

POLITICAL MEETING

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27.01.2022



BERGEN  
**CARBON  
SOLUTIONS**



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## INTRODUCTION

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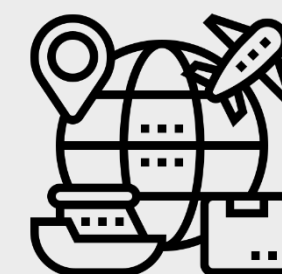
# WHAT ARE WE HOPING TO **ACHIEVE TOGETHER?**



Take Norway into a world leading material technology position.



Close collaboration with leading Norwegian industry.

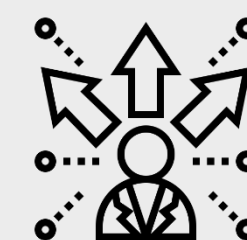


Evolve into a Norwegian industrial adventure and become an export industry.

## INTRODUCTION

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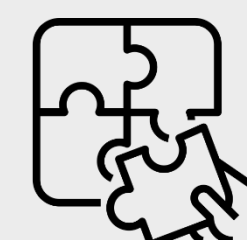
# HOW CAN WE MAKE IT HAPPEN?



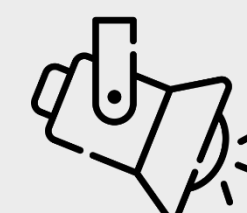
Define goals and opportunities nationally and internationally.



Cooperate and contribute to further development of Norwegian industry.



Contribute to CNF Arena being funded as a research branch for materials nationally and internationally.



Assist with making the technology known and establish cooperation with other nations.



Contribute to effective and necessary financing – if there is a need.

SHORT INTRODUCTION

# BERGEN CARBON SOLUTIONS



ABOUT BERGEN CARBON SOLUTIONS

# Bergen Carbon Solutions at a glance

## KEY FACTS

-  Founded in 2016
-  Located in Bergen, Norway
-  Competent team of engineers and PhDs
-  Unique and patented technology
-  Commercial production site secured
-  Listed on Euronext Growth Oslo (Ticker: BCS)



## CARBON NANOFIBERS



**Lighter**  
than plastic

**Stronger**  
than steel

**Leads electricity**  
better than copper

## WE USE CO<sub>2</sub> TO CREATE CARBON NANOFIBERS

- Lighter than plastic, stronger than steel, with exceptional thermal and electrical conductivity, properties that **can be transferred when combined with other materials**
- **Estimated CAGR of 25-27% towards 2024<sup>1,2</sup>**, covering a wide range of industrial and technological applications
- Market price between **NOK 5 000 per kg** and **NOK 27 000 per kg** depending on quality<sup>1</sup>
- Our products cover the whole range of qualities, meeting different customer needs.

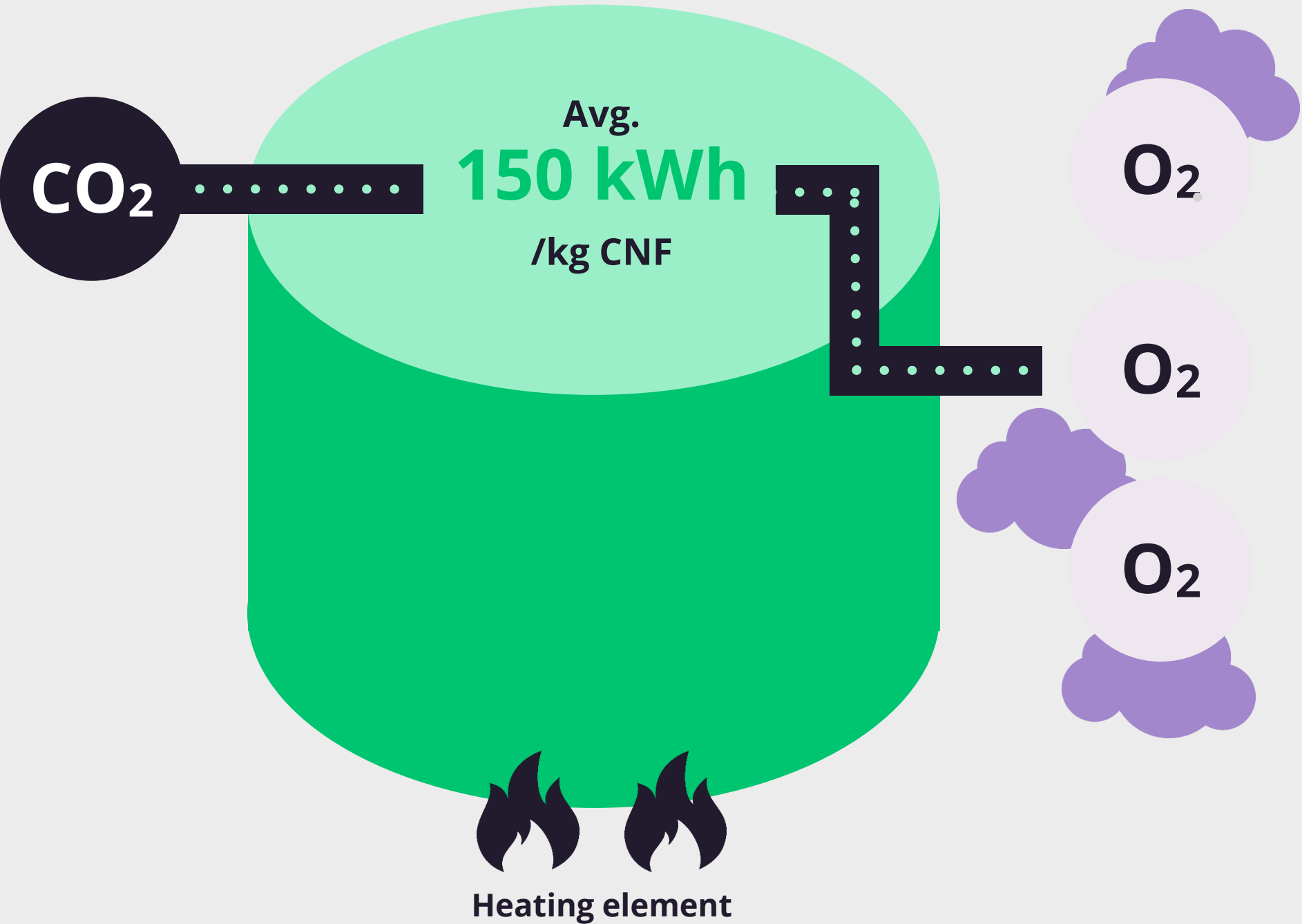
1: PwC analysis, October 2020)

2: "Reduction in CO2 emissions from using carbon nanofiber additives" (Alagic, Blomgren et al., 2022)

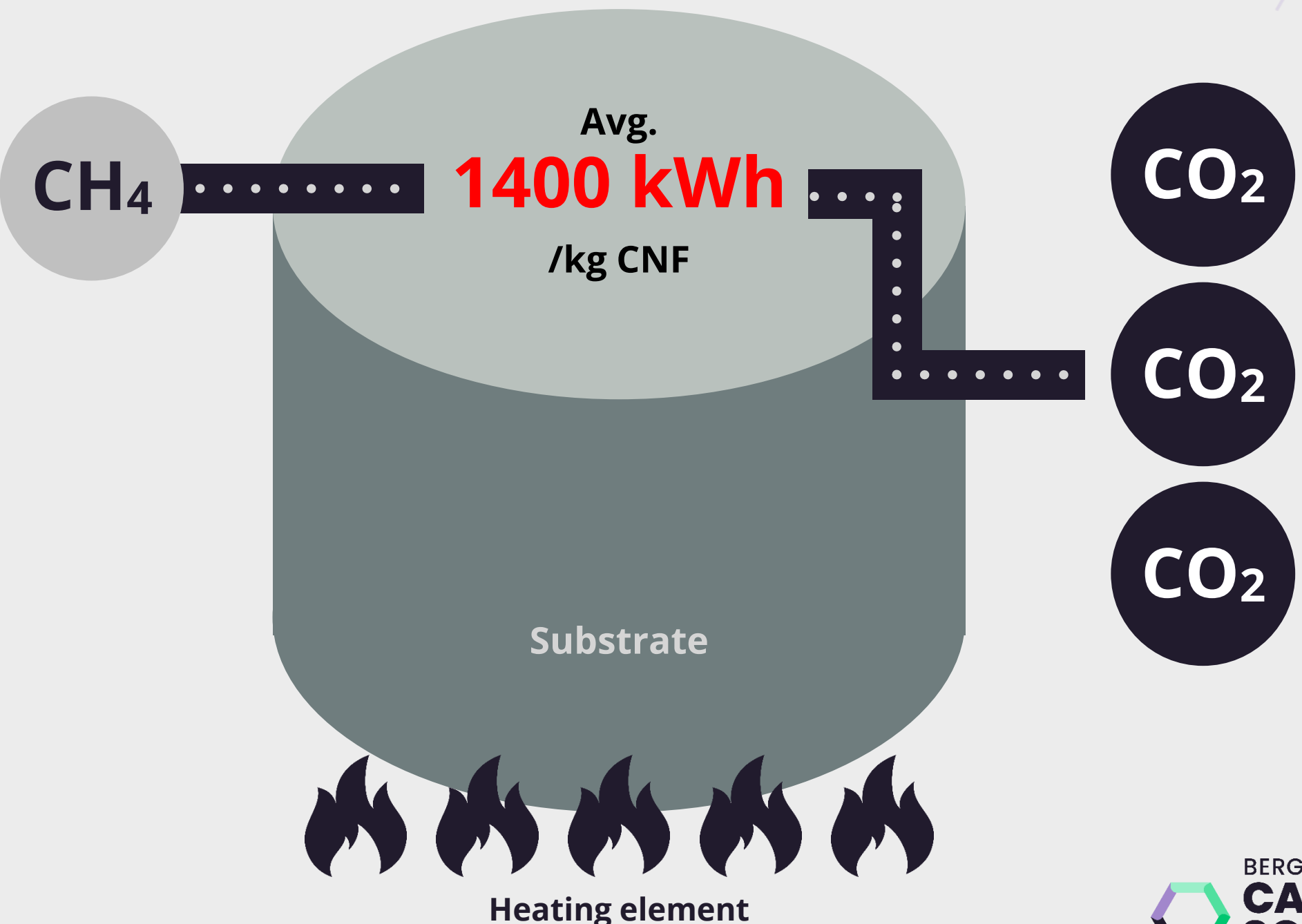
ABOUT BERGEN CARBON SOLUTIONS

Our technology is climate positive and uses significantly less energy than conventional methods

Bergen Carbon Solutions  
Positive CO<sub>2</sub> impact



Traditional Method  
Negative CO<sub>2</sub> impact



# Zero emission products enabling a low carbon footprint

Located in Bergen, Norway we've developed an energy efficient, carbon negative method to produce CNF out of CO<sub>2</sub>, using renewable energy, with O<sub>2</sub> as the only bi-product.

Our product **ECO-C** is also known as **green carbon nanofiber**.

Converting CO<sub>2</sub> into CNF will **positively contribute to UN's Sustainable Development Goals**.

Our environmental efforts will help our customers:

- Reduce their carbon footprint
- Market their products as carbon positive
- Apply for grants designed for environmental purposes



TECHNOLOGICAL BREAKTHROUGH

# DIEGEL 2.0 IS NOW IN OPERATION



**8x**

**HIGHER PRODUCTION  
CAPACITY THAN ITS  
PREDECESSOR**

We are pleased to announce that our first “Diegel 2.0” is now in operation at our test center at Flesland, Bergen.

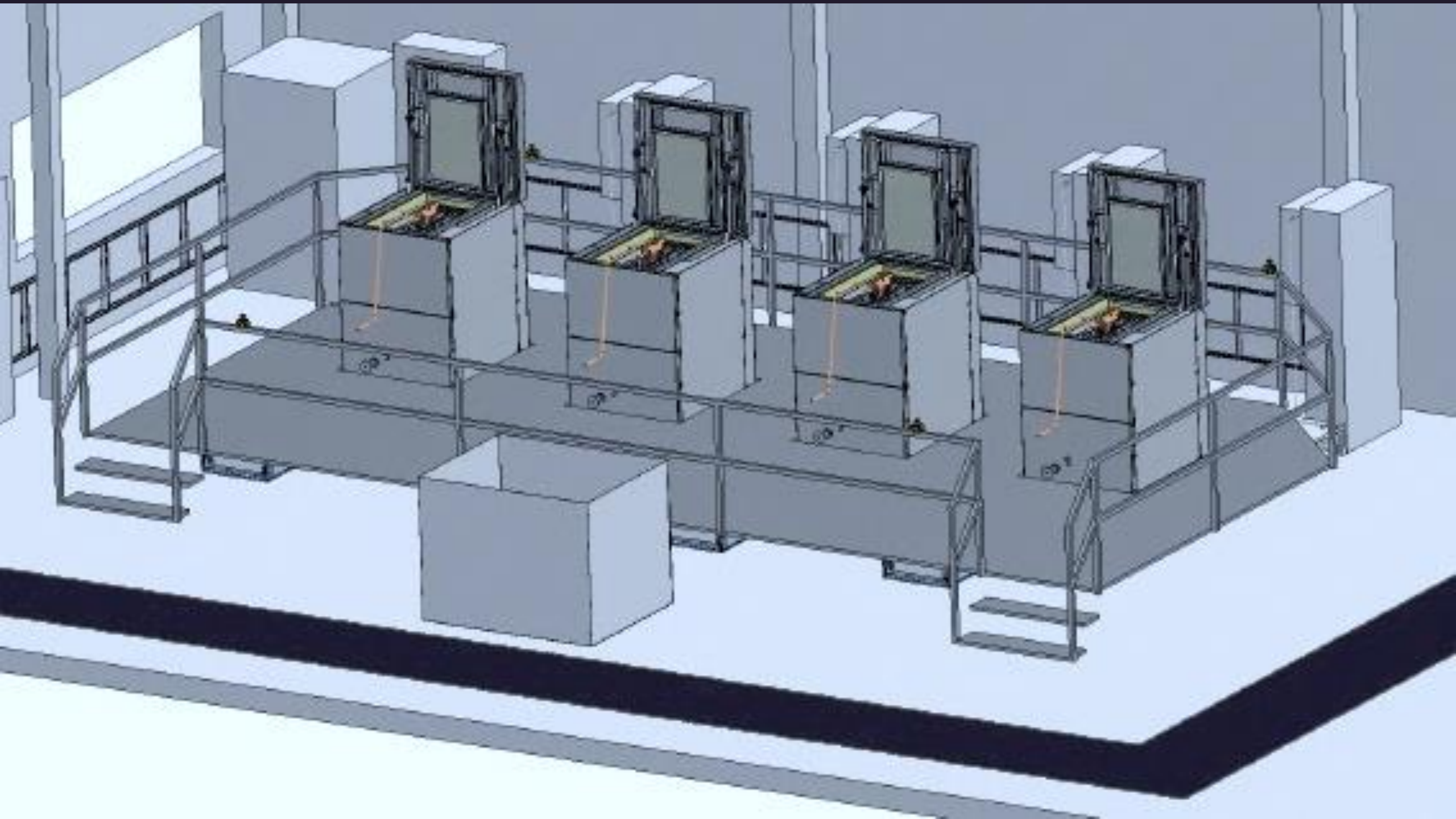
This represents an important milestone for the development of the company, as it proves that our technology is scalable.

Diegel 2.0 was initially made to be installed in a 2 x 40-foot container set-up, with an annual carbon nanofibers (CNF) potential of approx. 6.5 tonnes from 8 x “Diegel 2.0”.

With new full-scale production units, annual CNF potential is expected to rise significantly.

TECHNOLOGICAL BREAKTHROUGH

# TEST CENTER FLESLAND



By the end of Q1 2022, our test center in Bergen will have 4 x Diegel 2.0 in production as earlier guided.

This provides us with an annual production capacity of 3.25 tonnes at our test center.

We are in active discussions with Eviny Enotec, with the ambition of getting access to more electricity for us to run more production in our test center.

FROM CONTAINER TO CELL-DESIGN

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# ROLLING OUT FULL-SCALE FACTORY PRODUCTION UNITS

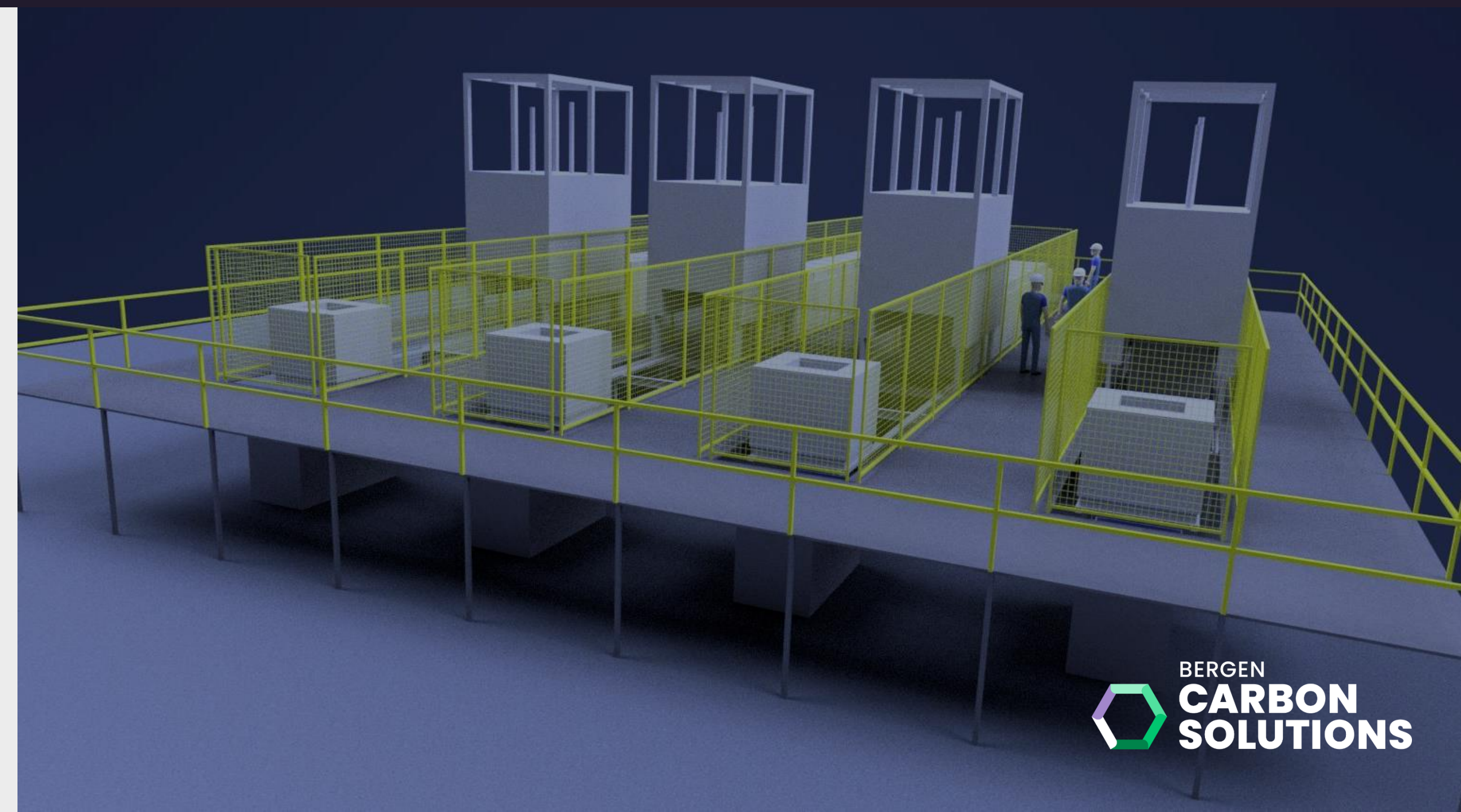
Bergen Carbon Solutions' initial plan was a container solution, with an annual CNF potential of approximately 6.5 tonnes per container module.

During the engineering process of the production modules, we discovered significant cost-reduction potential by switching to factory scale production units.

On *December 18<sup>th</sup>, 2021*, we successfully completed the first run of our “Diegel 2.0”, where the technology proved to be viable. As a result, production units can either be installed in *factory-scale production units* or *containerized modules* for external production sites.

With the flexible plan, and focus on full-scale factory production sites, it is expected to further strengthen our competitive advantage going forward.

We are excited to announce more information about the new design as soon as the pre-engineering phase of our new factory design is finished in Q1 2022.



## FULL-SCALE FACTORY

# WE HAVE A GREAT OPPORTUNITY TO REVIVE FORMER INDUSTRIAL SITES ALL ACROSS NORWAY

With full-scale production units, new factories will need employees with the right competence and reliable energy supply. Norway provides many locations consistent with these needs, which gives an unique opportunity to boost employment and use renewable energy sources all over Norway.

We have so far identified two locations for full-scale factory production sites; Mosjøen and Høyanger.

Both production sites have long traditions of industry, and possess both sufficient hydropower resources, skilled labour and industry knowledge.



**SKILLED  
LABOUR**



**SUFFICIENT  
HYDROPOWER**



**INDUSTRY  
KNOWLEDGE**



**ELECTRIC  
INDUSTRY**

## FULL-SCALE FACTORY

# OUR FIRST FACTORY: MOSJØEN

Mosjøen is centrally located on the Helgeland coast in Nordland County Municipality.

The area is widely known for its magnificent nature, but also its access to extraordinary amounts of renewable Norwegian hydropower.

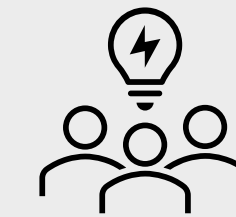
Access to skilled industrial labour, sufficient energy and the proximity to CNF Arena project makes Mosjøen a perfect first location for us.

Subject to engineering work, we aim for construction start at the end of Q2 2022 with ramp-up of the production capacity occurring through 2023.

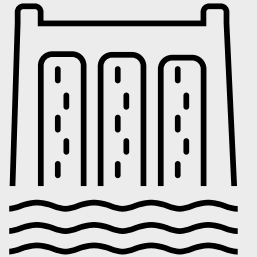
Expect to reach full capacity of 160 tonnes per annum by year-end 2023.



**SKILLED  
LABOUR**



**PROXIMITY TO  
CNF ARENA**



**SUFFICIENT  
HYDROPOWER**

**ANNUAL PRODUCTION CAPACITY: 160 tonnes\***

\*Preliminary numbers. Production expected to start in 1H 2023.



## FULL-SCALE FACTORY

# OUR SECOND FACTORY: HØYANGER

Høyanger is located in Vestland County, approximately 3 hours from Bergen. Høyanger is a modern industrial society that has grown in step with Hydro Aluminium.

The municipality has traditionally been very dependent on Hydro, but industrial diversity has developed over time. A modern infrastructure has been arranged, where all relevant service functions are available.

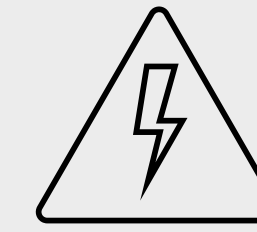
Access to skilled industrial labour, sufficient licensing hydropower and access to an attractive long-term power supply agreement makes Høyanger the optimal place for our second factory.

Since the facilities are already in place we expect the production of CNF from this factory to occur in late 2023 or early 2024 .

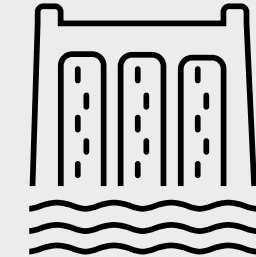
Ramp-up to occur through 2024 and we expect to reach full capacity of 240 tonnes per annum by year-end 2024.



**SKILLED  
LABOUR**



**ELECTRIC  
INDUSTRY**



**SUFFICIENT  
HYDROPOWER**

**ANNUAL PRODUCTION CAPACITY: 240 tonnes\***

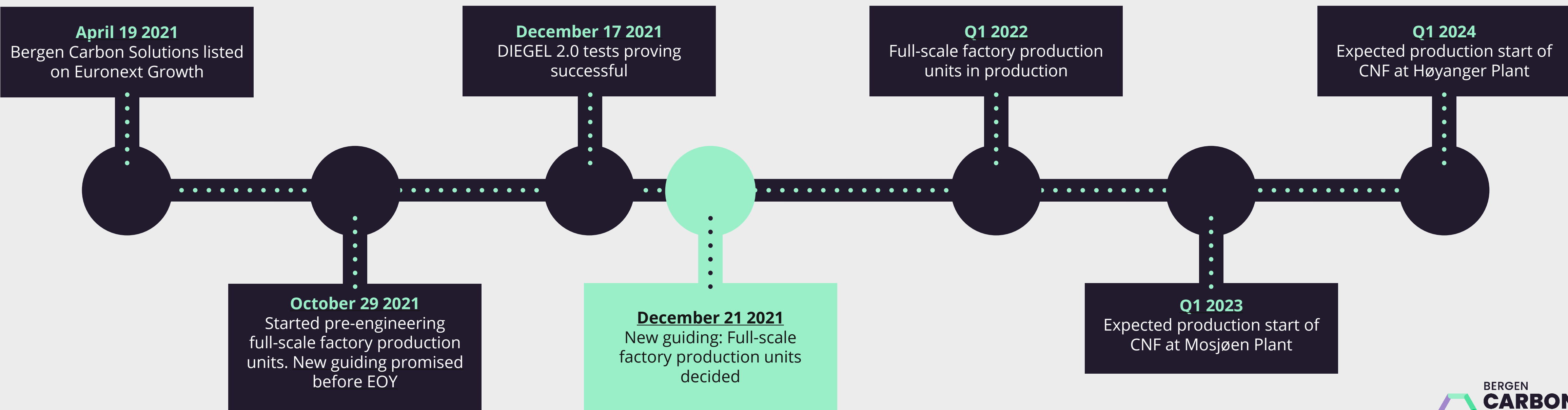
\*Preliminary numbers. Production expected to start in 1H 2024.



## FULL-SCALE FACTORY

# TIMELINE OF FACTORY PRODUCTION UNITS

On October 29, we promised a new guiding on full-scale factory production units before end of year (EOY). During pre-engineering and the completion of Diegel 2.0, Bergen Carbon Solutions have decided to move forward with the new production units. We expect the first factory to be in operation in 2023.



OUR LIMITLESS VISION

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# ***We aim to turn the world's biggest problem into our industrial asset***



Our goal is to be the largest climate positive producer of carbon nanofibers (CNFs), utilizing CO<sub>2</sub> sourced directly from industrial flue gas, releasing in the atmosphere O<sub>2</sub> instead of CO<sub>2</sub>.

Making carbon nanofibers from CO<sub>2</sub> will be used both to increase materials properties, and to reduce consumption of highly polluting applications.

# Reduction in CO<sub>2</sub> emissions from using carbon nanofiber additives

Presentation of NORCE's report

27 JANUARY, 2022

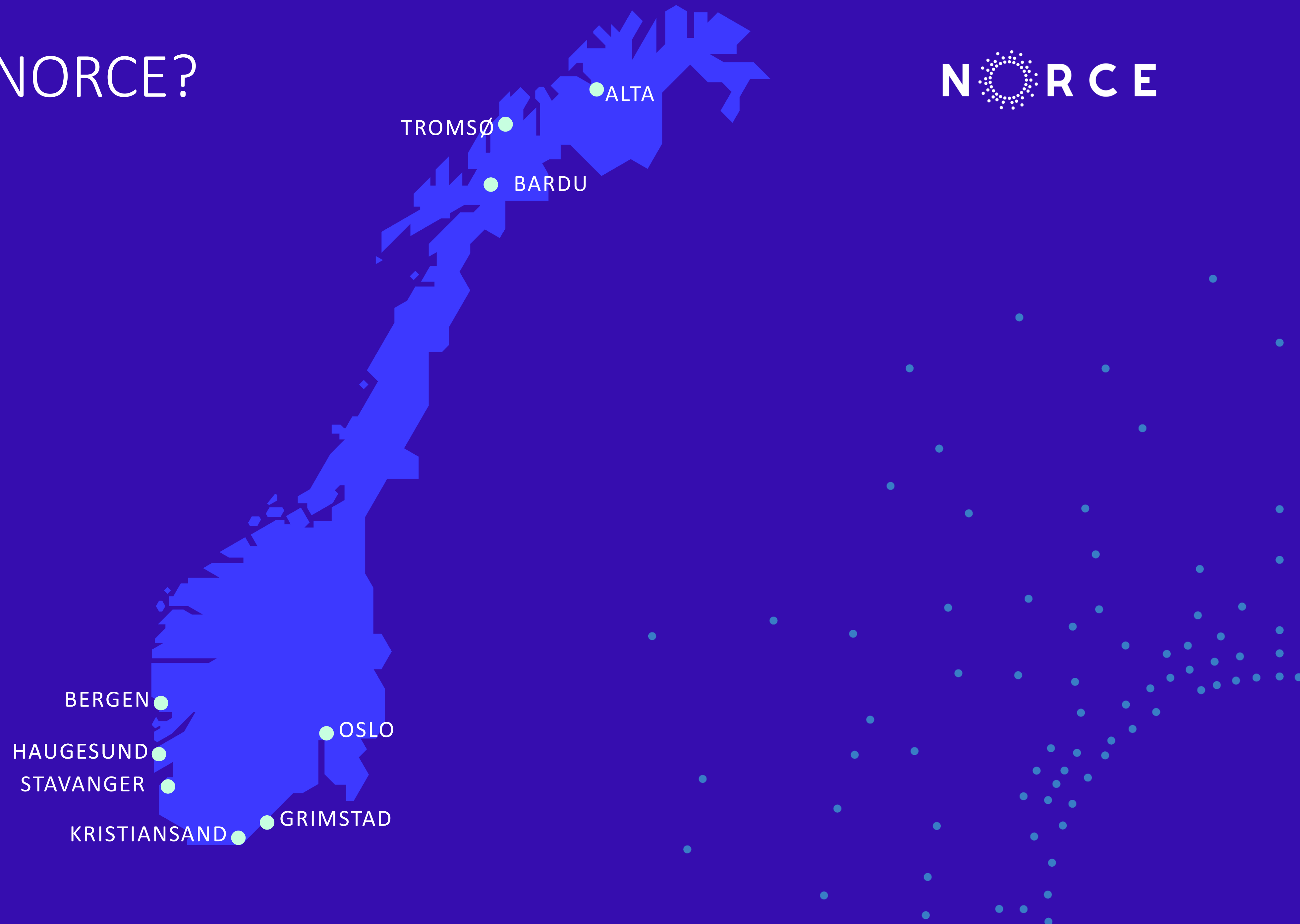
# What does NORCE do?



## 4 Strategic focus areas



# Where is NORCE?



# Who are NORCE?



## Key figures



**750**

EMPLOYEES



**950**

MILLION TURNOVER



**50**

NATIONALITIES



**75%**

DOCTORAL DEGREES



**2000**

PROJECTS



**750**

CUSTOMERS

What was our task?



Estimate possible reduction in CO<sub>2</sub> emissions from CNF addition

# What was our task?



## Estimate possible reduction in CO<sub>2</sub> emissions from CNF addition

- Not part of the estimate:
  - Price
  - Time
  - Market
  - Production

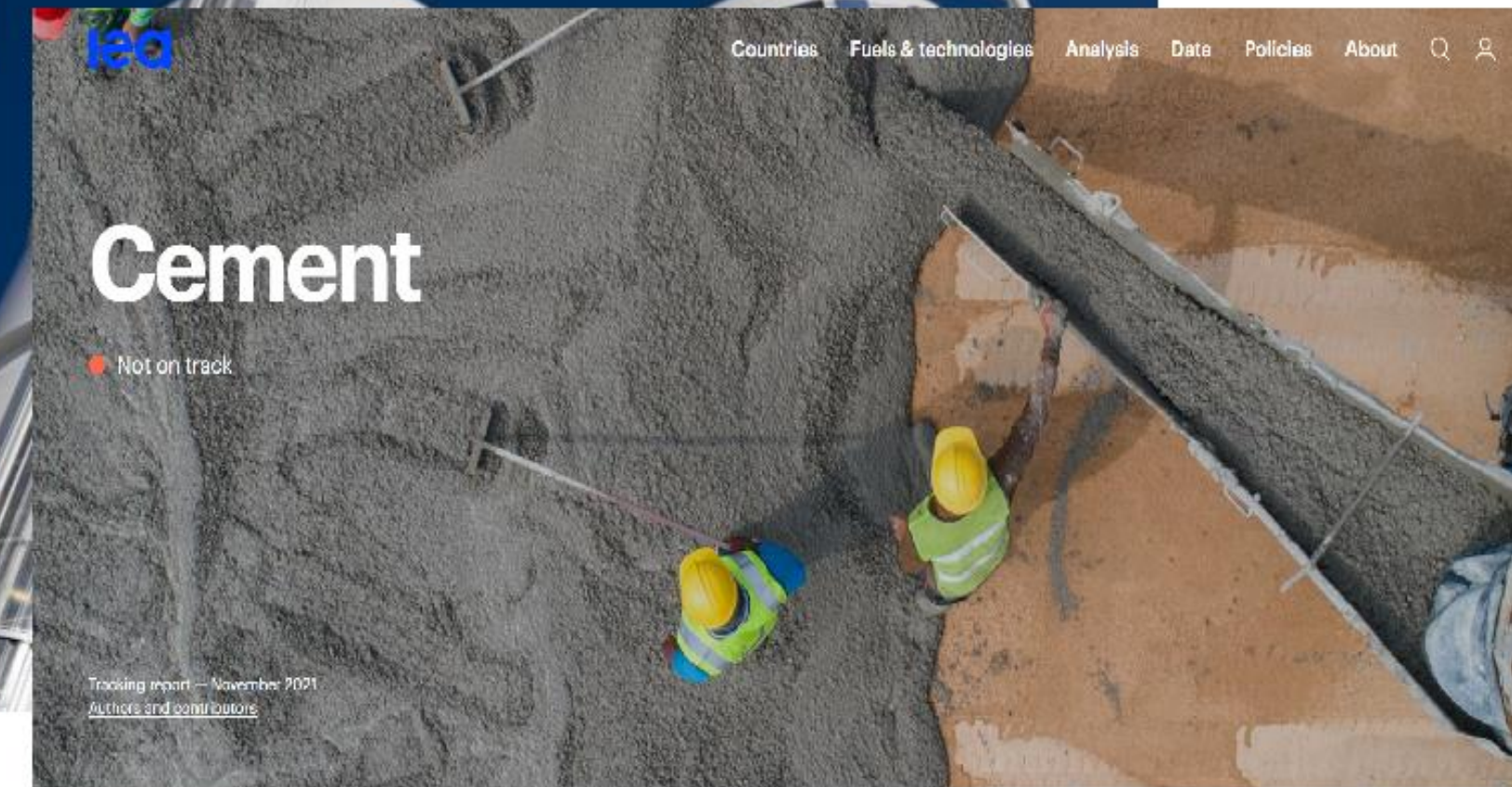
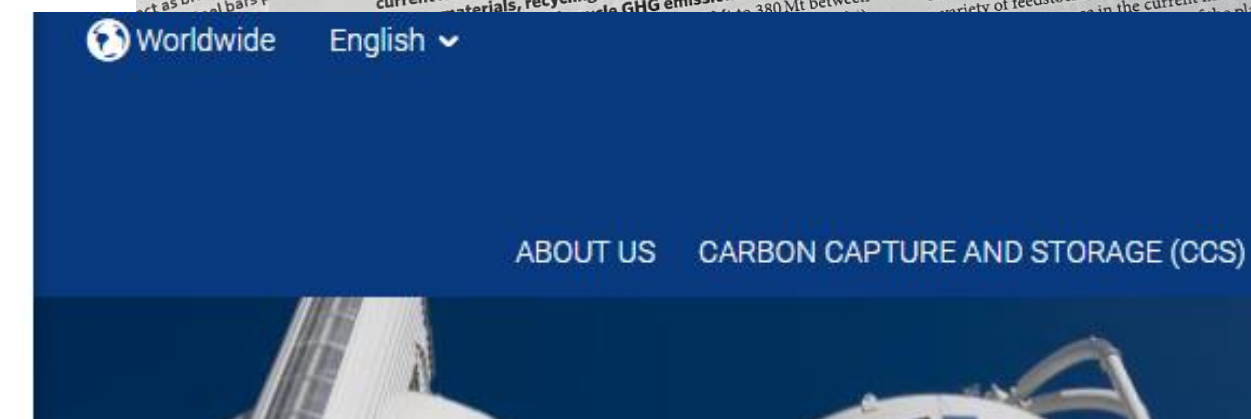
# What have we done?

- Read literature
- Talked to other researchers



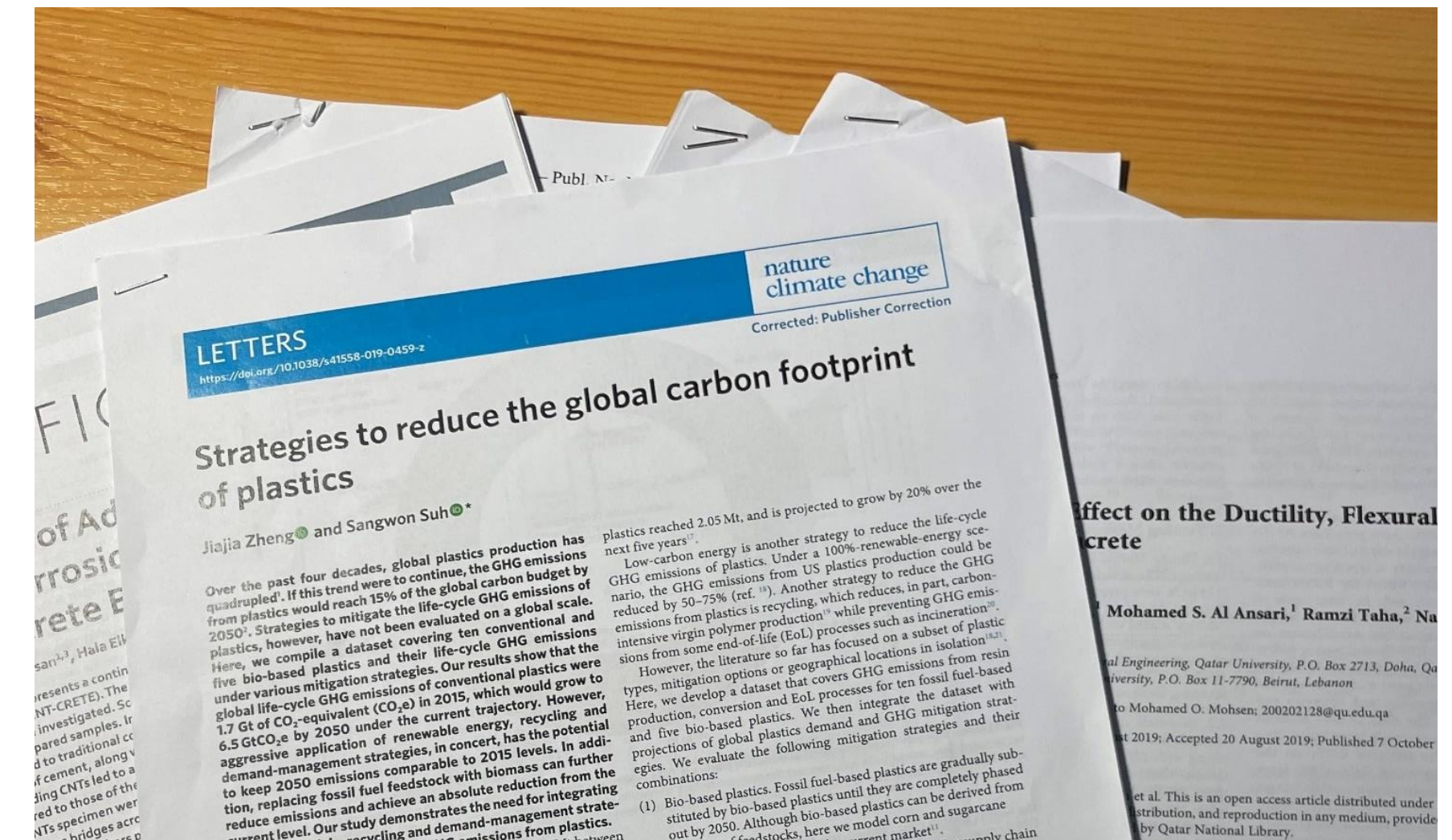
# What have we done?

- Read literature
- Talked to other researchers
- Read web sites of
  - Producers
  - International organizations
- Used prior knowledge



In this report

The direct CO<sub>2</sub> intensity of cement production increased 1.8% per year during 2015-2020. In contrast, 3% annual declines to 2030 are necessary to get on track with the Net Zero Emissions by 2050 Scenario. Emissions have to be reduced by 30% by 2030.



# What have we found?

- CNF can improve material properties
- CNF can thereby reduce CO<sub>2</sub> emissions
- Further work is needed

# Details



- Batteries



# Details



- Batteries
- Plastics



# Details



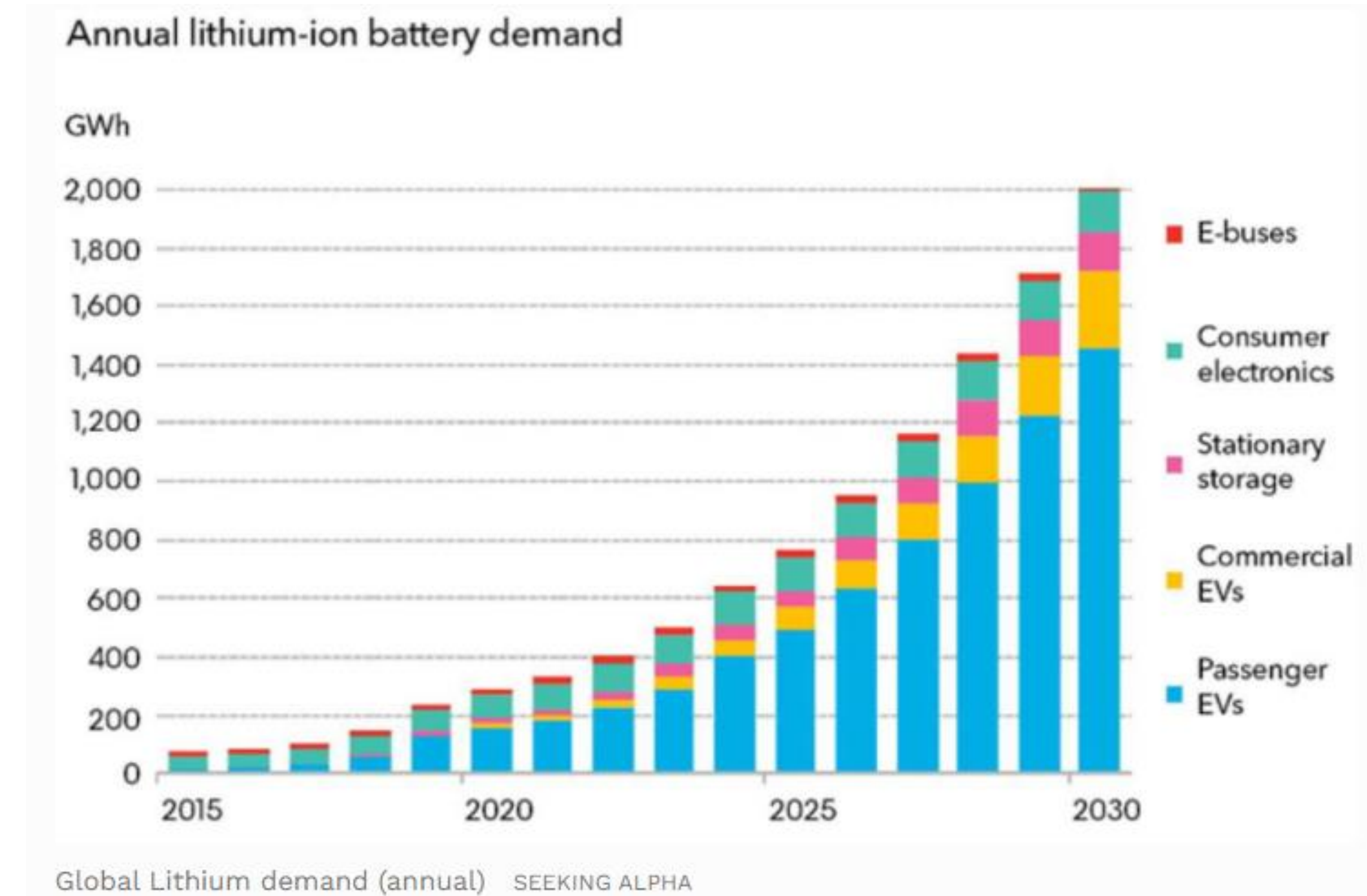
- Batteries
- Plastics
- Cement and concrete





# Batteries – production

- CO<sub>2</sub> emission: < 0.1 % of world total
- Rapidly growing



# Batteries – properties



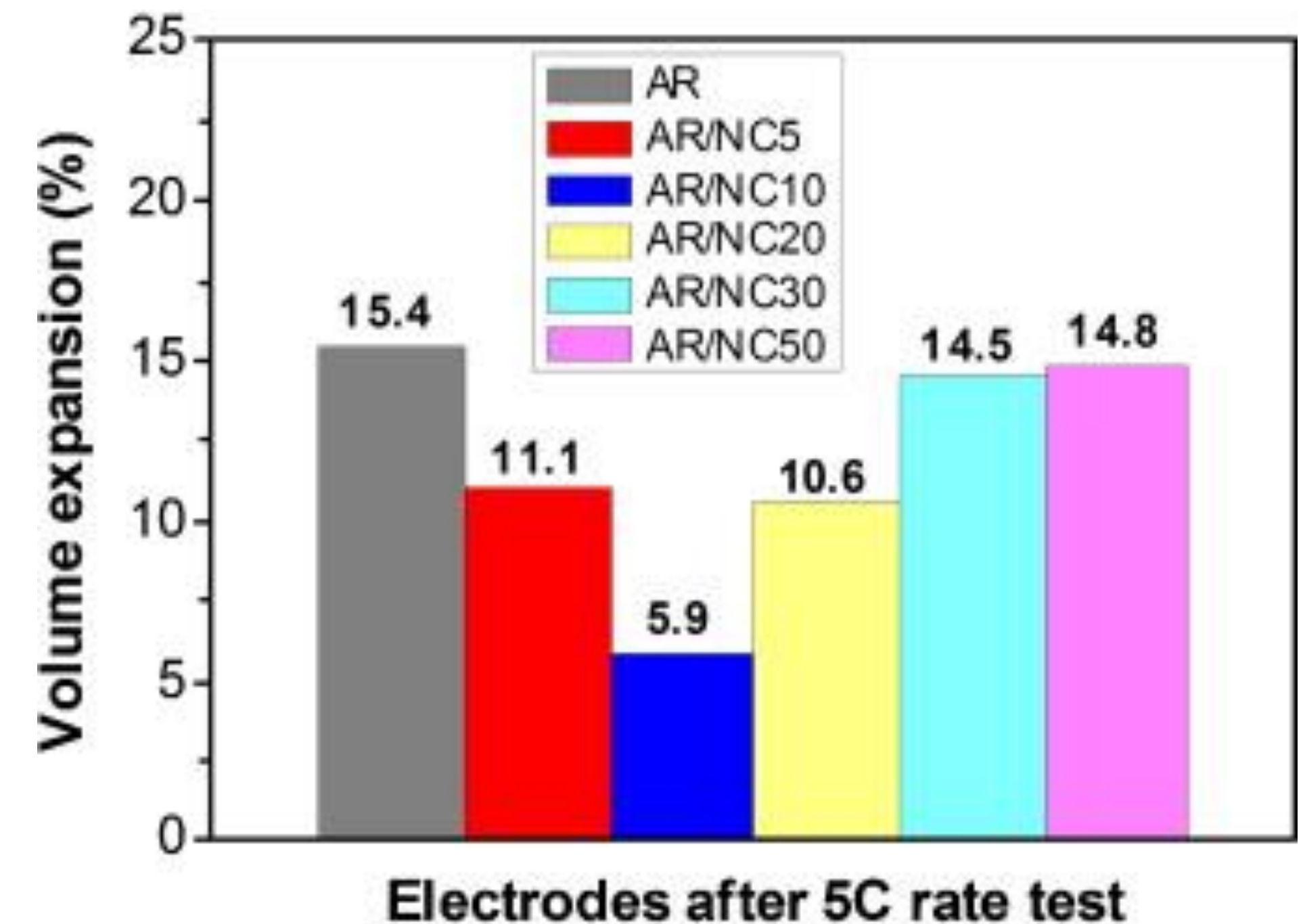
- Energy storage
- Fast charging and discharging
- Energy efficiency
- Many cycles

# Batteries – findings

- CNF can make anodes
  - lighter
  - longer-lasting
  - use silicon in addition to carbon as basis

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Park, Tae-Hwan, Jae-Seong Yeo, Min-Hyun Seo, Jin Miyawaki, Isao Mochida, and Seong-Ho Yoon. "Enhancing the Rate Performance of Graphite Anodes through Addition of Natural Graphite/Carbon Nanofibers in Lithium-Ion Batteries." *Electrochimica Acta* 93 (March 30, 2013): 236–40.  
<https://doi.org/10.1016/j.electacta.2012.12.124>.

# Batteries – uncertainties

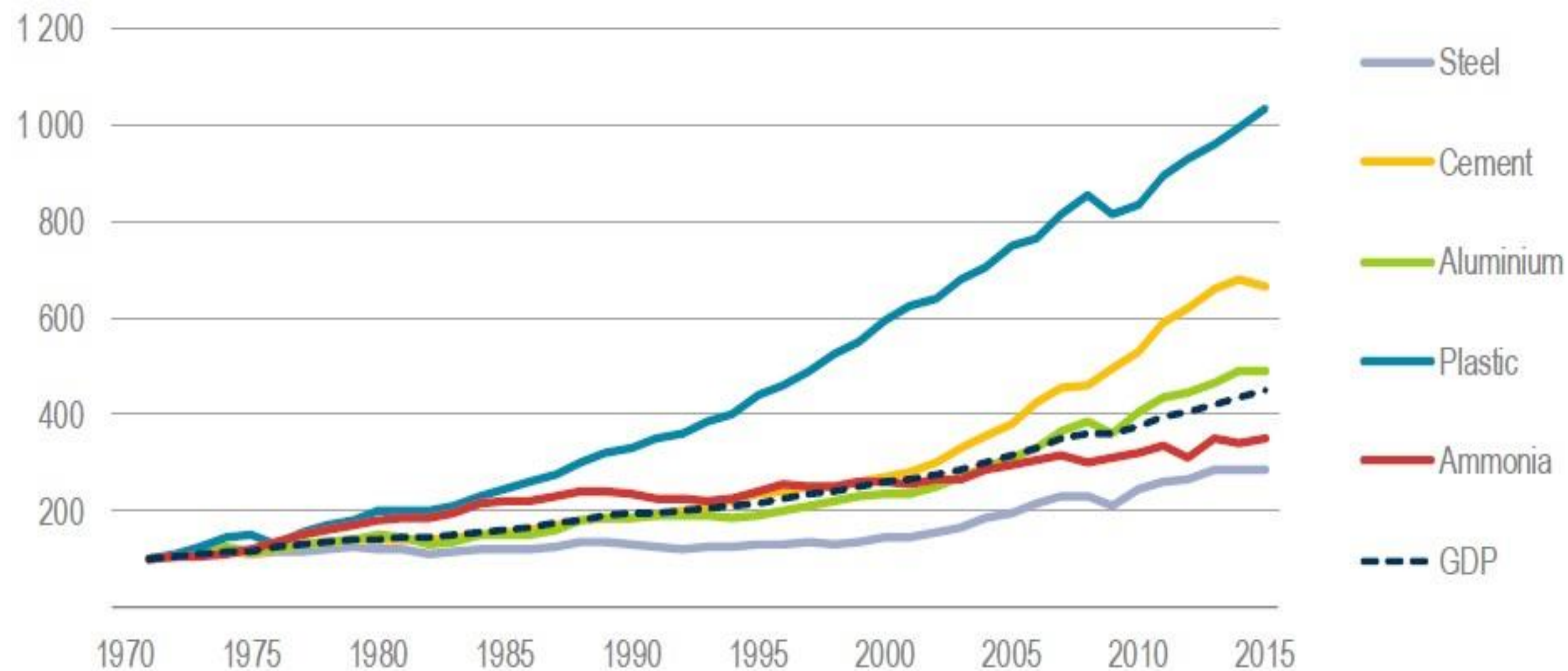
- Lab testing only
- Industry values close to theory
- Secret industry values





# Plastics – production

- Lifecycle GHG emissions: 4 % of world total (2015)
- 8 % annual growth rate 1950 - 2015



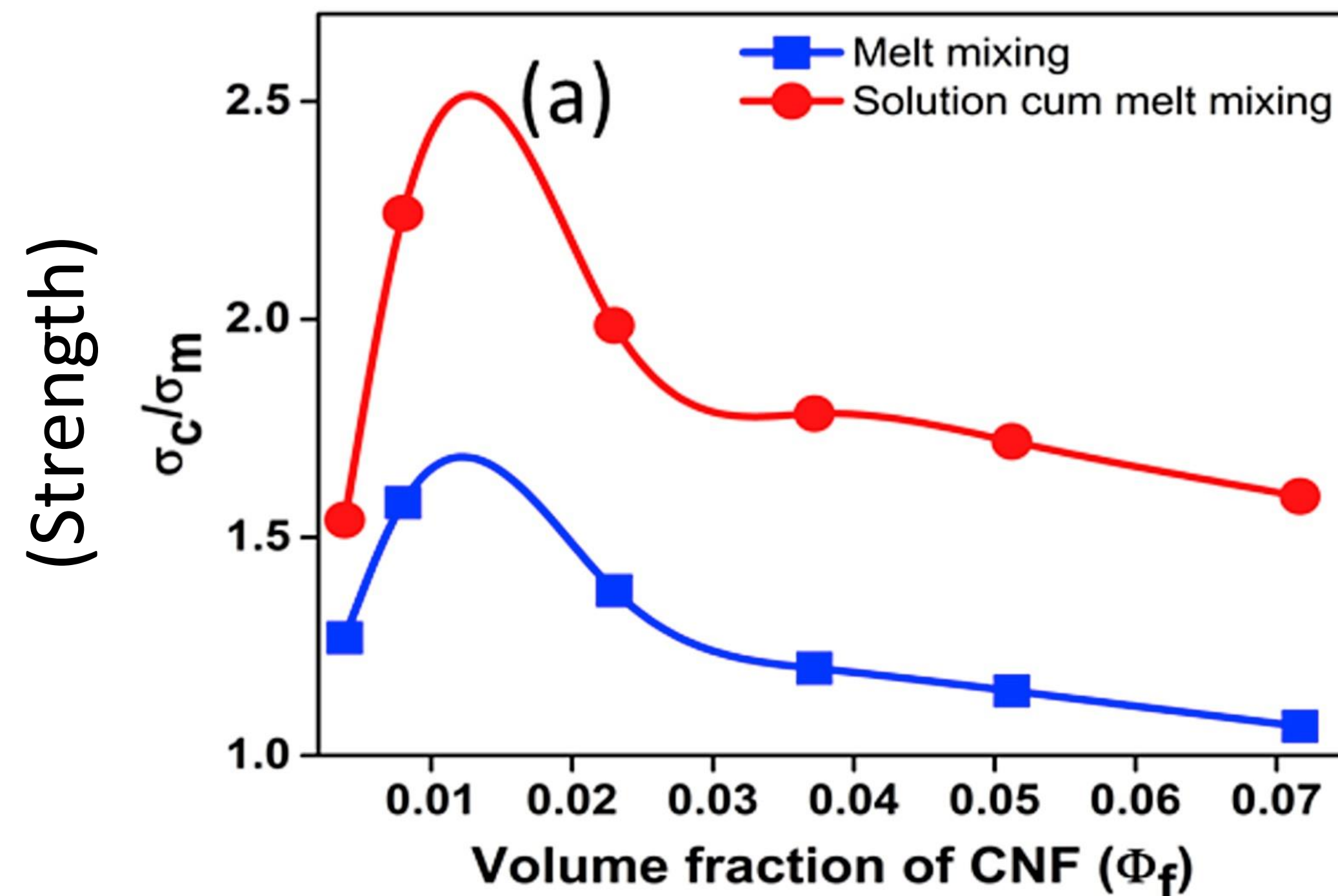
# Plastics - findings



- CNFs can improve plastic (PP and PE) properties:
  - Strength and stiffness
  - Thermal
  - Electrical

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  - Electrical



Mondal, Subhadip, Lalatendu Nayak, Mostafizur Rahaman, Ali Aldalbahi, Tapan K. Chaki, Dipak Khastgir, and Narayan Ch Das. "An Effective Strategy to Enhance Mechanical, Electrical, and Electromagnetic Shielding Effectiveness of Chlorinated Polyethylene-Carbon Nanofiber Nanocomposites." *Composites Part B: Engineering* 109 (January 15, 2017): 155–69.  
<https://doi.org/10.1016/j.compositesb.2016.10.049>.

# Plastics – uncertainties

- Mostly lab testing
- Mixing process
- New properties -> new products





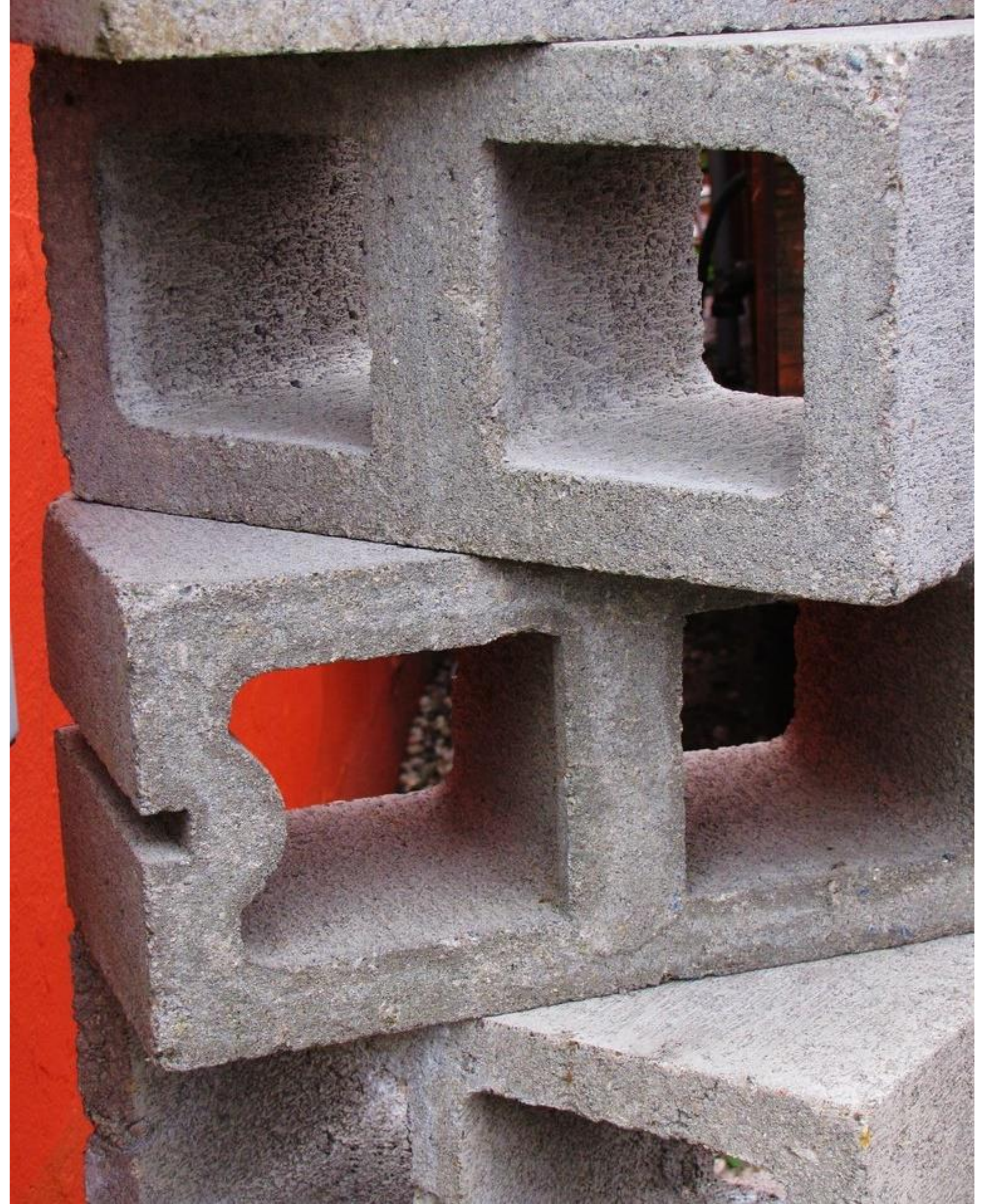
# Cement and concrete – production



- CO<sub>2</sub> emission: 7 % of world total
- 55 % of all cement is made in China
- In Norway: Kjøpsvik and Brevik

# Cement and Concrete – properties

- Strength
  - Pressure
  - Bending
- Corrosion

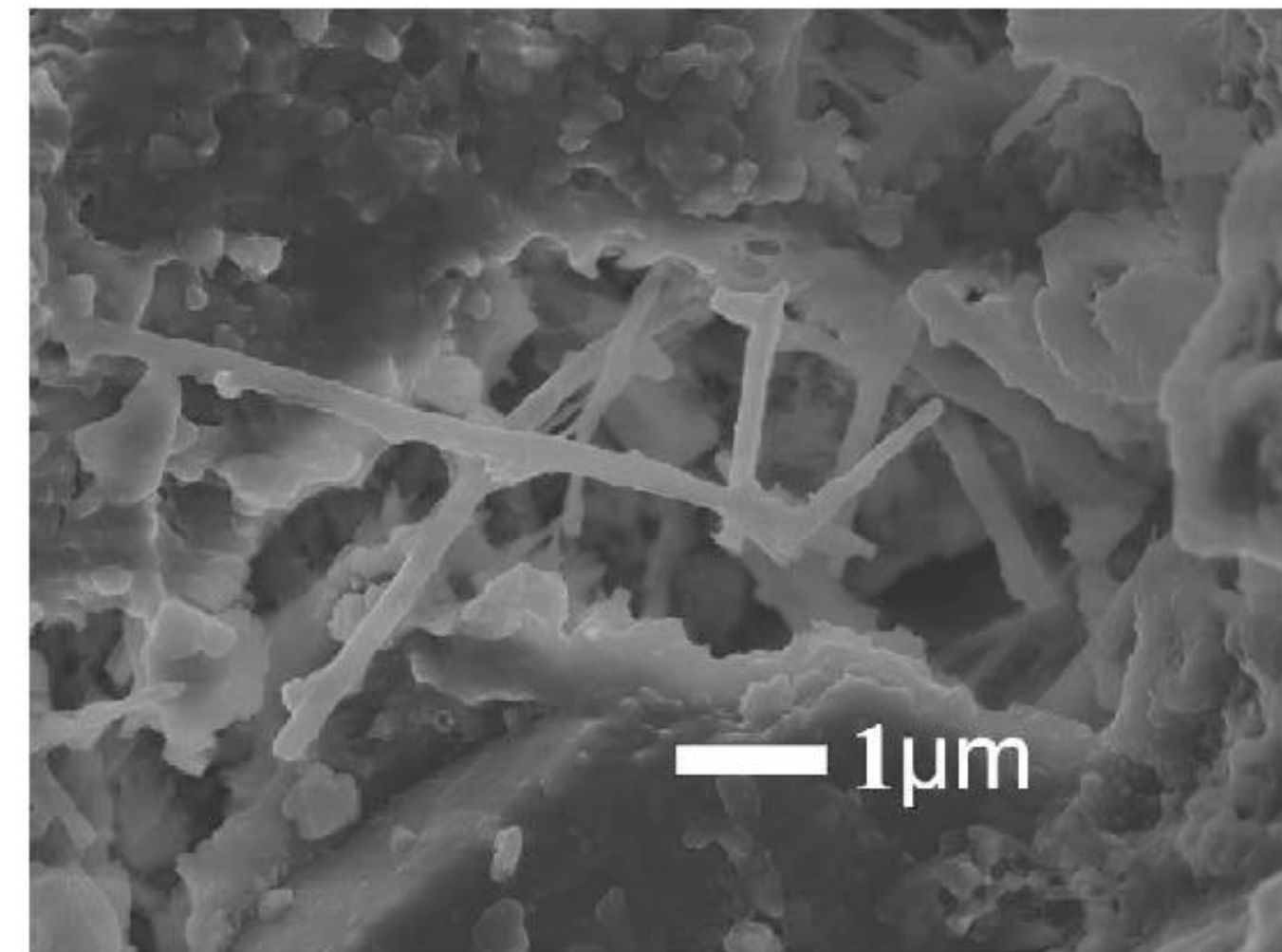


# Cement and concrete – findings

- CNF can make concrete
  - stronger
  - self-sensing
  - less open to water
  - stiffer
  - more fire-proof

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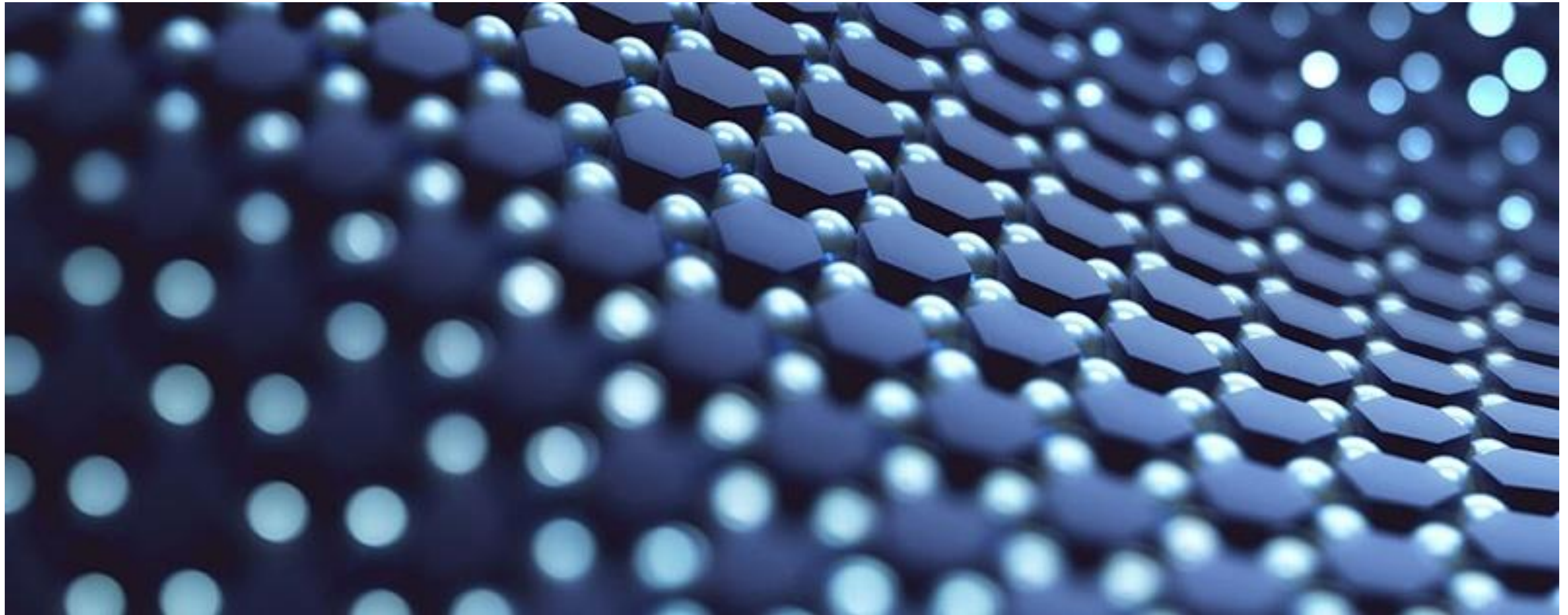


Tyson, Bryan M., Rashid K. Abu Al-Rub, Ardavan Yazdanbakhsh, and Zachary Grasley. "Carbon Nanotubes and Carbon Nanofibers for Enhancing the Mechanical Properties of Nanocomposite Cementitious Materials." *Journal of Materials in Civil Engineering* 23, no. 7 (July 2011): 1028–35. [https://doi.org/10.1061/\(ASCE\)MT.1943-5533.0000266](https://doi.org/10.1061/(ASCE)MT.1943-5533.0000266).

# Cement and concrete – uncertainties

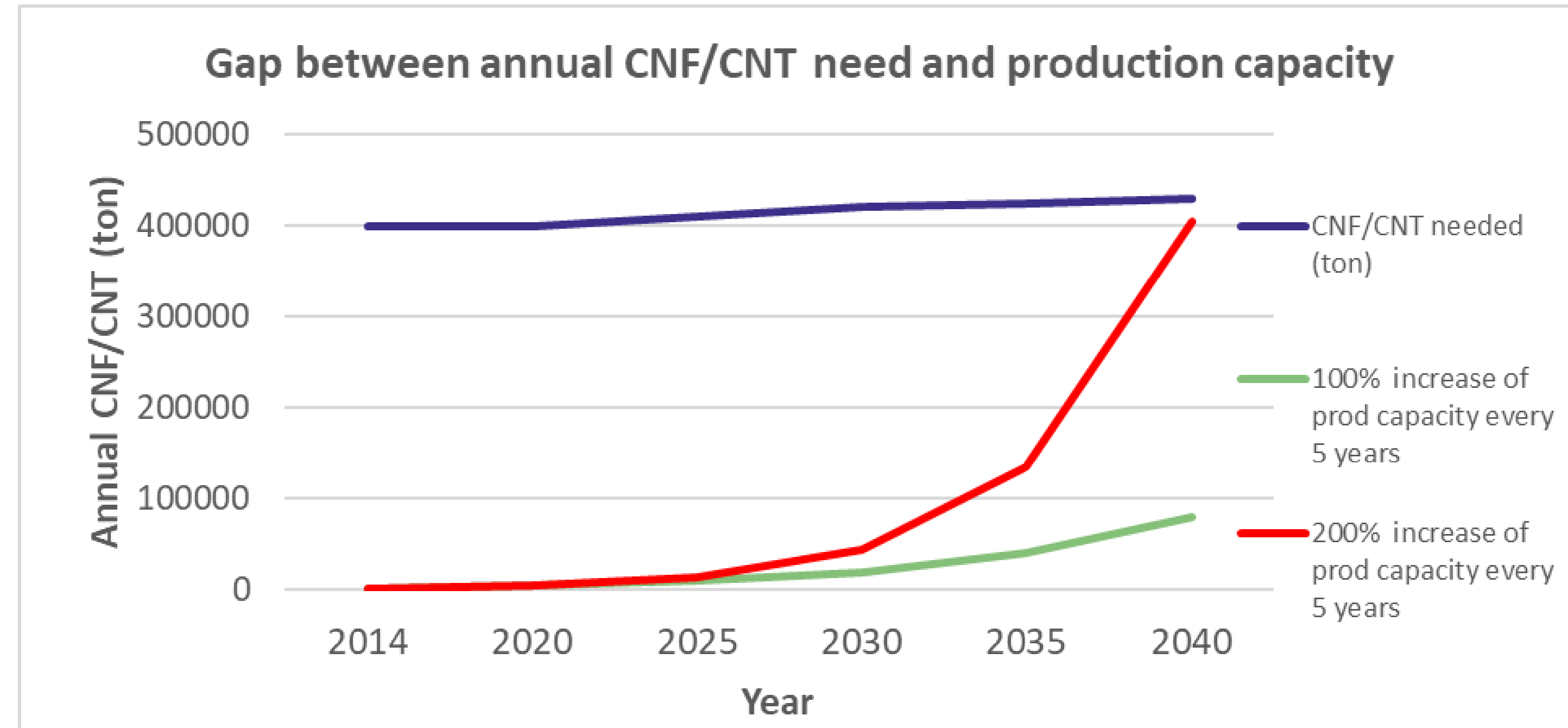
- Lab testing only
- Large spread in the results
- Mixing problems





# CNF production scale-up

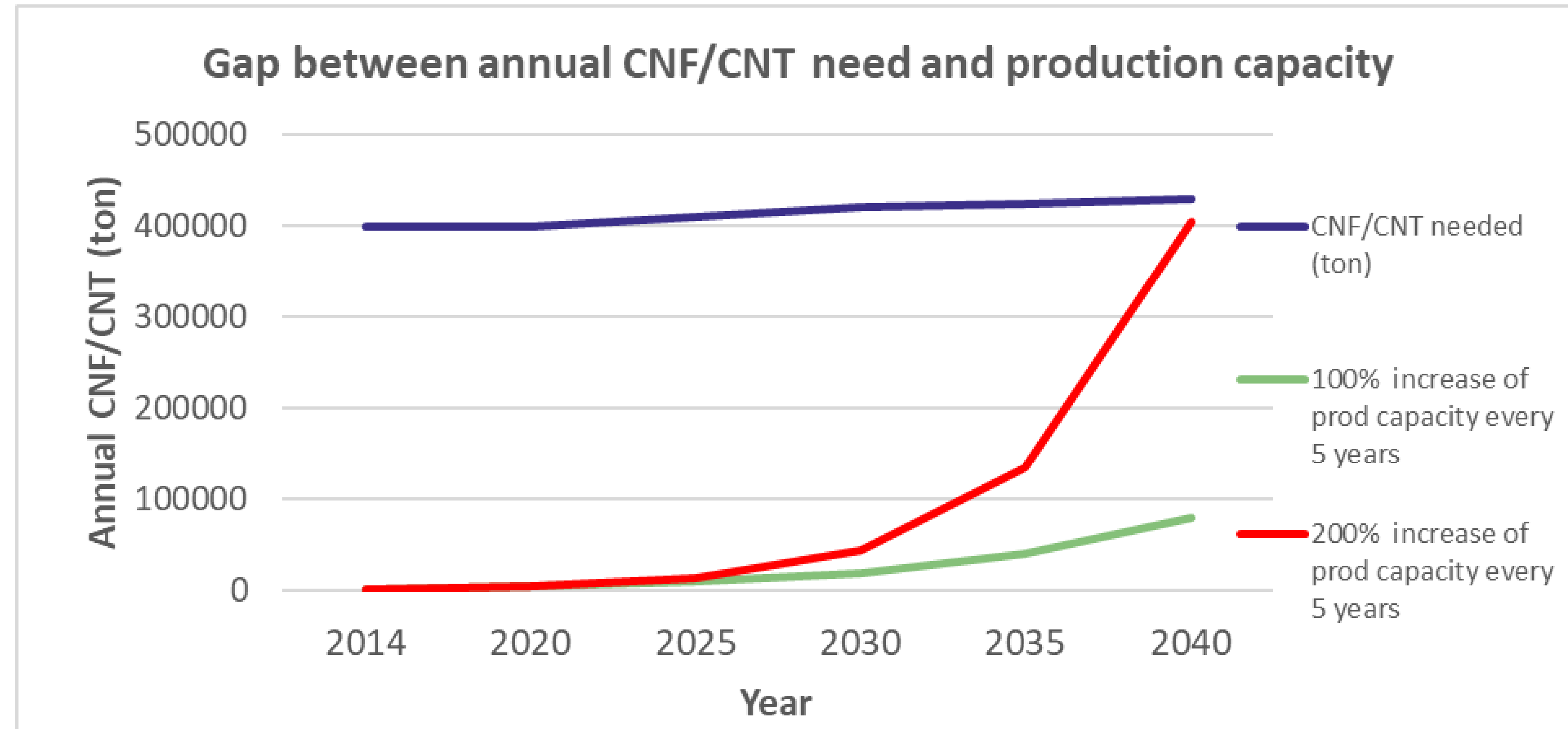
- Scale-up needed



Example if all concrete shall have 0.01 % CNF added

# CNF production scale-up

- Scale-up needed
- Norway well suited
  - Energy
  - Automation
  - Skilled workers



Example if all concrete shall have 0.01 % CNF added

# Benefits for society



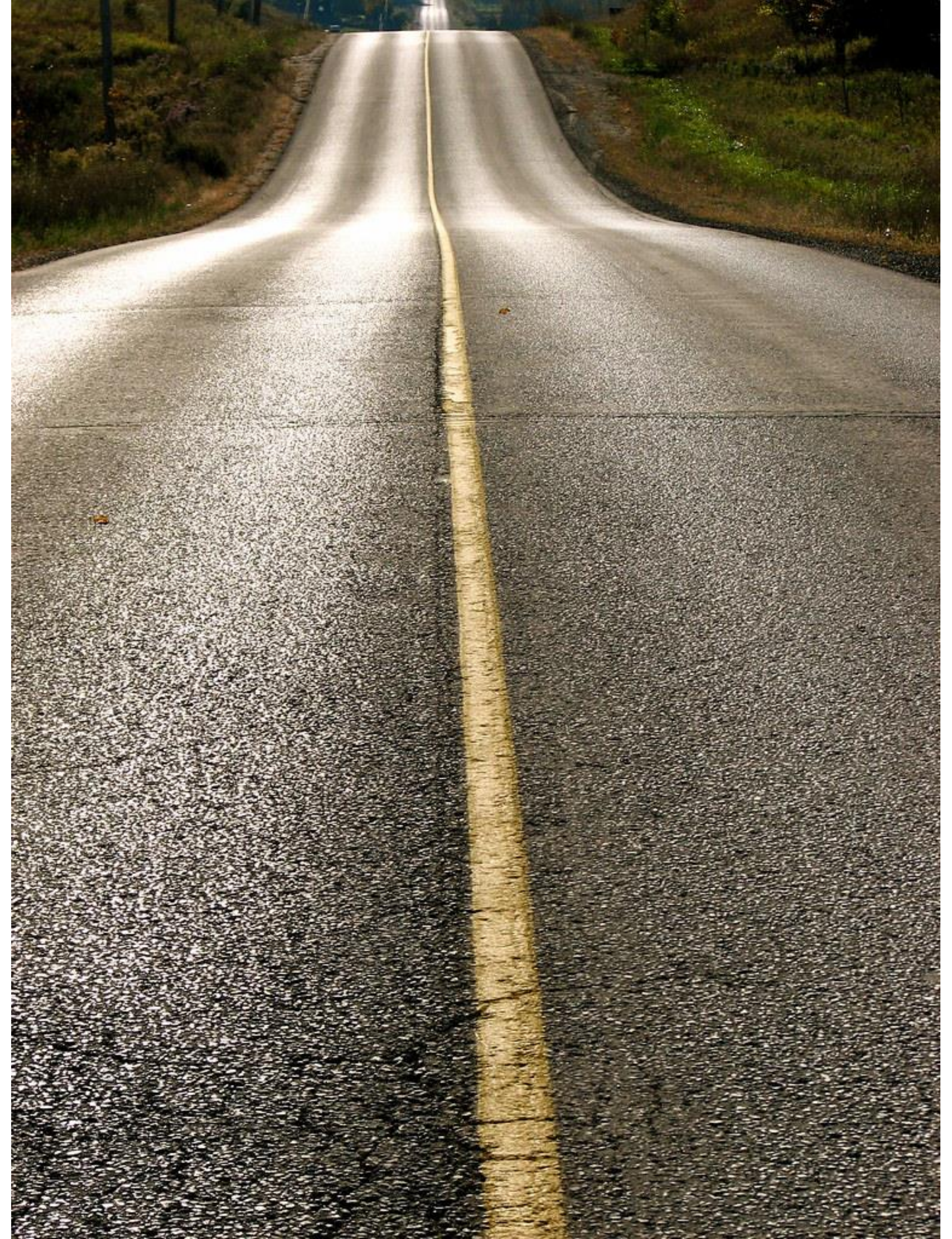
CNF producers and sub-suppliers

Greener end-user companies

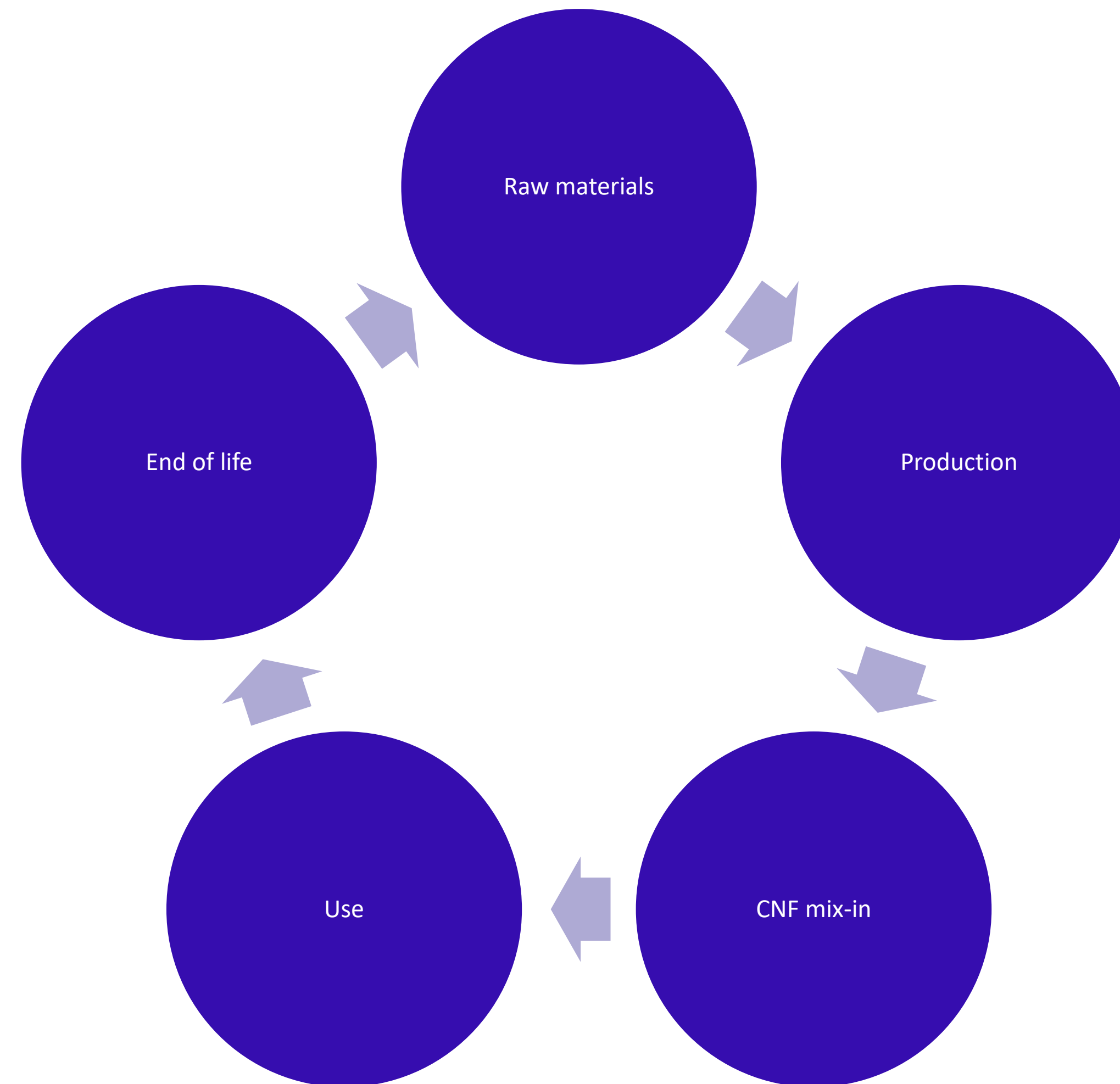
Learning for new products

# What next?

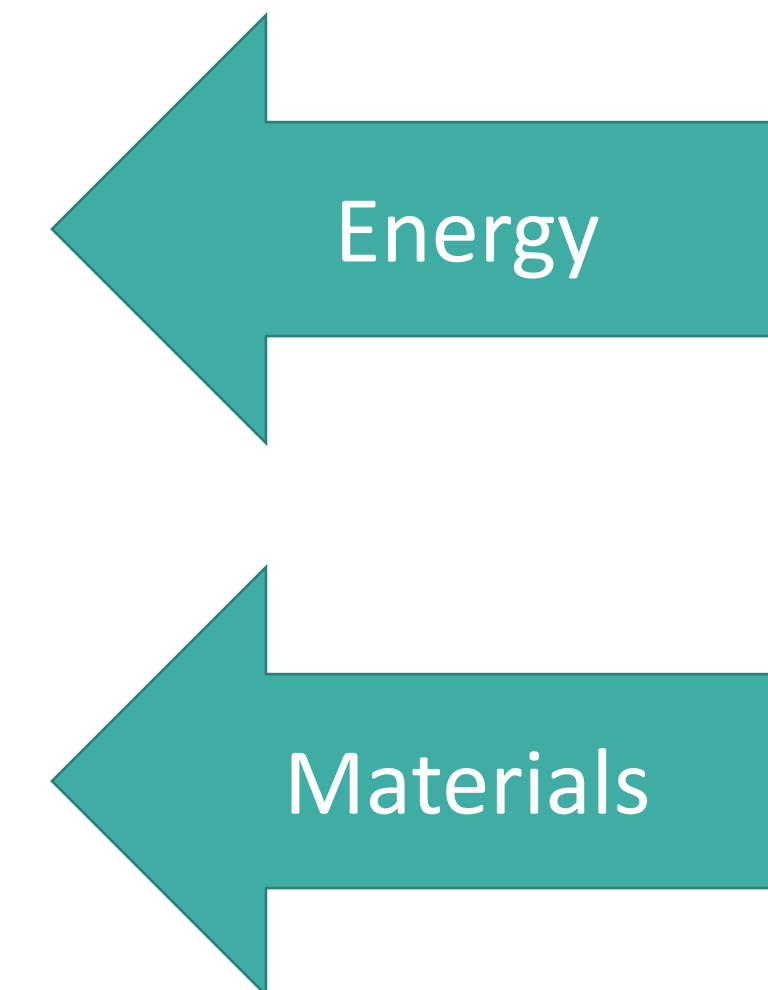
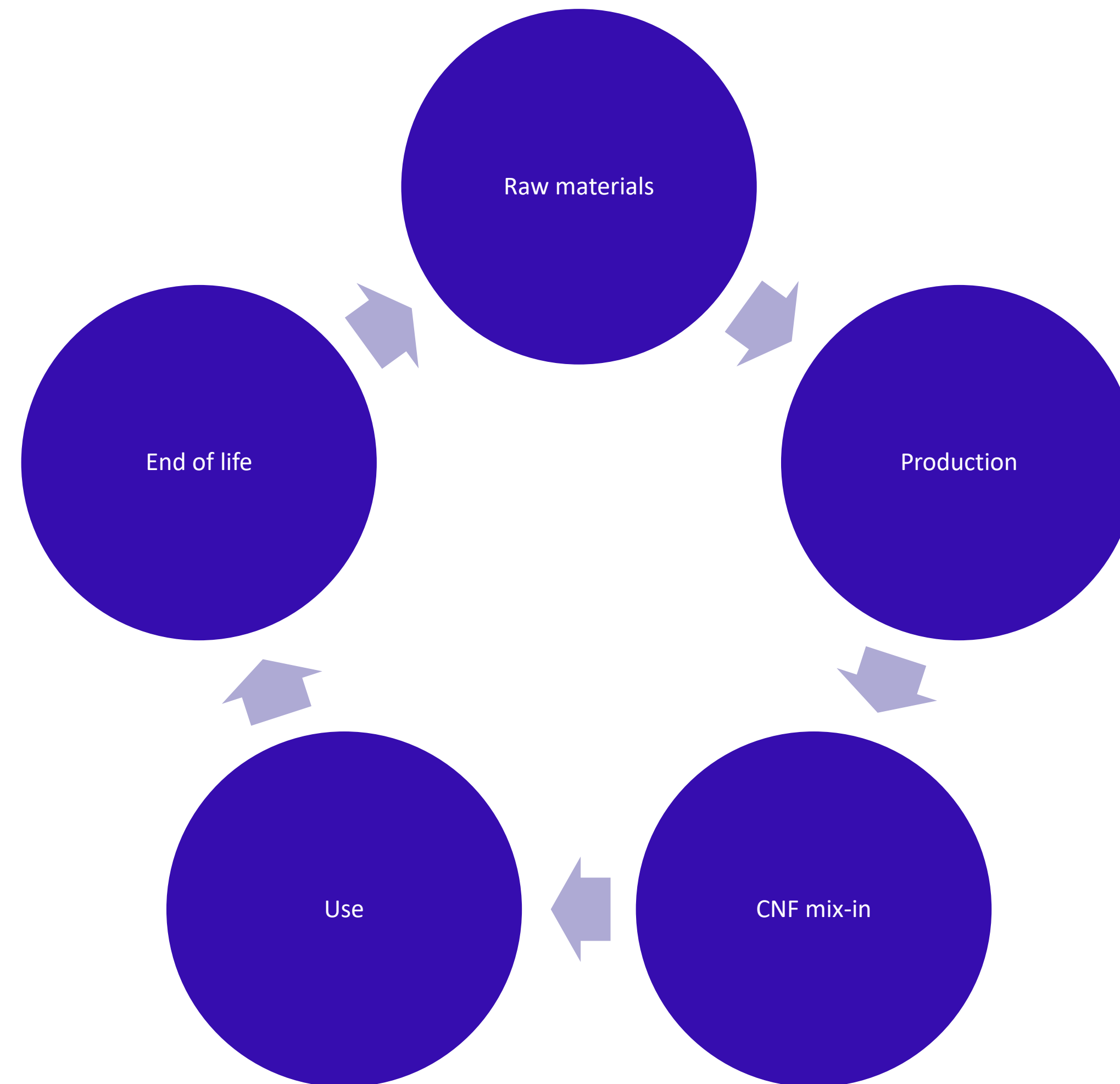
- Life cycle analysis
- Market analysis
- Pilot-scale testing



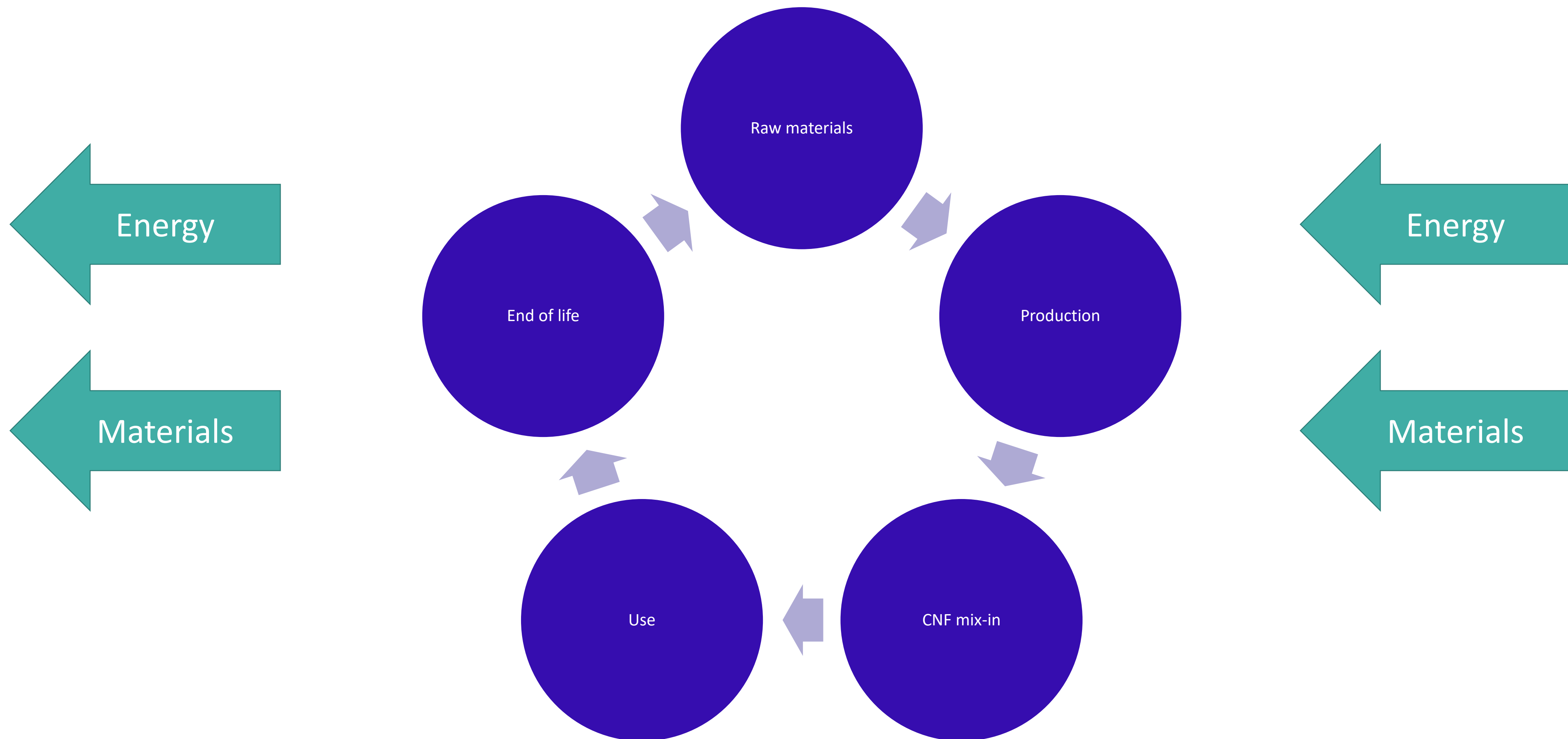
# Life cycle analysis



# Life cycle analysis



# Life cycle analysis



# Market analysis



- New products with CNF?
- CNF price?
- Cost of mixing in CNF?

# Pilot-scale testing



- Many samples
- Find and fix problems
- Compare to (secret) industry values

To conclude



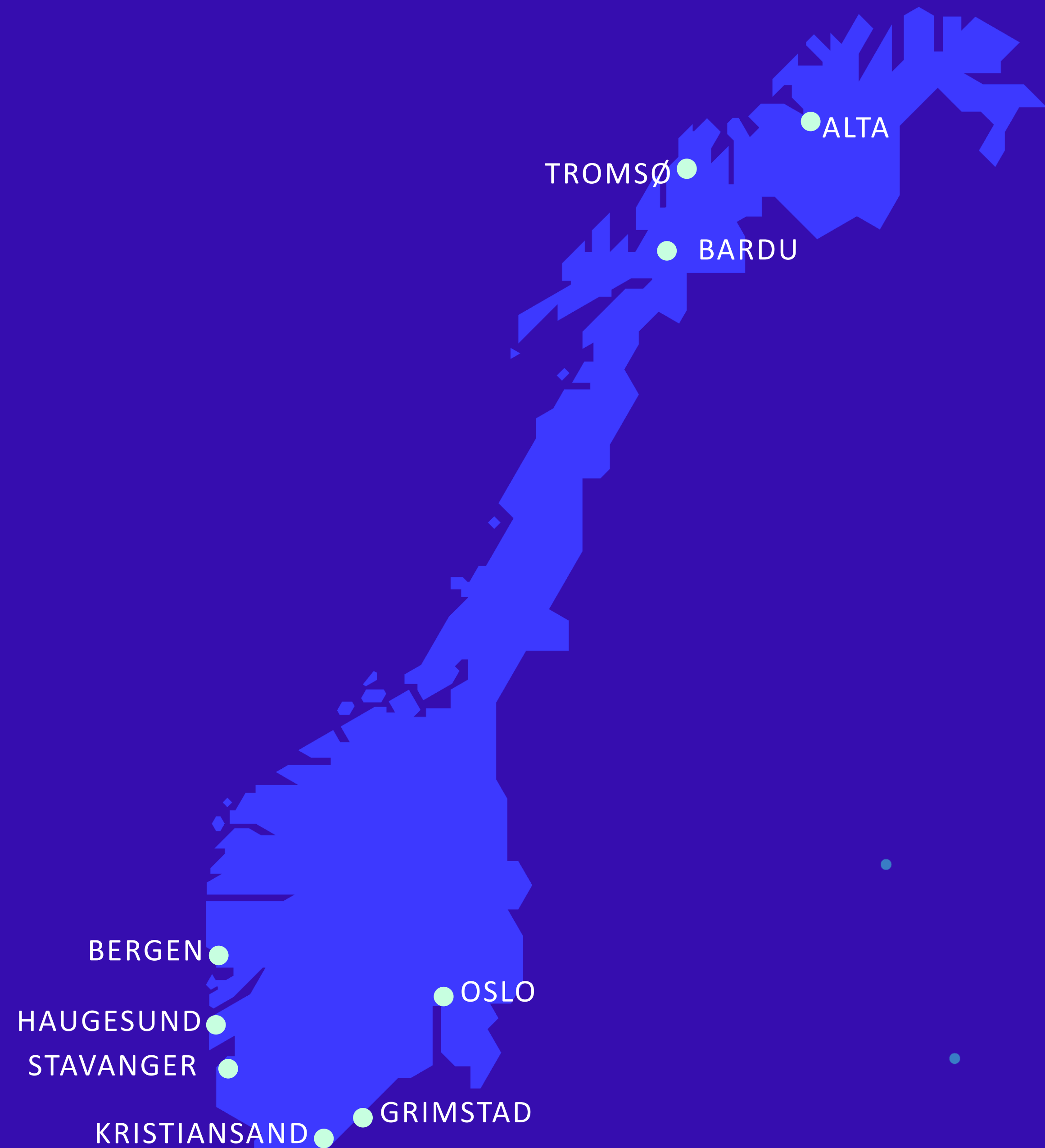
- CNF can improve material properties
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Thank you for your attention!

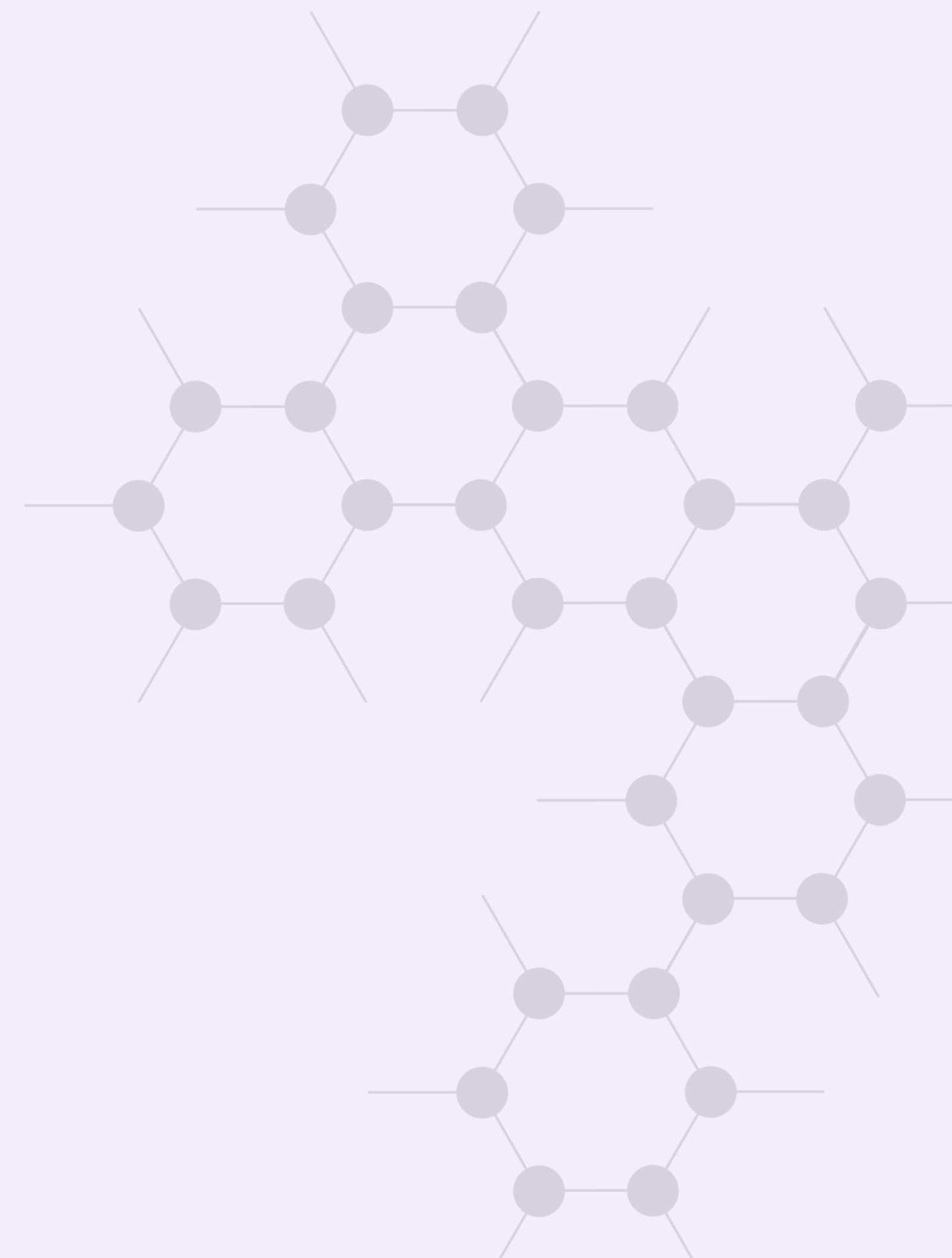
# Report reference



Alagic, Blomgren, Guo, Nordgård-Hansen and Thisted:  
“Reduction in CO<sub>2</sub> emissions from using carbon nanofiber  
additives” (2022).



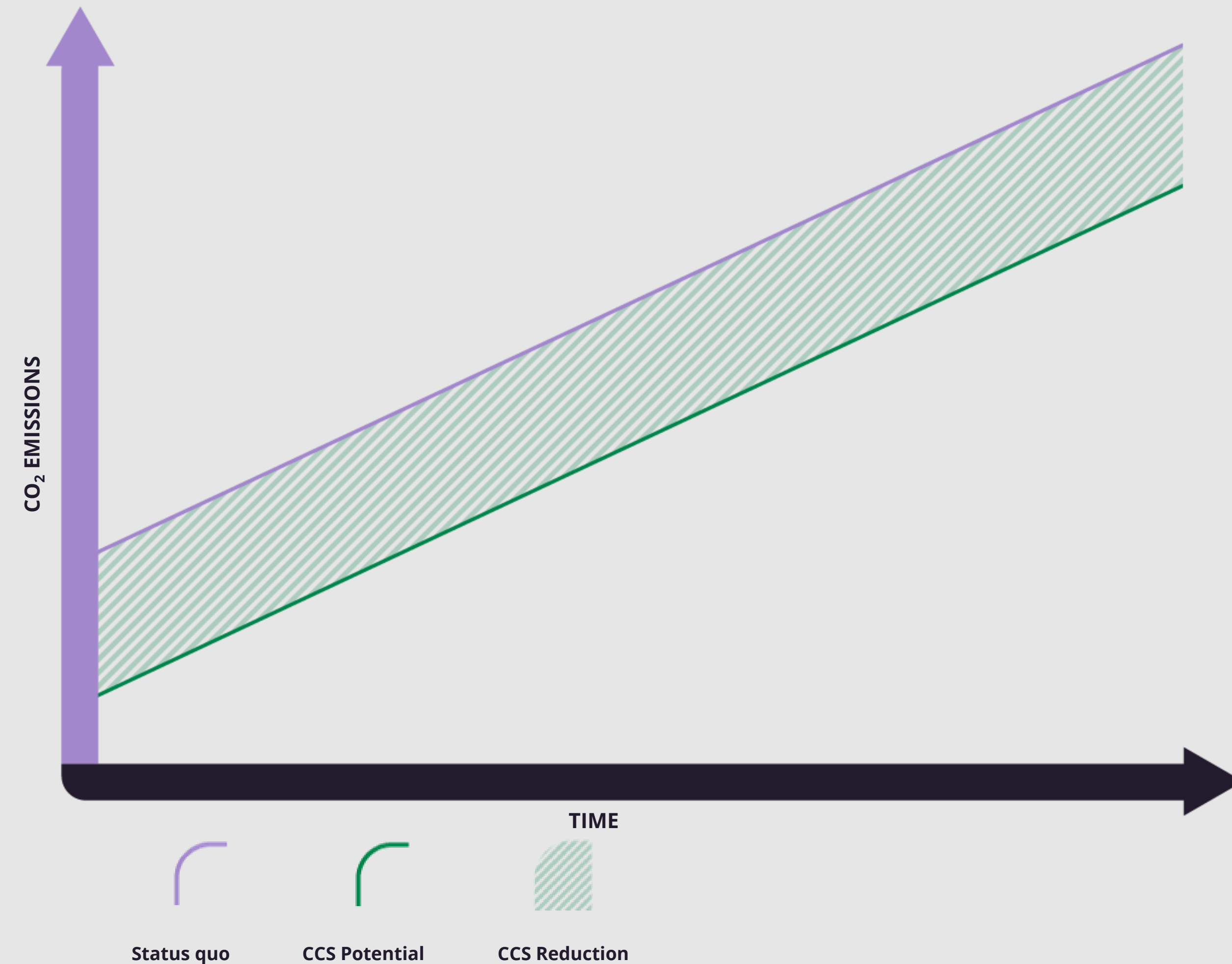
IMPLICATIONS OF  
**NORCE-REPORT**



## CARBON CAPTURE, UTILIZATION & STORAGE

# CCUS POTENTIAL<sup>1</sup>

- Carbon Capture and Storage (CCS) measures will help reduce CO<sub>2</sub> emissions. However, CCS reduction will correlate with rising emissions<sup>2</sup>. Thus, CCS alone will not be able to reduce emissions by a larger proportion than what technology enables companies to capture.



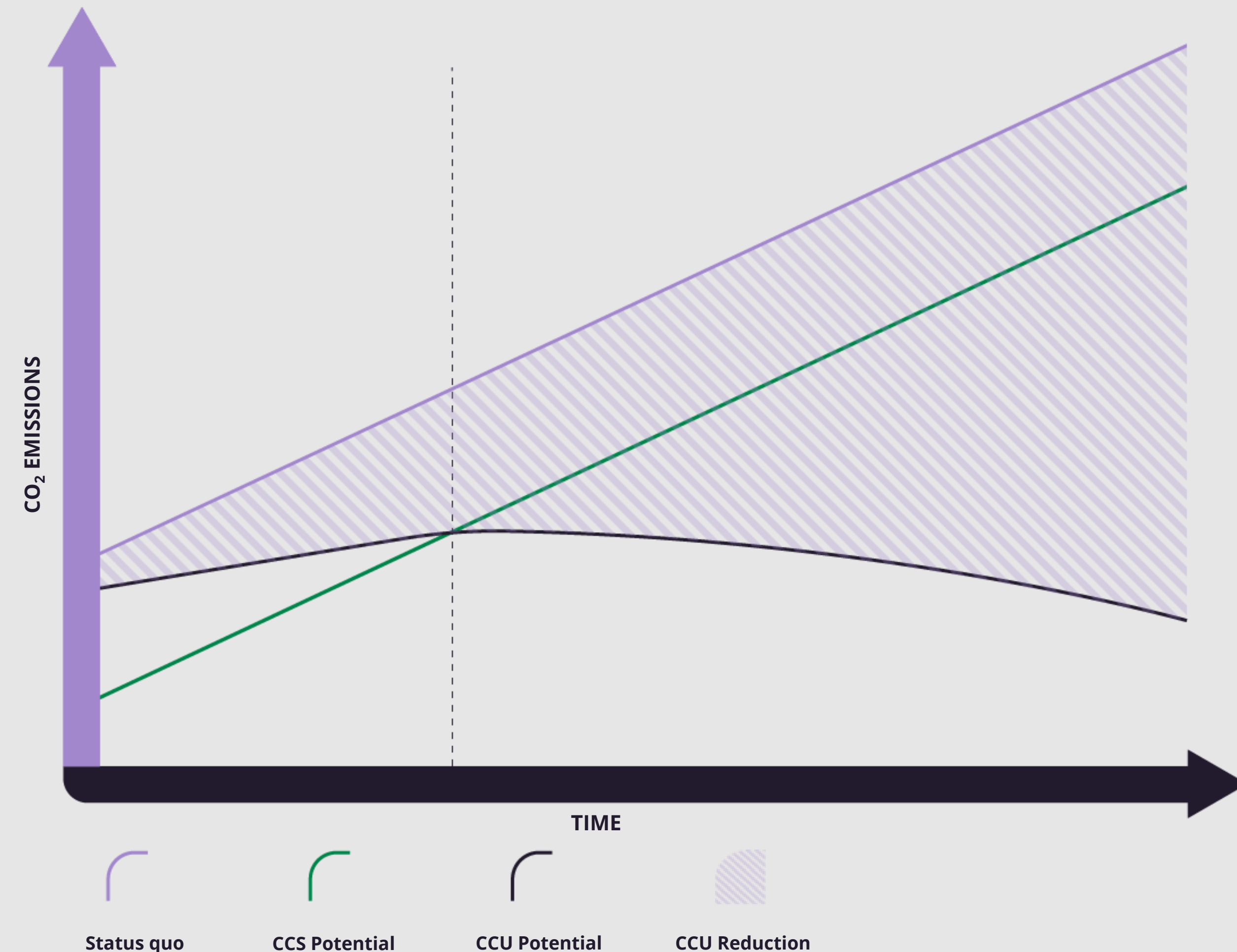
1: Model for illustrative purposes only.

2: Assumes CCS technology will capture emissions at a fixed rate going forward. Does not consider any technological advances.

## CARBON CAPTURE, UTILIZATION & STORAGE

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- BCS aims to turn the emissions itself into an industrial asset. Thus, BCS will reduce CO<sub>2</sub> emissions by utilizing industrial flue gas in the production, while also making carbon nanofibers to be used for improving materials' properties and reducing consumption of highly polluting applications.
- Hence, BCS' technology can capture emissions of today and utilize them to reduce emissions of tomorrow.



1: Model for illustrative purposes only.

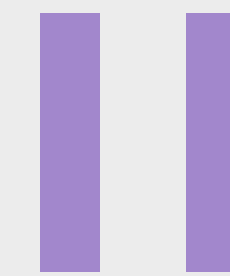
2: Assumes CCS technology will reduce emissions at a fixed rate going forward. Does not consider any technological advances.

## NORCE-REPORT: KEY TAKEAWAYS (1)

# Huge emission reduction potential<sup>1</sup>

- Material improvement from CNF/CNT lead to reduced production amount.
- 2 Gt CO<sub>2</sub> emission reduction potential from less production alone, in the next 10 years.
- These estimates do not account for ripple effects, meaning that the reduction potential is even larger.
  - E.g., less concrete production would also affect emissions from transportation at 7.9kg CO<sub>2</sub> per tonne concrete<sup>3</sup>.

Can reduce more than  
**2 000 000 000**  
tonnes CO<sub>2</sub> the next 10 yrs



**Equals > 6% of global CO<sub>2</sub> emissions  
from fossil fuel in 2020<sup>2</sup>.**

1: "Reduction in CO<sub>2</sub> emissions from using carbon nanofiber additives" (Alagic, Blomgren et al., 2022)

2: "Global Carbon Budget 2021" (Friedlingstein, Pierre, et al., 2021)

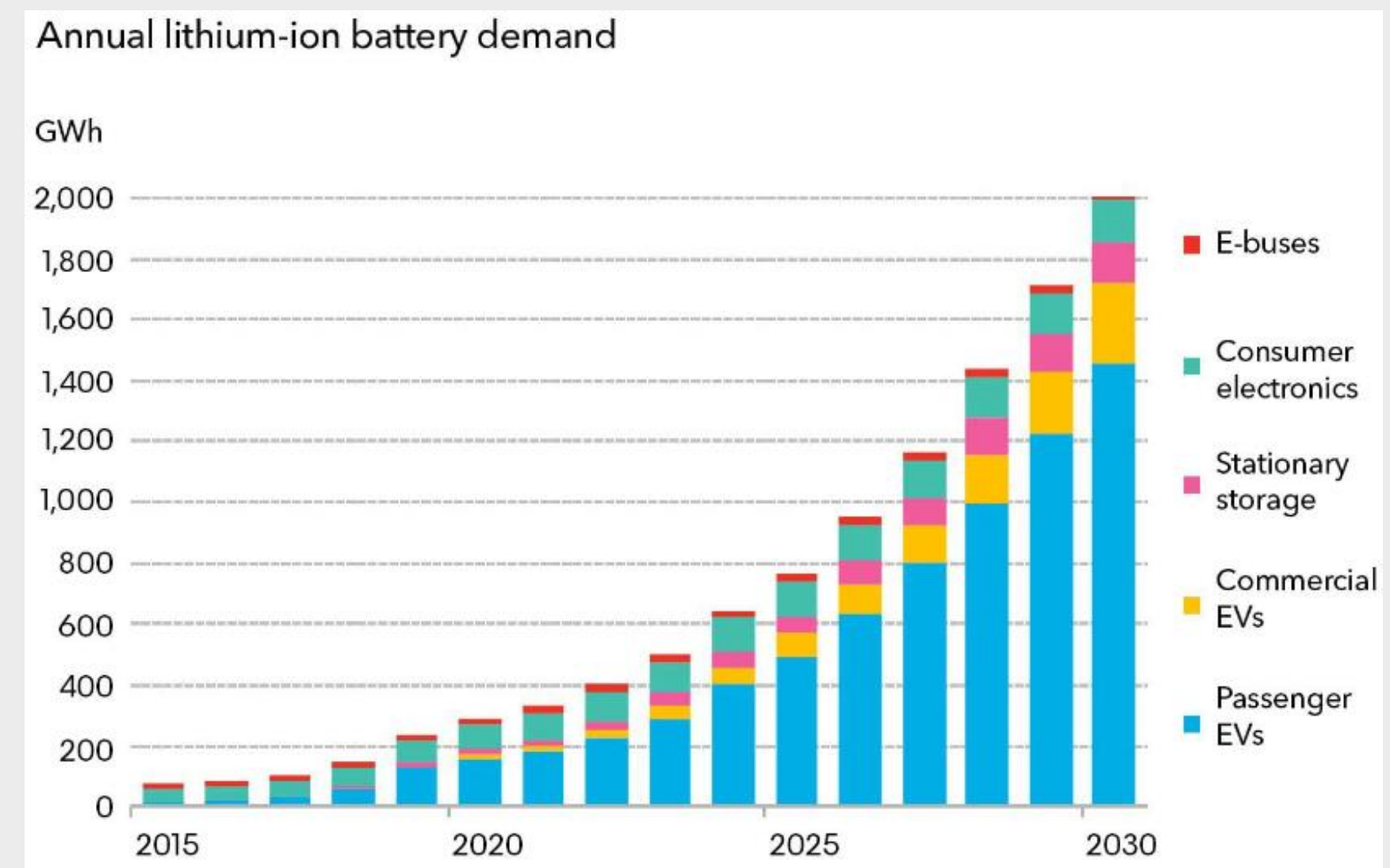
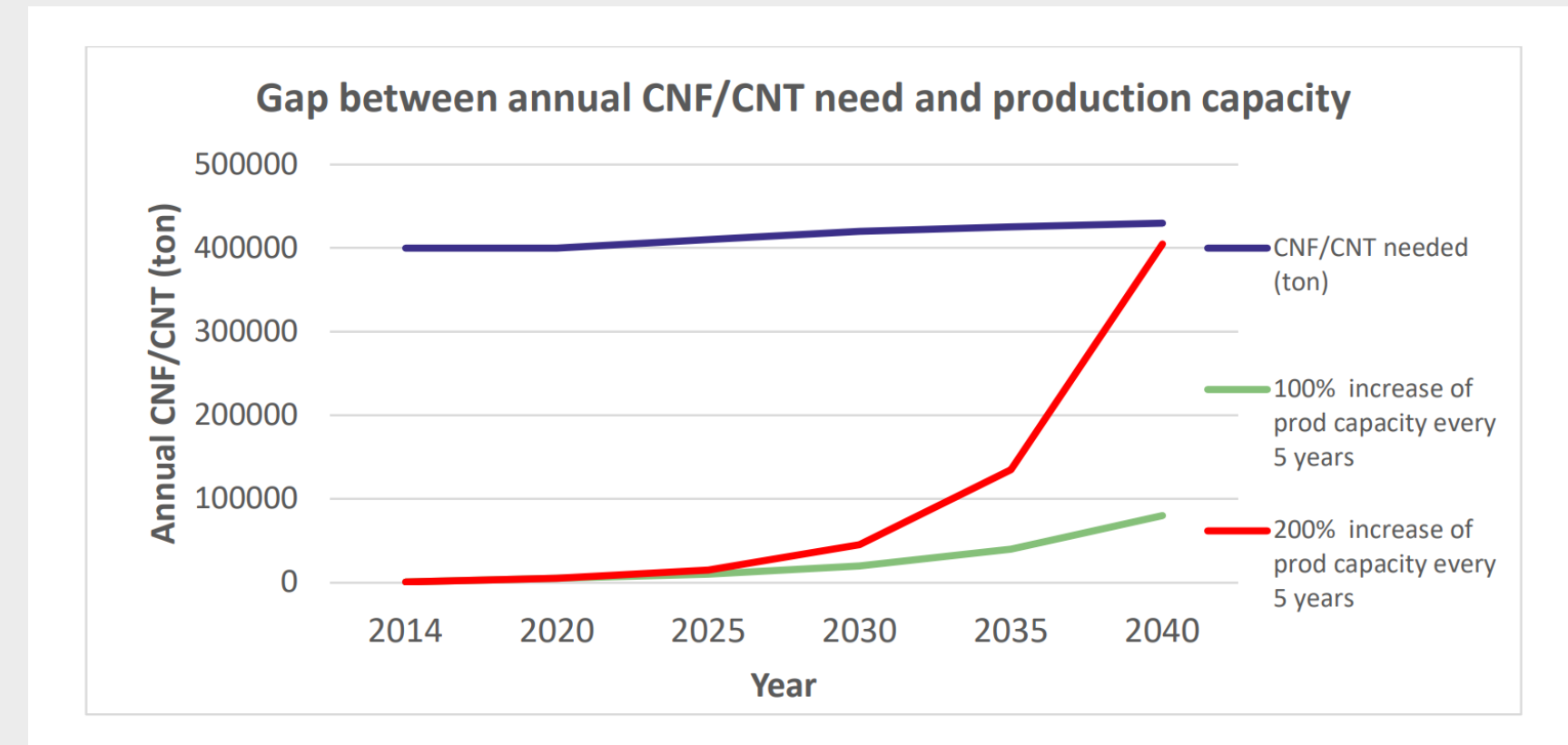
3: MPA The Concrete Centre, 2020

Globe-icon from flaticon.com

## NORCE-REPORT: KEY TAKEAWAYS (2)

# Huge market potential for CNF/CNT products in the future<sup>1</sup>

- Rapid technology development and material improvement in the past decade
- CFN/CNT need expected to grow in the future
- Demand from in the Norwegian-based rubber/plastics, electrical equipment and non-metallic mineral industries represent a very large market

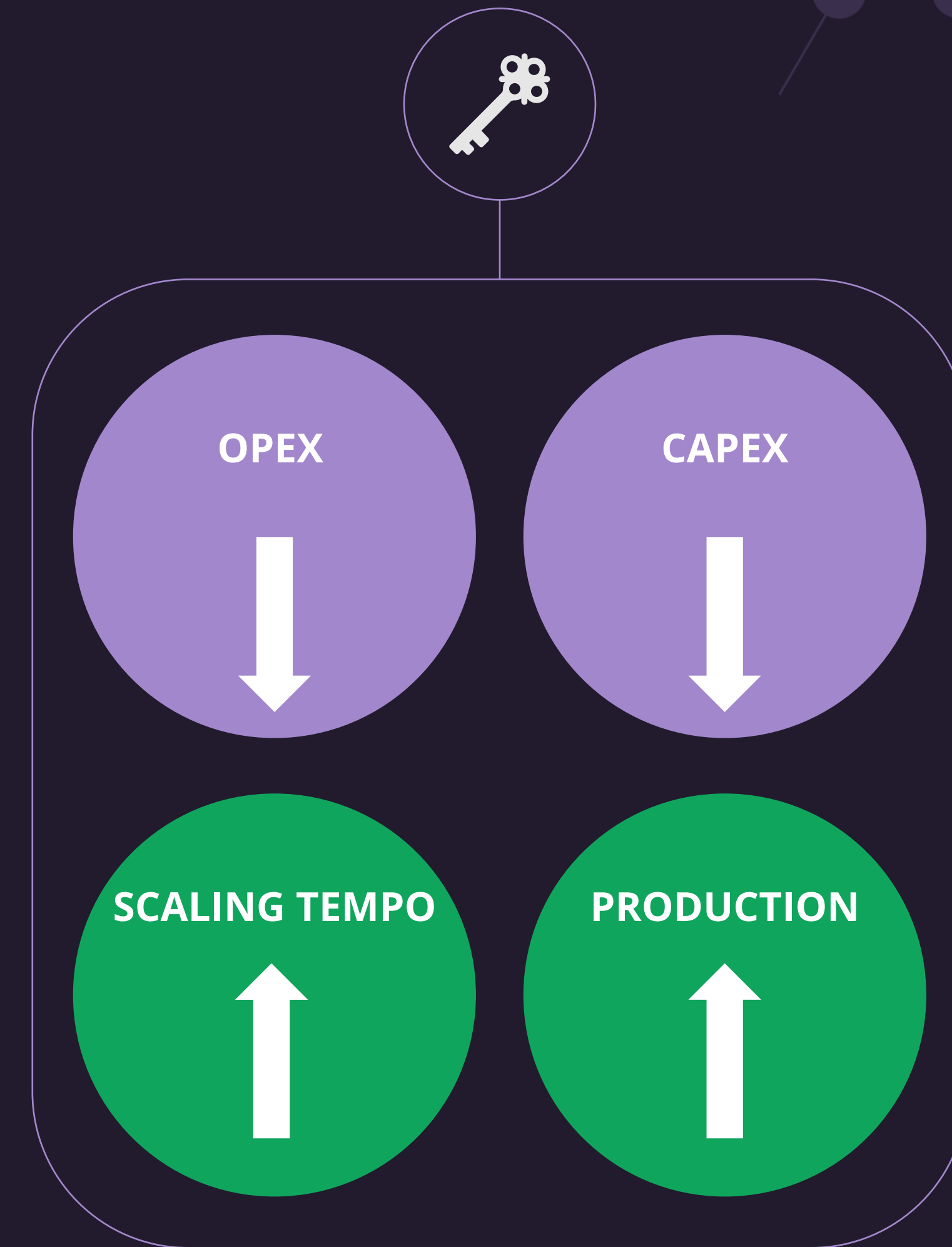


1: "Reduction in CO2 emissions from using carbon nanofiber additives" (Alagic, Blomgren et al., 2022)

\*Based on calculations in pre-engineering phase

# Scaling and cost reduction are keys to market adoption<sup>1</sup>

- Full market penetration of CNF/CNT requires fast upscale of production capacity and industrial scale adoption in new products.
- Technology for upscaling CNF/CNT production capacity and reducing costs are the keys to accelerate the market adoption

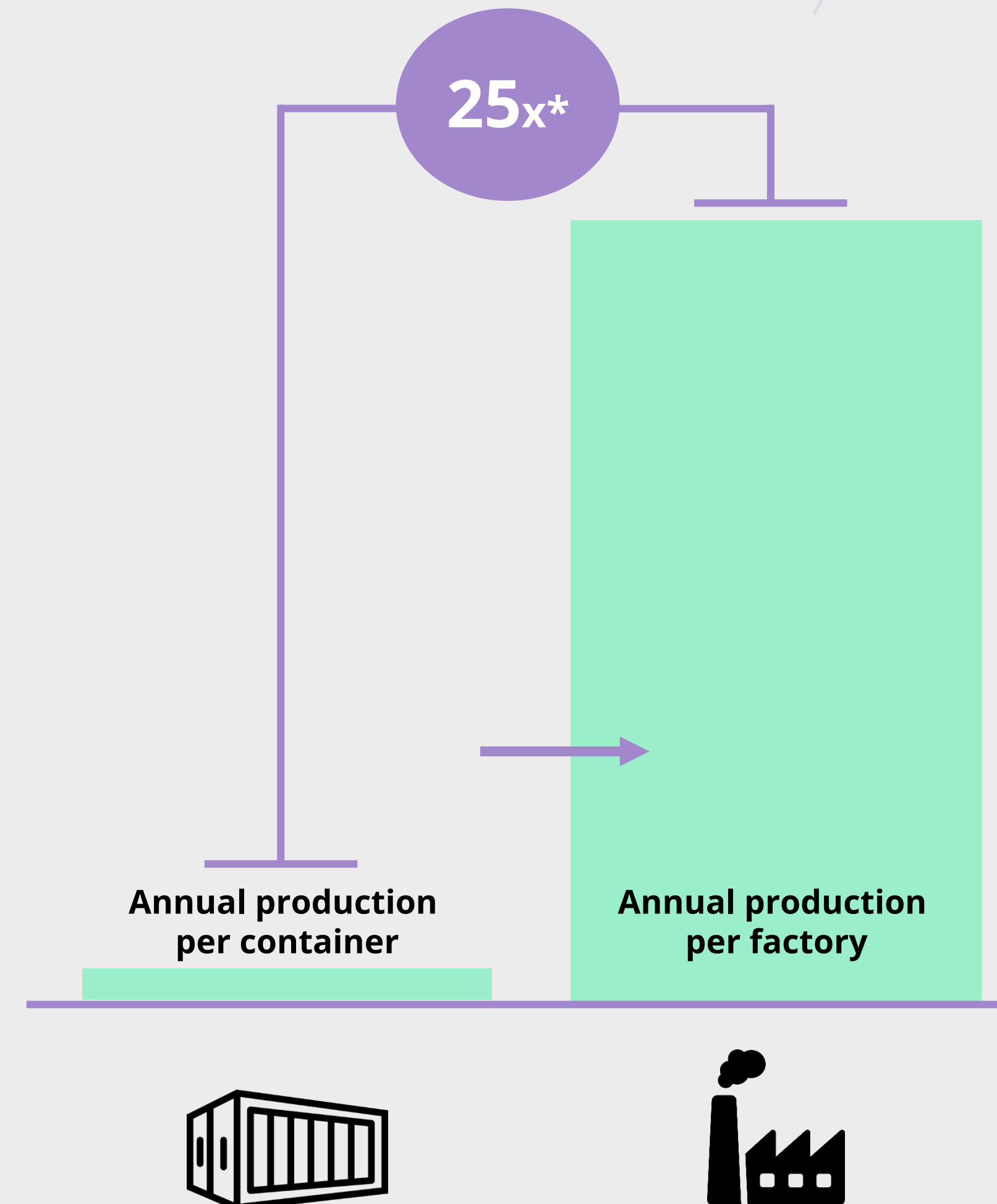


1: "Reduction in CO2 emissions from using carbon nanofiber additives" (Alagic, Blomgren et al., 2022)

## NORCE-REPORT: IMPLICATIONS

# Full-scale design positions Bergen Carbon Solutions towards market adoption

- Bergen Carbon Solutions' new FULL-SCALE design enables us to produce significantly more than we previously guided
- Our initial calculations indicate **25% lower\* capital expenditures** by making a factory setup compared with containers
- We expect a new design to **reduce the operating expenses (OPEX) by up to 20%\*** from the containerized solution

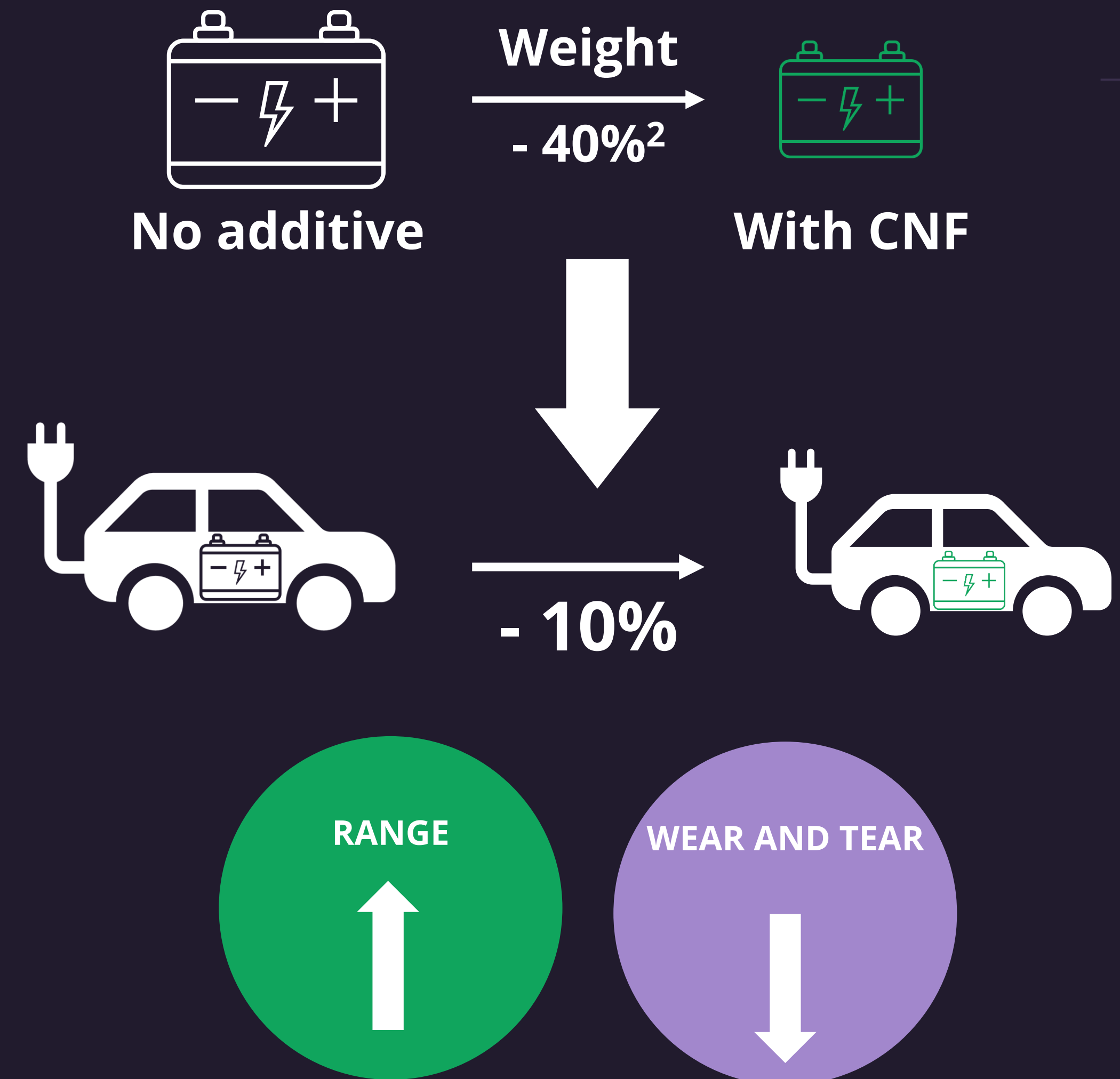


\*Based on calculations in pre-engineering phase

## SELECTED SEGMENT: BATTERIES (NORCE)

### Small improvement in battery performance, can significantly impact global emissions.<sup>1</sup>

- CO2 emission may increase by a factor of 10 within a decade unless production technologies improve.
- CNF-potential for currently dominating graphite anode and seems even more promising for next generation Silicon-based anodes.
- Reduction of total vehicle weight of 5-10% seem within reach with same vehicle performance



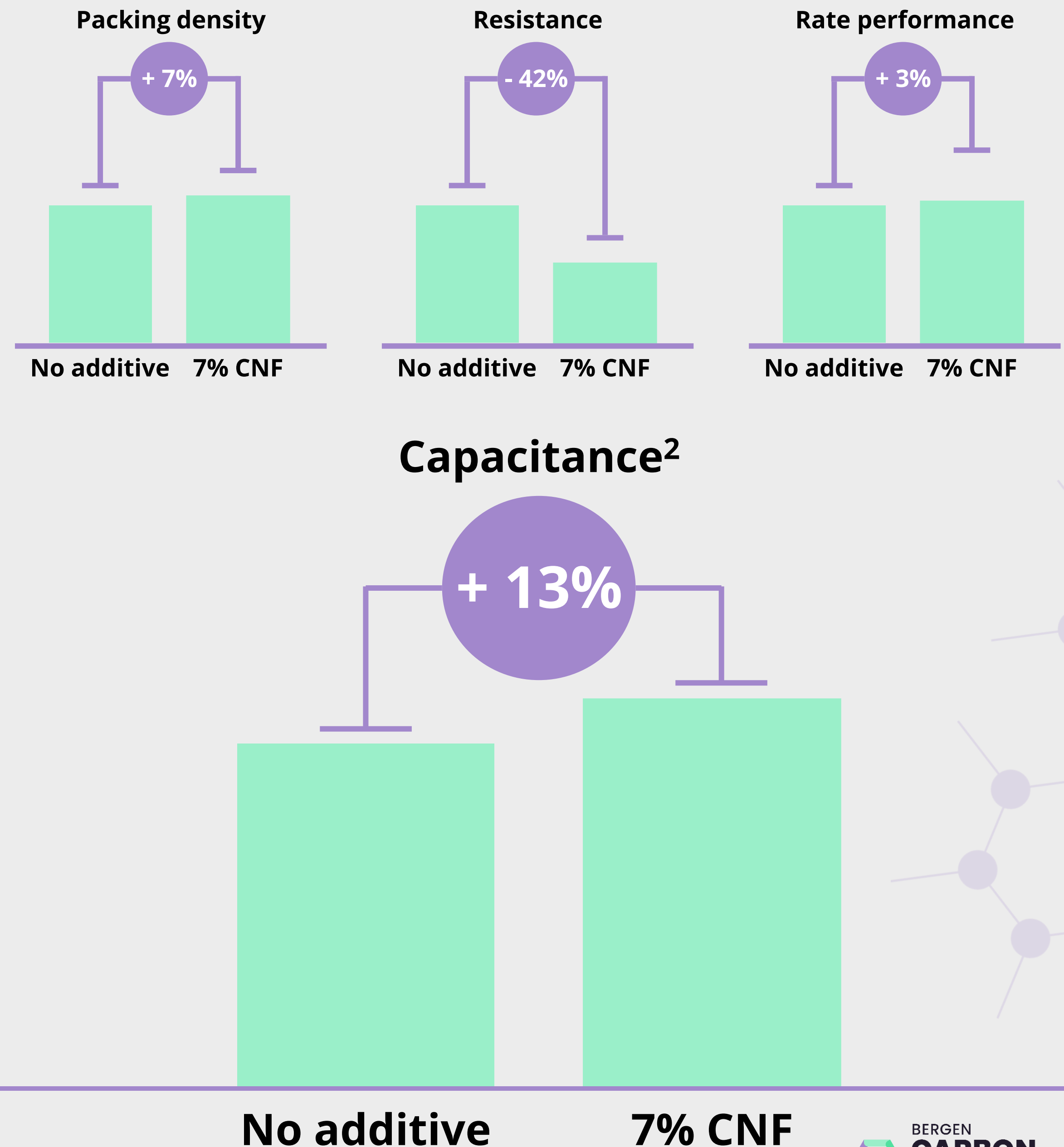
1: "Reduction in CO2 emissions from using carbon nanofiber additives" (Alagic, Blomgren et al., 2022)

2: Based on assumption that the battery pack constitutes roughly 25% of an electric vehicle today

## SELECTED SEGMENT: BATTERIES (BEYONDER)

# Significant increase in battery performance by adding our CNF<sup>1</sup>

- Addition of CNF in the electrode composite resulted in a 13% increase in volumetric capacitance, improved packing density, electrodes with very low resistance and higher rate performance even at high current densities.
- *"The carbon nanofiber sample was used as received without any pre-treatments."*<sup>1</sup>
- A great base for further research of optimal battery composition and large scale-testing



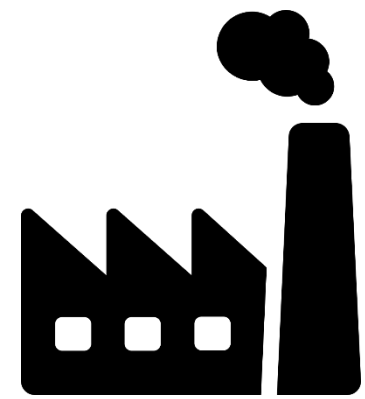
1: Report from Beyonder, received Jan. 2022

2: Volumetric capacitance

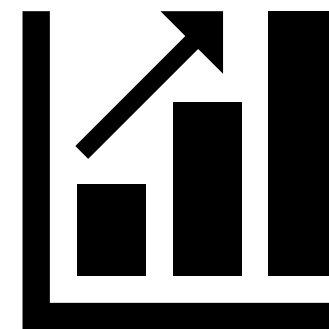
## NORCE-REPORT: KEY TAKEAWAYS (4)

# Adding CNF to the investigated material groups can create national value and employment<sup>1</sup>

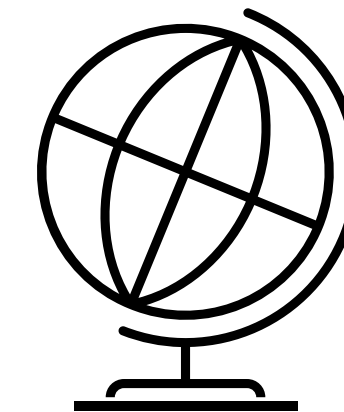
A **new industry** reliant on Norwegian labour and sub-suppliers (ripple effects).



Making end-products “greener” will **increase future demand**.

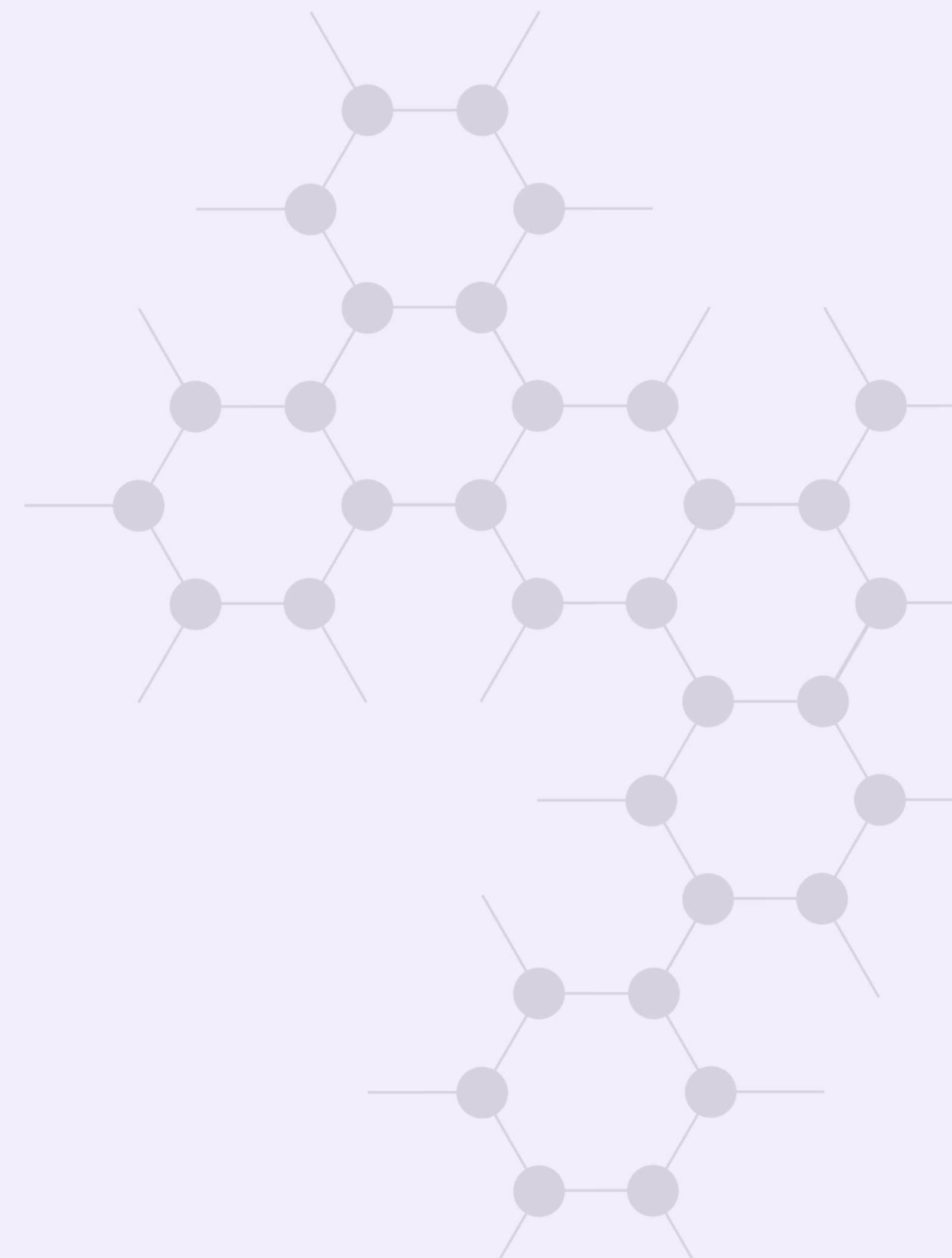


Direct providers can use experience to **export their products** internationally.



1: “Reduction in CO2 emissions from using carbon nanofiber additives” (Alagic, Blomgren et al., 2022)

INTRODUCING  
**CNF ARENA**

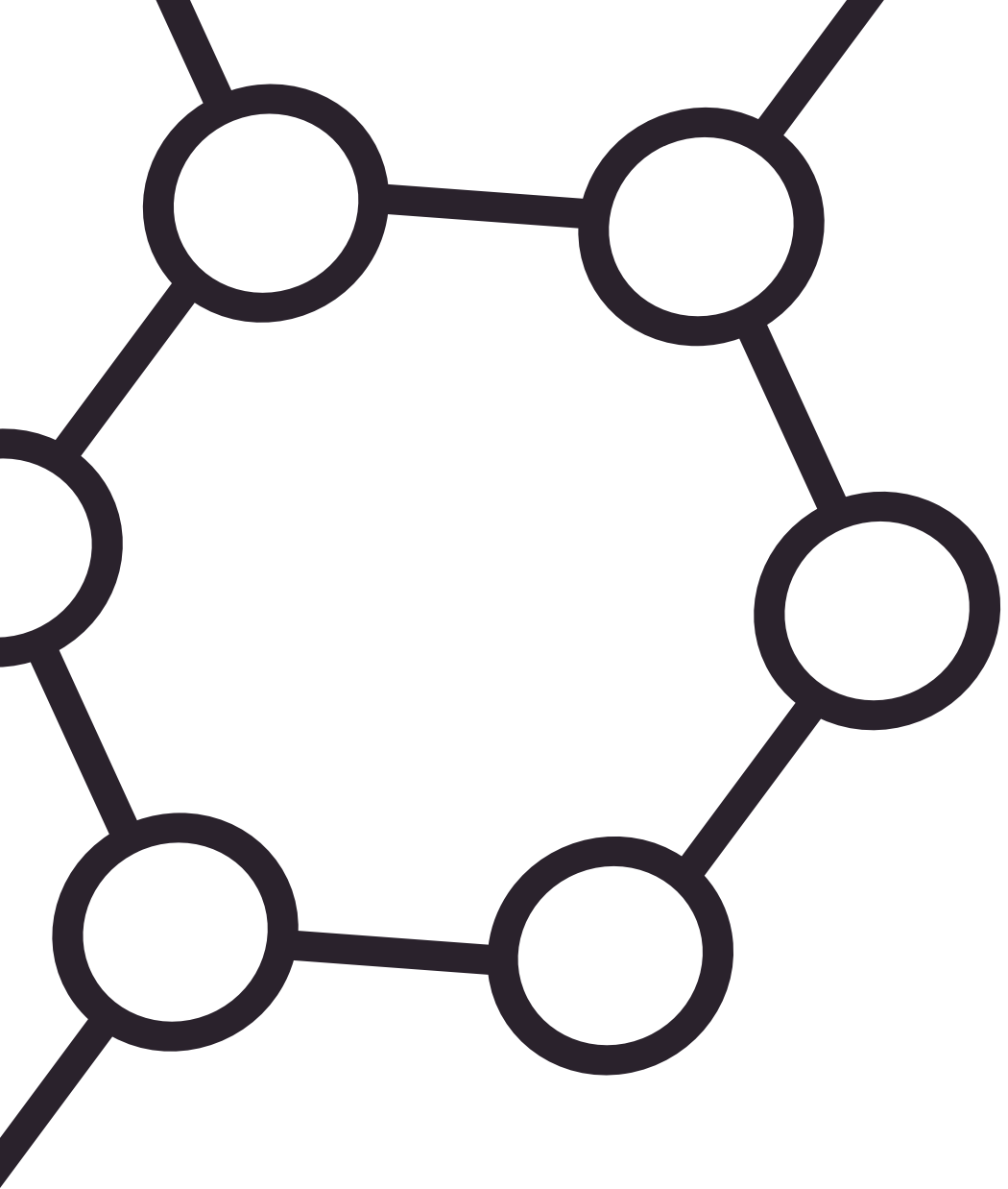


# CARBON DEVELOPMENT SOLUTIONS AS

*A Bergen Carbon Solutions venture*

Developing the future CCU-materials





# CARBON DEVELOPMENT AT A GLANCE

- ✓ Founded in 2022
- 📍 Located in Mosjøen, Norway
- 🤝 Owned by BCS and MON KF
- 🔬 R&D environment within CCU industry
- 📦 Key competence on CO<sub>2</sub>-based materials



# CARBON DEVELOPMENT VISION & MISSION

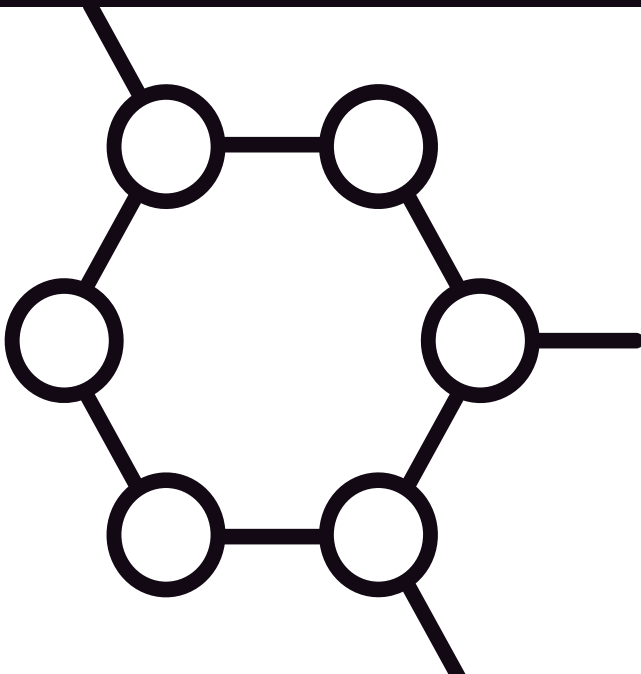
**Leading R&D service provider** within utilization of CO<sub>2</sub> produced carbon nano fibres in new materials

**Key partner** in developing materials for a broad range of applications

**Facilitator of disruptive material research and technology** for a circular and sustainable future

**Aid companies in improving their products** and making them more sustainable

Making CO<sub>2</sub> **part of the solution** for the green transition





# CARBON DEVELOPMENT

## WE ARE STARTING UP

Currently in start-up phase

Secured facilities in an innovative and specialised metallurgical environment

Access to instrumentation and infrastructure

Proximity to BCS production site

Currently hiring key personnel and building own instrumentation park



# CARBON DEVELOPMENT

## THE STORY BEHIND

A direct result of the feasibility study CNF Arena, funded by Nordland County

CNF Arena is a collaboration between MON KF and BCS

Main goals of CNF Arena;

- Developing the CO<sub>2</sub> value chain
- Establish collaboration with key partners
- Identify potential and market opportunity
- Identify disruptive R&D projects
- Develop concept for carbon lab

# CARBON DEVELOPMENT IMPACT POTENTIAL

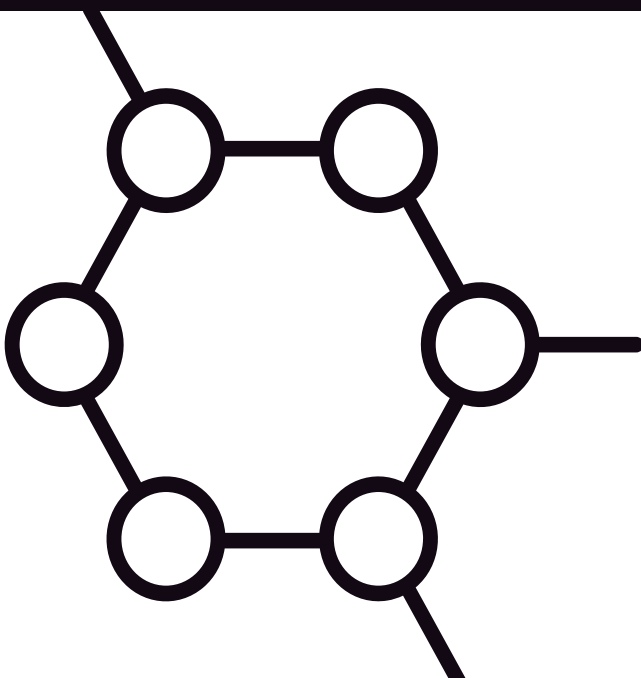
## REALISING THE POTENTIAL NEEDS SIGNIFICANT R&D EFFORTS

CNF has **unique properties** through being stronger than steel, lighter than plastics and more conductive than copper

A study performed by NORCE confirms a **huge market potential** for CNF due to a growing need within technology development and material improvement

By introducing CNF into various materials, it is possible to transfer CNF properties to the material, **obtaining unique improvements** for example within composite materials or concrete

**Significant R&D efforts are needed** to accelerate upscaling of new technology and industrial solutions



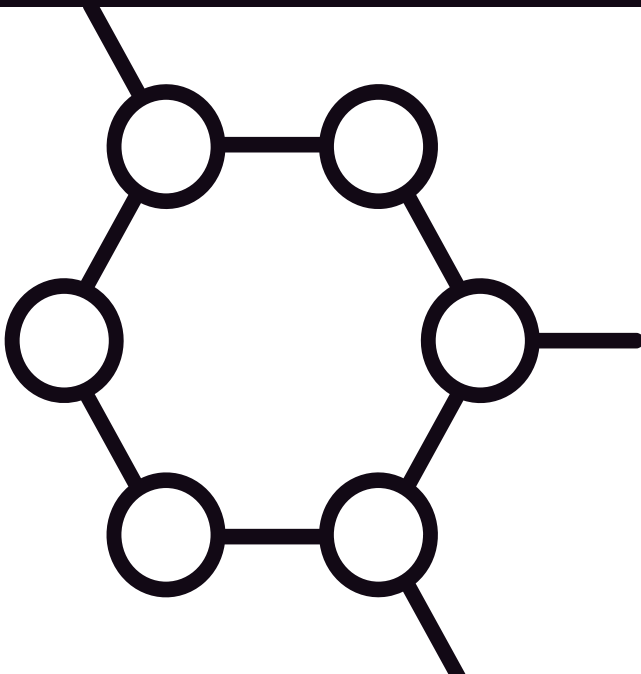
# CARBON DEVELOPMENT MAIN FOCUS AREAS

## CNF IN ALUMINIUM

We are currently initiating projects investigating how to improve aluminium traits using CNF. Among the traits we are aiming for is making aluminium more conductive than copper. Our collaborating partners have leading industrial competence in the field of aluminium.

## CNF IN CONCRETE

CNF can provide some exciting properties to concrete such as increased compressive strength and self-sensing (smart concrete). We are looking for innovative partners to develop the concrete of the future with lower CO<sub>2</sub> footprint compared to today's standards.



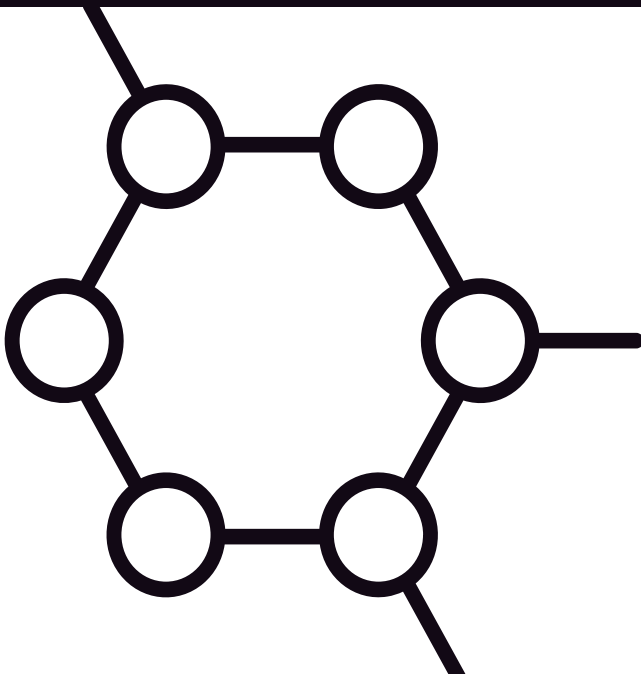
# CARBON DEVELOPMENT HOW CAN WE HELP?

## **Project partner**

We have extensive knowledge in working with R&D projects and various financial mechanisms. We are happy to provide access to our competence and facilities as a project partner or manager in project consortia.

## **Consultant**

We can aid in identifying the potential of utilizing CNF in your product. Do not hesitate to contact us for a non-committing chat about how we can help improving your product.

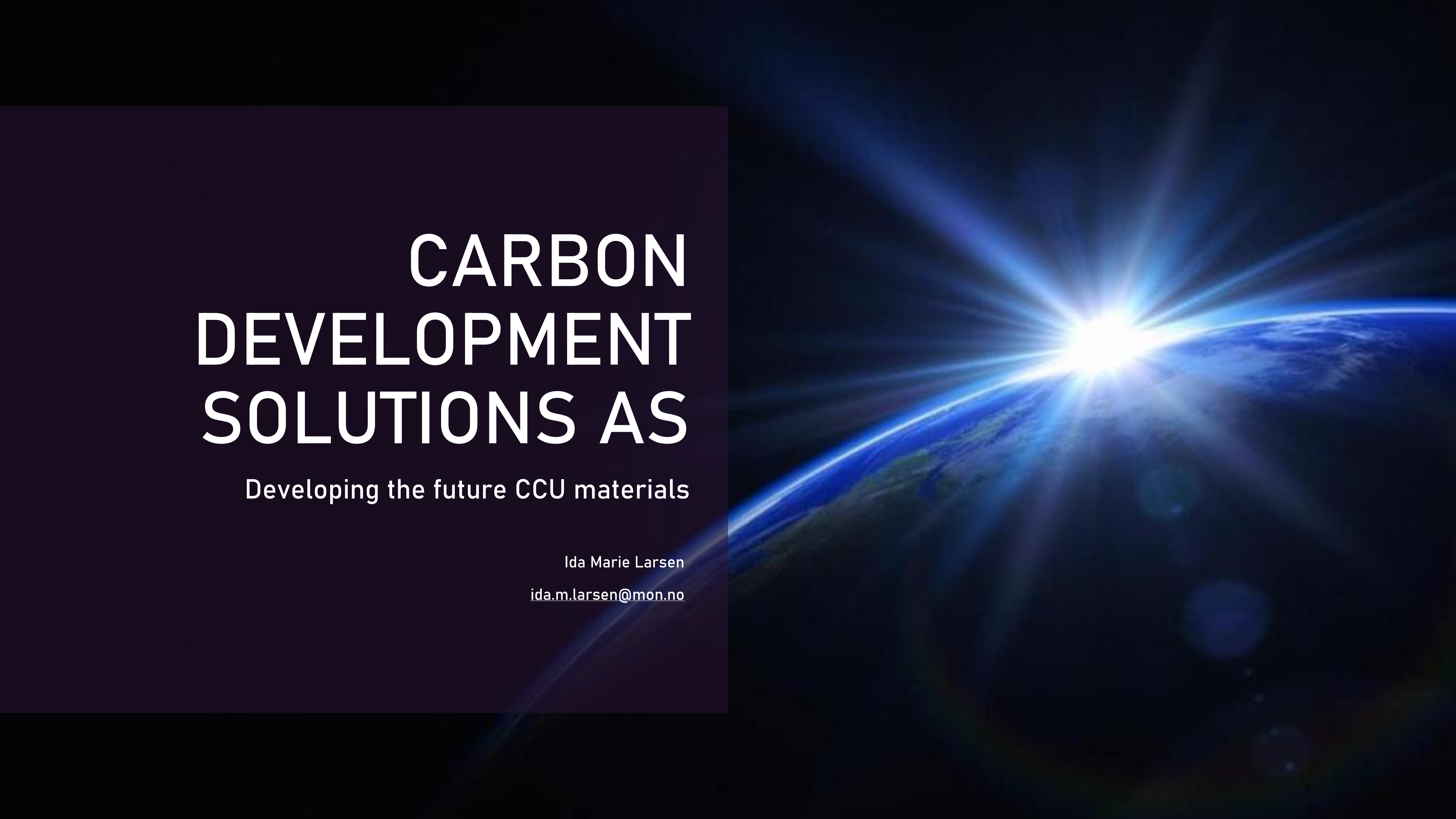


# CARBON DEVELOPMENT SOLUTIONS AS

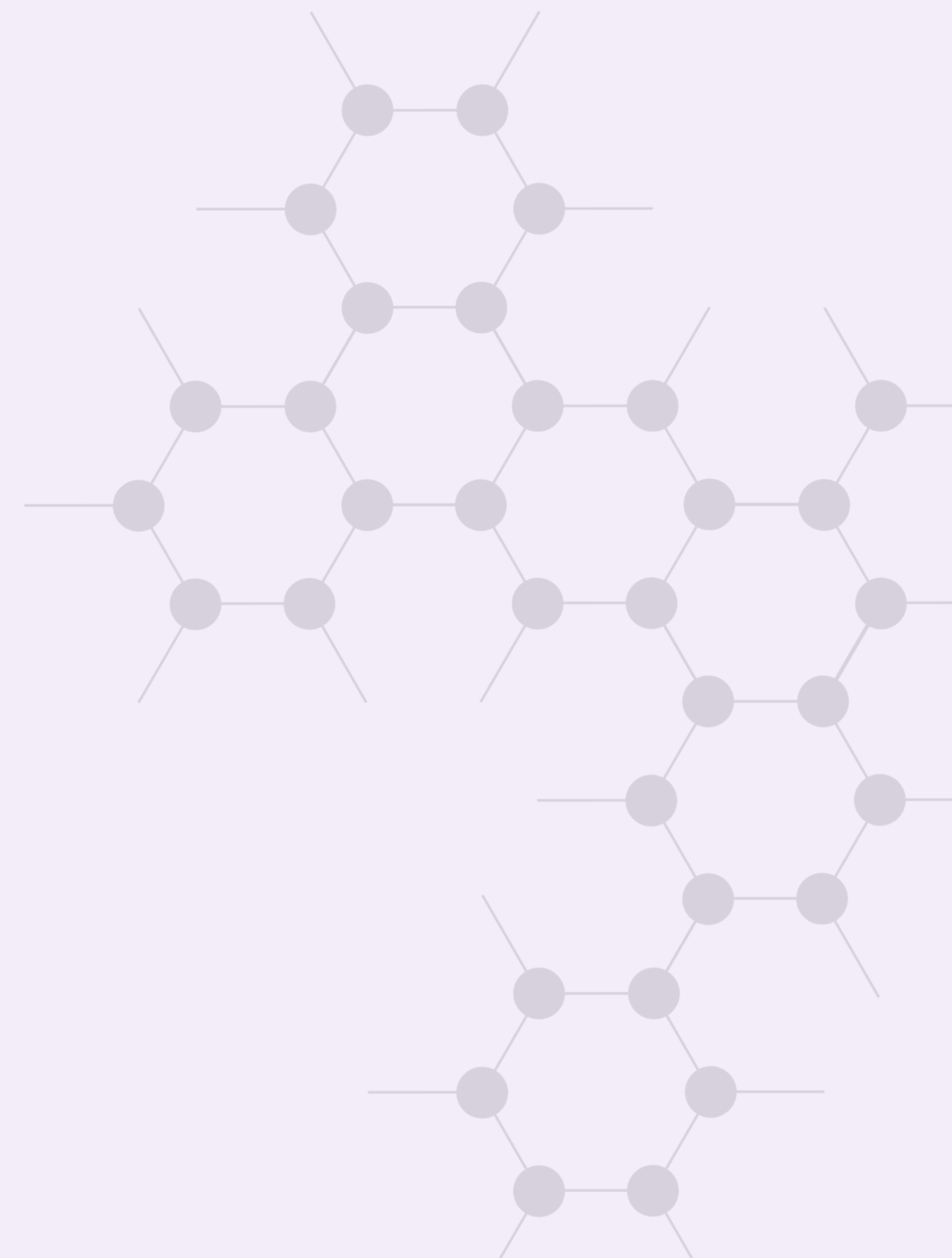
Developing the future CCU materials

Ida Marie Larsen

[ida.m.larsen@mon.no](mailto:ida.m.larsen@mon.no)



CONCLUSIONS  
**GOING FORWARD**



## CONCLUSION

**Norway is well positioned to be the future major supplier of industrial scale CNF/CNT<sup>1</sup>**

Share of increase in mainland<sup>2</sup> investments from 2022 expected to be 'green' (Norges Bank):



Norwegian industry met demand from the oil and gas industry through brand new products and enhancing existing products to fit new requirements.  
**With the right support and investment, we can do this again.**

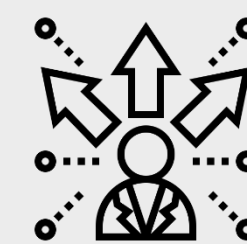
1: "Reduction in CO2 emissions from using carbon nanofiber additives" (Alagic, Blomgren et al., 2022)

2: Mainland Norway is a national accounting term used when excluding activity related to petroleum, pipeline transport and international shipping.

## CONCLUSION

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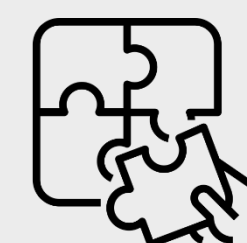
# WHAT TO WE NEED TO **MAKE IT HAPPEN?**



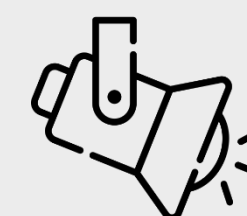
Define goals and opportunities nationally and internationally.



Cooperate and contribute to further development of Norwegian industry.



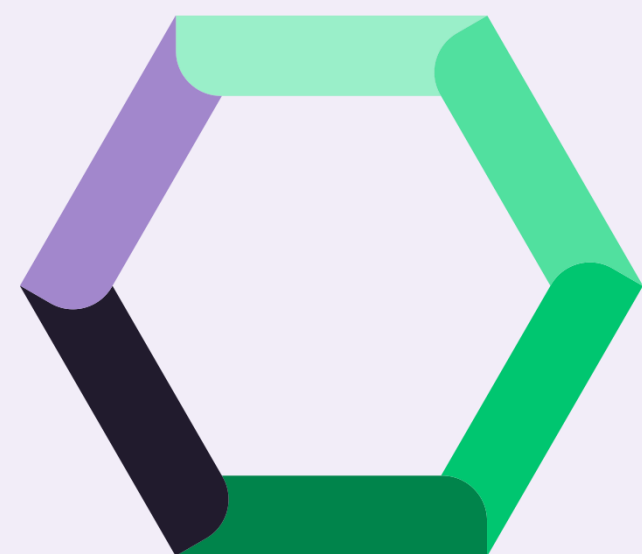
Contribute to CNF Arena being funded as a research branch for materials nationally and internationally.



Assist with making the technology known and establish cooperation with other nations.



Contribute to effective and necessary financing – if there is a need.



BERGEN  
**CARBON  
SOLUTIONS**

