PROSESS21

Department of Chemical Engineering 75-year Jubilee Seminar

17th October 2024

Dr. Håvard Moe, SVP Technology Elkem ASA and Head of steering committee Prosess21

Task given by the organising committee

"It would be great to hear Prosess21's/industry's perspective on what is needed in terms of competence and research in chemical process technology to achieve a green transition in Norway's process industry."

What is Prosess21?

National strategy for the Norwegian process industry

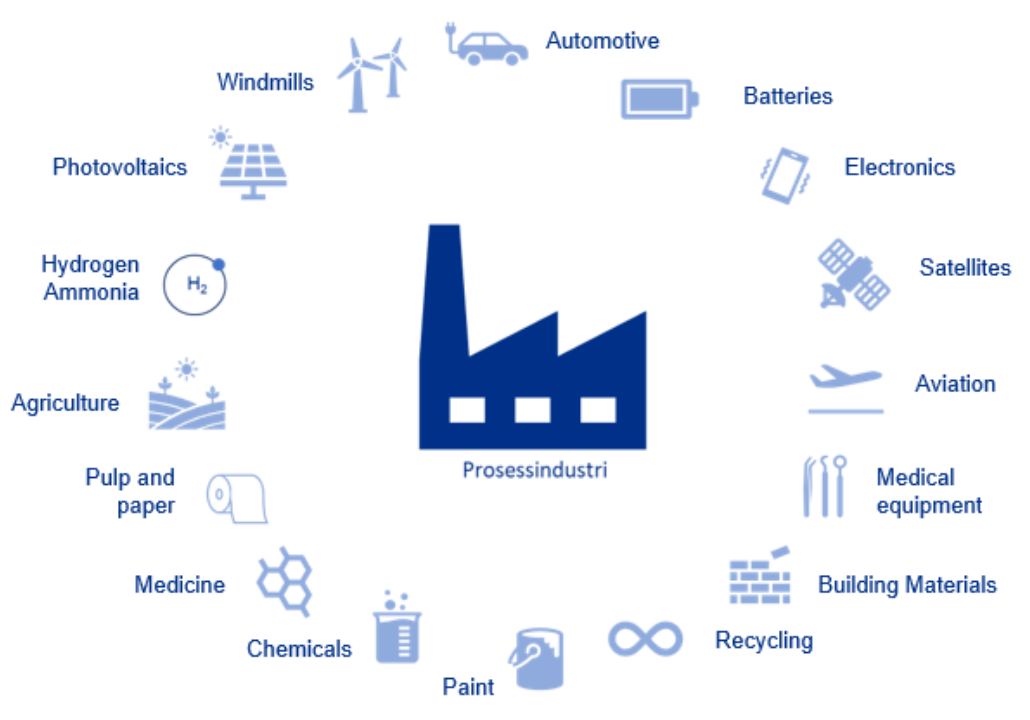
The main task of Prosess21 is to provide strategic advice and recommendations on how Norway can best achieve a development towards minimal emissions from the process industry by 2050, while also facilitating sustainable transition, growth, and value creation.

Lenke til mandat (norsk)

Link to mandate (english)

Contents

- Introduction to Process21
- The Norwegian process industry in brief
- Main challenges for the European and Norwegian process industry
- Sicalo – a potential game changer for Silicon metal production
- Personal reflections on competence and research in chemical process technology
- Concluding remarks



Process21 deliverables from 2018 to 2021

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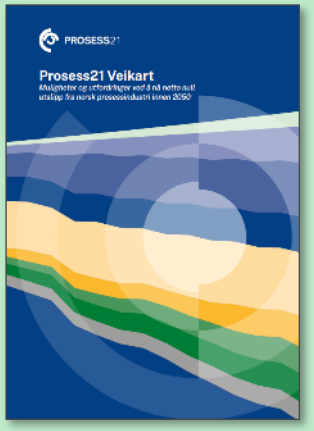
Expert group reports

- Entrepreneurship
- Product development
- Bio-based Process industry
- Circular economy
- New Process Technology
- Carbon capture
- Digitalization
- Foreign investments
- Competence
- Energy

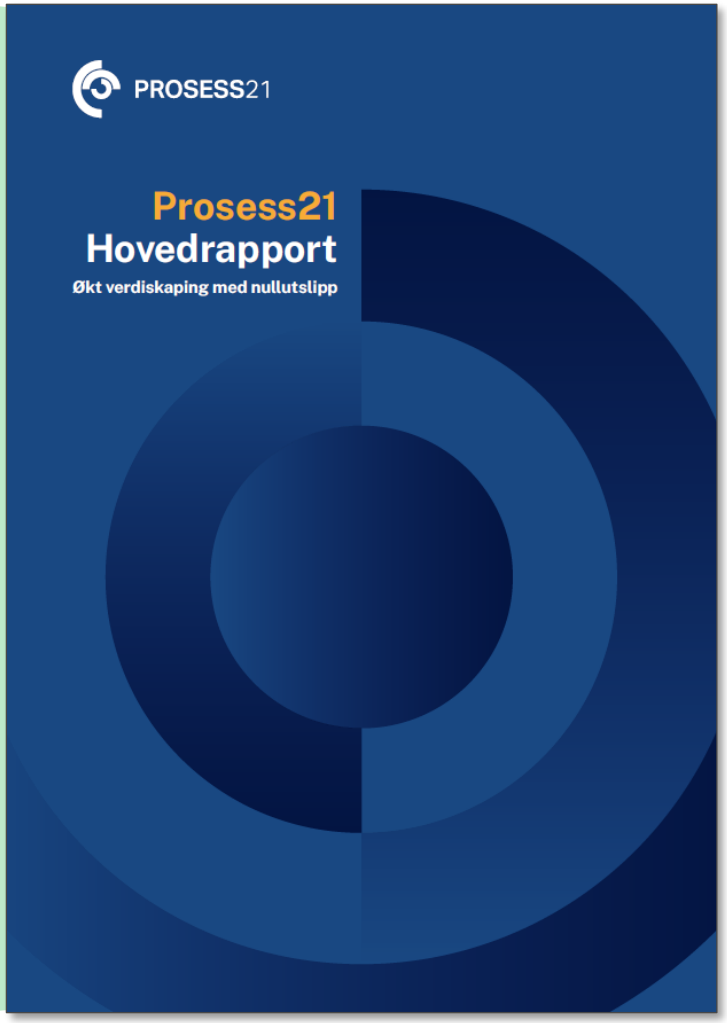
Resource effort

- > 1 200 participants
- > 300 organizations
- 10 Expert group reports
- 4 External studies
- 18 Steering committee meetings
- 70 Expert group meetings
- 12 Workshops
- > 20 000 Hours from private sector
- > 7 500 Hours from public sector

Prosess21 Roadmap



Thematic reports

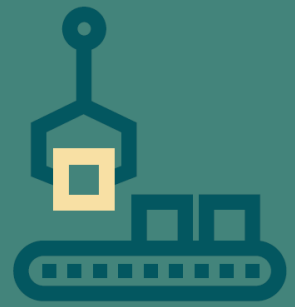


www.prosess21.no

Nærings- og fiskeridepartementet

ROADMAP 2.0

THE GREEN INDUSTRIAL INITIATIVE



Source: https://www.regjeringen.no/contentassets/b5a51f3220474b3197ea21feb260f5b3/en/roadmap-2.0_the-green-industrial-iniative.pdf

the Government's visions for the nine priority areas

Process industry

Norway will have the world's cleanest, most modern and energy-efficient process industry, based on high-tech solutions and great value creation through specialised products.

Solar PV industry

Norway will develop a profitable solar industry with the potential to grow, which can contribute to the implementation of the green transition and play a key role in the further development of the solar industry in Europe.

Offshore wind

Norway will become a leading nation in the field of offshore wind, with an industry that develops and builds superior wind power solutions. The Government's ambition is to allocate areas with potential for 30 GW of offshore wind production on the Norwegian continental shelf by 2040.

Hydrogen

Norway will develop a value chain for the production, distribution and use of hydrogen produced with low or zero emissions and contribute to developing the hydrogen market in Europe.

Forestry industries

Norway will have the world's most sustainable forestry industry. Bioresources from the sea and from land will be used to make climate-friendly and profitable products, including biofuels, and help develop industrial jobs and long value chains in Norway.

Manufacturing

Norway must have a profitable, innovative, highly efficient and sustainable manufacturing industry that, based on expertise and the Norwegian working life model, delivers top-quality products with a low climate and environmental footprint to the entire world.

Batteries

Norway will further develop a coherent and profitable battery value chain, from sustainable mineral extraction to recycling of batteries. Norway strives to be an attractive host country for profitable activity along the entire battery value chain and attract large battery investments and gigafactories.

CCS

Norway will continue to work on world-leading industrial solutions for carbon capture, storage and utilisation that create profitable jobs in Norway and that cut global climate emissions in a cost-effective manner.

Green maritime industry

Norway will remain a maritime superpower internationally, leading the way into the green transition by developing, building and deploying zero-emission solutions and autonomous vessels.

Steering committee for Prosess21

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Head of stering committee

Trude Sundset
Hydro ASA

Lise Winther
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Prosess21 core team

9 of 13 members have educational background from NTNU

Øyvind Gregersen
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MSc Metallurgical Eng. 1986

Lars Petter Maltby
Norwegian Research Council

PhD Mechanical/Process Eng. 1993
MSc Mechanical Eng. 1989

Where are products of the process industry found?

Energy Solar

Electronics

GE Omnipaque®/Visipaque® contrast media

Energy Wind

Construction

Automotive

Energy battery

Aviation

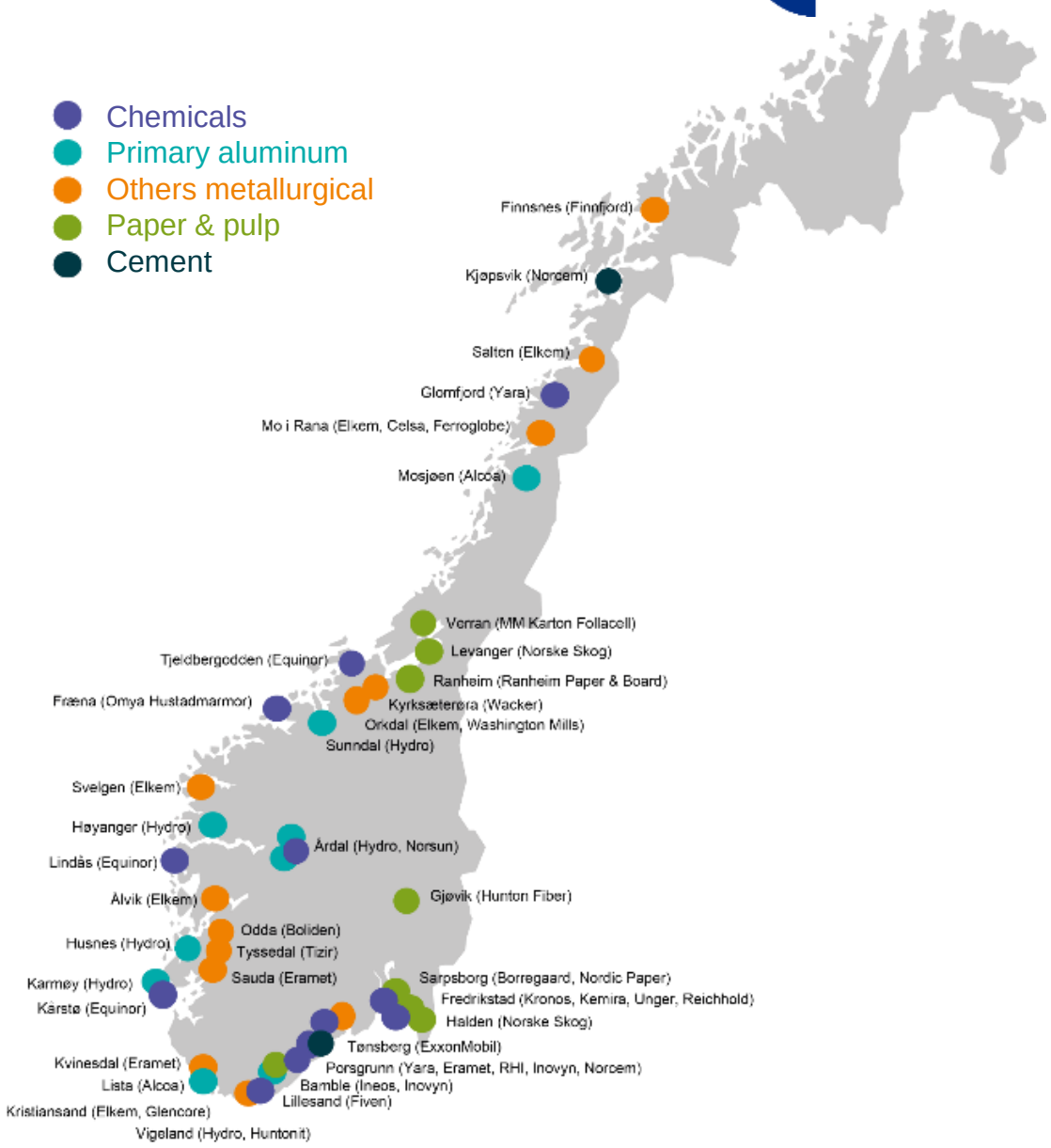
Recycling

The Norwegian Process Industry

The Norwegian process industry has more than hundred years of history and is today one of the largest sectors with factories spread over the whole country.

Key figures:

- 12 % of Norwegian exports (physical products)
- Utilizes about 1/3 of Norwegian renewable energy
- 23% (10,5 Mt) share of Norwegian GHG emission



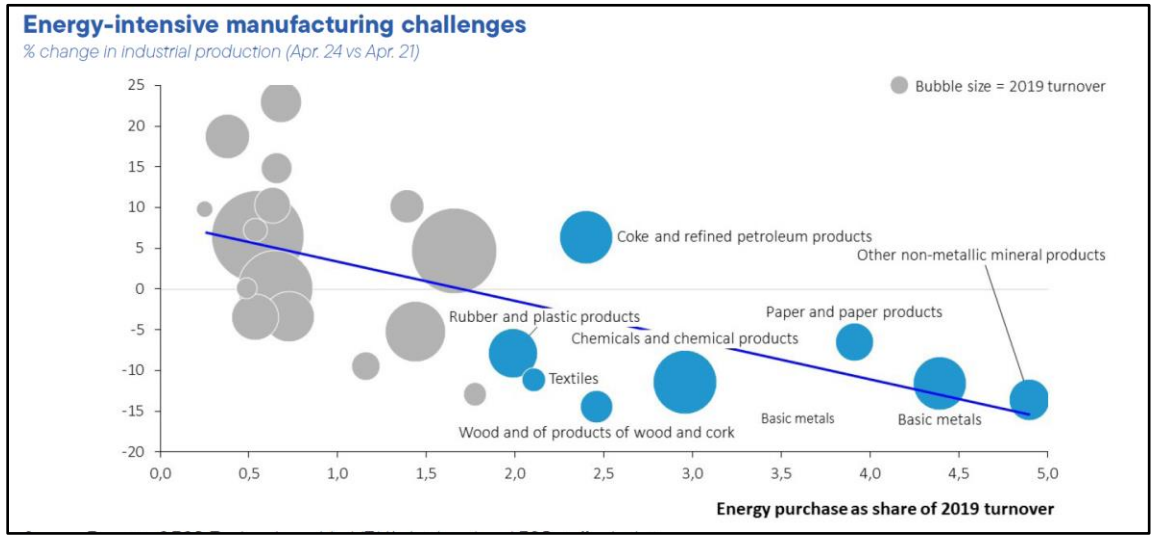
Kilde: SSB/Eurostat

EU is losing competitiveness

Europe has been worrying about slowing growth since the start of this century

Five root causes of the competitiveness gap for the process industry

- Structurally higher energy and raw material costs
- Energy inputs represent a substantial share of the value chain
- Carbon pricing increases relative production costs
- Decarbonising requires far-reaching transformation of assets and processes, which calls for substantial investment
- Static industrial structure which produces a vicious circle of low investment and low innovation

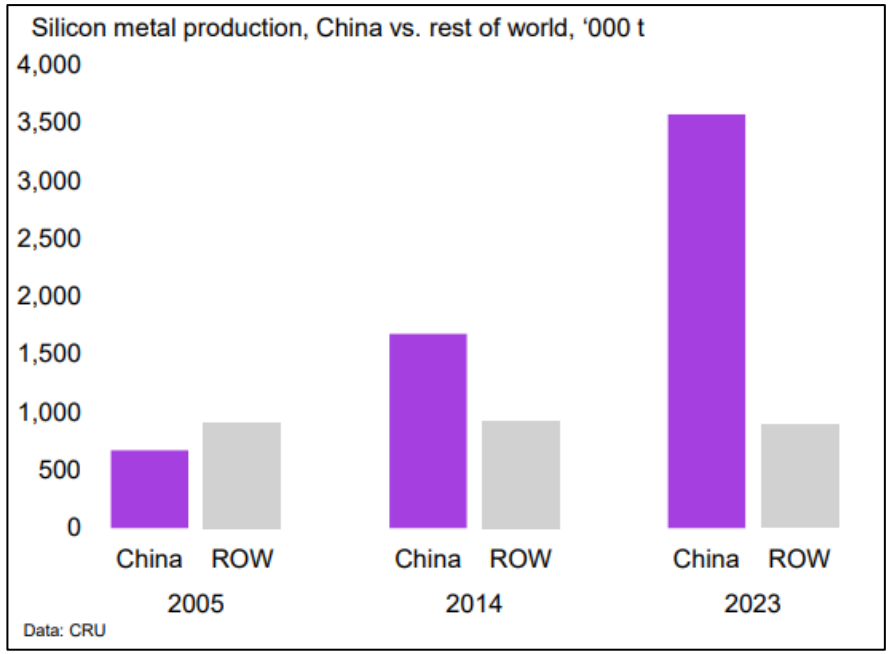


"We have reached the point where, without action, we will have to either compromise our welfare, our environment or our freedom" – Mario Draghi

Source: EU competitiveness: Looking ahead - European Commission (europa.eu)

Challenges for the Process Industry
Some takeaways from the Draghi report

SILICON PRODUCTION CAPACITY BUILD-UP



Source: CRU Conference 2024, CRU London Head Office

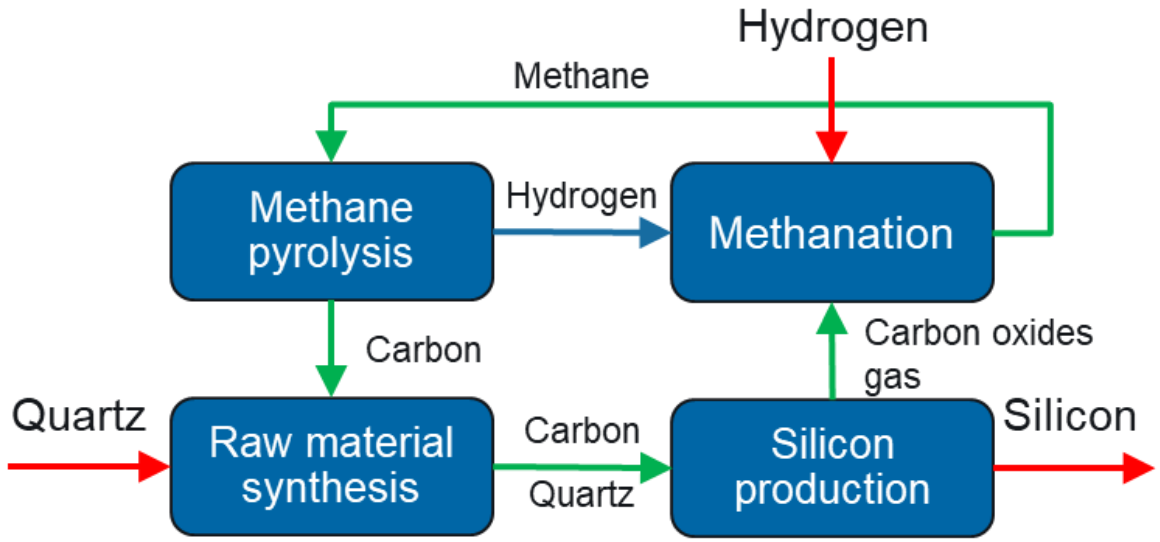
THREE FUNDAMENTAL CHALLENGES

- IP
  - Foster an environment for innovation and best practice sharing in a static industrial structure
- Resource efficiency
  - With structurally higher energy and raw material costs, resource efficiency is paramount (a good cost position is never a disadvantage)
- CAPEX
  - Compared with China, the cost of industrial plant projects is much higher in Europe. Hence, capital efficiency should be emphasized when developing new chemical processes

Sicalo – Silicon production with carbon looping

► A potential changer for the global silicon industry

- Sicalo is a new concept for silicon production where all direct CO_2 emissions and the need of carbon reduction materials are eliminated.
- The carbon in the process off gas is captured, recycled and reused as a solid carbon reduction material to produce silicon.
  (Carbon Capture and Looping – CCL)
- The potential reduction in direct CO_2 emissions from Elkem's smelters is 2 million tons/year.
- Carbon looping may become a game changer for the silicon industry globally, providing cost efficient production of silicon at minimum climate and environmental footprints.



- **2020:** The Sicalo concept was initiated.
- **2021:** An R&D project established with dedicated resources.
- **2022-2024:** Phase 1 is ongoing with laboratory and bench scale testing with financial support from an RCN IPN project where SINTEF and Norce participates.
- **2024:** Start-up of Phase 2 medium-size pilot testing of key processes. External funding secured by approval of Horizon Europe and ENOVA projects and participation in the Research council of Norway's projects GreenBox and FME HyValue.

Personal reflections

Competence and research in chemical process technology

WHAT IS CHEMICAL ENGINEERING?

- Chemical engineering is the branch of engineering concerned with the design, construction, and operation of machines and plants that perform chemical reactions on an industrial scale.
- Examples of processes are: oil production and refining and production of inorganic fertilizer, plastics, fine chemicals, metals, paper, synthetic fiber, new materials and food.
- Despite many different products and productions methods, there are from a chemical engineer's viewpoint many similarities between the different processes.
- Especially the idea that one can assemble any process from a certain number of building blocks (unit operations) is important.

SUCCESSFUL CHEMICAL ENGINEERS

In addition to the typical and traditional competences, successful chemical engineers

- Can distinguish between actual process behavior and limitations in process instrumentation and sensors
- Understand process dynamics / dynamic behaviour of complex industrial processes
- Use advanced software and simulations to troubleshoot, and make decisions based on quantitative information
- Modify processes and implement operational changes in real life
- Work well with operators and other colleagues with no or limited academic background

Technology as competitive advantage
Additional competency for future chemical engineers

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PROFITABLE CHEMICAL COMPANIES

Profitable chemical companies are characterised by:

- High quality products
  - Customers are willing to pay more for their specialty product vs the alternative
- Efficient operations
  - Automated processes with high raw materials and energy yields.
- Raw materials at the right quality and cost
  - Align product and raw material specifications
- Low CAPEX
  - Cost efficient construction and modification projects
- Safe operations
  - In-depth understanding of process safety risks
- Environmental compliance
  - Compliance with emissions permits and requirements for recycling and biodegradable materials

FUTURE FOCUS FOR CHEMICAL ENGINEERS

The Norwegian Process Industry may benefit from increased focus on:

- Chemical and metallurgical specialty products
  - If competitors have scale and cost advantages, you need to get better paid for your products
- Circular economy
  - Design products and processes for recycling
- Utilization of large variations in power price
  - Future power prices will have large variations within intervals of 1-10 minutes
- Integrated process and facility development
  - Low CAPEX production processes, ideally in combination with the ability to take advantage of power price variations
- Process safety
  - Hydrogen, ammonia and CO_2 are expected to be important for the future low-carbon society. These substances represent serious health and safety risks

Concluding remarks

- The process industry in Europe faces fierce competition from China and the USA. Decarbonisation without carbon leakage represents a major challenge for the industry.
- CCS will play an important role in the future. However, carbon looping and other alternative technologies for GHG emission reductions may offer more cost-efficient alternatives.
- Several graduates from the Department of Chemical Engineering have taken central positions and contributed to the development of the Norwegian Process Industry. The department should continue developing the programme content and research topics, to further support profitable transformation of the process industry.

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Back-up