SUSTAINABILITY IN ELKEM

11.10.2018

Elkem
A Bluestar Company

Elkem group in brief

- Founded in 1904 by Sam Eyde
- Owned by China National Bluestar since 2011
- 110 years of history as a technology provider

5,600 employees
(1,350 in Norway)

24 plants worldwide,
Headquarter in Norway

22 BNOK
Revenue in 2015

470 R&D people
Global R&D centres in Norway and Lyon

Elkem

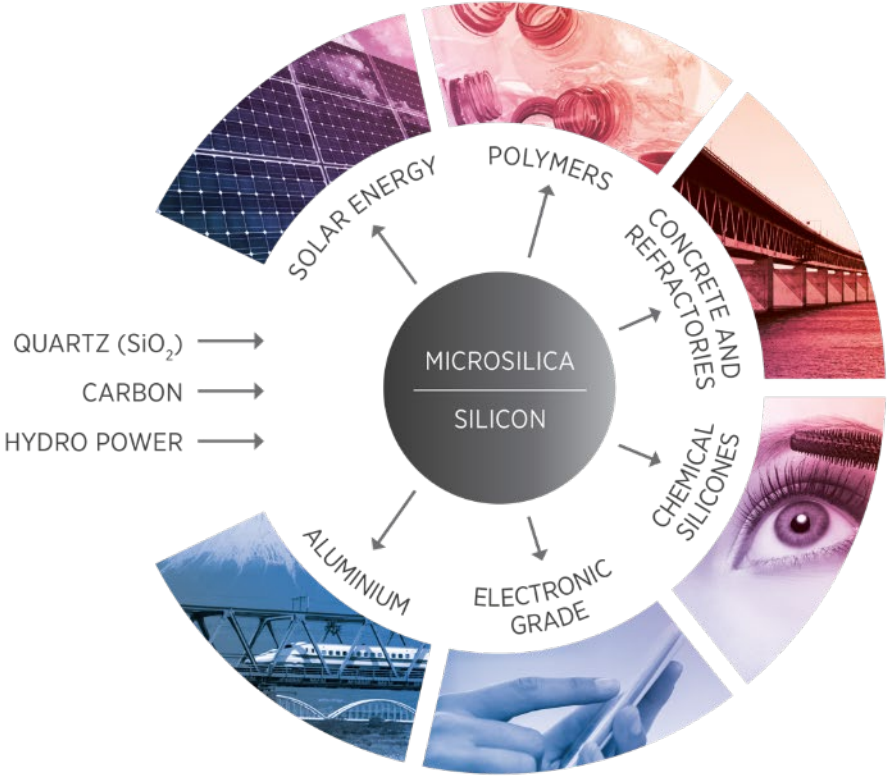
Elkem provides materials that are **vital to modern societies**

27 PLANTS WORLDWIDE
Headquarter in Norway

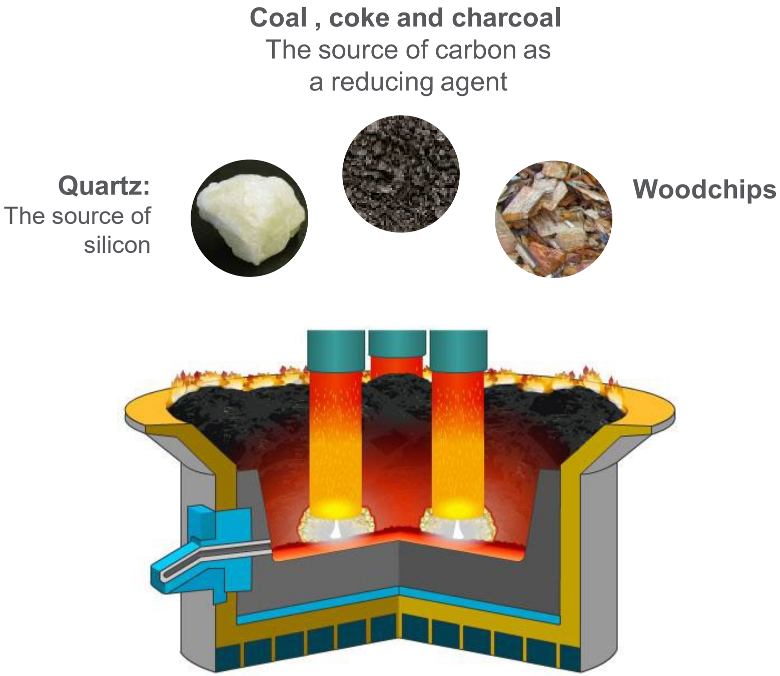
400 R&D PEOPLE
Global R&D centres in Norway and Lyon

6.200 EMPLOYEES
Worldwide

21,4 B NOK
Revenue in 2017



CO_2 emissions are inevitable with present production technology



- The overall (ideal) chemical reaction in the furnace is:

$$SiO_2 + (1+x)\ C \ = \ x\ Si + (1-x)\ SiO + (1+x)\ CO$$

–where x is the furnace silicon yield, that is how much of the silicon in the quartz that is tapped

- The CO and SiO gases burn above the furnace surface forming SiO_2 (microsilica®) and CO_2:

$$SiO_2 + (1+x)\ C + (1+x)\ O_2 = x\ Si + (1-x)\ SiO_2 + (1+x)\ CO_2$$

ELKEM CONVERTS NATURAL RESOURCES TO PRODUCTS THE WORLD NEEDS

CO-2 emission - 1300.000MT/y

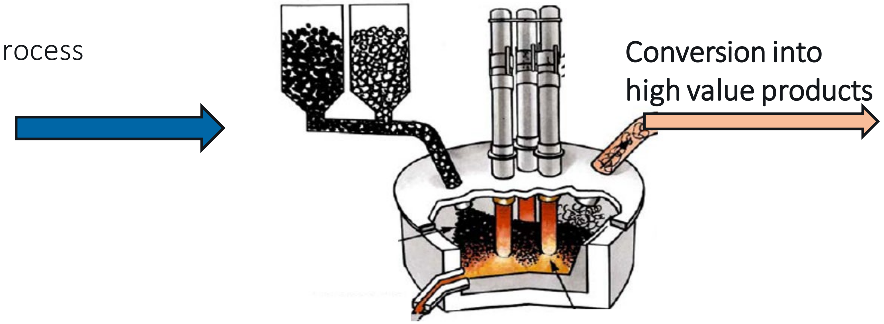
- Biobased reductants;
  -300.000 tonn woodchips
  - 30.000 tonn charcoal
- Energyrecovery 6-700GWh
- Other Energy savings
  > 200GWh last 3 years

Source: Alloy Consult

Elkem's contributions to the low-carbon economy

Elkem's portfolio of innovation projects includes:

1. New products for the low-carbon society, e.g.
   solar silicon, battery technology, thermoelectric power generation
2. Increased raw material and energy efficiency through all production processes -> Reduced CO_2 emissions per kg product
   - Yield from raw materials to finished goods
   - Energy recovery
3. Replace coal from fossil sources with bio-carbon
4. Utilize the value of chemical components and energy in the process off-gas.
   - Next generation energy recovery systems
   - Production of chemicals
   - Biomass production
5. Preparation for CCS and CCU



Closed silicon alloy furnace

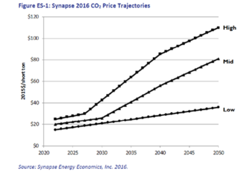
Elkem has prepared a biocarbon strategy as a step towards becoming a more "green" company

Key external drivers:

Stricter regulations

- EU for 43% reduction within 2030
- To reach Norway's climate targets the government has suggested that the industry use up to 40% charcoal
- "License to operate"

CO_2 price



- Price projections between 20 and 50 USD/MT in 2030
- Canada initiate tax 10 to 50 CAD/MT in 5 years

"Green" focus in society

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

Elkem wish to be a leading player in sustainable production of silicon and ferrosilicon based alloys

Charcoal in silicon production

Charcoal is regarded as CO2 neutral. Using charcoal instead of fossil coal in the production of silicon and ferrosilicon could reduce Elkem's CO2 emissions significantly. This is a key part of Elkem's sustainable production strategy.

The Si and ferroalloy industry might see:

- More governmental taxes on emissions of fossil CO_2. Established carbon emission trade markets.
- Governmental restrictions in using coal. Requirement for increased portion of sustainable bio carbon.
- Customer requirements for "green" and sustainable products

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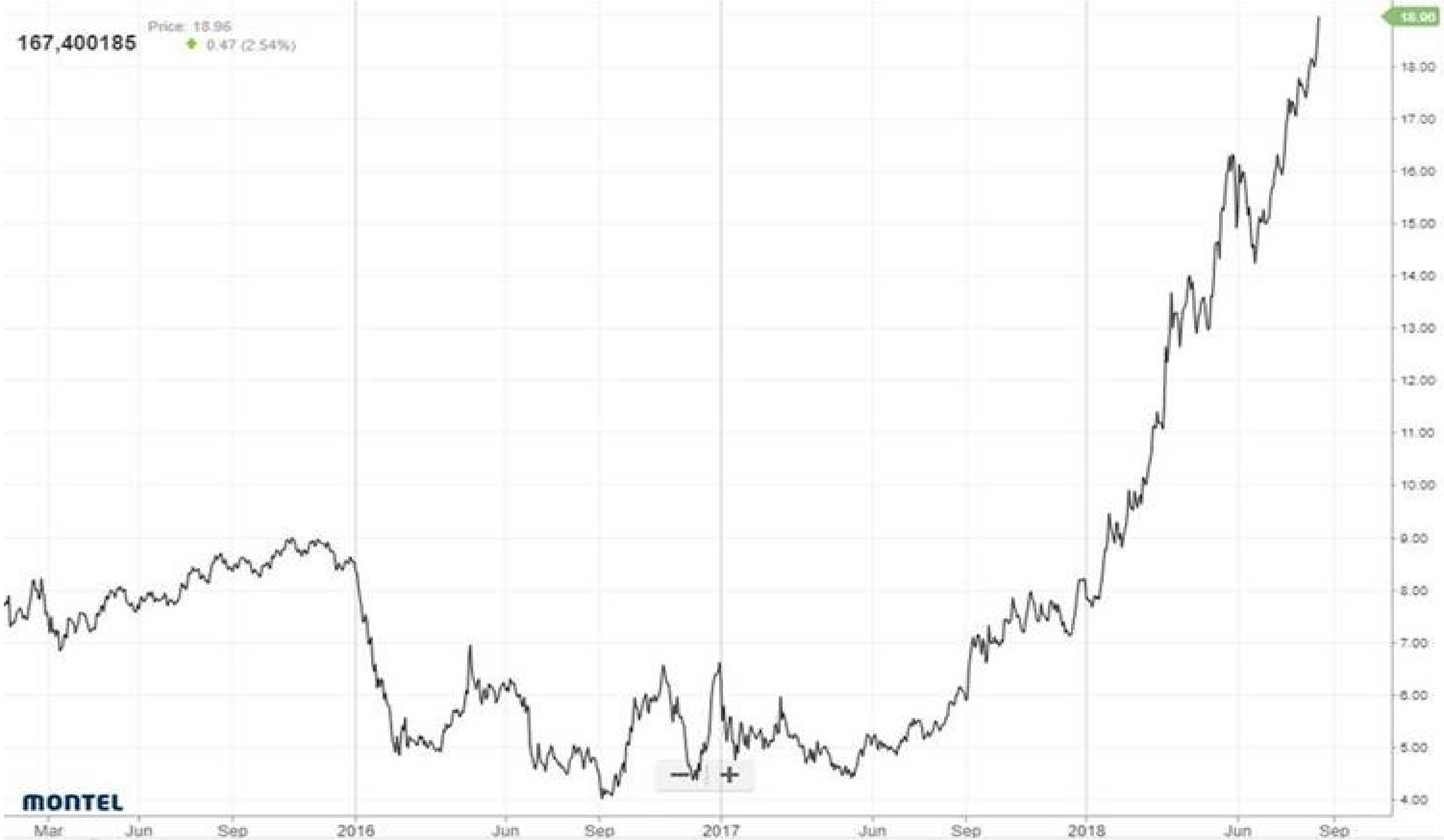
- CO2 prisen



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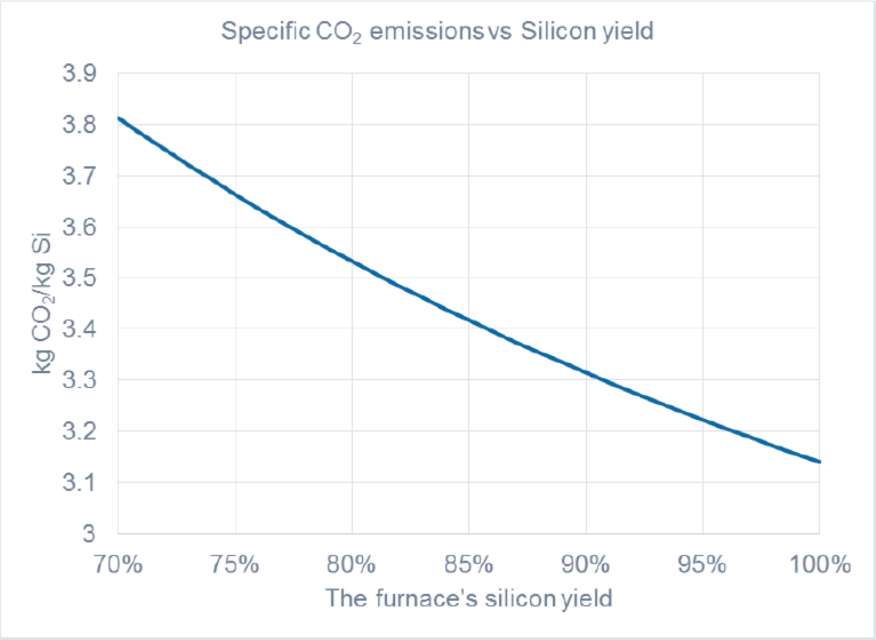
Process efficiency improvement lowers specific CO_2 emissions

The theoretical specific CO_2 emission at 100 % silicon yield (with pure carbon used) is:

3.14 [kg CO_2/kg Si]



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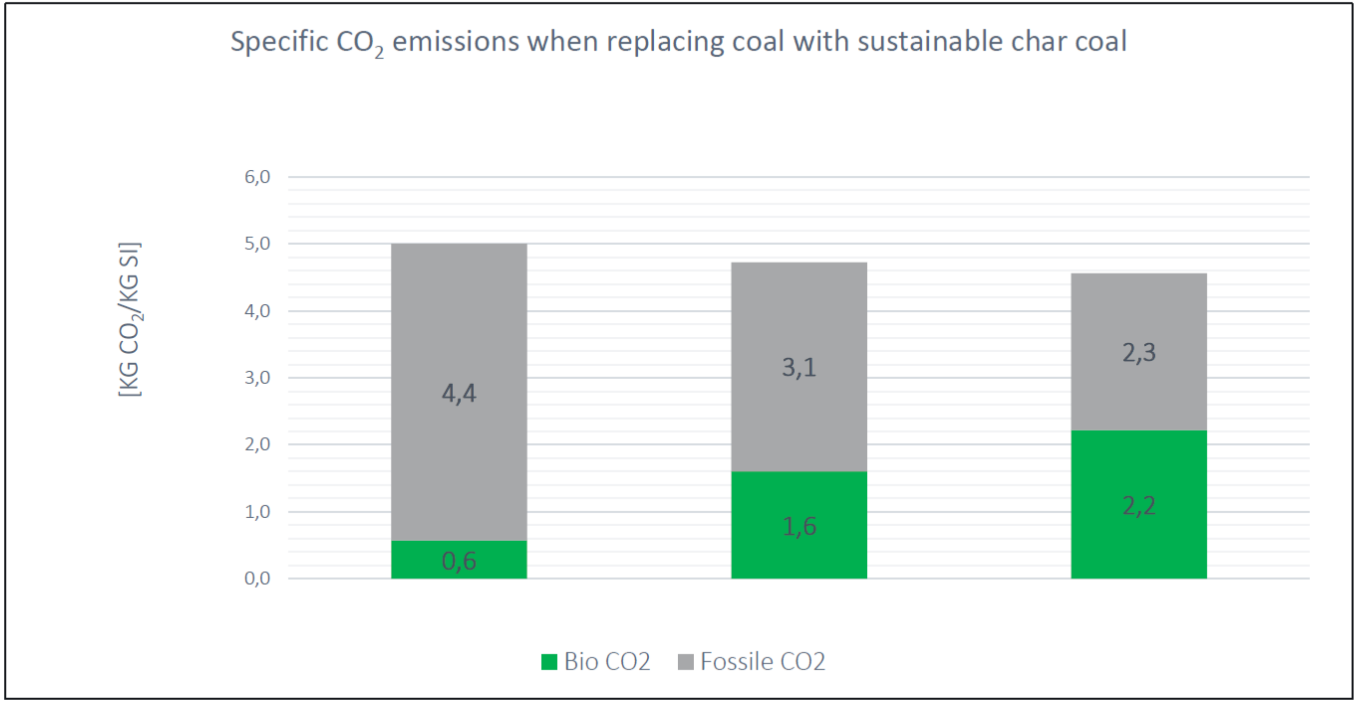
Use of sustainable charcoal also reduces total CO_2 emission



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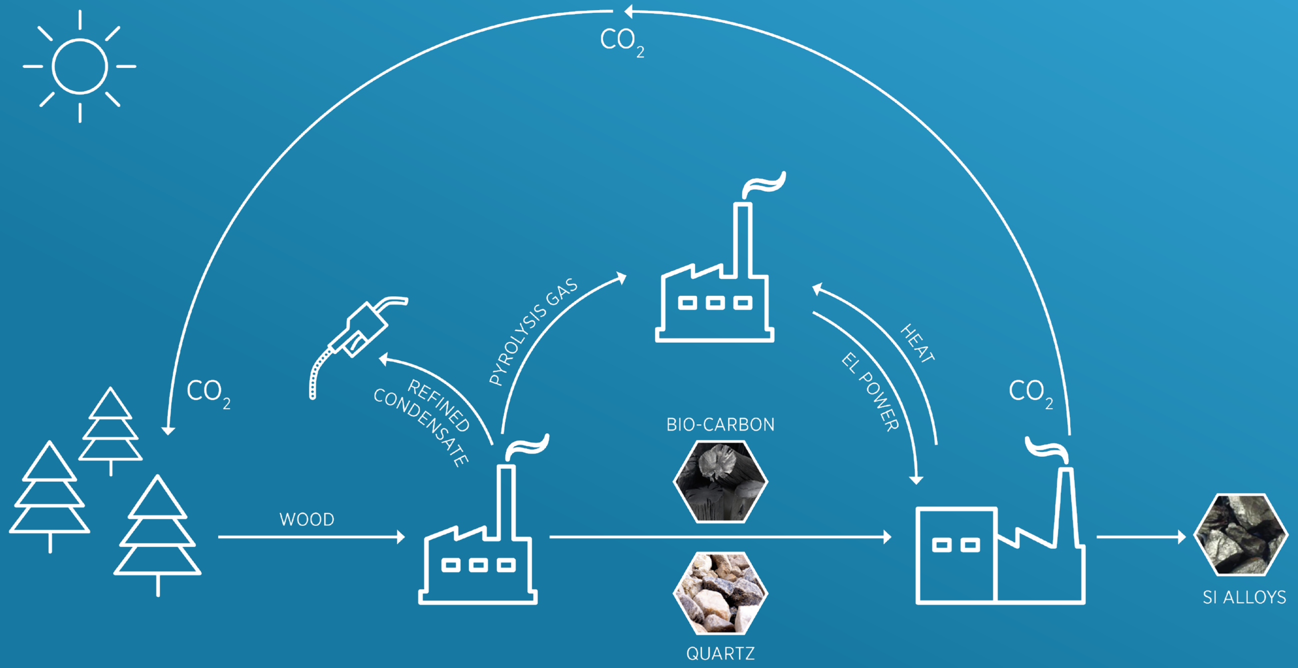
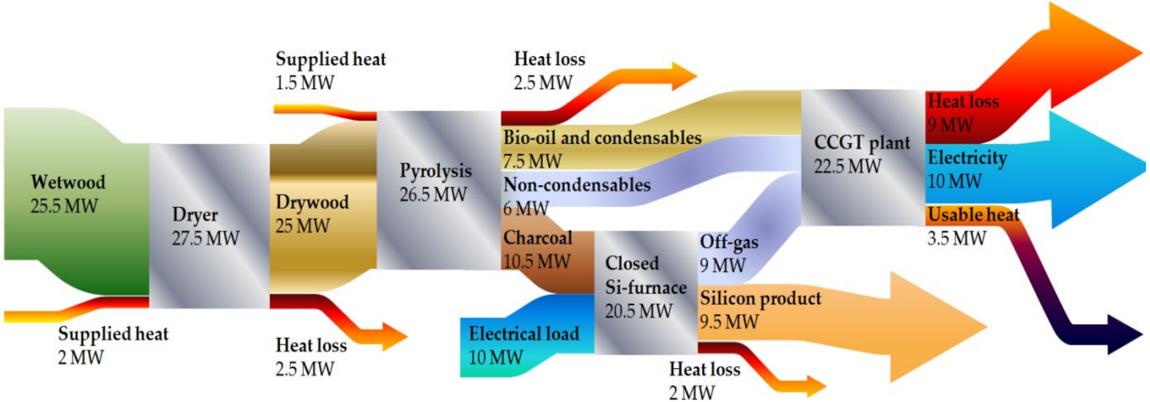
Sustainability in own processes: carbon neutral metal production



CARBON NEUTRAL METAL PRODUCTION IS POSSIBLE!

Business case / Background:

- Elkem's resource efficiency and environmental emissions:
  - Waste heat: ~5,9 TWh
  - CO_2: ~1,3 millon tonnes
- Elkem needs to reduce energy consumption and CO_2 emissions and increase energy recovery to be prepared for future requirements



Elkem decentralized integrated production of biocarbon and Si

Production

-15 % fines
-Gases
-Condensate

Si production

Decentralized production		
	Mass	**Energy**
Gate		
Biomass in	100 %	100 %
Gas	25 %	10 %
Fines	4 %	9 %
Charcoal	21 %	51 %
Condensate	50 %	30 %
Final distribution		
Charcoal	21 %	51 %
Gas	25 %	10 %
Condensate	50 %	30 %
Fines	4 %	9 %

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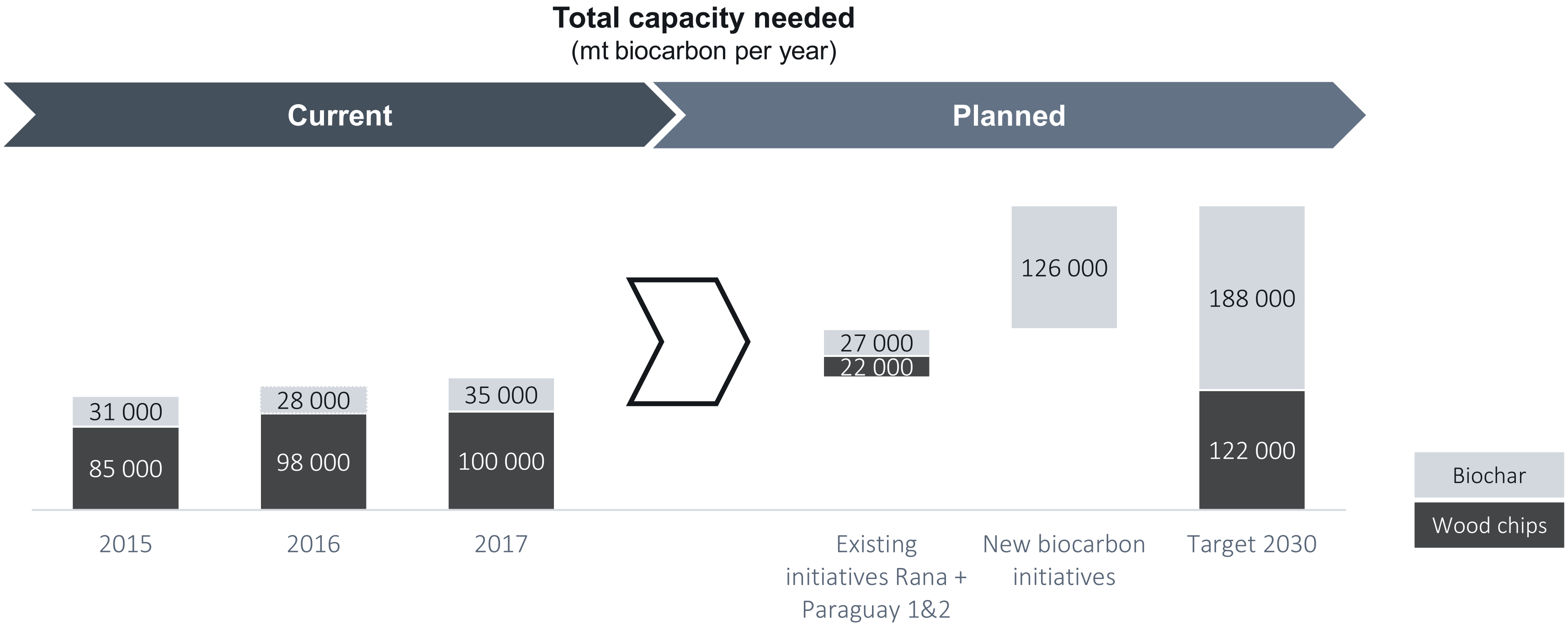
SINTEF

Route for by-products

- Fines
  - Briquettes; use in process
  - Briquettes; consumer product
  - Powder; charcoal injection in blast furnaces
  - Powder; heat and power production
  - Powder; gasification → FT→ refining →Aviation fuels
- Gas
  - Heat and power production
  - Catalytic upgrading
- Condensate
  - Heat and power production
  - Gasification → FT→ refining → Aviation fuels
  - Chemical extraction/isolation/catalytic hydro-processing

THE AMOUNT OF BIO OIL IS HIGHLY DEPENDENT ON THE WOOD FEED STOCK AND THE PYROLYSIS PROCESS

Business case: Follow recommendation from Norwegian government to use biocarbon* to reach 40% goal in 2030

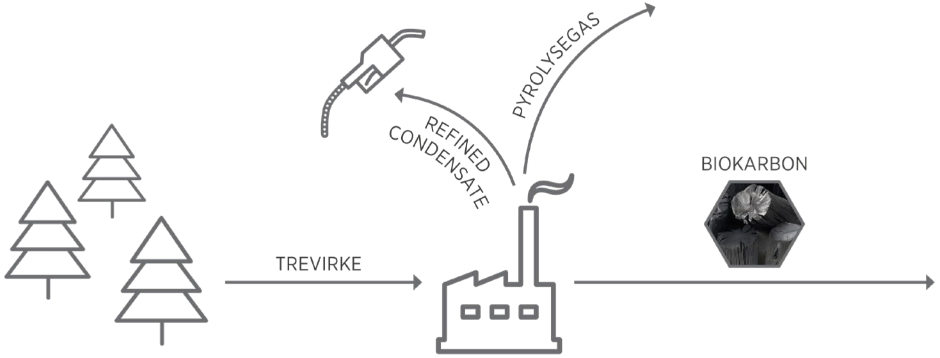


*Biocarbon as 76% (wb) charcoal

Including Canada, Iceland and Paraguay

Carbonization technology
- Like this?

PyrOPT focus areas



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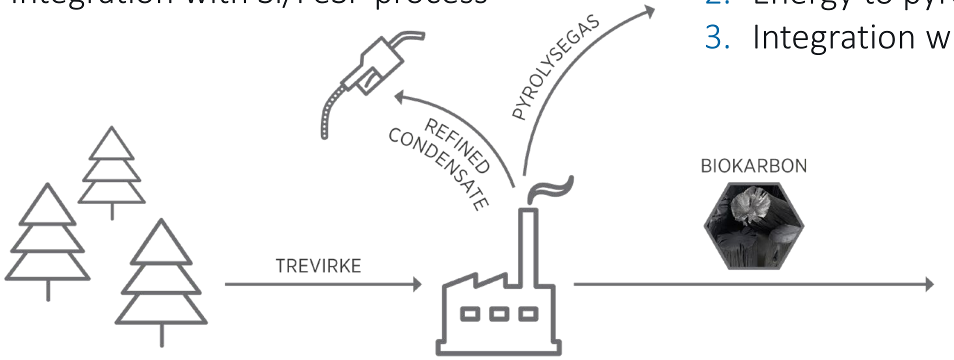
PyrOPT research objectives

Vapour/Oil/ Condensate:
1. Upgrading strategy
2. Optimal utilization
3. Integration with Si/FeSi process

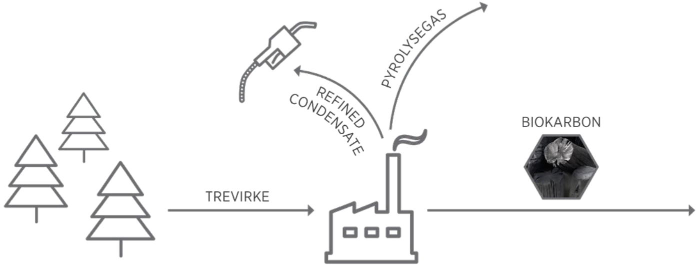
Non condensables:
1. Optimal Utilization
2. Energy to pyrolysis process
3. Integration with Si/FeSi process



Biocarbon:
1. Maximizing carbon yield
2. Properties tailored for Si/FeSi production
3. Minimizing waste of fines

PyrOPT research objectives

- Primary objective:
  - Develop a novel cost-competitive pyrolysis process for producing a biocarbon material from wood feedstocks suitable as reductant in Si/FeSi production.

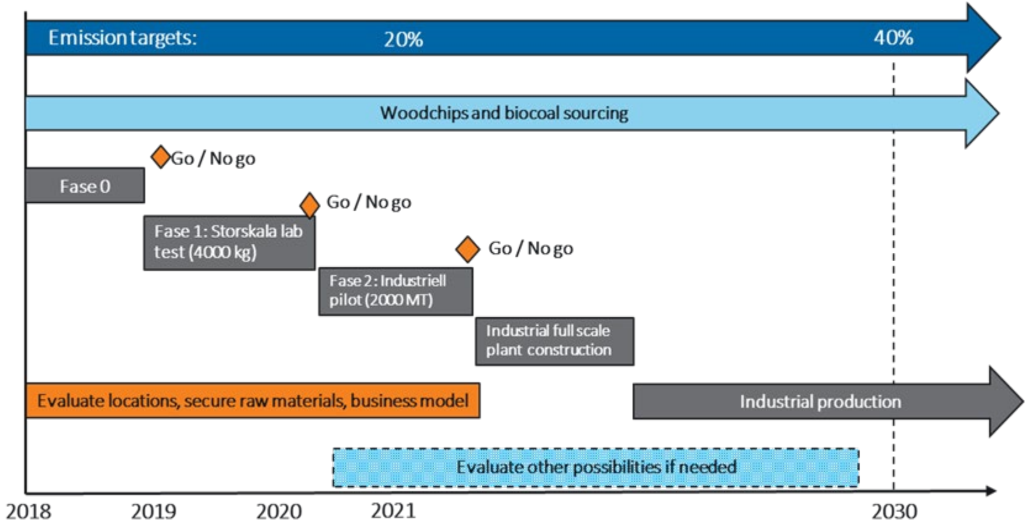


- Secondary objectives:

1. Maximize the usage of renewable, sustainable bio-based raw materials in the silicon and ferrosilicon production process
2. Maximize the fixed carbon yield from an atmospheric carbonization process
3. Minimize the fines production from an atmospheric carbonization process and optimize mechanical properties of charcoal in order to reduce the amount of fines during handling and storage.
4. Determine optimal utilization of side streams from an atmospheric carbonization process
5. Determine the feasibility of intermediate pyrolysis with direct vapour upgrading
6. Educate students in the art of charcoal production and obtain fundamental understanding of underlying mechanisms

Goal: *To reach fixed carbon yields 20% higher compared to current carbonization technologies without using pressurized processes*

PILOT E - TIMELINE FOR BIOCARBON AGGLOMERATES



Four phases, the first phase is completed. The next three phases are:

2. Production of 4000 kg briquettes for initial furnace tests
3. Construction of an industrial pilot plant with annual capacity of 3000 mt. Production of 2000 mt briquettes for repeated furnace tests.
4. Construction of first one and then 1-3 additional industrial full-scale facilities.