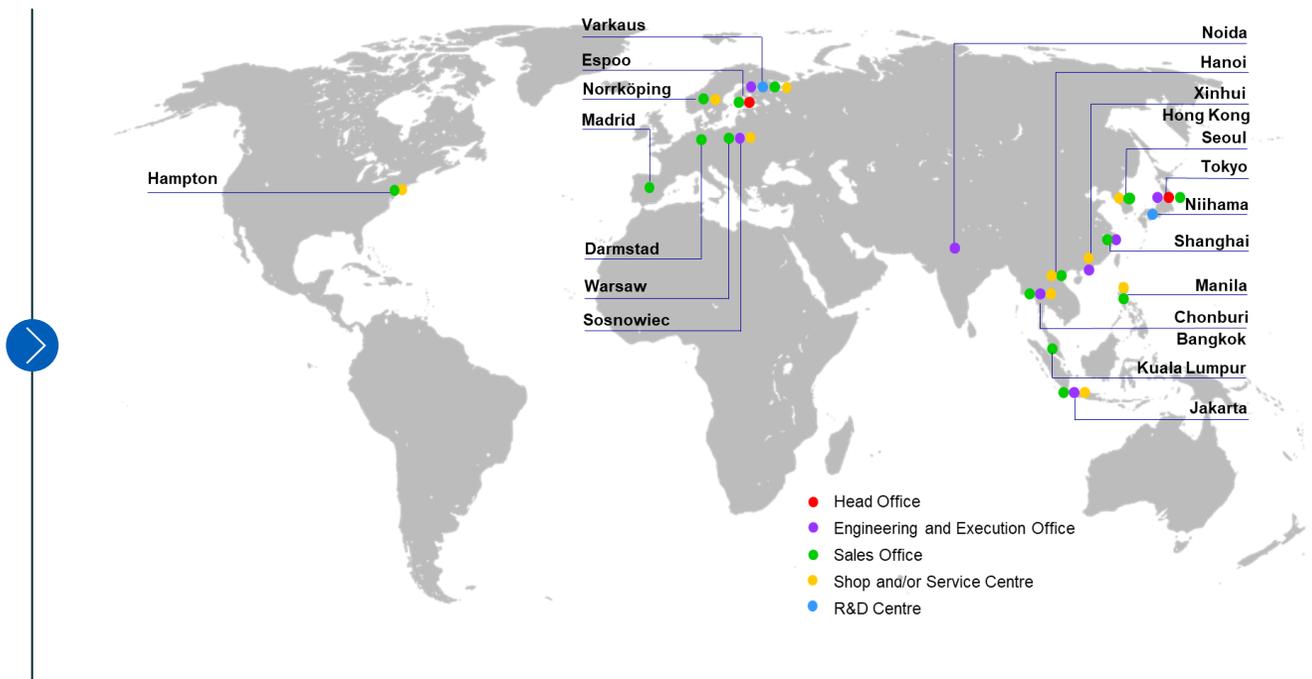
SFW provides Energy and Environmental technologies and services

A global business with 1,800 highly-skilled people

SFW at a glance

- Part of Sumitomo Heavy Industries (JPN)
- Roots in Ahlstrom (FIN) and Foster Wheeler (USA)
- Over 100 years of delivering energy solutions
- Traditional focus on combustion and fluegas cleaning
- 890 plant references worldwide using our technologies
- Market leader in circulating fluidized bed combustion
- Strong foothold in North America, Europe and Asia

Global presence and track record in North America, Europe and Asia



4 business areas
 Energy Generation, Circular Carbon, Services, Energy Storage

Strong owner SHI
 2022 revenue EUR ~6bn

> 100 years experience
 Delivering energy solutions



SFW response to decarbonization and climate change mitigation

Helping our customers to reach decarbonization goals



Energy generation

Combustion of biomass and waste for low-carbon and dispatchable heat & power

Carbon capture

Oxyfuel, Calcium Looping and Hot Potassium Carbonate for carbon neutral energy generation

Services

Life cycle solutions enabling high plant availability and efficiency

Waste to value

Gasification of biomass and waste into syngas for production of biofuels & chemicals

Energy storage

Large Scale Long Duration storage in liquid air for stabilizing the grid with increasing vRES

SFW's long history with Fluidized Bed Gasification

Over 40 years experience with biomass and waste gasifiers

Eleven gasifiers, incl. 2 pilots, 2 demos, and 7 commercial plants

Our Fluidized Bed Gasifier References

Start-up	Customer	Country	MWth	Feedstock	Application
2009	NSE Biofuels	Finland	12	Biomass	Biodiesel demo
2002	Electrabel	Belgium	50	Biomass	Biomass co-firing
2000	Corenso United	Finland	50	Plastic Waste	Recycling & Energy Recovery
1997	Lahti Energia	Finland	50	Biomass & waste	Bio/waste co-firing
1993	Sydkraft	Sweden	18	Biomass	Biomass IGCC demo
1986	Kemira	Finland	4	Coal, peat	Pilot
1985	Portucel	Portugal	15	Biomass	Lime kiln
1984	ASSI Karlborg	Sweden	27	Biomass	Lime kiln
1984	Norrsundet Bruks	Sweden	25	Biomass	Lime kiln
1983	Oy W. Schauman	Finland	35	Biomass	Lime kiln
1981	Alhstrom Lab	Finland	3	Fossil, bio & waste	Pilot

Additional operating experience

- Lahti long term tests on gas cooling and filtration in 2003-2004
- Karhula atmospheric pilot gasification test runs with O₂-enriched air in 2005
- Corenso REF gasification tests / demonstration in commercial scale in 2011-2012
- Corenso O₂ enriched air gasification in commercial scale 2013 ->

Värnamo Gasifier reference – startup 1993

Air-blown pressurized 18 MWt Circulating fluid-bed (CFB) gasifier for biomass IGCC (6 MWe/9MWt)

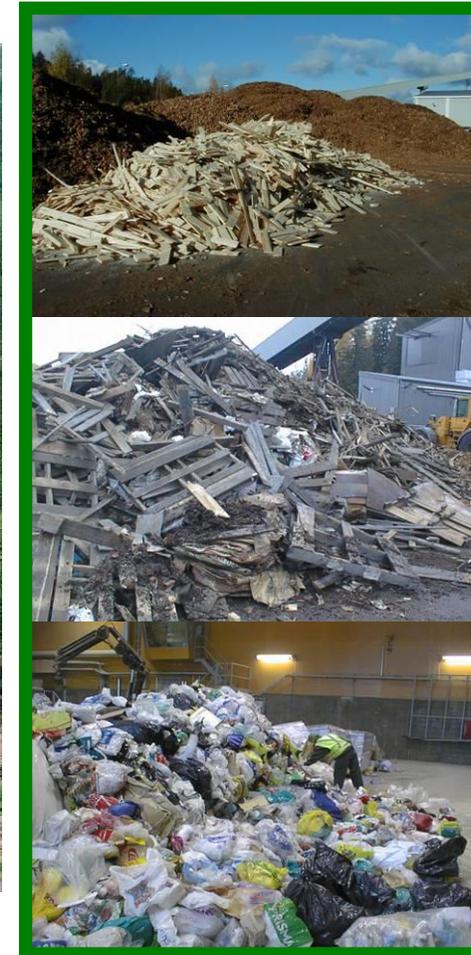
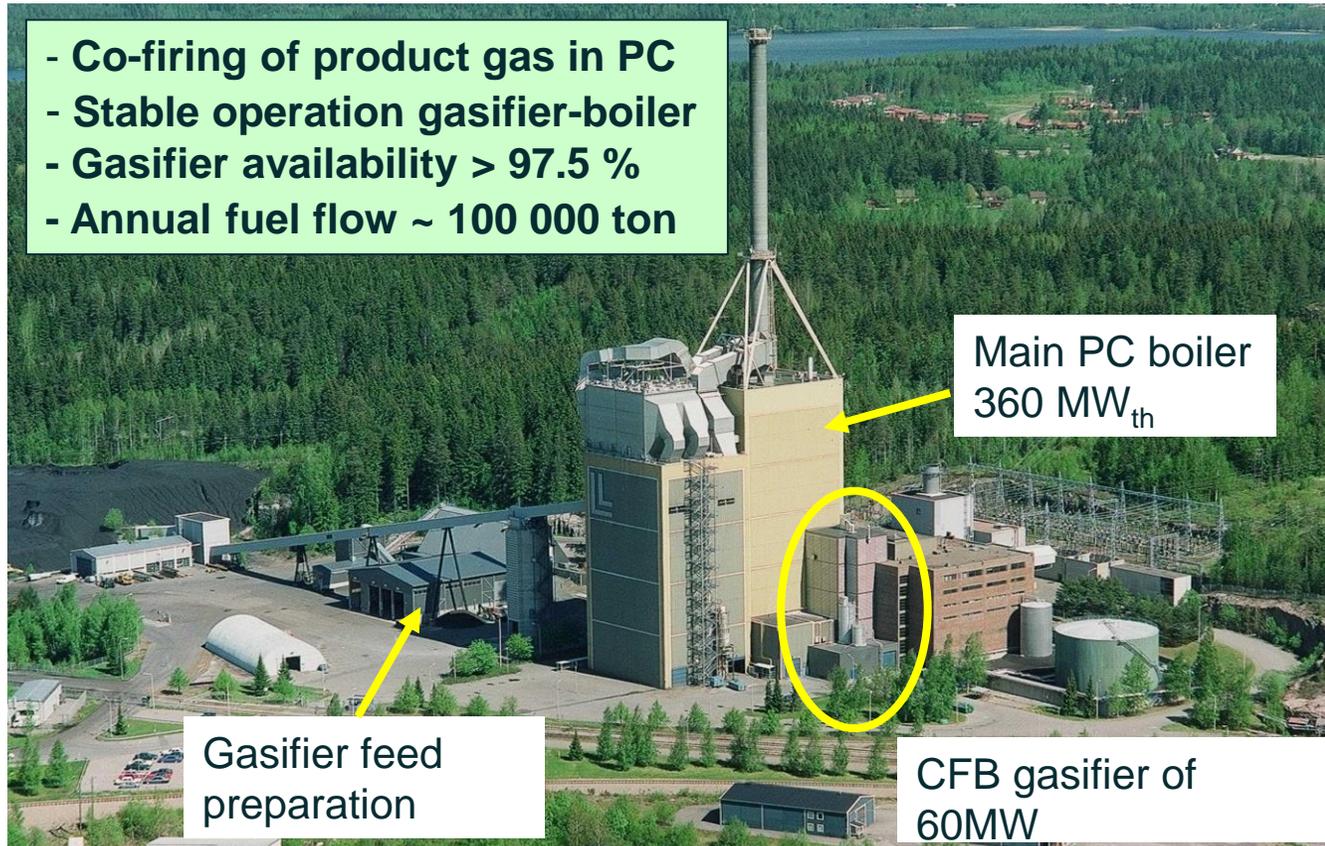
- World's first complete IGCC plant using wood fuel
- Built by Sydkraft AB
- Developed by Sydkraft and SFW as Bioflow IGCC
- 8500 gasification hours and 3600 IGCC operating hours
- Different wood fuels, willow, straw and RDF were tested
- High pressure gasification technology works
- Gas can be burnt in a gas turbine with stable conditions
- Mothballed in 2002 because not economically viable

Power / heat generation	6 MWe /9MW_{th}
Fuel input (wood chips)	18 MW
Net electrical efficiency (LHV)	32%
Total net efficiency (LHV)	83%
Gasification pressure / temperature	18 bar (g) / 950 °C
Lower calorific value of Product Gas	5 MJ/m³n



Lahti Gasifier reference - startup 1997

Airblown 60 MW_{th} Circulating fluid-bed (CFB) gasifier for mixture of biomass and recycled waste fuels



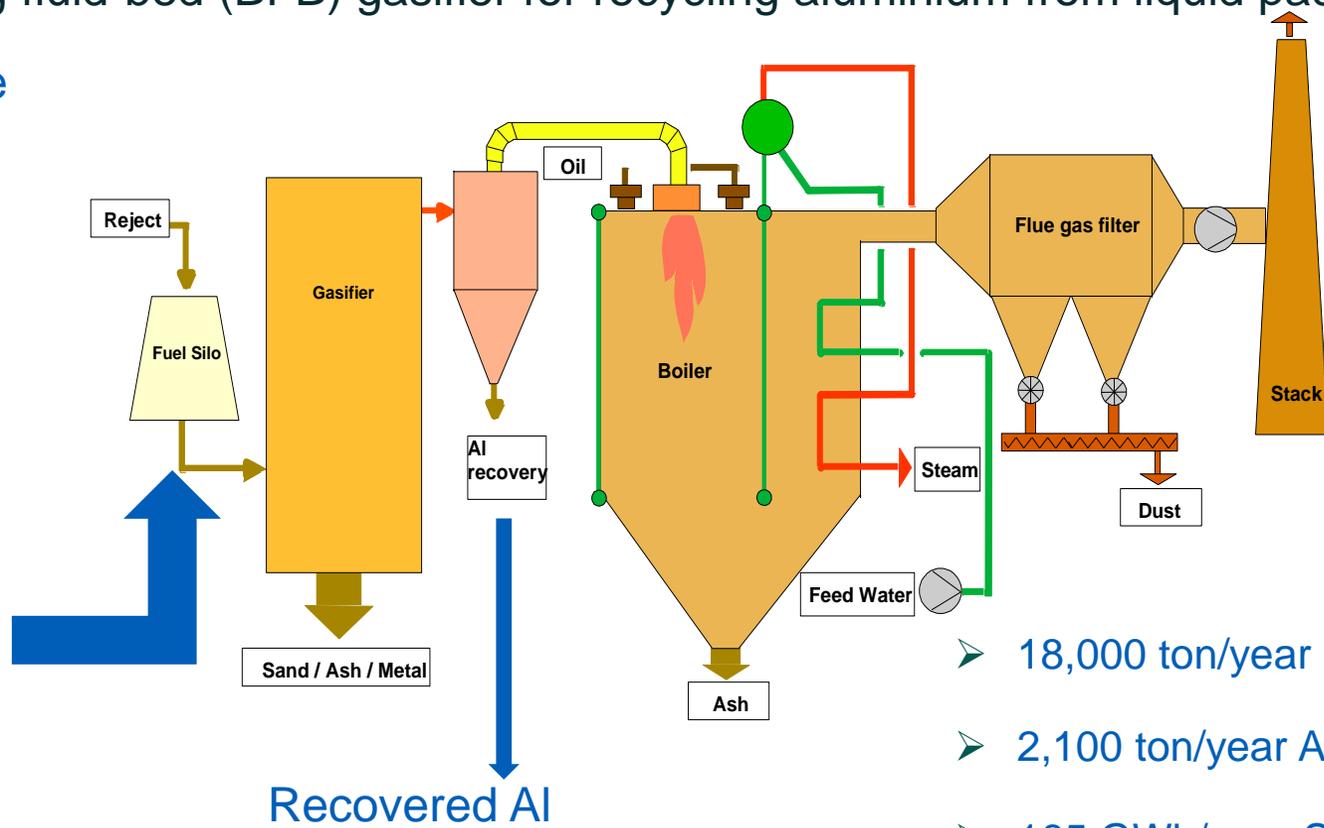
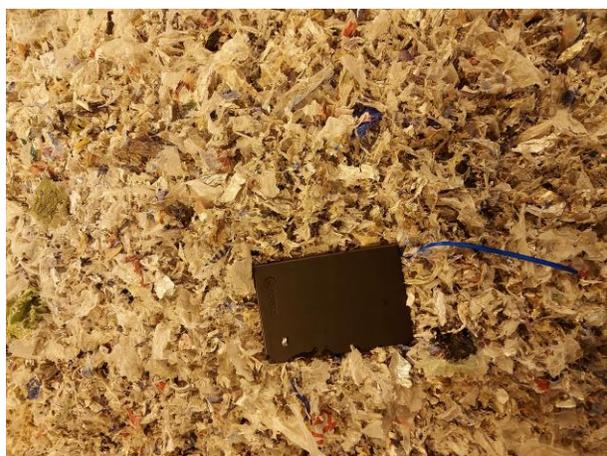
Corenso Gasifier reference - startup 2000

Airblown 50 MWt Bubbling fluid-bed (BFB) gasifier for recycling aluminium from liquid packaging board waste

Liquid packaging board waste



Rejects: plastics + Al



- 18,000 ton/year Waste Fuel Consumed
- 2,100 ton/year Aluminium Recycled
- 165 GWh/year Steam Energy produced
- CFB mode possible for RDF
- O2 enriched air mode possible for higher load



Shift from heat & power to biofuels & chemicals

Strong demand from aviation, shipping and heavy road freight for low-carbon fuels



IRENA options compatible with net zero

AVIATION

- 1) **Biojet fuel**
- 2) E-fuels
- 3) Battery-powered aircrafts.

SHIPPING

- 1) **Advanced biofuel**
- 2) E-fuels



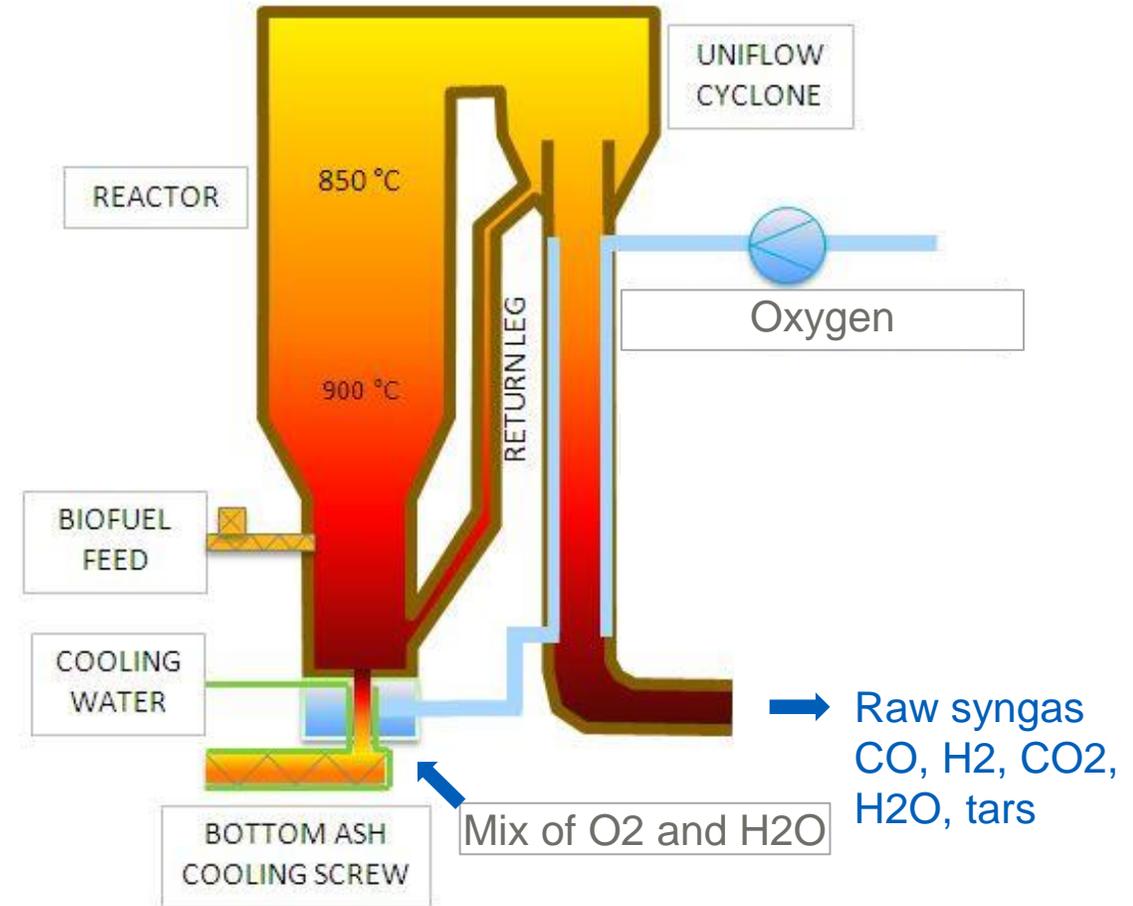
ROAD FREIGHT

- 1) Battery electric vehicles
- 2) Fuel cell electric vehicles
- 3) **Advanced biofuels**



Atmospheric Direct Oxy-steam CFB* Gasification technology

- High mass and heat transfer and long residence time
- Diverse bio / waste feedstocks and limited pretreatment
- Limestone for in-situ tar cracking in the gasifier bed
- High carbon conversion into the syngas
- Fluidized bed gasifiers can be easily scaled up
- Atmospheric pressure ensures reliable feedstock feeding
- Oxy-steam ensures simple system without combustor
- Syngas with high CO₂ facilitates CO₂ removal
- Synergy with green H₂ (O₂ and H₂ from electrolysis)



* CFB = Circulating Fluidized Bed

NSE Biofuels Demonstration Plant – startup 2009

Oxy steam 12 MWth Circulating fluid-bed (CFB) gasifier for biomass to renewable diesel

- NSE Biofuels Oy is JV of Neste and Stora Enso
- NSE teamed with VTT and SFW to develop and demonstrate gasification to convert biomass into diesel
- SFW provided the gasification and syngas cleaning
- VTT provided tar reformer knowhow
- NSE provided the Rectisol and Fisher-Tropsch
- Oxy-steam gasification testing 06/2009 – 06/2011
- Wood chips, saw dust, bark, forest residues
- Now in operation as Lime kiln Gasifier

- **Successfully demonstrated technical viability of liquid biofuels from biomass via gasification.**



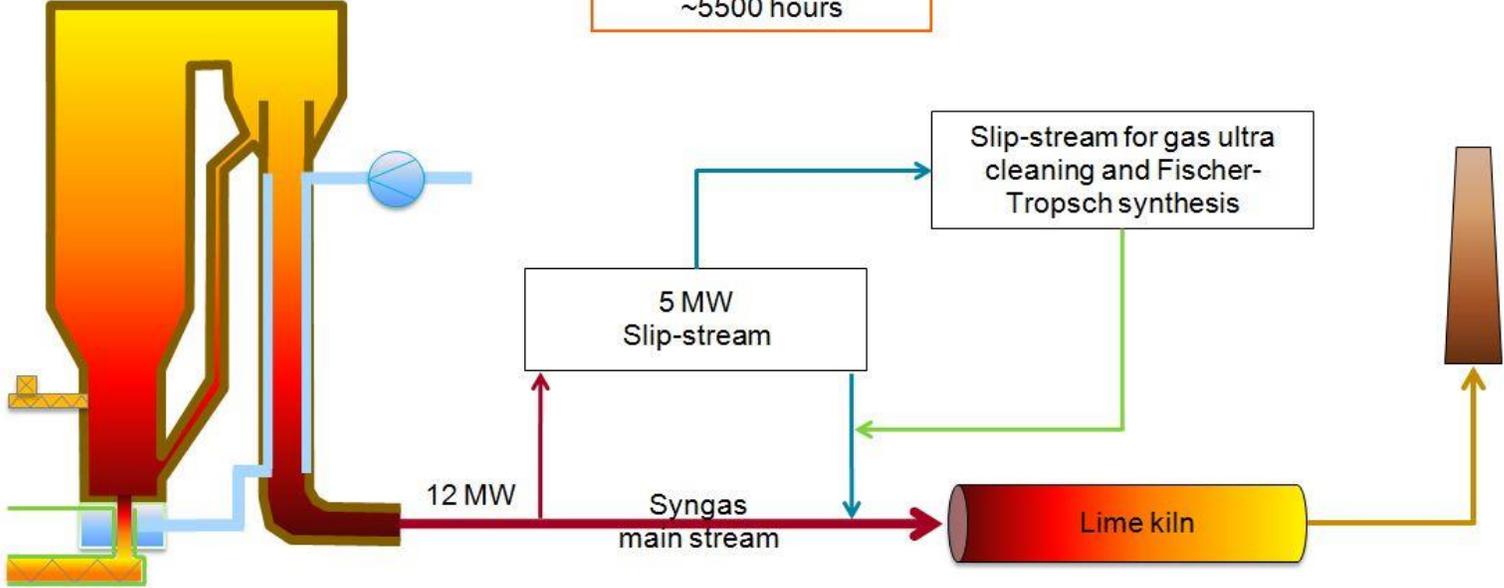
[Photo: NSE Biofuels Oy]

NSE Biofuels - Testing hours

Demonstration of O₂/steam-blown gasification using different types of biomass
 Demonstrated successfully in atmospheric pressure
 ~9000 hours

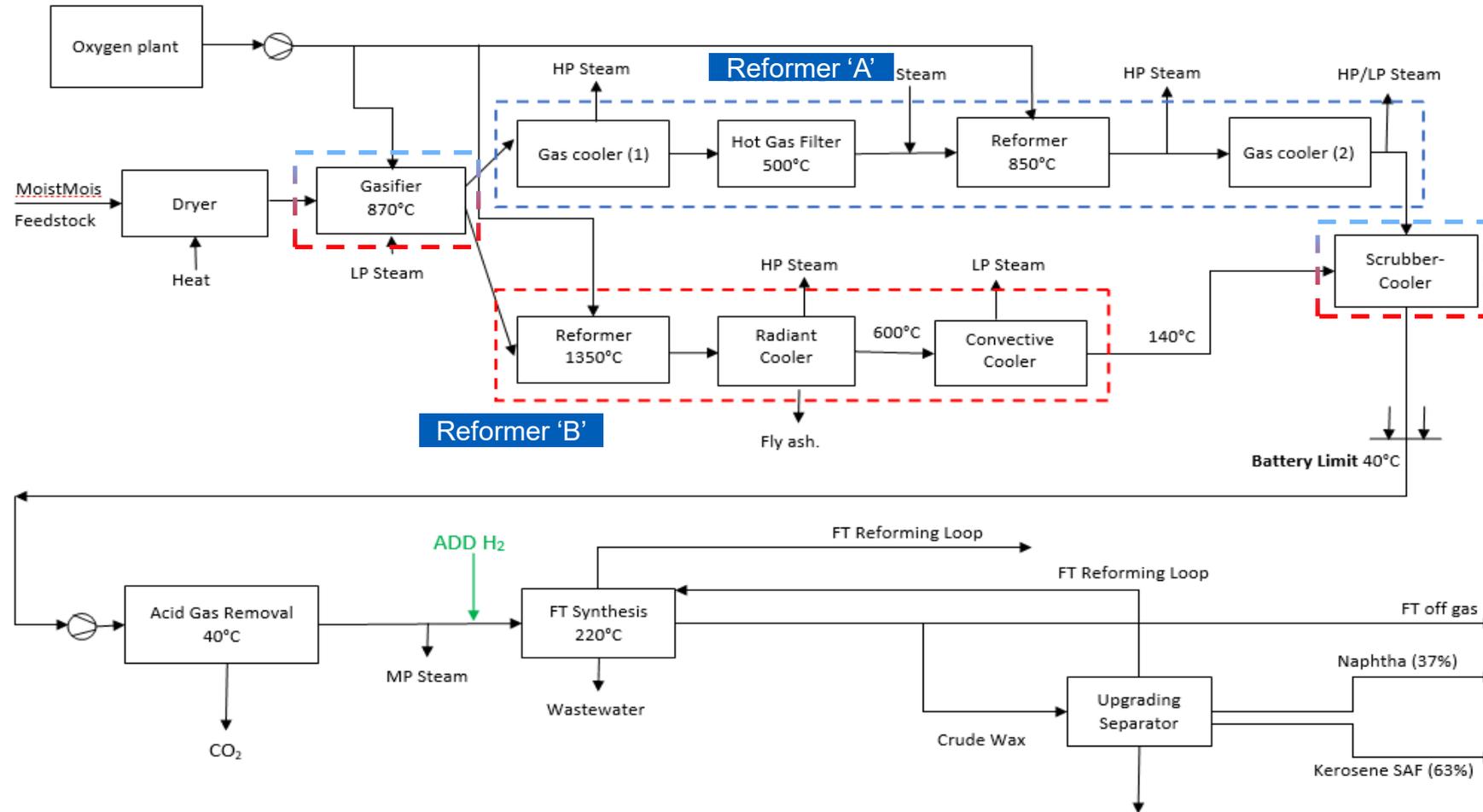
Demonstration of product gas treatment: cooling, cleaning and tar reforming
 Demonstrated successfully in atmospheric pressure
 ~5500 hours

Availabilities		
	2010	2011
O ₂ -H ₂ O gasification	94.30 %	96 %
5 MW Slip-stream	47.20 %	93 %



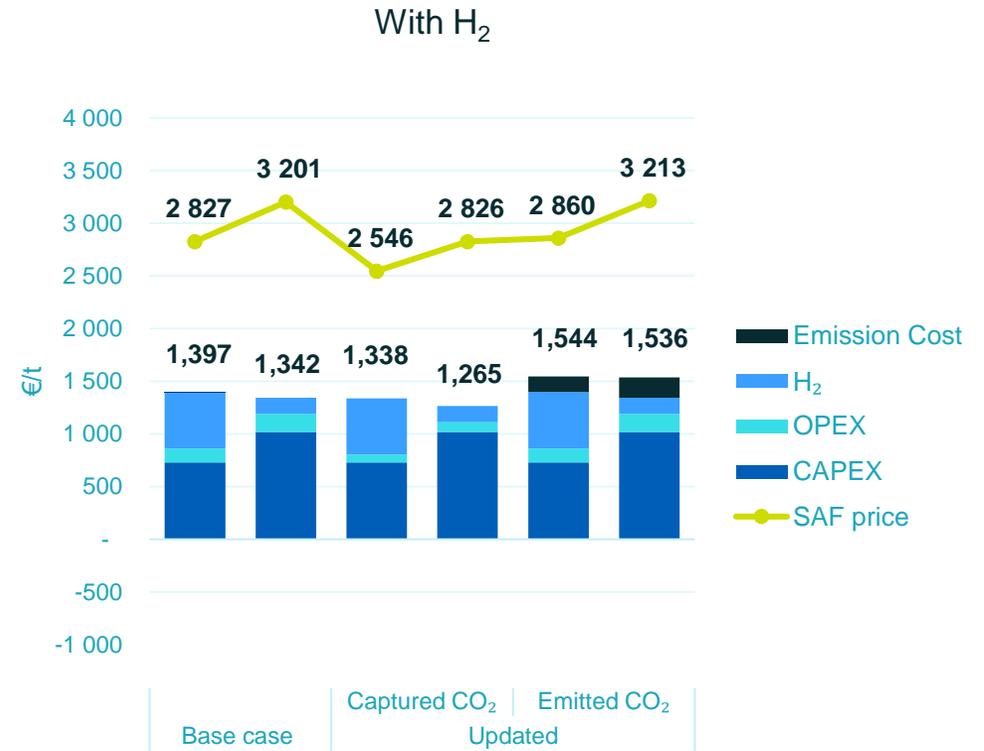
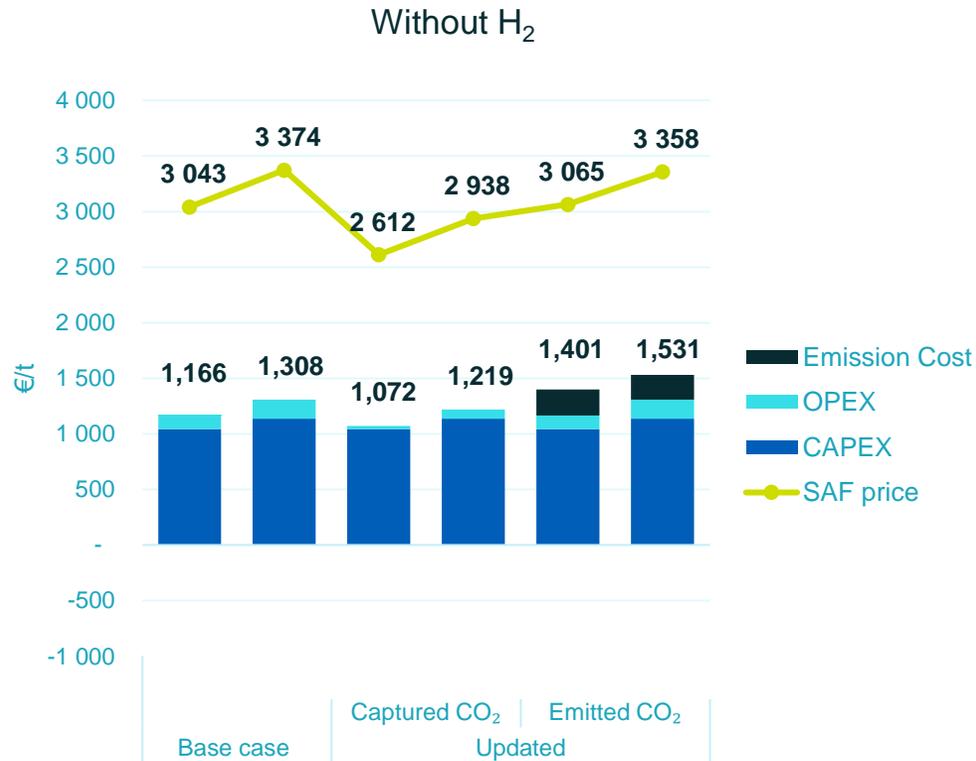
Complete cycle from wood based biomass to FT primary wax was demonstrated => technically feasible

FT SAF in Focus: SFW Syngas Production islands



Levelized cost Summary at 10% IRR

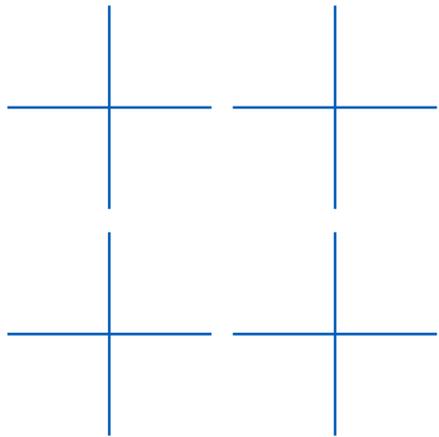
300 MWf- 2 Line SFW UCG Island (Naphtha price: 734€/t)



Conclusions so far: SFW Syngas Production Islands to FT-SAF

- Depending on reformer concept, adding supplementary Hydrogen can increase business case in some cases depending on Green Hydrogen price obviously.
- Price and availability of Hydrogen and 'usable Carbon' in syngas are very sensitive variables in the feasibility.
- Economics of scale, biorefinery business case:
 - Greater capacity from 150 to 300 MWth decrease LCOF by between 20 and 13%
 - Greater capacity from 150 to 300 MWth decrease SAF price by between 23 and 17% at 10% IRR
- All projects must be assessed on their own unique characteristics and variables – there are many!
 - Feedstock characteristics and availability, additional hydrogen price and availability, market mechanisms for biogenic CO₂ (e.g. different in EU and North America), etc. to name some.
 - We at SFW are happy to look for Your “gasification route to SAF” Biorefinery project together to optimize the feasibility of the project!

SFW Gasification as pathway to biofuels from biomass & waste



- Scope SFW can include the gasification and syngas cleaning
- 40 years of experience and 11 reference plants with fluidized bed gasification
- Wide range of biomass and waste feedstocks
- Solid biomass to liquid biofuels via Oxy-steam gasification demonstrated in 12 MW plant
- Readiness for commercial 200 MWth single line oxysteam gasifiers for biomass and waste
- Readiness for a commercial clean syngas plant for biomass
- Readiness for a Foak clean syngas plant for waste

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Thank you!

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