



Unlocking Biomass Potential

Decarbonising energy
production and bio-
chemical industry

April – 2024

The Yilkins Company

COMPANY DETAILS

- Dutch company founded in 2015
- Headquartered in Groningen, The Netherlands
- Test center in Ruurlo, The Netherlands
- 20 Employees
- Worldwide Project portfolio towards 600 M€
- Strong team with learnings taken from past 25 years of biomass conversion practice

OUR PROPOSITION

- Offering: Drying and carbonization technology (torrefaction, charcoal, biochar) – **skid based**
- Patented drying and torrefaction equipment
- Business model based on licensing and equipment sales
- Offers Performance warranty back-stop insurance guarantee (via NER)



*Demonstration plant in Ruurlo,
The Netherlands, 2017 - today
Capacity: 0.25 ton per hour*



*Streekpellets white pellet plant,
The Netherlands, 2018 - 2020
Capacity: 10 kton/a*



*Futtera, 6-lines torrefaction plant,
Portugal, 2019 - 2021
Capacity: 120 kton/a*

Yilkins' founders



Rob Voncken (CEO)

- Former DSM executive in biochemical (business development, strategy, innovation) incl. Managing Director Incubator and Vice President Strategy
- CEO of BioMCN, a leading 2nd generation Biomethanol producer and initiator of the 'Woodspirit project' (torrefaction + entrained-flow gasification project)
- Initiator and President of the Dutch Association of Sustainable Biofuels
- Interim CEO Topell Energy – closing down operations
- Entrepreneur in the Bio-based business landscape



Patrick (Peter) Bergman (CTO)

- ECN Research & Development - pioneering torrefaction & gasification research
- Spin doctor renewable development at HVC. Optimization of the biomass/waste to value production chains
- R&D manager Topell Energy – REVAMP of the DUIVEN torrefaction plant.
- Top authority in the field of torrefaction & gasification and all thermal conversion processes.

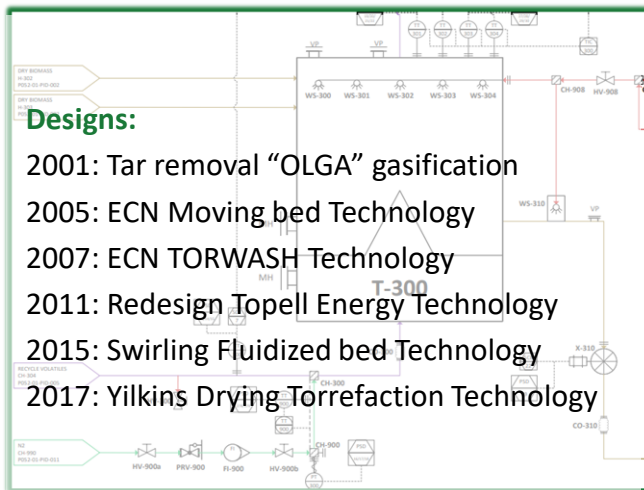
Yilkins' knowledge

Patrick (P.C.A.) Bergman (CTO)

- Most cited author in field of torrefaction
- Main inventor of various patents for different companies
- Several plant designs torrefaction

Designs:

- 2001: Tar removal "OLGA" gasification
- 2005: ECN Moving bed Technology
- 2007: ECN TORWASH Technology
- 2011: Redesign Topell Energy Technology
- 2015: Swirling Fluidized bed Technology
- 2017: Yilkins Drying-Torrefaction Technology

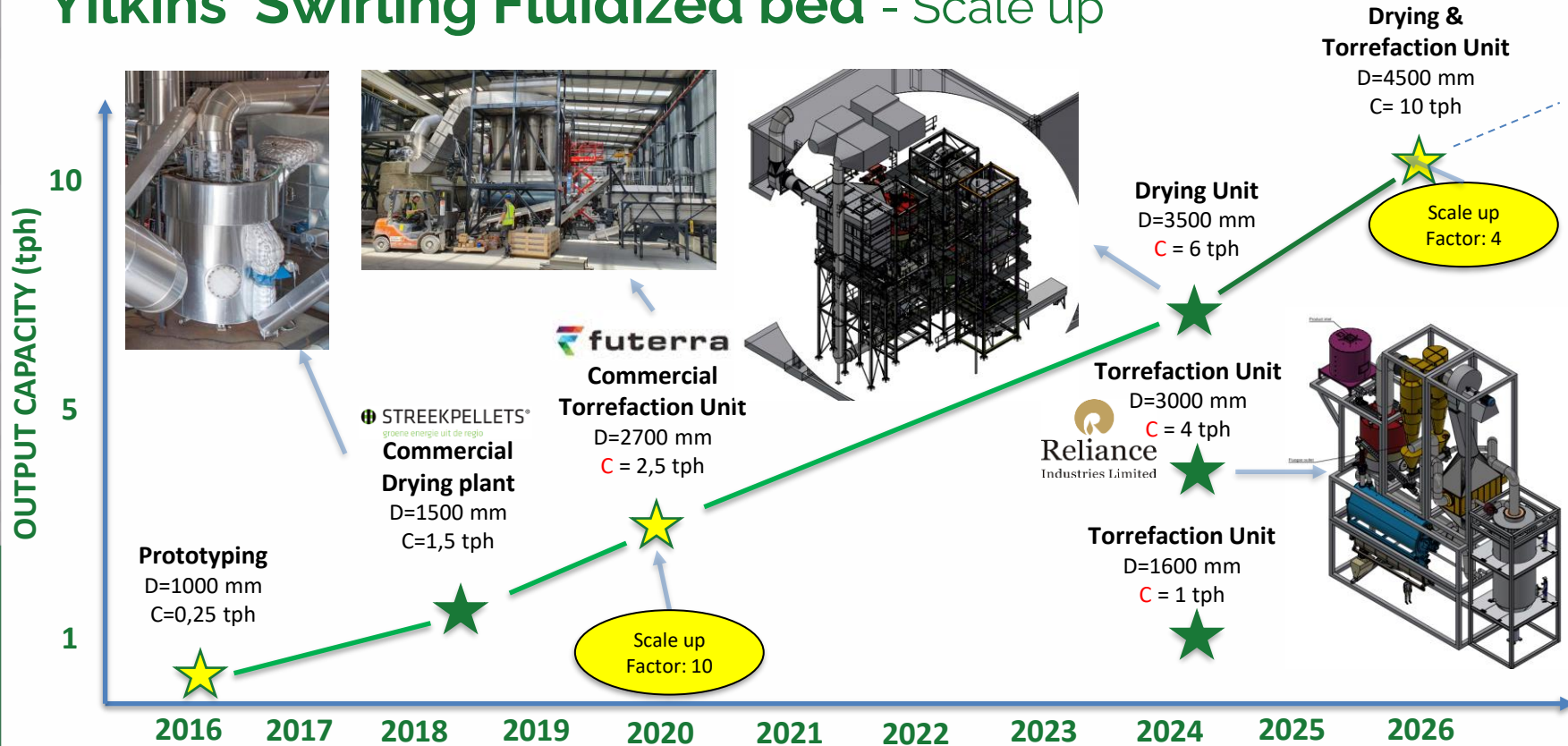


Bergman TRILOGY
2005 – "Defining the field"



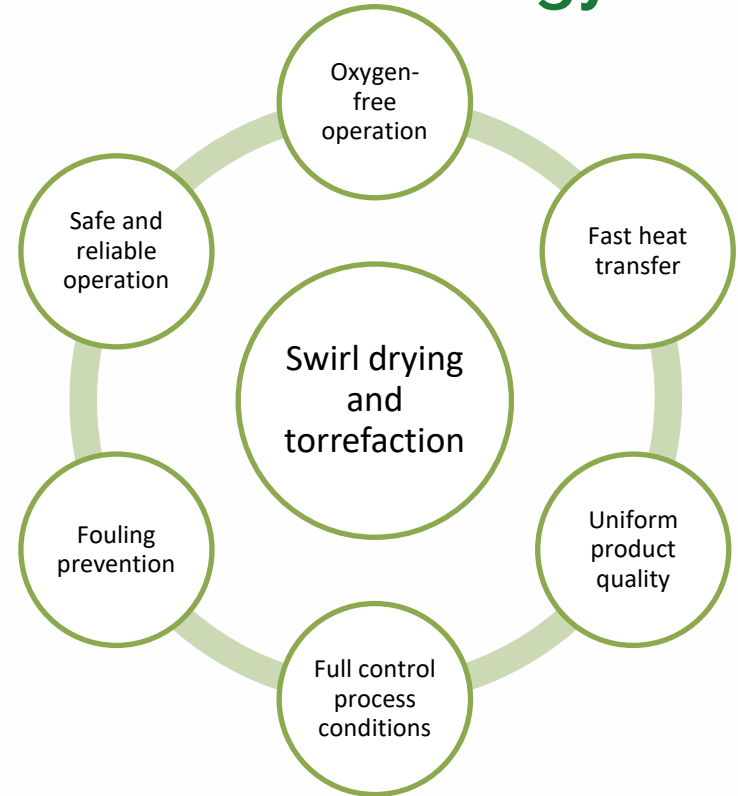
- METHOD AND SYSTEM FOR GASIFYING BIOMASS**
CA2458365A1 (C) • 2003-03-06 • STICHTING ENERGIE [NL]
Earliest priority: 2001-08-22 • Earliest publication: 2003-02-25
Method and device for cleaning synthesis gas obtained during gasification of biomass. The synthesis oil which is released in this process is subjected to a cleaning step, as a result of which oil with a
- Werkwijze en stelsel voor de productie van vaste stoffen uit grondstoffen.**
NL1025027C2 • 2005-06-21 • STICHTING ENERGIE [NL]
Earliest priority: 2003-12-15 • Earliest publication: 2005-06-21
No abstract available
- Torrefaction process for treating biomass in order to produce biofuel, carried**
NL1029909C2 • 2007-03-09 • STICHTING ENERGIE [NL]
Earliest priority: 2005-09-08 • Earliest publication: 2007-03-09
The pressure in a torrefaction reactor (2) is chosen so that water in liquid form is present. Treating claims are also included for the following: (A) a treatment apparatus for carrying out the above pro aid of the above process.
- PROCESS AND DEVICE FOR TREATING BIOMASS**
HRP20120203T1 • 2012-03-31 • STICHTING ENERGIE [NL]
Earliest priority: 2006-01-06 • Earliest publication: 2007-07-09
Postupak za obradu materijala, poput biomase ili otpada, koji se sastoji u-osiguravanju materijala materijal prevodi u torificirani materijal, naznačen time što materijal koji sadrži preostalu vlagu je u kroz torrefakcijski reaktor (10) u smjeru transporta (B), sušenje materijala u komoni za sušenje (54)
- PROCESO Y DISPOSITIVO PARA TRATAR BIOMASA**
CU23539A3 • 2010-06-17 • STICHTING ENERGIE/ONDERZOEK CT NL [NL]
Earliest priority: 2008-07-04 • Earliest publication: 2010-06-17
Un procedimiento para tratar biomasa comprende la provisión de un material que contiene una ca torrefacto. El material con la humedad residual contenida se seca de manera esencialmente com material secado. El material se transporta a través del reactor de torrefacción en una dirección de
- METHOD AND DEVICE FOR TREATING BIOMASS**
EP2668249A1 (B1) • 2013-12-04 • TOPELL ENERGY B V [NL]
Earliest priority: 2011-01-27 • Earliest publication: 2012-07-31
No abstract available
- COOLING PROCESS OF TORREFIED BIOMASS**
WO201619009A1 • 2016-08-18 • BLACKWOOD TECH BV [NL]
Earliest priority: 2015-02-12 • Earliest publication: 2016-08-18
The present invention relates to a process for cooling hot torrefied biomass, which process compr dust and organic volatiles to form a condensate comprising dust and organic volatiles; and a cycled system for producing torrefied biomass comprising such a cooling device.
- GAS-SOLID CONTACTING DEVICE**
NL2022774B1 • 2020-09-28 • YILKINS B V [NL]
Earliest priority: 2019-03-20 • Earliest publication: 2020-09-24
A device (10) for processing a flow of particulate material by contact with a gas flow comprising a h contact zone (22). The contact zone (22) has at least one cylindrical partition (34) extending from housing (12) is also provided with an inlet (44) for supplying particulate material to the inner secto

Yilkins' Swirling Fluidized bed - Scale up



The value proposition of Yilkins' Swirl technology

- Capable of processing a wide variety of biomass residues and organic waste materials
- We provide solutions to achieve the lowest possible Total Cost of Ownership (TCO):
 - Feedstock Flexibility: use of **low-grade biomass**
 - Maximizing the **thermal efficiency**
 - **Scalable, safe, and reliable** torrefaction solution
 - Solve the **pelleting difficulties** of torrefied biomass (high energy consumption, poor pellet quality)
 - **Holistic approach** to drying, torrefaction, and pelleting
 - **Skid-based, small footprint, standardization**
 - **Energy integration** up and downstream
 - **Logistic costs**
- Creating novel, sustainable, economic, net-zero solutions together with our customers and partners





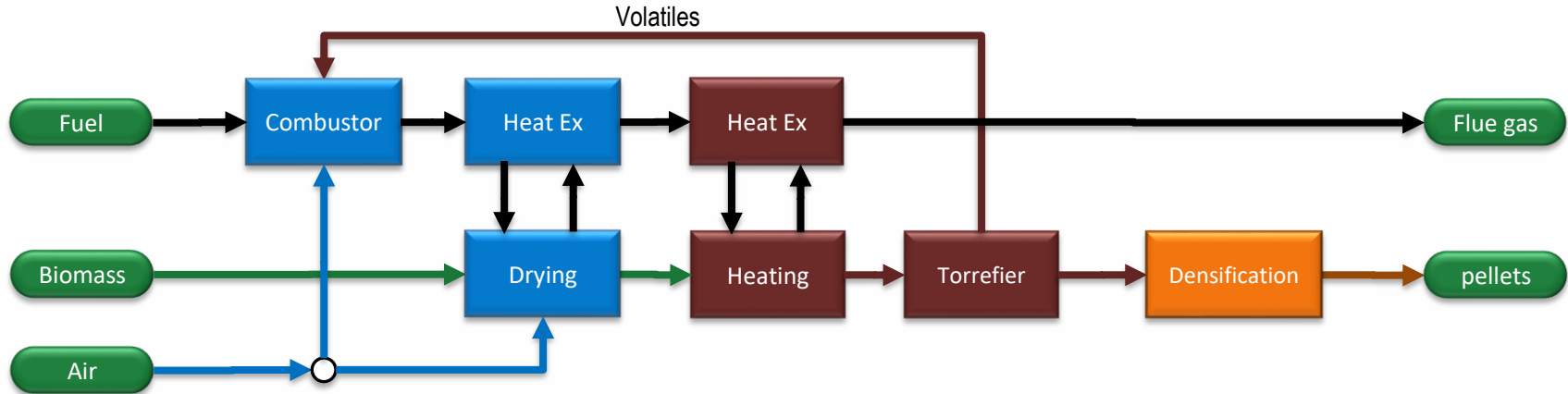
Value Chain Opportunities | market potential



Yilkins technologies enabling sustainability and circularity

Yilkins: makes your biomass, residues and raw materials worthwhile

Yilkins solution- Feedstock flexibility



Forest residues



Sawdust



Straw



Bagasse



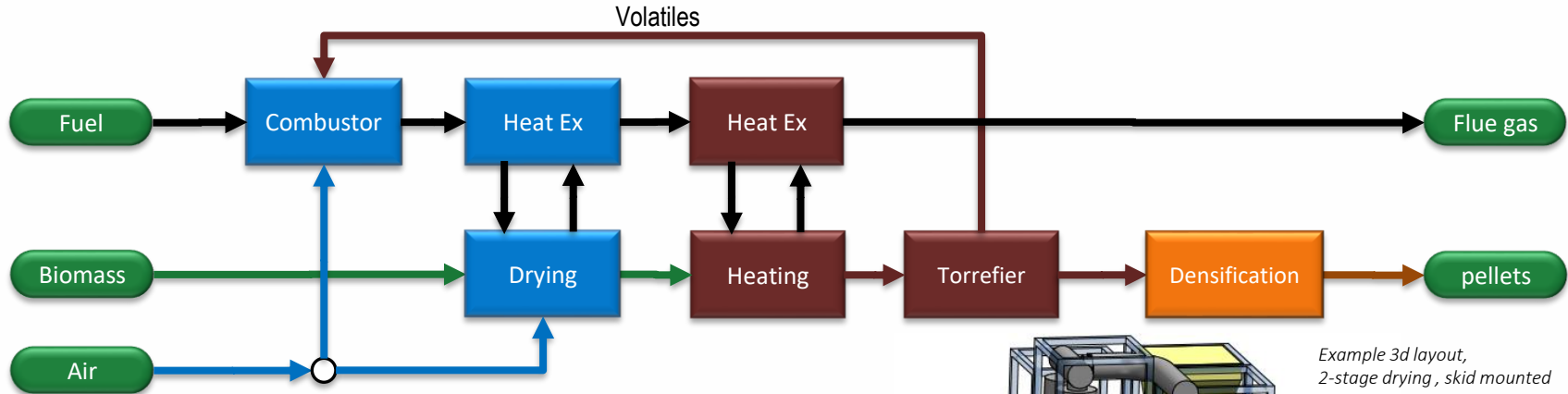
Cocoa shells



Spent grains

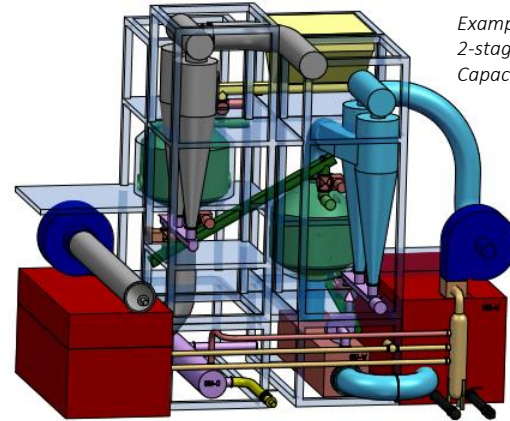


Yilkins solution – Energy efficient drying



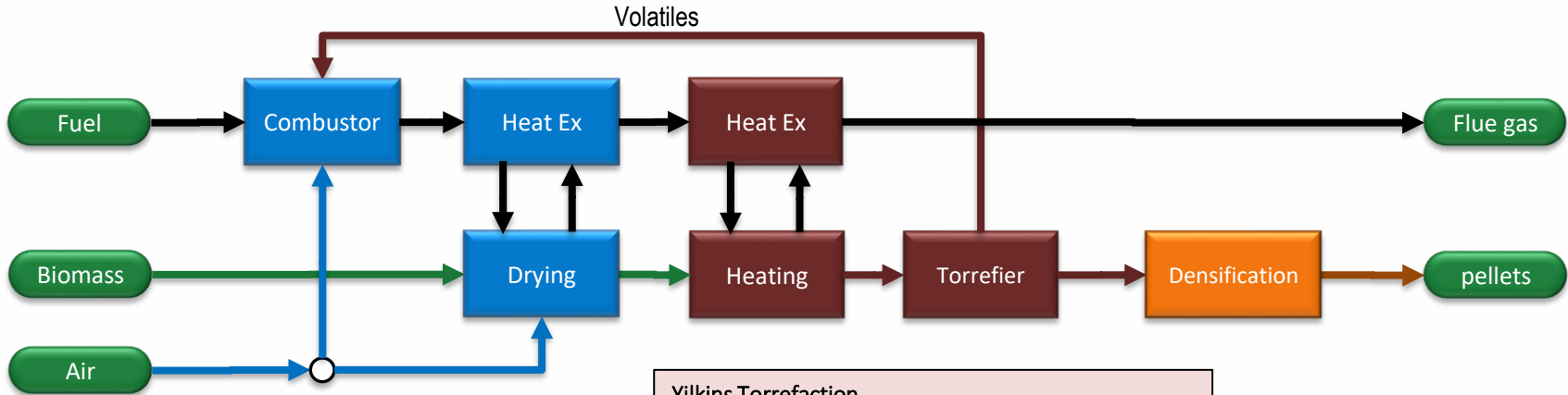
Yilkins Drying

- Swirl bed technology
- Energy consumption of 1,500-1,800 kJ/kg H₂O
- Energy savings of over 50%
- Inherently safe due to the absence of oxygen in drying medium
- Dynamically matching with torrefaction
- Small footprint - SKID-based
- Condensate to be re-used as heat / water



Example 3d layout,
2-stage drying, skid mounted
Capacity: 2,5 tons per hour

Yilkins solution – Energy integrated torrefaction

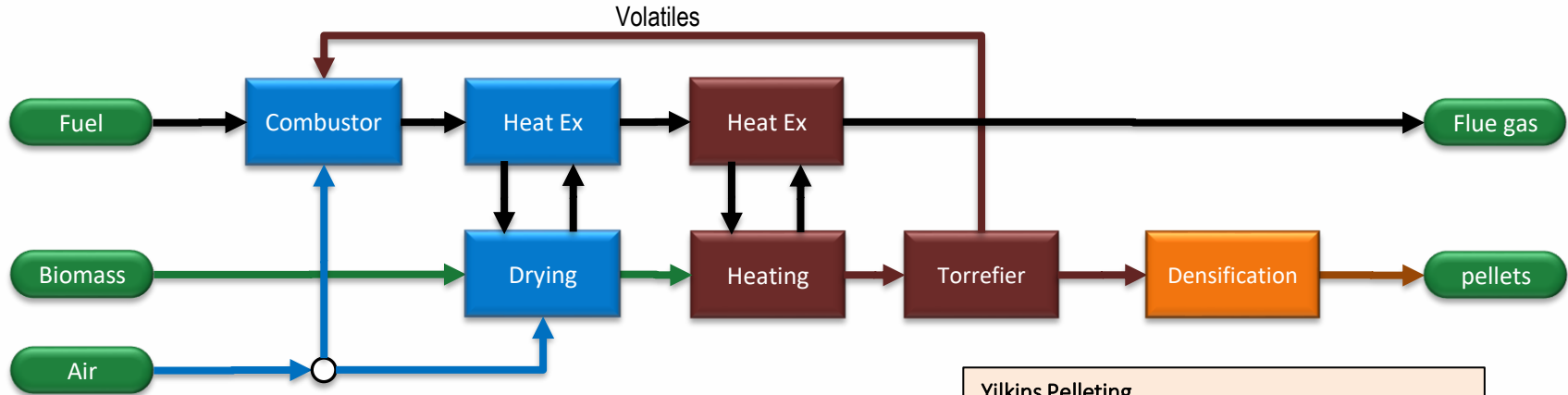


Yilkins Torrefaction

- Staged torrefaction with swirl bed technology
- Easy scalable by separating heat exchange from torrefaction conditions
- Max. control over torrefaction conditions ($\pm 1^\circ\text{C}$)
- Designed to avoid condensation issues
- Small footprint – SKID-based
- Homogeneous product qualities
- Scale-up; straightforward and easy



Yilkins solution- Homogenously torrefied pellets



Yilkins Pelleting

- Power requirements of 55 to 80 kWh/ton
- Durability > 97.5%
- No binding agents needed
- Optimized concept for water-resistant and hydrophobic pellets

Optimizing the Total Cost of Ownership (TCO)

Costing Base

- Integrated Yilkins plant of 80 kton/a torrefied pellets
- Feedstock: agricultural residue at 50% moisture content
- Both Yilkins and Competition based on the same torrefaction mass and energy yield
- Resulting Feed-to-product ratio of 2,51
- Economic inputs
 - Biomass: 10 €/ton (ar)
 - Fuel costs: 5 €/GJ
 - Electricity: 0,10 €/kWh
 - Binding agent: 300 €/ton
 - CO₂ credits: 80 €/ton
- OPEX OPTIMIZATION IS WITHOUT CAPEX INCREASE

Impact analysis

- Minimised cost- or additional income items due to high thermal efficiency by Yilkins drying
- Minimised cost items due to optimized torrefaction combined with densification
- Cost items assumed being equal to competition

ITEM	YILKINS	Δ	COMPETITION
	€/ton	€/ton	€/ton
DIRECT COSTS			
Feedstock	25,1	0,0	25,1
Fuel	2,7	-8,2	10,9
Electricity	16,0	-5,0	21,0
Binding agent (pelleting)	0,0	-6,0	6,0
Maintenance	3,9	-0,9	4,8
Die replacement (pelleting)	0,58	-0,6	1,17
Lubricants + Small consumables		0,0	
Ash disposal	0,02	0,0	0,06
INDIRECT COSTS			
Labour costs	6,2	0,0	6,2
Laboratory costs	2,1	0,0	2,1
Insurances	0,2	0,0	0,2
Royalties/License fee			
OPERATING EXPENSES	56,8	-20,7	77,5
OPEX MINUS FEEDSTOCK	31,7		52,4
CO2 EFFICIENCY CREDITS		8,1	
BENEFIT MARGIN YILKINS	€/ton	28,8	
	€/a	2.300.000	
CREATED MARGIN > YEARLY DEPRECIATION OF CAPEX			

Production chains from efficiency perspective

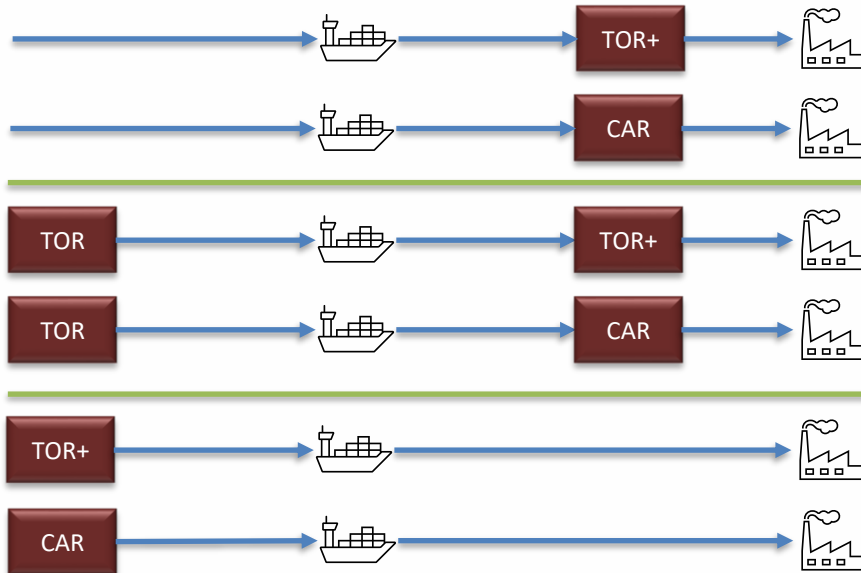
Yilkins Base cases of devolatilization of the biomass

- “Classic” torrefaction (TOR): aim is to change properties with maximum thermal efficiency (maximum of energy retainment in the solid product)
- Severe Torrefaction (TOR+): aim is to increase carbon content to level of $\pm 60-75\%$. Achievable in operating window torrefaction and at the cost of significant energy release to the volatiles
- Carbonization (CAR): Typical slow pyrolysis conditions to get to high carbon or fixed carbon levels at level of $>85\%+$. Highest level of devolatilization.

		TOR	TOR+	CAR
Input	ton/h	25,0	25,1	25,1
output	ton/hr	10,5	7,1	4,8
Input moisture content	%mass	50%	50%	50%
F/P ratio		2,39	3,55	5,25
Combustion power rate	MW	10,1	23,6	32,6
Excess Energy	MW	0,1	13,9	23,2
Thermal efficiency	NCV basis (ar)	98%	79%	63%
Carbon efficiency	Mass basis (db)	84%	66%	55%
NCV Product	GJ/ton (db)	23,0	27,4	32,6
Cfix	%mass	25%	42%	60%
Carbon content	% mass	57%	66%	82%

Comparison of different operating modes.
Feedstock is typical coniferous woody biomass

Production chains from efficiency perspective



Biomass transportation to centralized set-up

- Strongly limited by biomass logistics, only very dense biomass feasible
- Efficiency determined by volatiles utilization at steel plant
- Local biomass availability normally precondition

Stand-alone torrefaction at biomass location (black pellets)

- High efficiency commodity, lowest transportation costs
- Efficiency determined by volatiles utilization at steel plant
- Best control over business case and CO2 emission rights

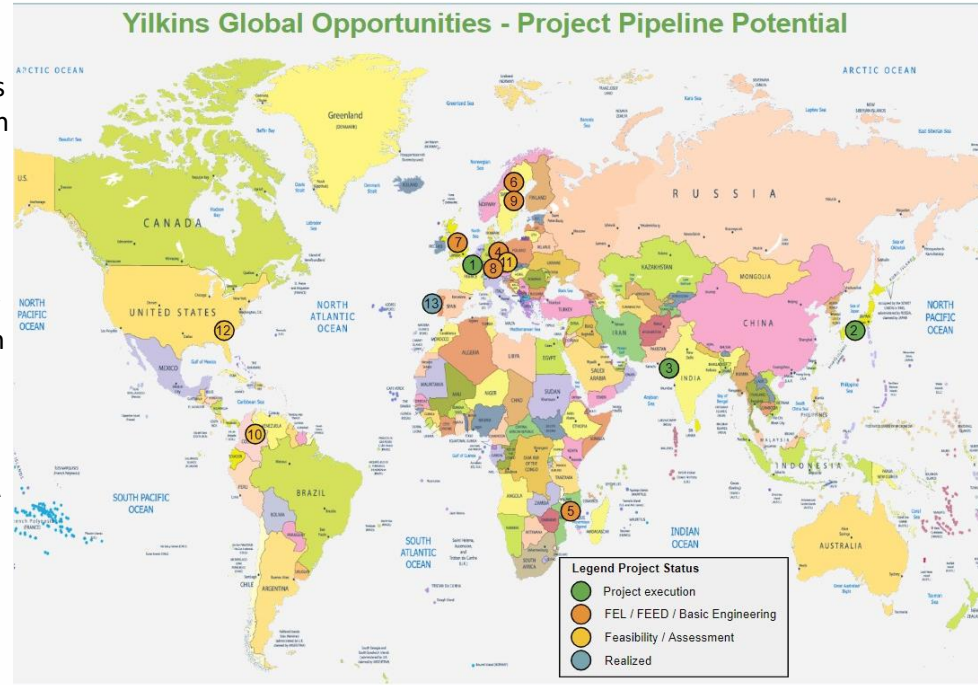
High grade carbon products at biomass location

- Moderate to poor efficiency to solid product
- Only feasible with volatiles utilization at production location

Yilkins' business is growing fast around the world

Projects - highlights

- **ThyssenKrupp** selected the Yilkins torrefaction technology exclusively for the preparation of various biomass streams for their entrained-flow gasification technology to turn biomass into high-quality syngas for the production of SAF, renewable diesel, green hydrogen, and chemicals.
- A **global beer brewer** bought Yilkins drying technology for turning spent grains into local energy for its breweries. A first project is underway that can lead to implementation at 30-40 plants around the world.
- Yilkins has sold a Torrefaction plant to **Reliance in India** to replace petcoke as feed for their gasifiers. A first plant that can lead to the implementation of multiple plants (4 Mton petcoke/a).
- Yilkins has sold a Torrefaction plant to **Tokuyama in Japan** to co-fire in its power plants with a total feed capacity of 1,5 Mton/a.



Yilkins' business is growing fast around the world (2)

Projects in Yilkins portfolio

Project	Country	Capacity (ton/a)	Feed stock	Application	COD	Current Status
1	France	20.000	Brewery spent grain	Heat (steam)	Q2-2025	Signed, execution ongoing
2	Japan	4.000	Empty Fruit Bunch	Power	Q2-2025	Signed, execution ongoing
3	India	20.000	Cotton stalk	Gasifier	Q1-2025	Signed, execution ongoing
4	Germany	80.000	Forest residues	Gasifier	2025	FEL2 – ongoing - BE planned Q2-2024
5	Mozambique	45.000	Banagrass	Green steel	2026	BE planned Q2-2024
6	Sweden	256.000	Forest residues	Gasifier	2026	FEL2 completed - BE planned Q1-2024
7	UK	704.000	Forest residues	Gasifier	2027	FEL2 ongoing – BE planned Q1-2024
8	Germany	480.000	Forest residues	Gasifier	2027	FEL2 / Process Design Package - ongoing
9	Sweden	640.000	Soft Wood	Gasifier	2028	FEL1 completed - FEL2 planned Q3-2024

Upscaling & Partnerships highlights

- Cooperation agreement signed with TetraTech (US) for project support/engineering/skid manufacturing for US market
- Cooperation agreement signed with Praj (India) for skid manufacturing
- Cooperation agreements with TransitionHero and Advice (both The Netherlands) for engineering support
- Cooperation agreement with CPM (The Netherlands) for pelletization optimization

Yilkins has mature capabilities

- From laboratory set-up, pilot plant to demonstration plant in 4 years.
- Commercial equipment supplied to customers
- Due Diligence by DNV-GL / NER; considers Yilkins technology bankable
- Commercial projects realized
- Project portfolio sums up towards 600 million Euro – investment opportunities



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Capacity: 120 kton /a*



From biomass to energy, heat and chemistry • From spent mushroom compost to soil improver • From digestate to phosphate-rich soil improver

YILKINS Drying Solutions

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