
Thermal Solutions
for every challenge.

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Advances in Carbon Fiber Manufacturing Equipment

ONEJOON GmbH

17th -19th Nov. 2020

www.onejoon.de
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01 Introduction

02 Improved Economics
for CF Production

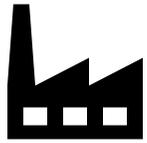
03 Equipment
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04 Outlook



ONEJOON acquires Eisenmann Thermal Solutions

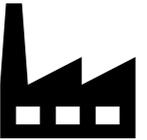
Background and CF Market Position



EISENMANN

*1951

1st Dryers for ST/Sz for CF in 1999
1st OxOvens and LT/HT Furnaces in 2005



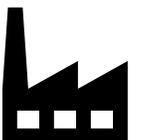
Ruhstrat

*1888

1st UHTF for CF in 1987



Cooperation with Eisenmann and Ruhstrat began in 2008 resulting in a merger

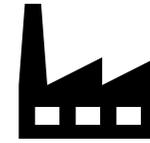


EISENMANN Thermal Solutions (ETS)

*2015



Preferred Supplier for many Aerospace and Industrial CF manufacturers



ONEJOON

*2000

Over 100 kilns, high temperature furnaces and material handling systems for electronic parts and battery materials



Cooperation with ETS for battery materials started in 2016, JV established in 2019

ONEJOON acquires ETS in January 2020



Korea, Germany, China, USA



Technology leader for high end battery kilns



Market leader for Carbon Fiber Thermal Process Equipment

172 Oxidation Ovens, 42 LT/HT Furnaces, 8 UHT Furnaces



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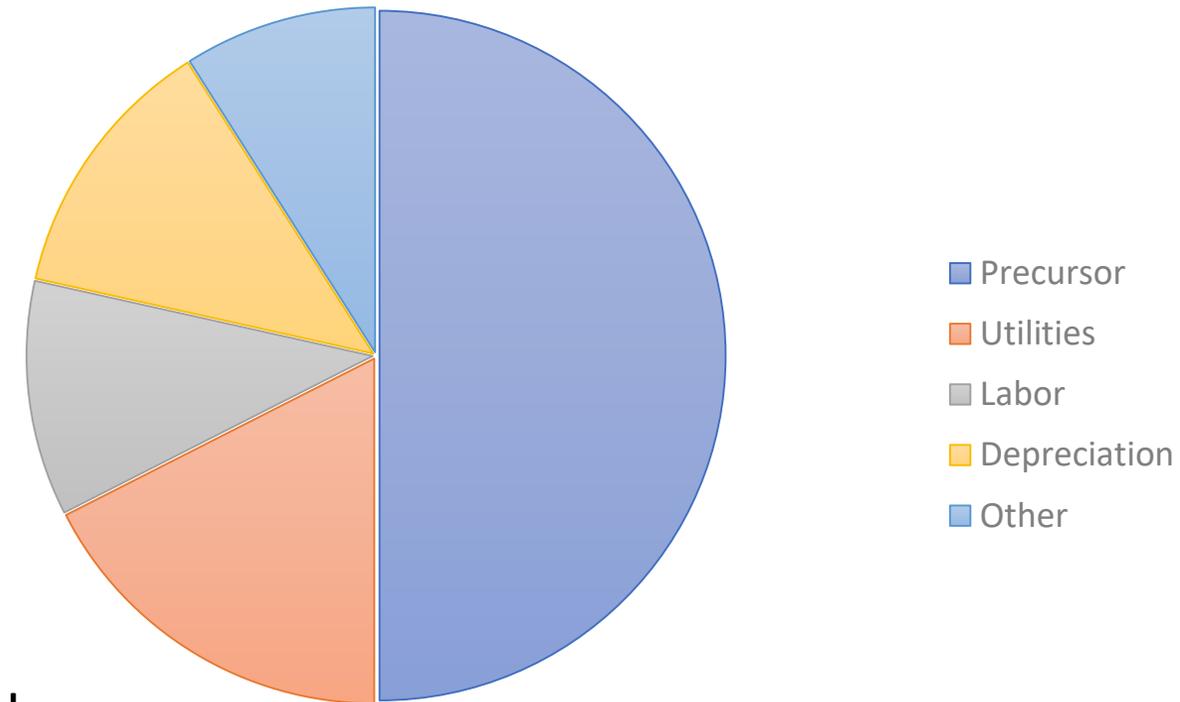


Many approaches to make CF more affordable:

- Alternative, low cost precursors
(Lignin, Textile PAN, Polyethylene, ...)
- New Production Technologies

→ Only pilot scale, unproven on production scale

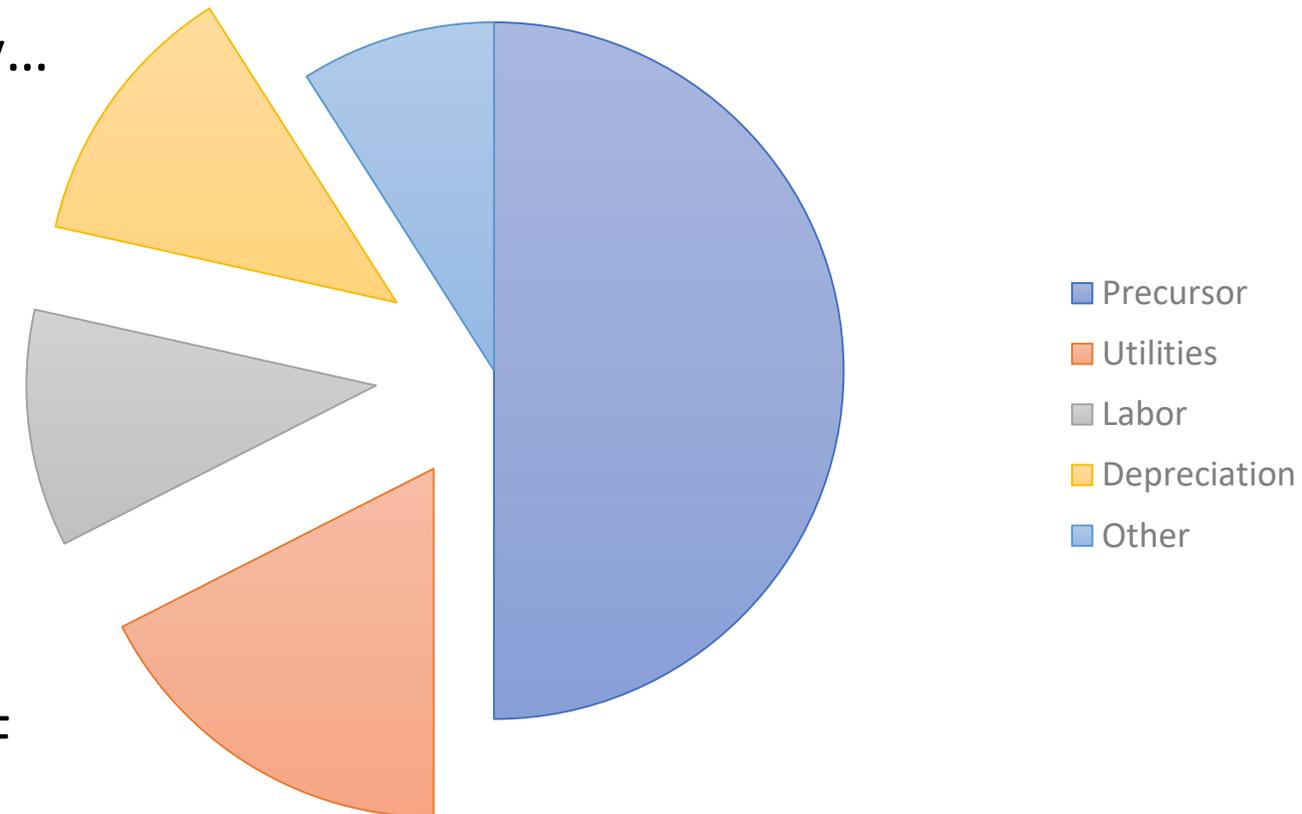
Generic Estimation - Costs of CF (as of 2011)



Equipment manufacturers can help to reduce costs for utilities, labor and depreciation by...

- Designing the equipment for better performance, ease of service and maintenance, etc.
- Reducing the CAPEX/kg CF with larger CF Lines

Generic Estimation - Costs of CF (as of 2011)



Ways to achieve this:

1.  Economies of scale - build larger CF lines and reduce CAPEX / kg CF

2.  Reduce utility costs / kg CF

3.  Improve equipment maintenance, cleaning and operation



1.  Economies of scale - build larger CF lines and reduce Capex / kg CF

Wider Tow Bands

~ 2010: 1.8 - 3.0m
~ 2020: 3.0m → 4 - 5m

→ 3.0m lines have become an industry standard

→ best-in-class performance is pivotal to reduce waste by providing uniform properties over the full width of the tow band.

→ customers today are now requiring equipment with larger tow bands without compromising performance and material quality.



Increased Production Line Capacities

Faster Line Speeds

- ~ 2010: average 8 -10m/min
- ~ 2020: average 10-12m/min, max. 15m/min

- ~ 20% increase in line speed
- More CF producers targeting 15m/min, some even more

Shorter Cycle Times

- | | | |
|---------|------------------------|----------------------------------|
| ~ 2010: | Oxidation 60 - 120 min | Carbonization 90 – 120 sec, each |
| ~ 2020: | Oxidation 45 - 90 min | Carbonization 60 – 120 sec, each |

- Long oxidation cycle times have been reduced by ~ 25%
- Carbonization cycle time less impacted but more inquiries for shorter cycles



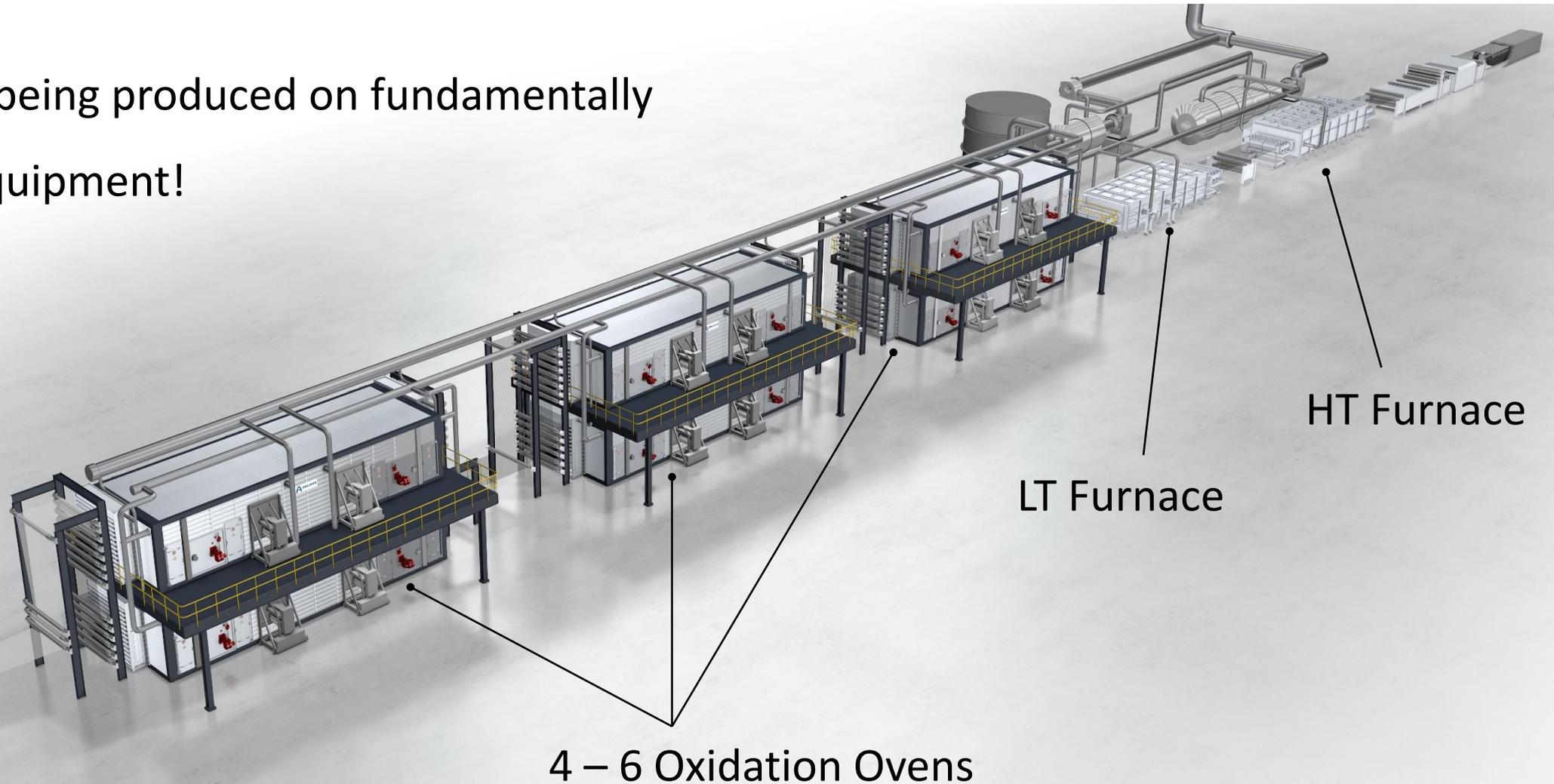
Single Line Production Capacity (12k / 48k)

	<u>12k</u>	<u>48k</u>
~ 2010	750 – 1,500 mt/yr.	1,000 – 2,000 mt/yr.
~ 2020	1,500 – 3,500 mt/yr.	2,000 – 4,500 mt/yr.

	~ <u>2010</u>	~ <u>2020</u>
Nameplate line capacity	100%	200%



More Fiber being produced on fundamentally
the same equipment!

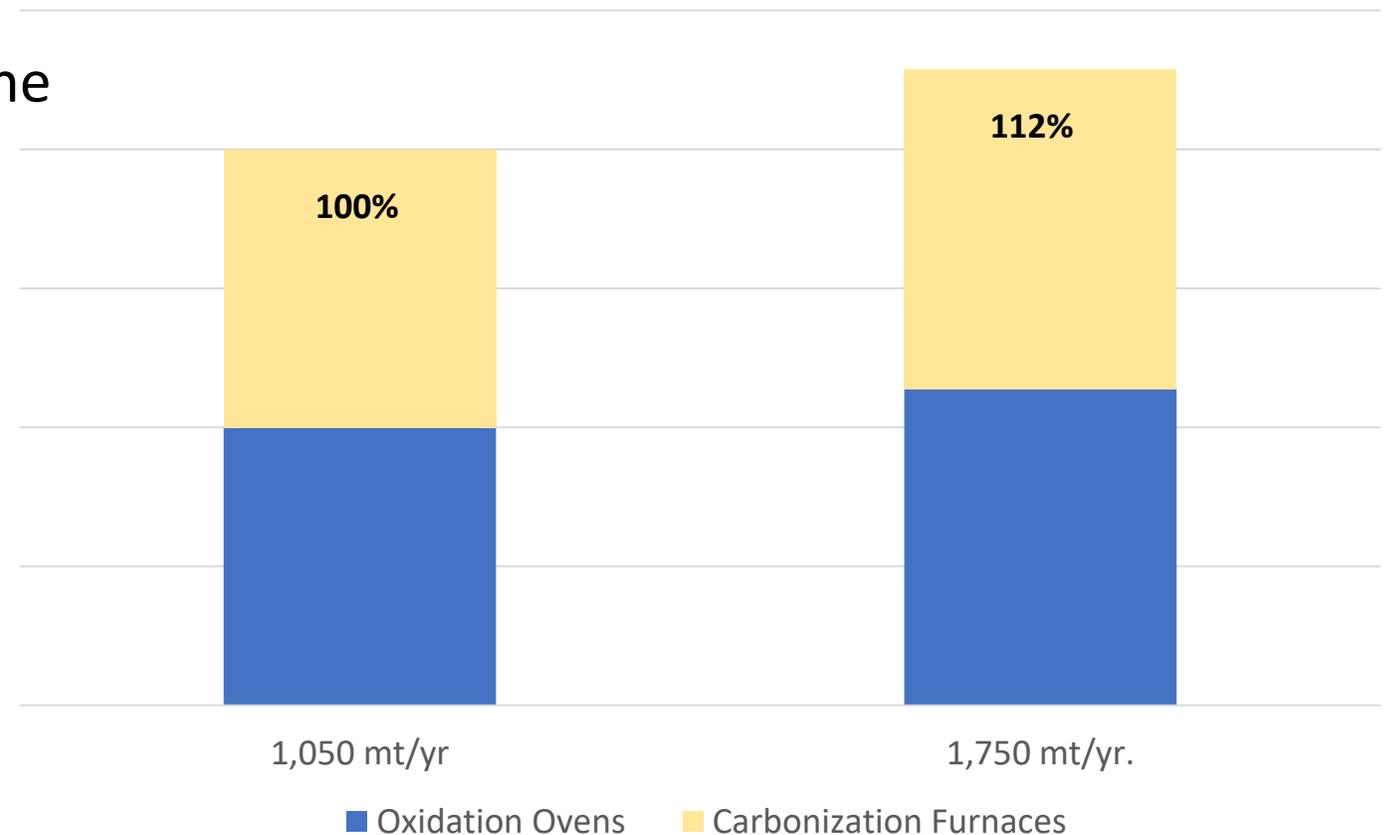


Comparing a 1,050 mt/yr. production line with a 1,750 mt/yr. production line

CAPEX +12% for base equipment compared to +67% production capacity

CAPEX /kg CF – 33%*

Investment Costs Relation - Equipment Only, No Services



*Other CAPEX may not scale as advantageously



1. Economies of scale - build larger CF lines and reduce Capex / kg CF

- Larger tow band widths
- Higher line speeds
- Shorter cycle times (especially in oxidation)

→ increasing nominal line capacities

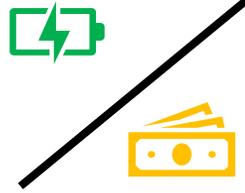
→ A single new CF line accounts for 1,500 – 4,500 mt/yr. capacity addition to the market

→ The investment in larger equipment is more economical considering the CAPEX for ovens and furnaces



Reduced Utility Costs

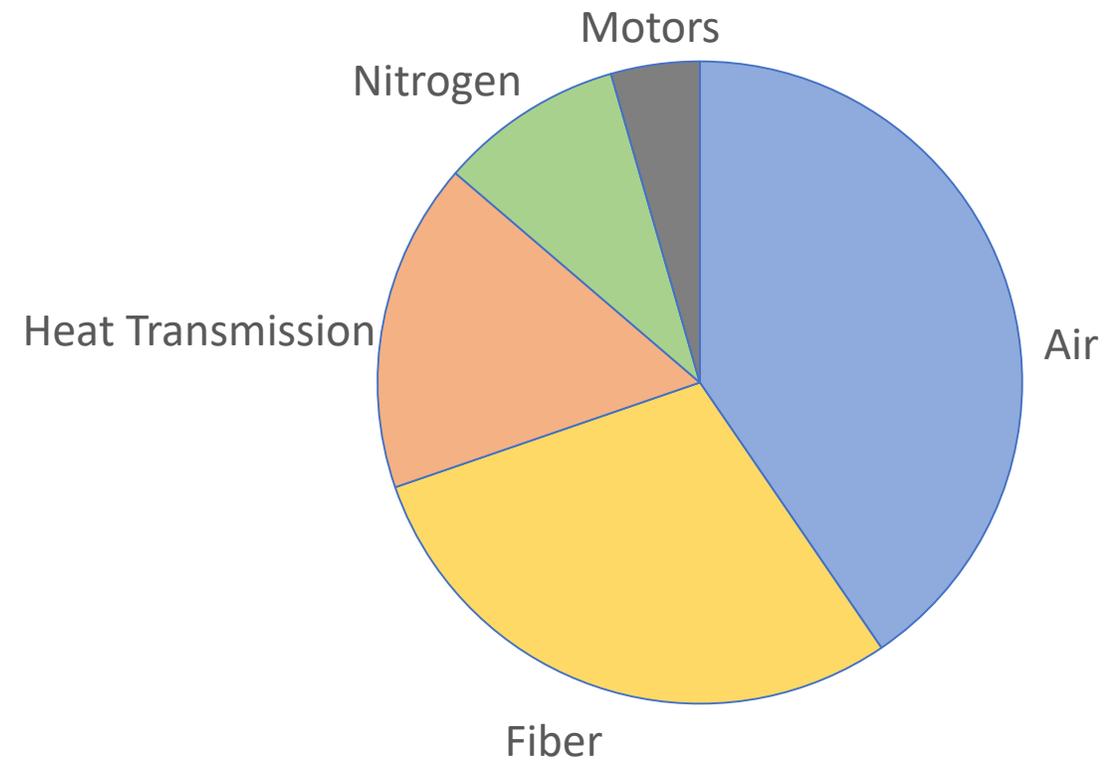
2.



Reduce utility costs / kg CF

Energy consumption is the main driver for utility costs / kg CF

Energy Consumption
Ovens + Furnaces

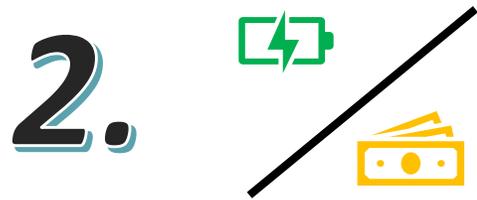


Impact of equipment scale up on the energy consumption

- Throughput increases → energy needed for the fiber increases as well
(tow band width = number of tows, line speed)
- Larger Equipment → more energy needed to heat up air and nitrogen
(tow band width, not impacted significantly by line speed)
- Increased heat loss for larger equipment, but scales at a lower rate



Reduced Utility Costs

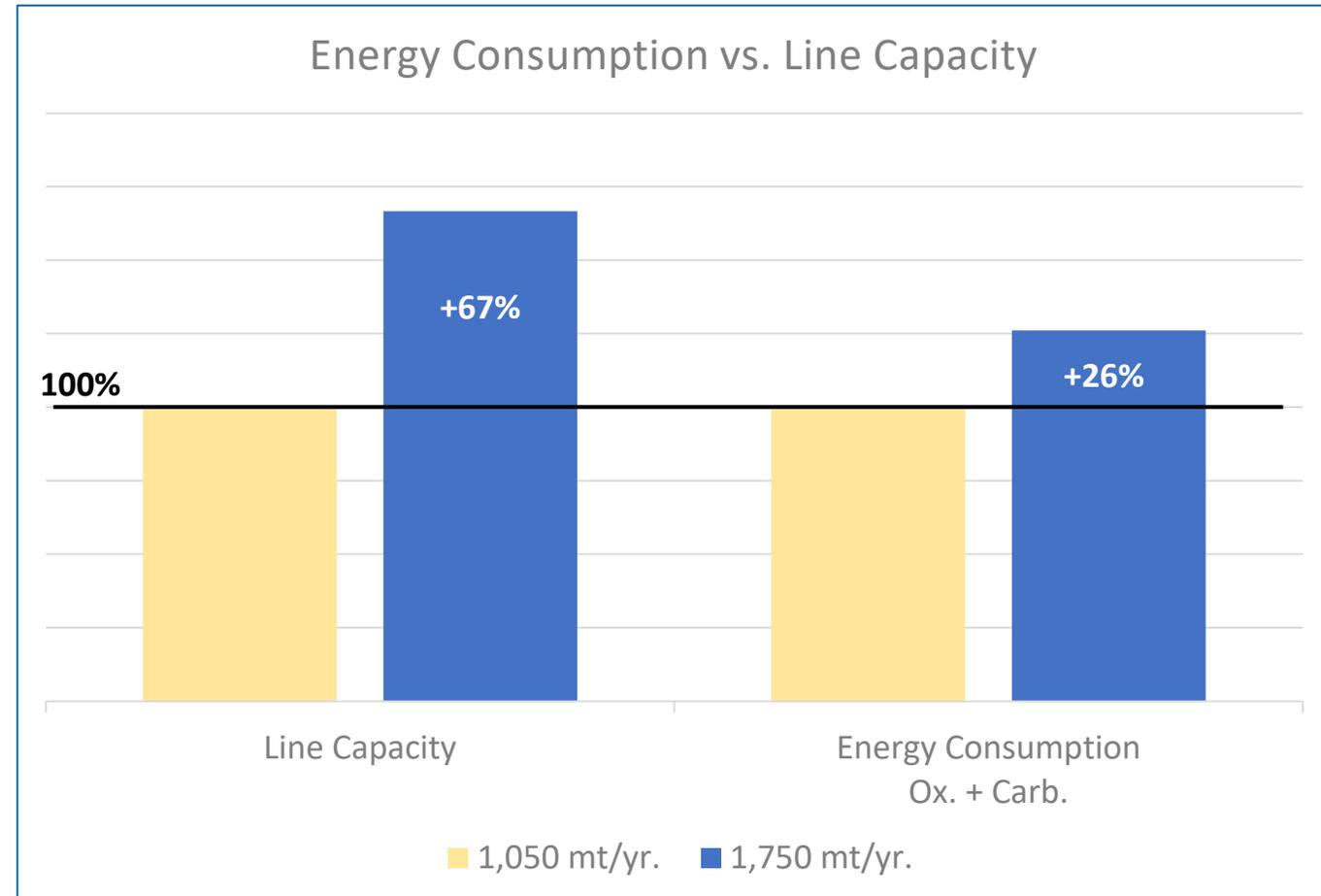


Reduce utility costs / kg CF

Increased Line Capacity +67%

Energy Consumption +26%

→ - 24% Energy Consumption / kg CF



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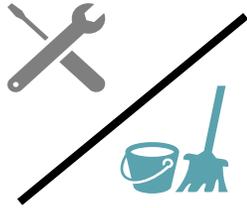
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3.



Improve equipment maintenance, cleaning and operation

All CF manufacturers want to minimize any down time for maintenance and cleaning.

Lost production time is lost revenue.

Cleaning is the primary reason for fiber line down time.

Innovations to allow operators to perform general cleaning and maintenance activities while in operation increases fiber line up time.



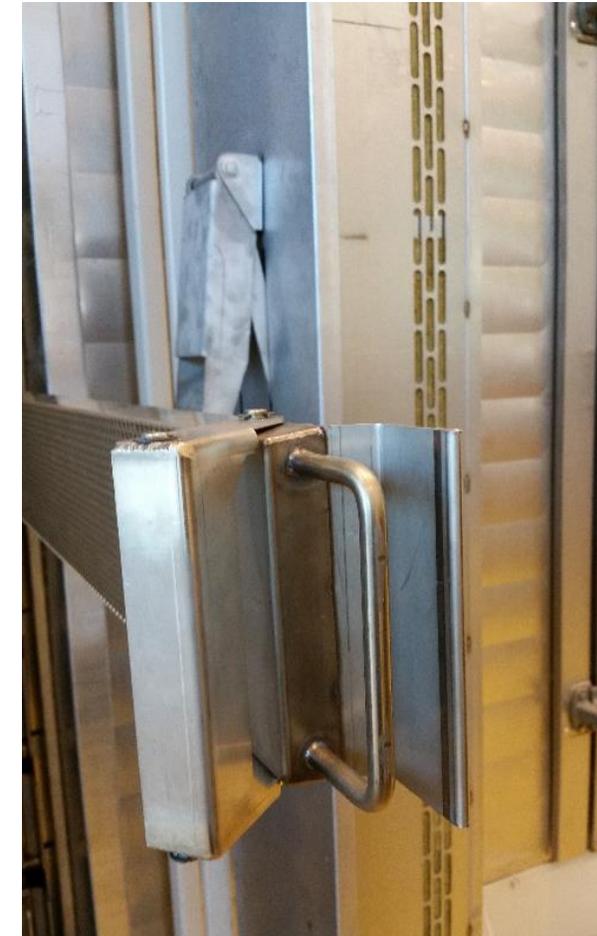
Oxidation:

- Roll out fans
- Highly efficient natural gas heat exchangers
- Hybrid heat systems



Oxidation:

- Removable screens & easy lock doors
- Auto Louver Systems



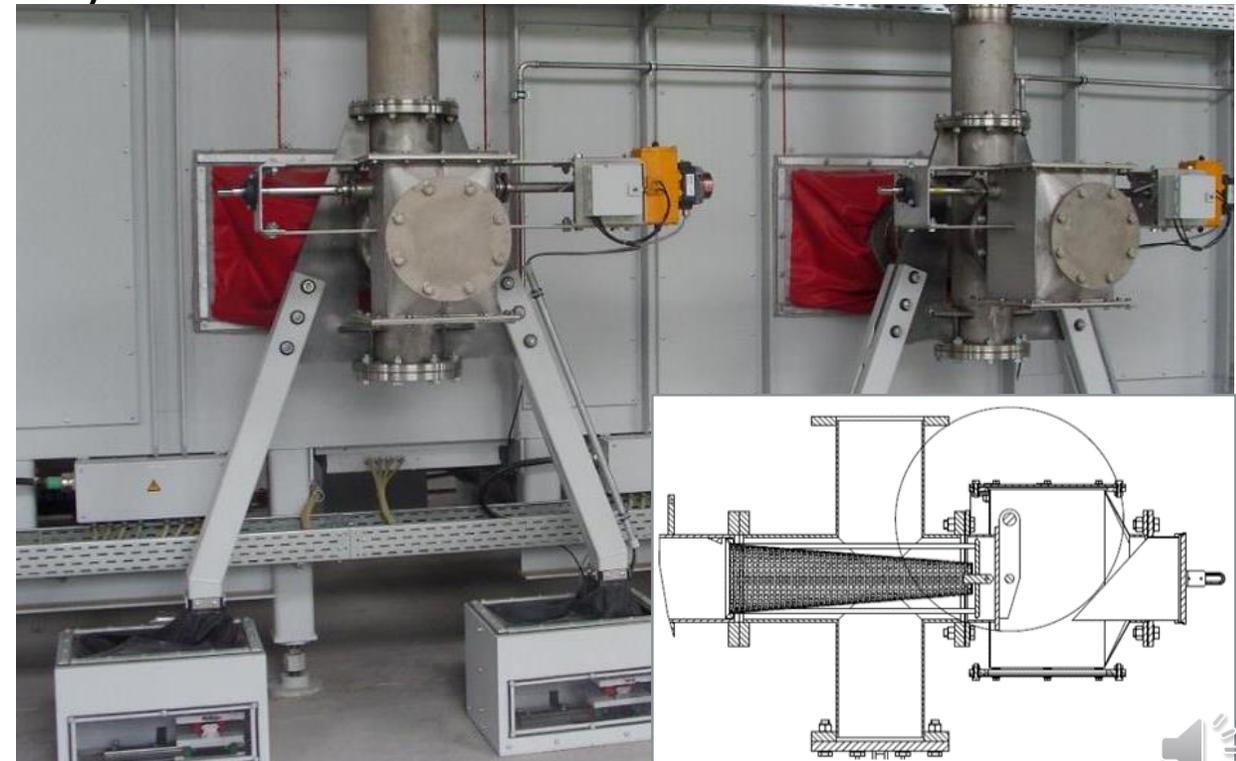
Oxidation:

- AVMS – Air Velocity Monitoring System



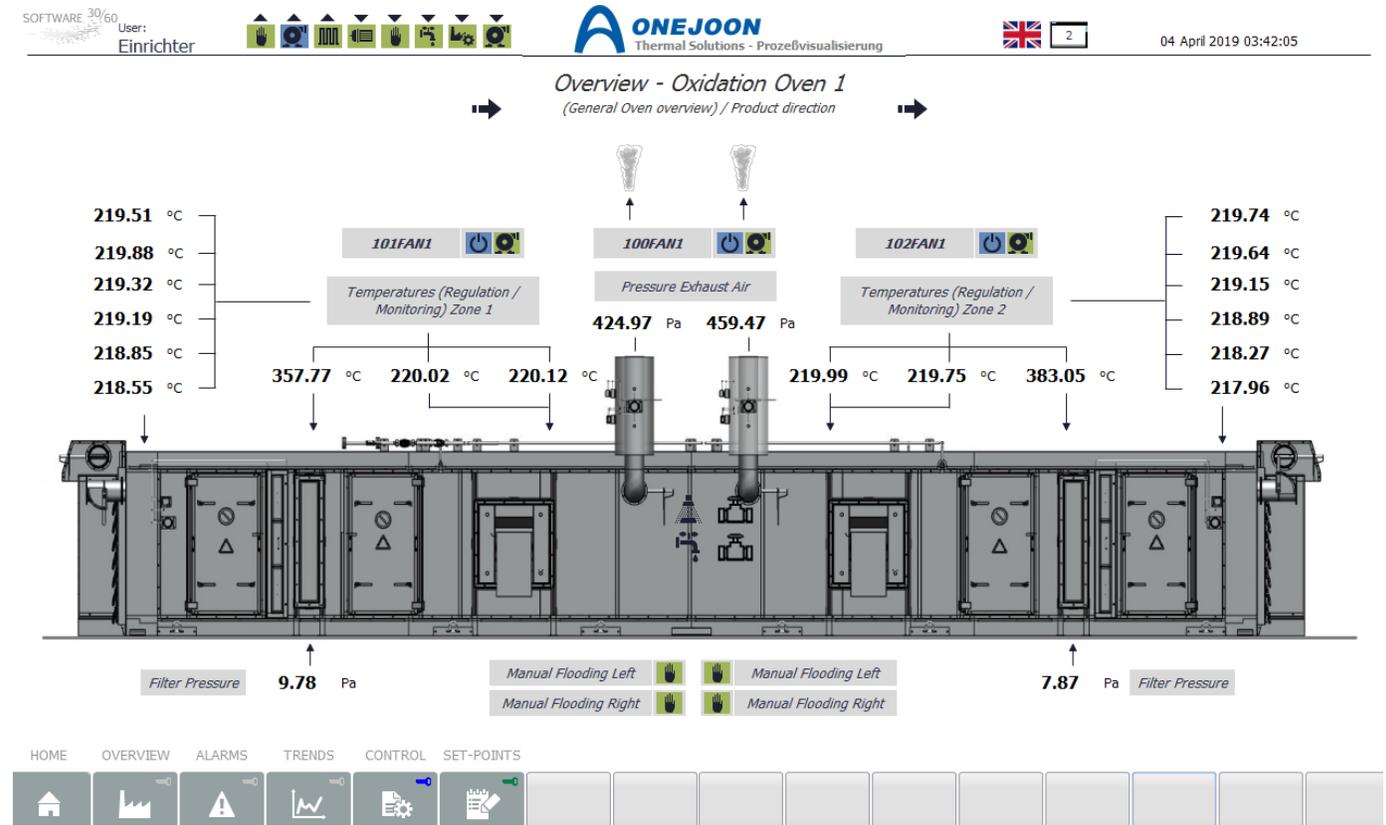
Carbonization Furnaces:

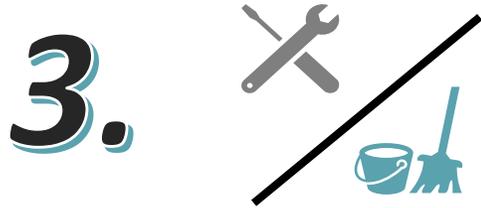
- Movable, freely positionable exhaust gas ports w/ filter cartridges (LTF)
- Alternative muffle designs and materials (LTF)
- Improved insulation concepts
- Advanced end seal systems
- Improved access for operation



Software and El. Hardware

- Improved Hardware + Software design architecture
- Modular Software, faster commissioning
- Intuitive user interface





3. Improve equipment maintenance, cleaning and operation

- Most CF Producers have the same needs, only a few require highly customized equipment (80:20)
- Standard equipment today already include significantly more features than ~ 2010
- Advanced features increase production 'Up-Time'

	~ <u>2010</u>	~ <u>2020</u>
Nameplate line capacity	100%	200%

Actual line capacity



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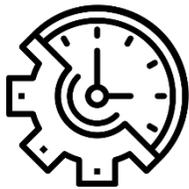




Larger carbon fiber lines, higher line speeds



New equipment designs for large tow band widths



Improved production efficiency



Thank you for your attention!



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