Project 101178144

QUEEN

QUARTZ ENRICHMENT ENABLING NEAR-ZERO SILICON

hello . hola . hallo . bonjour . ciao

ahoj . zdravo . привіт . witam . dakujėm

Funded by
the European Union

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Elkem Silicon Products
Kristiansand, Norway

Funded by
the European Union

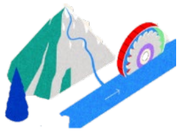
Elkem’s value chain

Input factors

Quartz

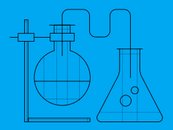
Coal

Biocarbon



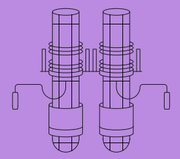
Renewable power

High temperature/chemical processes



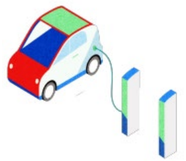
Silicones

Silicon, ferrosilicon, foundry products & microsilica



Carbon solutions

Examples of applications and markets

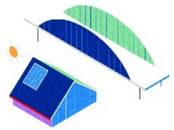


Mobility & transportation

Science & chemicals

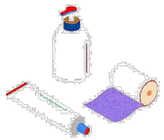
Healthcare

Digital communication

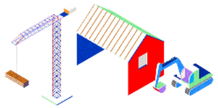


Smart cities & construction

Energy & power



Personal care & consumer goods



Advanced manufacturing

Elkem

Napoli, 27/11/2025

Elkem

QUARTZ ENRICHMENT ENABLING NEAR-ZERO SILICON

Agglomerating Alternative Raw Materials for Sustainable Silicon Production

Learnings from the QUEEN Project Trials at Elkem

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Main Features

Project Period

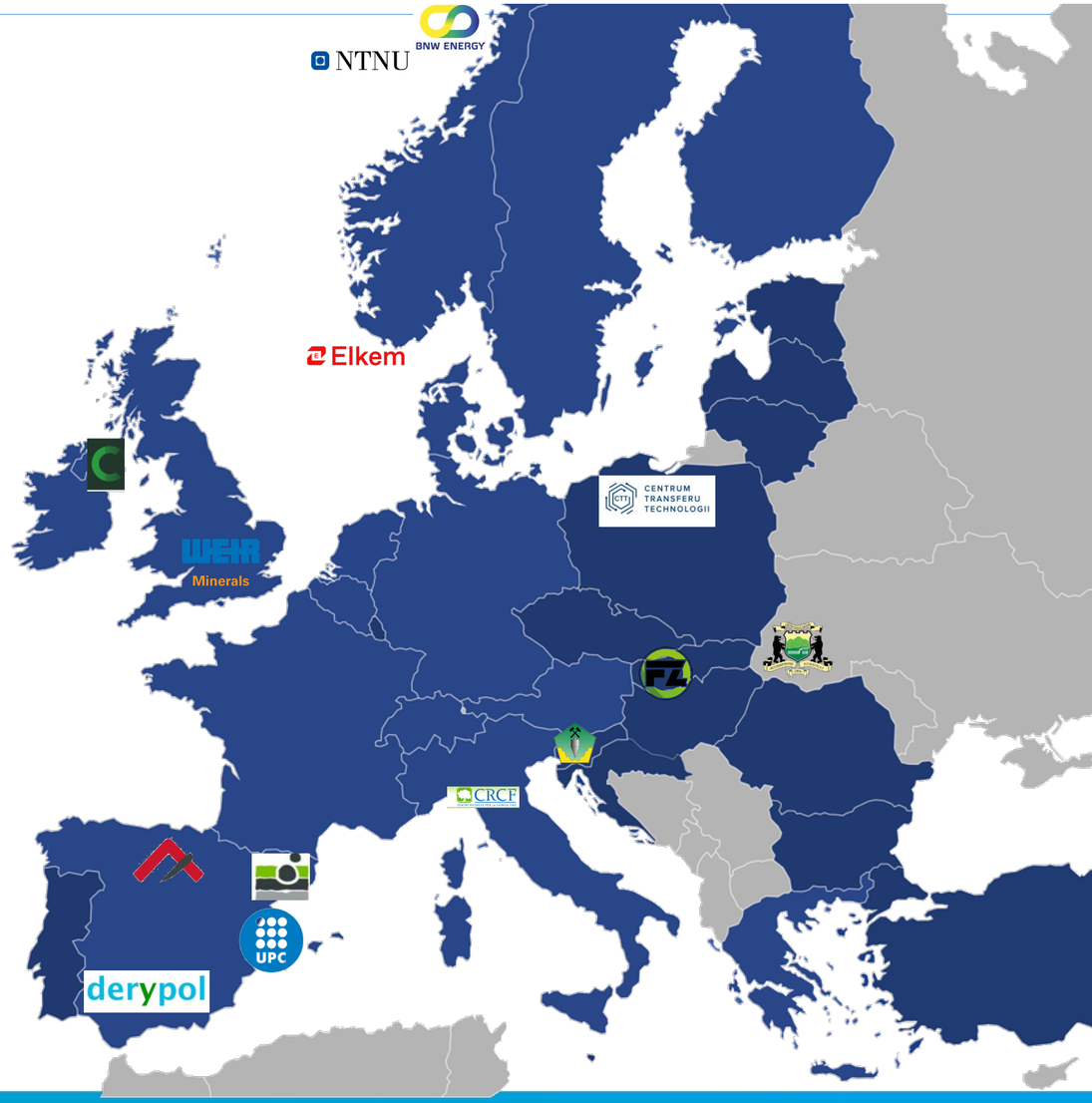
❑2024-2028

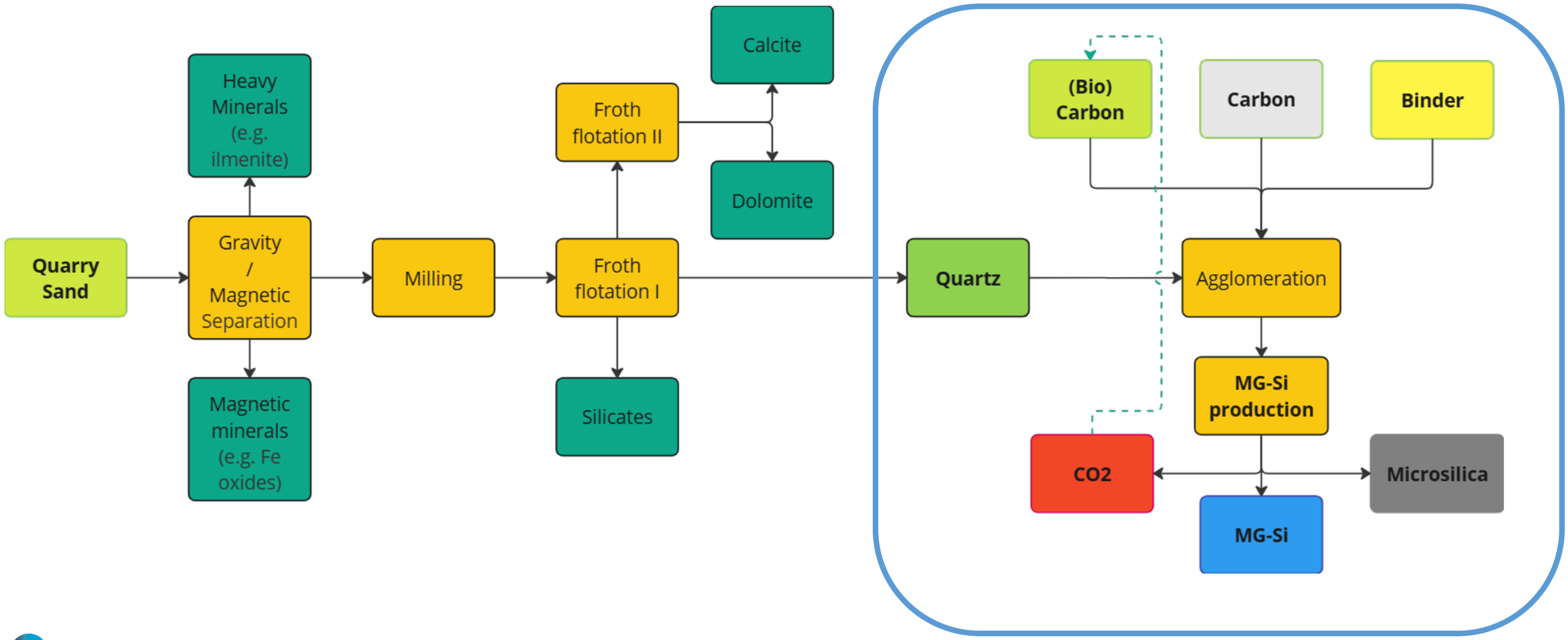
Project Objective

- Purification of quarry sands to qualify for use in production
- Development of a method to agglomerate quarry sands
- **From TR 4 to TRL 7**

Budget & Funding

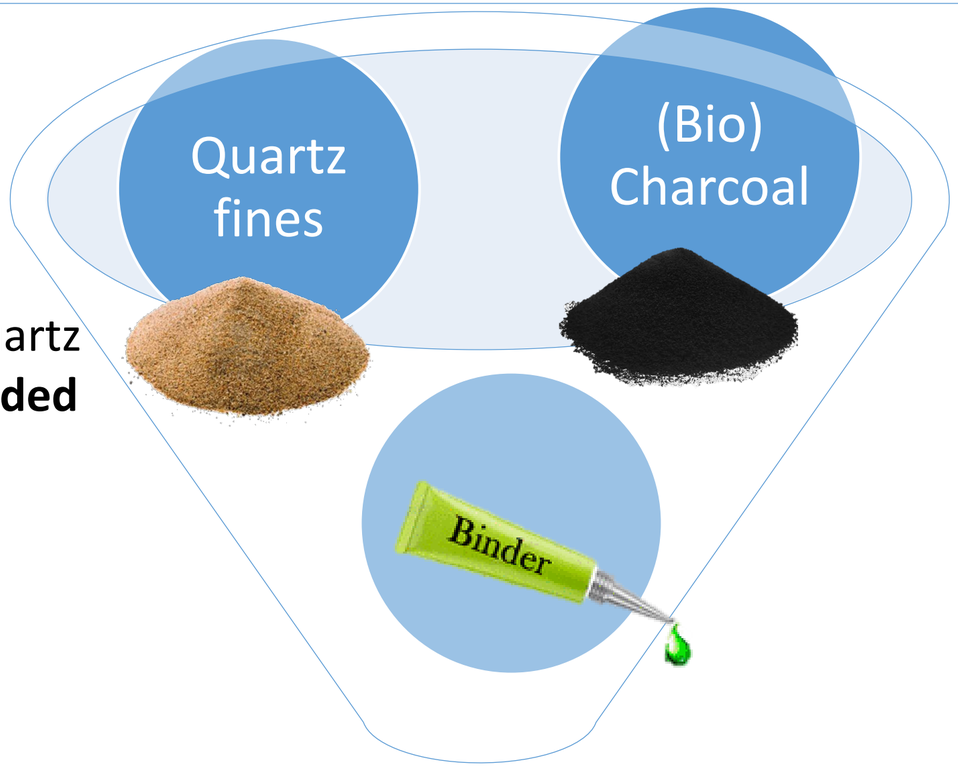
- Project Budget: 7.2 M€




Quarry Sand
Gravity / Magnetic Separation
Heavy Minerals (e.g. ilmenite)
Magnetic minerals (e.g. Fe oxides)
Milling
Froth flotation I
Froth flotation II
Calcite
Dolomite
Silicates
Quartz
(Bio) Carbon
Carbon
Binder
Agglomeration
MG-Si production
CO2
Microsilica
MG-Si

Approach

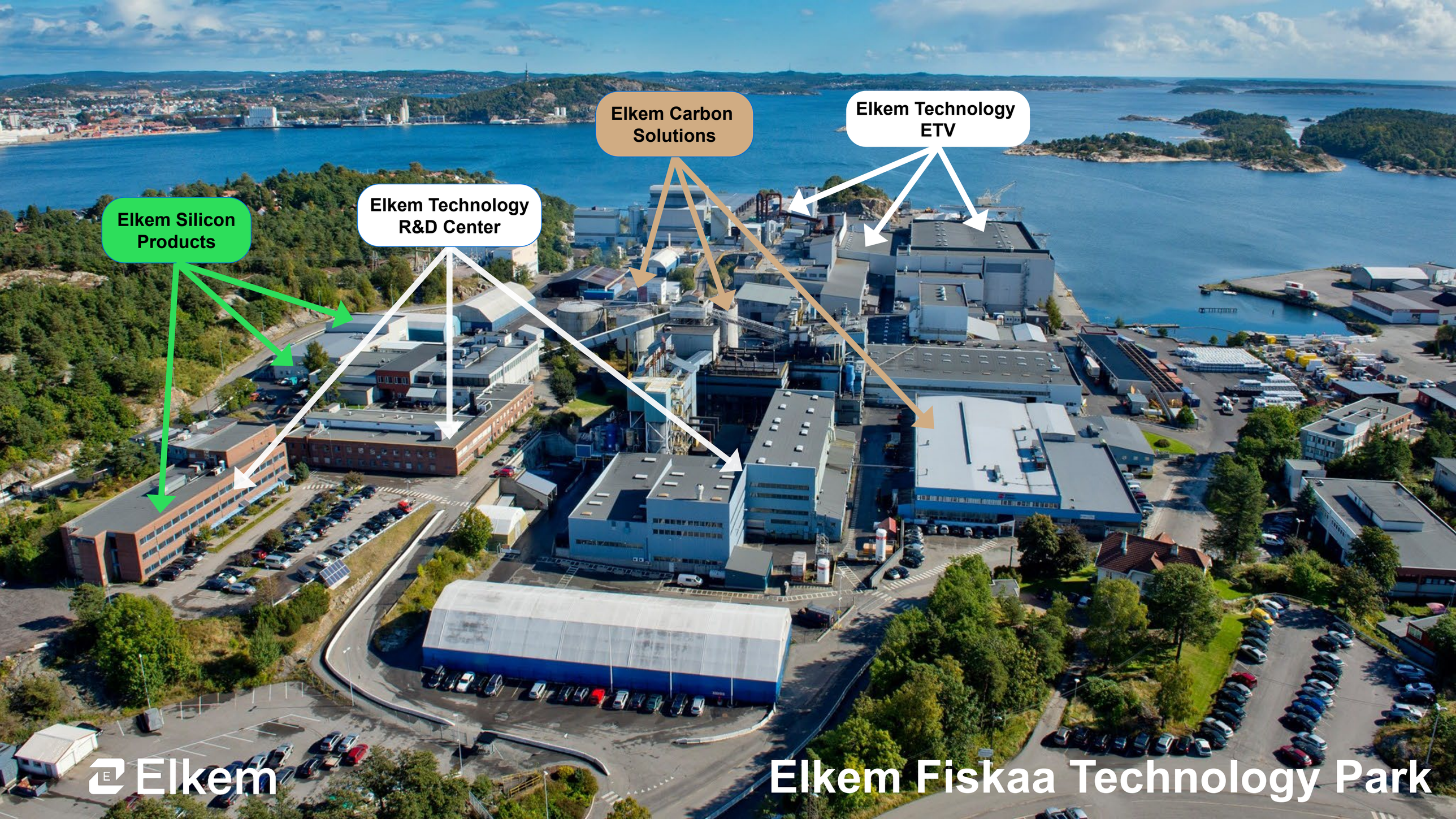
- Less waste of quartz
- **Purification needed**



- Less fossil carbon used
- Contribution to the reduction of CO_2 emissions

Hybrid agglomerates

- No major changes in Si production


Elkem Carbon Solutions
Elkem Technology ETV
Elkem Technology R&D Center
Elkem Silicon Products
Elkem
Elkem Fiskaa Technology Park

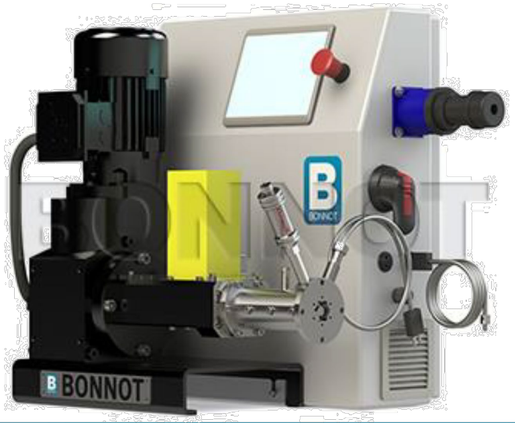
Agglomeration facilities at Elkem Fiskå – lab scale

Eirich mixer

- Max sample volume: 3 L
- Star shaped impeller head
- Frequency converter for stepless impeller RPM adjustment

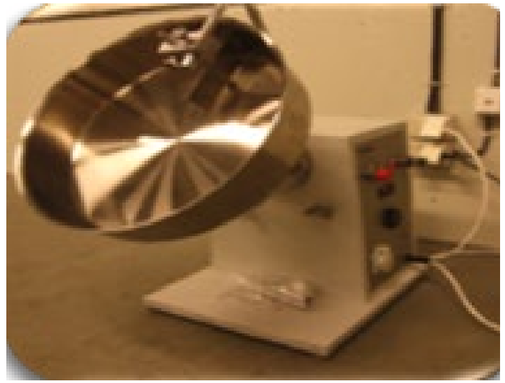
Extruder

- Max capacity: 10 kg/h
- 2mm and 3,2mm die plate holes
- Continuous pressure and temperature readings



Pelletising disc

- Max capacity: 5 kg/h
- Tunable spinning rate



Agglomeration facilities at Elkem Fiskå – pilot scale

Eirich mixer

- Max sample weight: 600 kg
- Star shaped impeller head
- Frequency converter for stepless impeller RPM adjustment

Pelletising disc

- Max capacity: 10 kg/h
- 2 mm and 3.2 mm die plate holes
- Continuous pressure and temperature readings

Briquette

- Maximum capacity 400 kg/h
- Pillow- shaped (quadratic)- 4 cm
- Almond- shaped- 4·3.2 cm

Funded by the European Union

Which binders can be used?

Binder type	PROs	CONs
Water	▪ Non-toxic and environmentally friendly ▪ Easy to handle ▪ Inexpensive	▪ Limited effect ▪ Effective at temperature < 100 °C
Inorganic materials	▪ High thermal stability ▪ Mechanical strength	▪ Might require high curing temperature ▪ Non-flexible in properties
Organic polymers	▪ Flexible properties ▪ Curing at room temperature	▪ Degradation with heat and/or UV ▪ VOC emissions ▪ Cost
Organic polymers + crosslinkers	▪ Flexibility in compositions ▪ Enhanced durability	▪ Complex formulation ▪ Cost

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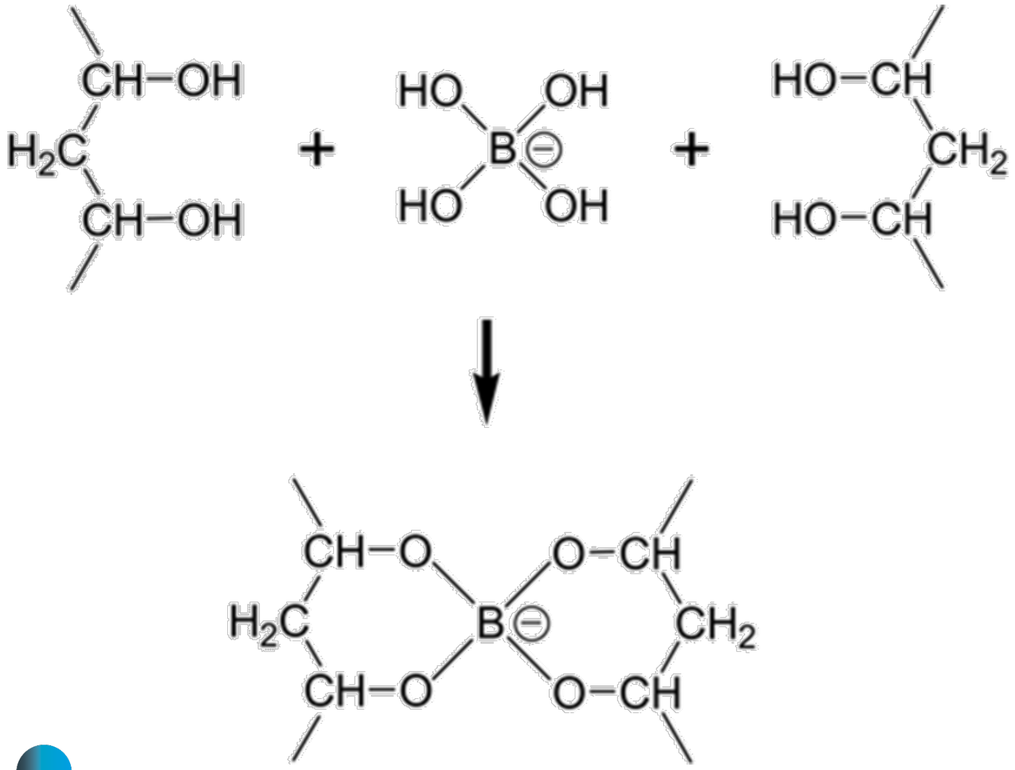
Which binders can be used?

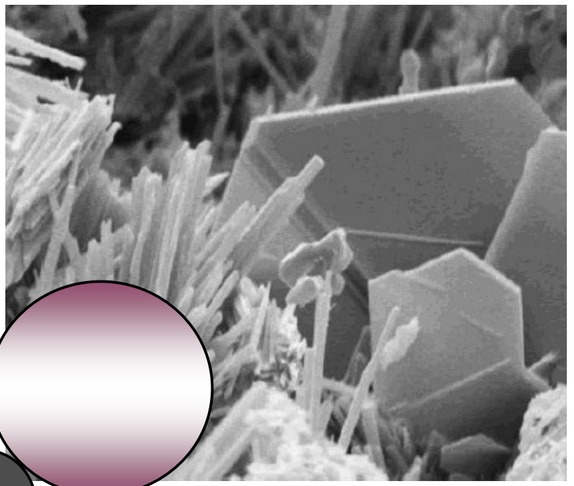
Polysaccharides + Borax

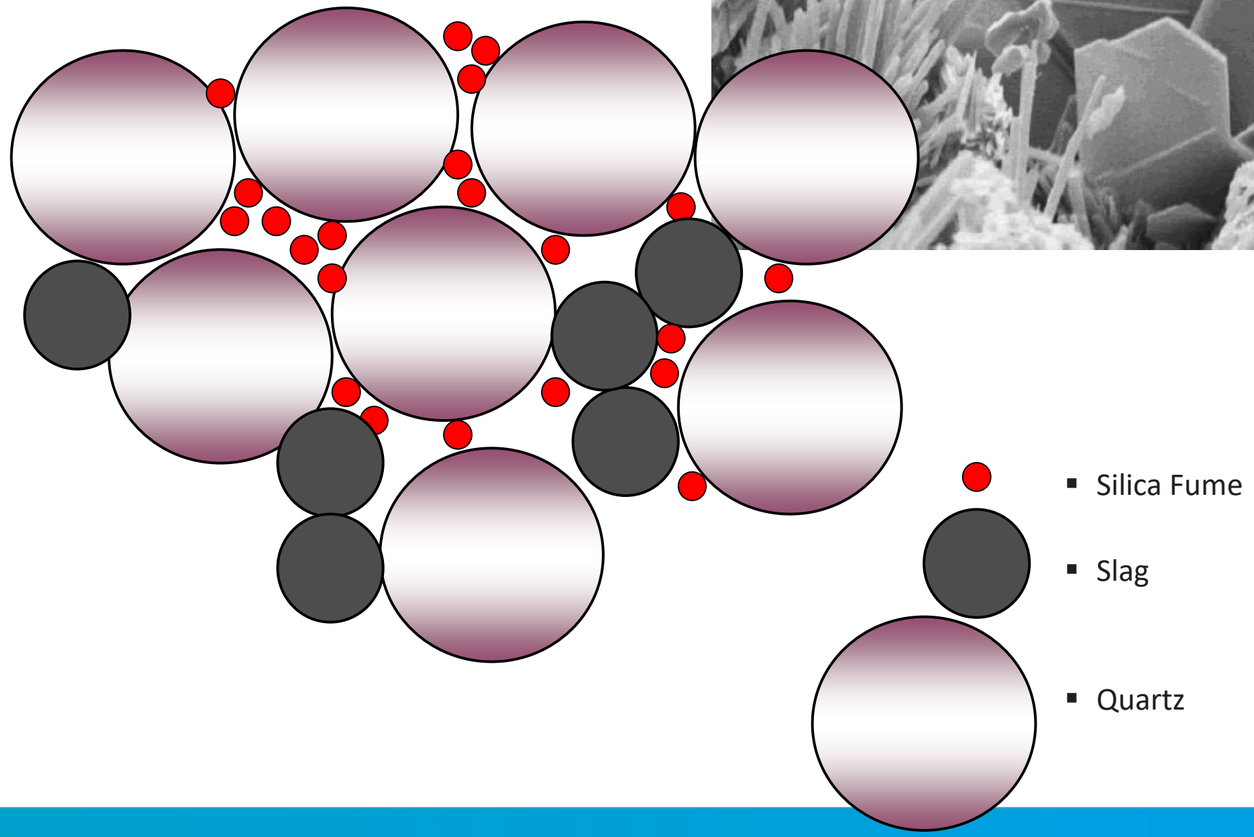
- Works by means of esterification



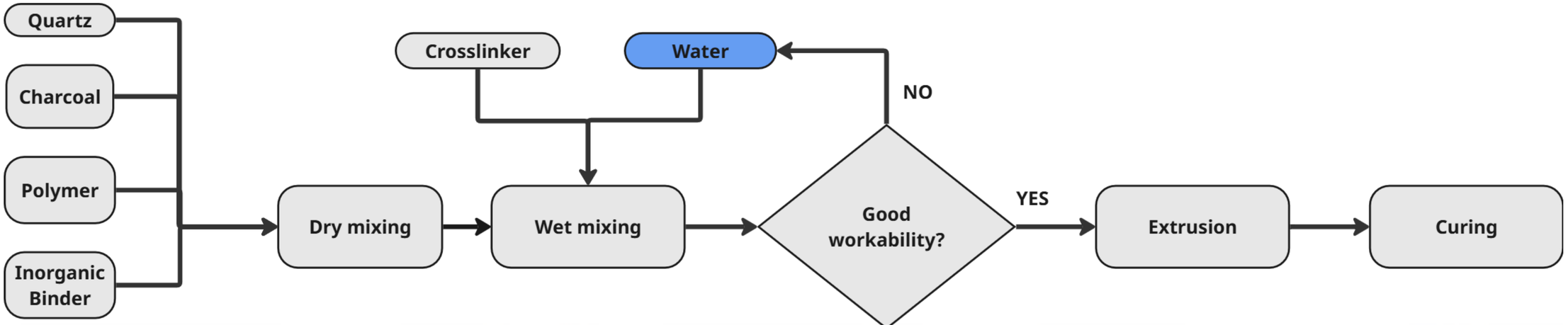
Slag + Silica Fume

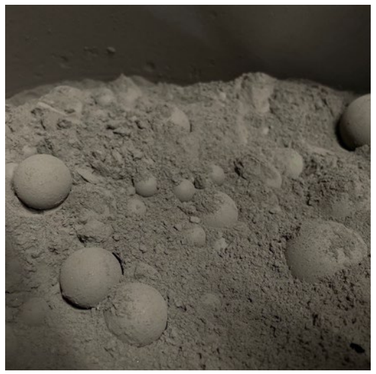
- Works by means of hydration





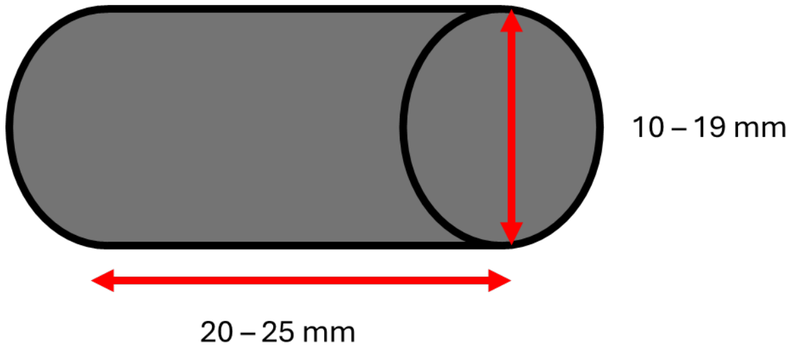
Process flow





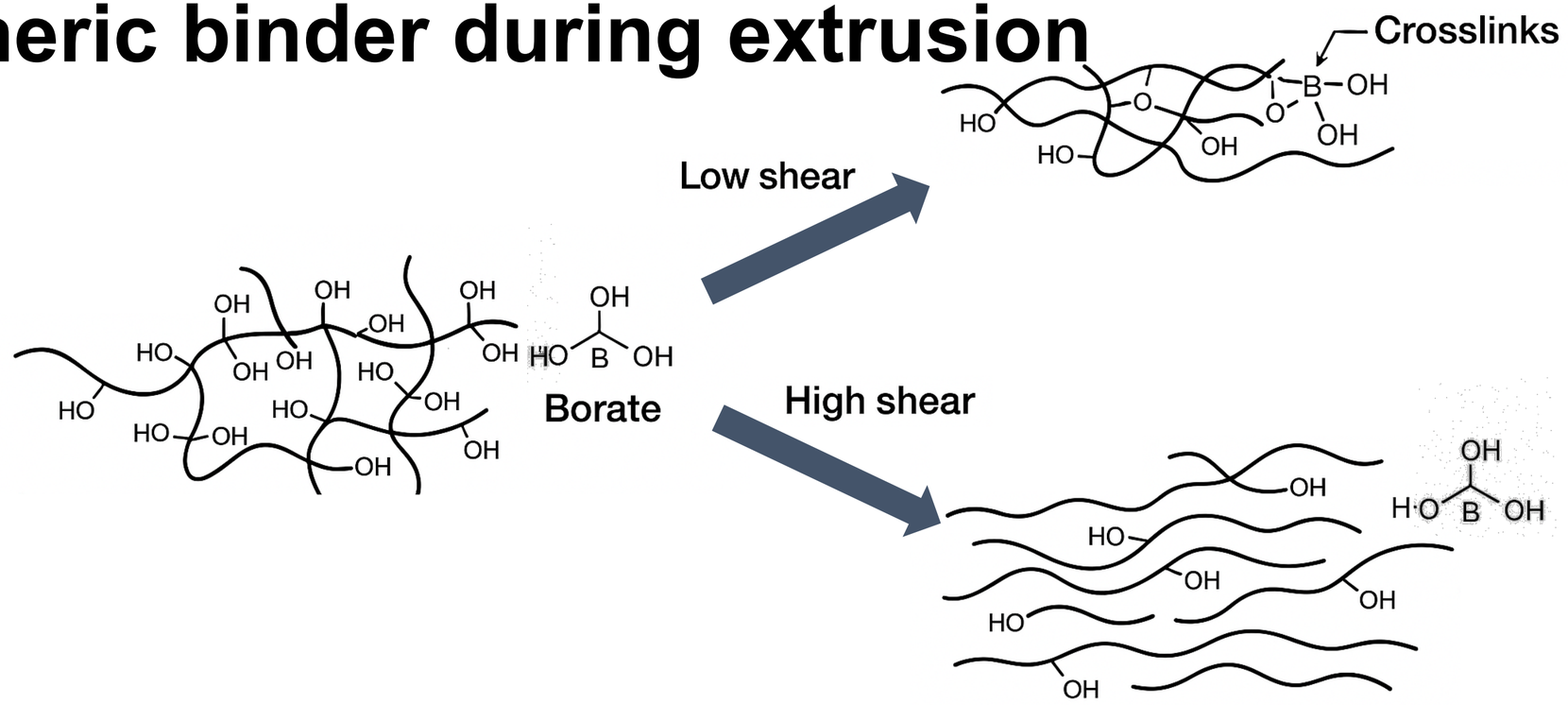
Goals and design of tests

- prove that it is possible to extrude quartz-charcoal composites
- investigate the effect of the following parameters
  - Charcoal to quartz ratio
  - Binding system
    - *Crosslinked polymer*
    - *Hybrid*
  - Extrusion rate
  - Curing time



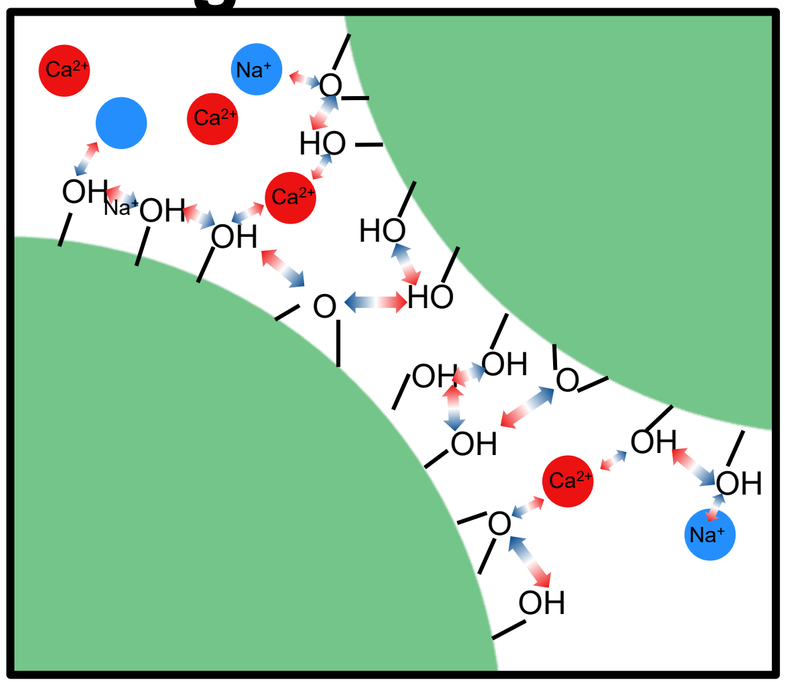
Mixing → Extrusion → Early curing (1 day) → Late curing (28 days)

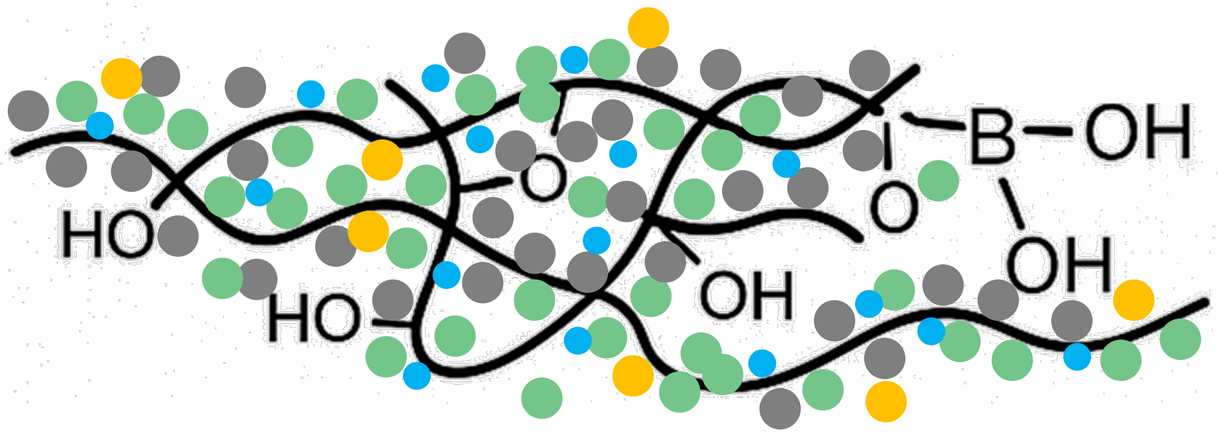
Polymeric binder during extrusion



Mixing | Extrusion | Early curing (1 day) | Late curing (28 days)

Inorganic binder during curing





- Quartz
- Charcoal
- Slag
- Microsilica®

Mixing → Extrusion → Early curing (1 day) → Late curing (28 days)

Conclusions

- Elkem has the facilities and experience needed to work on the optimisation of quartz-charcoal agglomerates
- Extrusion of composite materials is a feasible process step demonstrated in the project.
- The effect of binder formulation changes throughout the process steps, impacting agglomerate quality and process stability:
  - Polymers affect extrusion
  - Inorganic system affects curing

Way forward

- Recipe development remains challenging due to complex interactions between raw materials, binders, and process conditions
- Further optimisation and scale-up are needed to enable robust industrial production
- Optimisation of extruded recipes is expected to be over by September 2026

Acknowledgements

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KREMEN
industrija in rudniki nekovin

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Project 101178144

queen

QUARTZ ENRICHMENT ENABLING NEAR-ZERO SILICON

thanks . takk . merci . gracias . gràcies . grazie

dziękuję . дякую . hvala . dakujem

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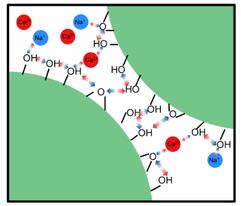
Charcoal/Quartz

Modulation of Pozzolanic kinetics and products quantities

Charcoal is the weak component

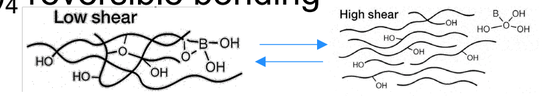
Adhesion of quartz and charcoal granules



Swells with water

Polymer binder

$B(OH)_4$ reversible bonding

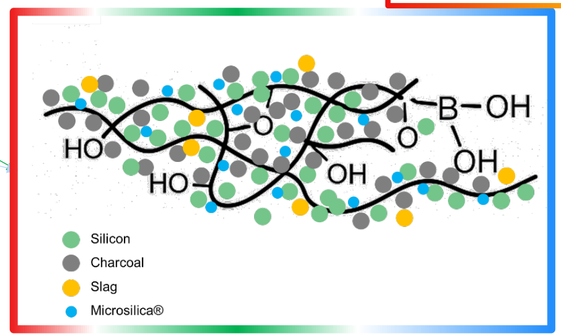


Less extended 3D network

Reduced strength

Extrusion rate

Time



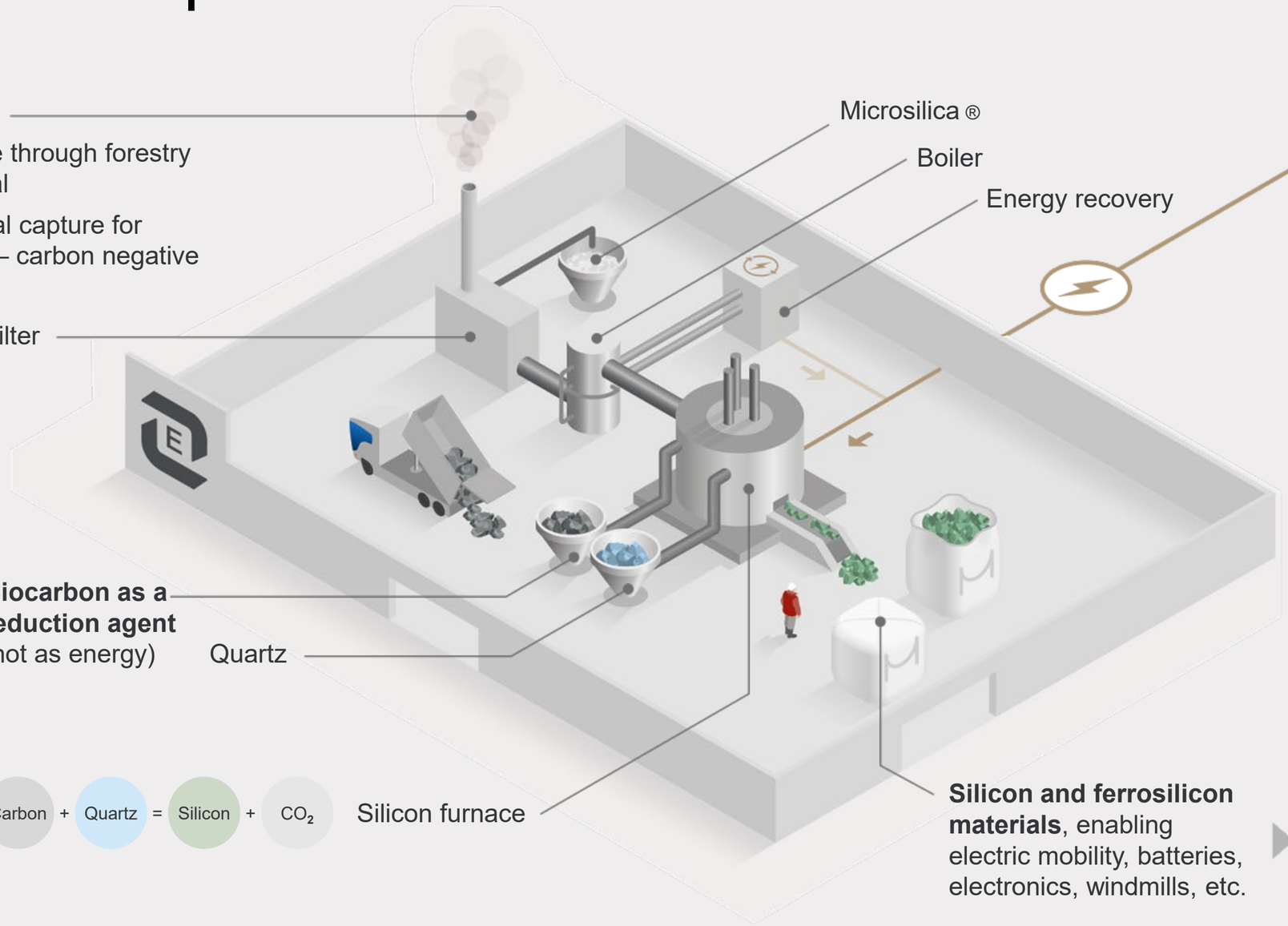
Mixing

Extrusion

Early curing (1 day)

Late curing (28 days)

Elkem silicon production



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