Preferred partner

Value creation
through **innovation**

CCS-teknologien er klar

- La oss få gjennomført et miljøprosjekt i Norge

Oscar Graff | Leder for karbonfangst og lagring (CCS)

Oslo, 10.02.2016

This is Aker Solutions

Employees: **16,000**

Revenue: **33.0 bn**

EBITDA: **2.7 bn**

EBIT: **2.0 bn**

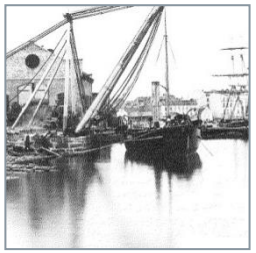
Market Cap: **6.6 bn**

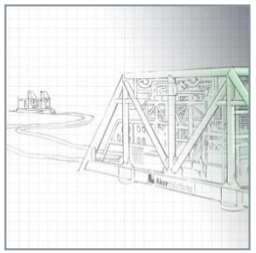
Revenues and profits are in NOK and are based on the annual results for 2014.

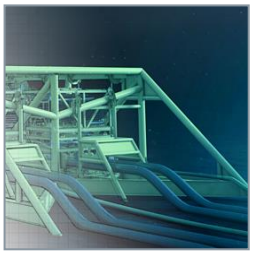
Market capitalization as of January 8, 2016.

1€= ~9,5 NOK, 04.02.2016

- Aker Solutions is a global provider of products, systems and services to the oil and gas industry
- Built on more than 175 years of industrial tradition
- Employs approximately 16,000 people in about 20 countries







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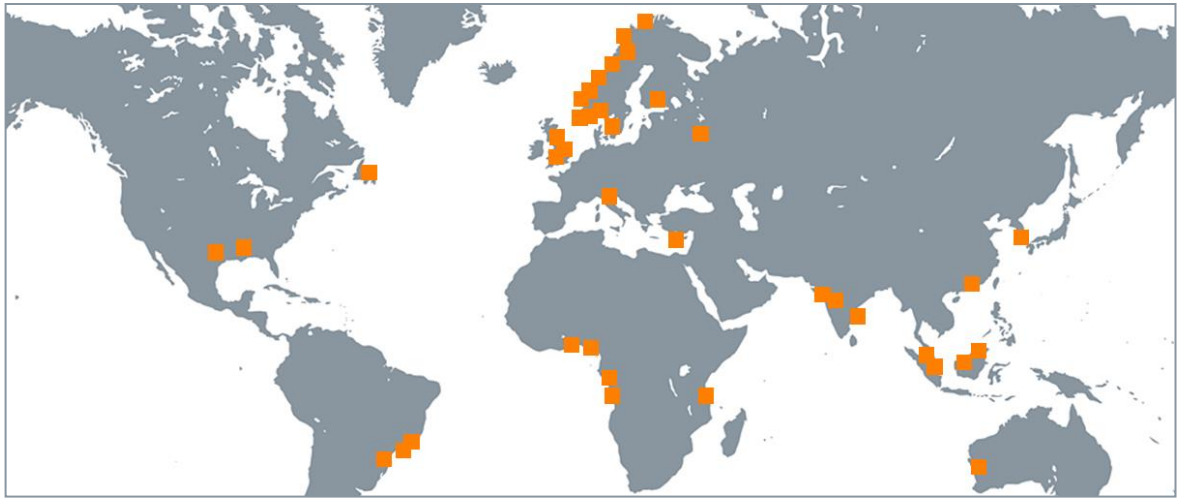
Where We Are – Global Footprint

Countries: **~20**

Locations: **~50**

- engineering hubs
- service bases
- manufacturing plants
- sales offices
- project management



Angola
Luanda

Australia
Perth

Brazil
Curitiba
Rio das Ostras
Rio de Janeiro

Brunei
Kuala Belait

Canada
St. Johns

China
Shenzhen

Cyprus
Limassol

Finland
Helsinki

Ghana
Accra

India
Mumbai
Pune
Kakinada

Italy
Milan

Malaysia
Kuala Lumpur
Labuan
Port Klang

Norway
Bergen
Egersund
Fornebu
Hammerfest
Kristiansand
Kristiansund

Norway [cont.]
Moss
Sandnessjoen
Stavanger
Tranby
Tromso
Trondheim
Ågotnes

Nigeria
Lagos

Republic of the Congo
Pointe-Noire

Russia
Moscow

South Korea
Geoje

Sweden
Gothenburg

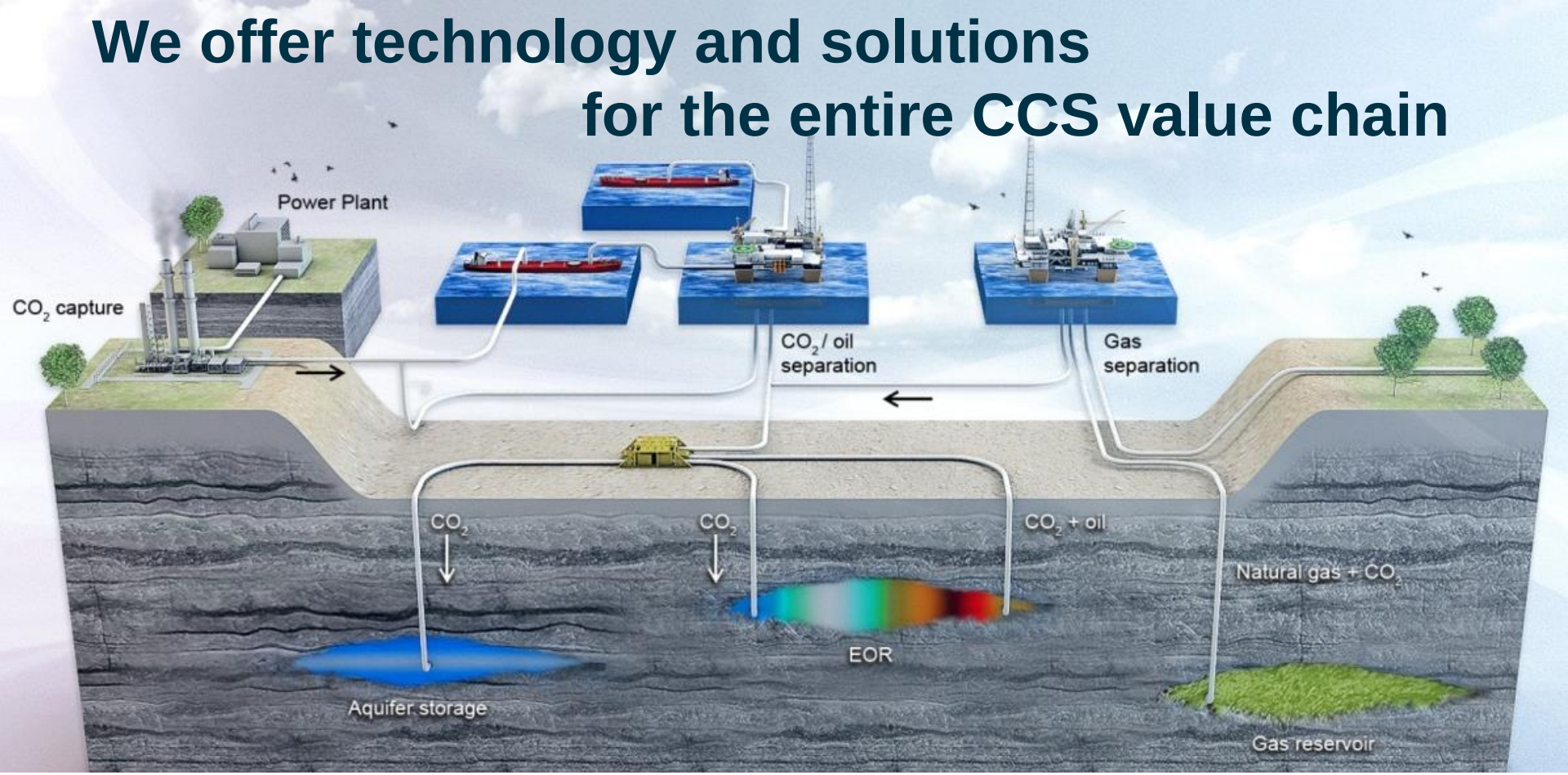
Tanzania
Dar-es-Salaam

UK
Aberdeen
London
Great Yarmouth
Hastings
Maidenhead
Glasgow

USA
Houston
Mobile

AkerSolutions™

We offer technology and solutions for the entire CCS value chain



- **Carbon capture technology**
- CO_2 transport solutions
- CO_2 injection templates (subsea)
- CO_2 storage evaluations
- EOR evaluations
- CO_2 separation from natural gas
- Closed flare systems (CO2 avoidance)
- Equipment delivery

Engaged in CCS activities since 1996

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CCS in Aker Solutions

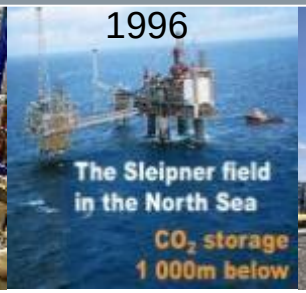
A global supplier of cost-effective CO_2 capture plants and technology

Technology ownership: Aker Solutions (100%), Fornebu (Oslo), Norway

- A focused technology company
  - 20 years of CCS know-how and experience acquired via Aker projects
  - Core competence within flue gas treatment and CO_2 capture
  - Invested ~400 MNOK (~€42M) in capture technology
  - Leading one of the largest CCS R&D programmes in Europe (SOLVit)
  - Operating a unique, advanced mobile test unit (MTU), engaged in several CCS projects.
  - Design, construction, start-up and operation of amine plant at Technology Centre Mongstad (TCM)
  - About 30 experts and 300 employees in Aker companies have been engaged in CCS
  - A leading technology provider of carbon capture world-wide (fossil fuels, refineries and cement)
  - Ongoing testing of CC on WtE plant in Oslo, Norway
- Aker Solutions' step by step business approach:

Develop – Test – Improve – Deploy

NTNU/SINTEF Lab Rig



Sleipner Field

Kårstø CO_2 Pilot

Kårstø Demo Study

Mobile Test Unit (MTU)

Large Scale Pilot TCM

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SOLVit

Solvents for the next generation of post combustion CO_2 capture systems

AkerSolutions SINTEF NTNU CLIMIT GASSNOVA

Unique carbon capture R&D program in Europe

AkerSolutions

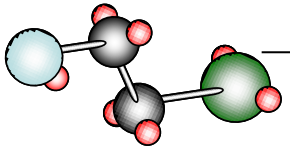
SOLVit – main objectives

- Develop and demonstrate solvents with minimum energy consumption and lowest possible environmental impact. This is done step-wise and systematic:

88 months
332 MNOK
50 researchers
Six pilot plants
90 solvents

SOLVit staged development and piloting

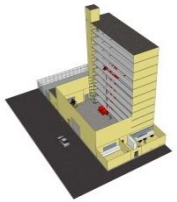
Theoretical evaluations



Lab-bench scale

Lab-pilot scale

Full-height pilot, Tiller



Real exhaust
- MTU
- Heilbronn

TCM & Norcem

- Solvent developments & testing
- Emission monitoring
- Material testing (steel & PP)
- Reclaiming testing (IFE)

Develop demonstration program to transfer experimental data to **cost-effective process and plant design**

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Achievements – Improved Energy Efficiency

- Compared to project references “Bellingham plant“ (NG) and Esbjerg pilot plant (Coal) a reduction of the energy consumption with 10-25% has been demonstrated in pilot plants with 1st generation solvents.
- Applying an advanced process flow sheet increases energy saving of 1st gen. solvents with up to 35% compared to reference

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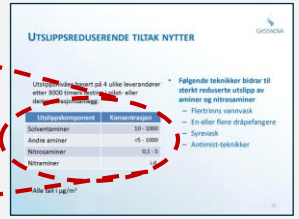
Achievements – Demonstrated very low emissions at TCM

- Very low emissions were achieved when treating flue gas form the gas fired CHP plant at Mongstad.
- These tests were part of the CCM qualification – **Best in class**

- CCM TQP emission levels results (Gassnova):
  - Ranges of emission levels from carbon capture technology suppliers measured as part of CCM Technology Qualification Program (TQP)
  - Ranges for all technology suppliers
    - Solvent amines: 10 – 10 000 µg/m³
    - Other amines: < 5 – 1 000 µg/m³
    - Nitrosamines: 0.1 – 5 µg/m³
    - Nitramines: i.d.



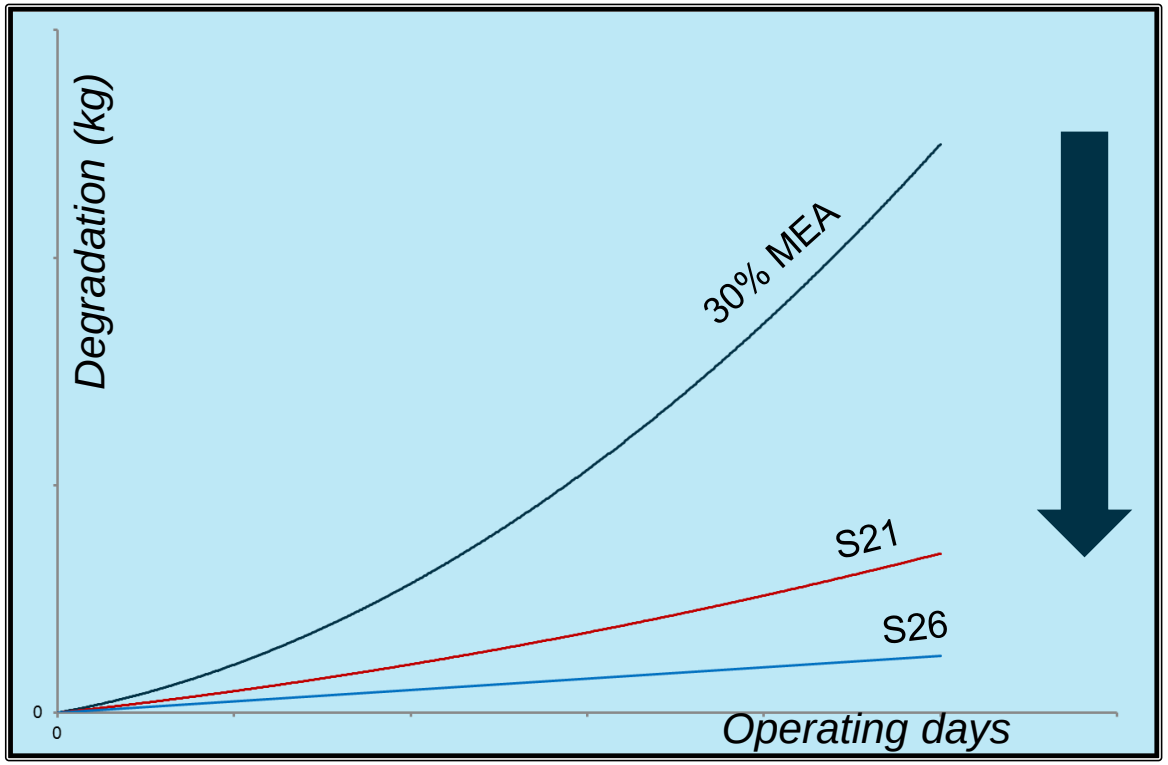
(ref. CO2 conference 2014, Trondheim)

- ACC™ Emission Control System:
  - Solvent amines: 9 µg/m³
  - Other amines: < 6 µg/m³
  - Nitrosamines: 0.07 µg/m³
  - Nitramines: < 0.1 µg/m³

- Lower limits in the CCM TQP emission levels ranges identical to results demonstrated by Aker Solution's ACC™ ECS technology

- Results from CCM Technology Qualification Program using ACC™ advanced solvent
- Sampled and analysed by third parties KEMA (Netherlands) and Rambøll (Finland)
- Gassnova slide excerpt from *Kaasa, S. CO_2-konferansen 2014, Kursdagene Tekna, Trondheim, 2014*.

Excellent test results at TCM - Solvent degradation



Reduced degradation:

- less make-up
- less emissions
- less reclaiming
- less waste
- less corrosion
- cheaper materials

= **Cost reduction**

Demonstrating the superior degradation resistance of Aker Solutions' ACC™ advanced solvents: S21 & S26

Note: Our S26 solvent is ten times better than the standard amine (MEA)

Achievements – Reduced degradation

- Discoloration of solvents (indicator of solvent stability) during operation on coal flue gas at EnBW's Heilbronn pilot plant

MEA Reference Campaign, 920 h

SOLVit CC2 Campaign, 1 210 h

SOLVit CCx2 Campaign, 2 090 h

No further discoloration until end of campaign

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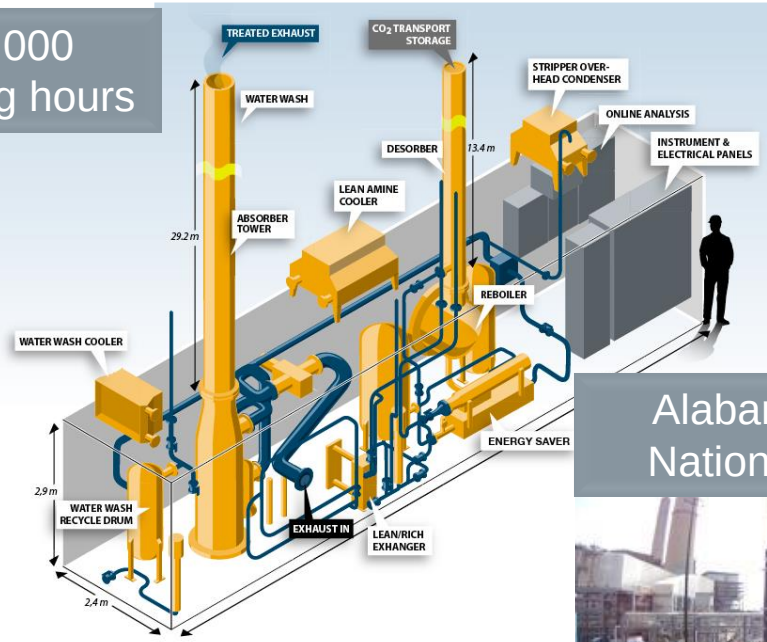
MTU, Mobile Test Unit - Advanced CO_2 capture pilot

Test campaigns in industrial environment since 2008: coal & gas power, refinery & cement industry

Over 20 000 operating hours



MTU in operation at Longannet Power Plant

2009

ACC™ 1st in UK

Alabama, US National CCC

2011

ACC™ 1st at NCCC

Risavika & TCM Norway

2008 **2012**

ACC™ 1st at TCM

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Technology Centre Mongstad (TCM)

- World's most advanced amine plant
- Designed and delivered by Aker Solutions/Kvaerner
- Excellent industrial scale test results from 2 years operations
- Demonstrated scale-up from MTU with SOLVit solvents

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Conclusions from TCM

- The test campaigns at CO_2 Technology Centre Mongstad (TCM DA) have shown that ACC™ advanced solvents S21 and S26 show good energy performance and are superior to 30 wt% MEA with respect to solvent degradation, ammonia emission and nitrosamine formation.

- Based on the successful execution and evaluation of the campaigns, it can be concluded that Aker Solutions' Advanced Carbon Capture™ technology is proven and ready for full scale implementation.

Key performance

- Operation
- Emissions
- Solvent stability, degradation
- Reclaiming
- Energy performance

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Cooperation with Norcem in Brevik, Norway

Norcem is part of the Heidelberg Group and cooperates with ECRA

Norcem is one of three candidates for national CCS demo project in Norway

Norcem has selected our ACC™ technology for further developments

- 1st large scale testing globally on a cement factory – pioneer work!
- Excellent test MTU results from May 2014 till October 2015
- Ongoing study (capture, integration, intermittent storage & ship loading
- Cement industry is a good candidate for carbon capture:
  - High CO_2 content (18-22 volume-%), (Gas power= 3,5%, coal= 13%)
  - Available waste heat for the amine plant (almost for free)
  - Gives more compact and competitive capture plants

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Ongoing MTU test and study of CC at Klemetsrud WtE plant

- Klemetsrud is one of three candidates for national CCS demo project in Norway

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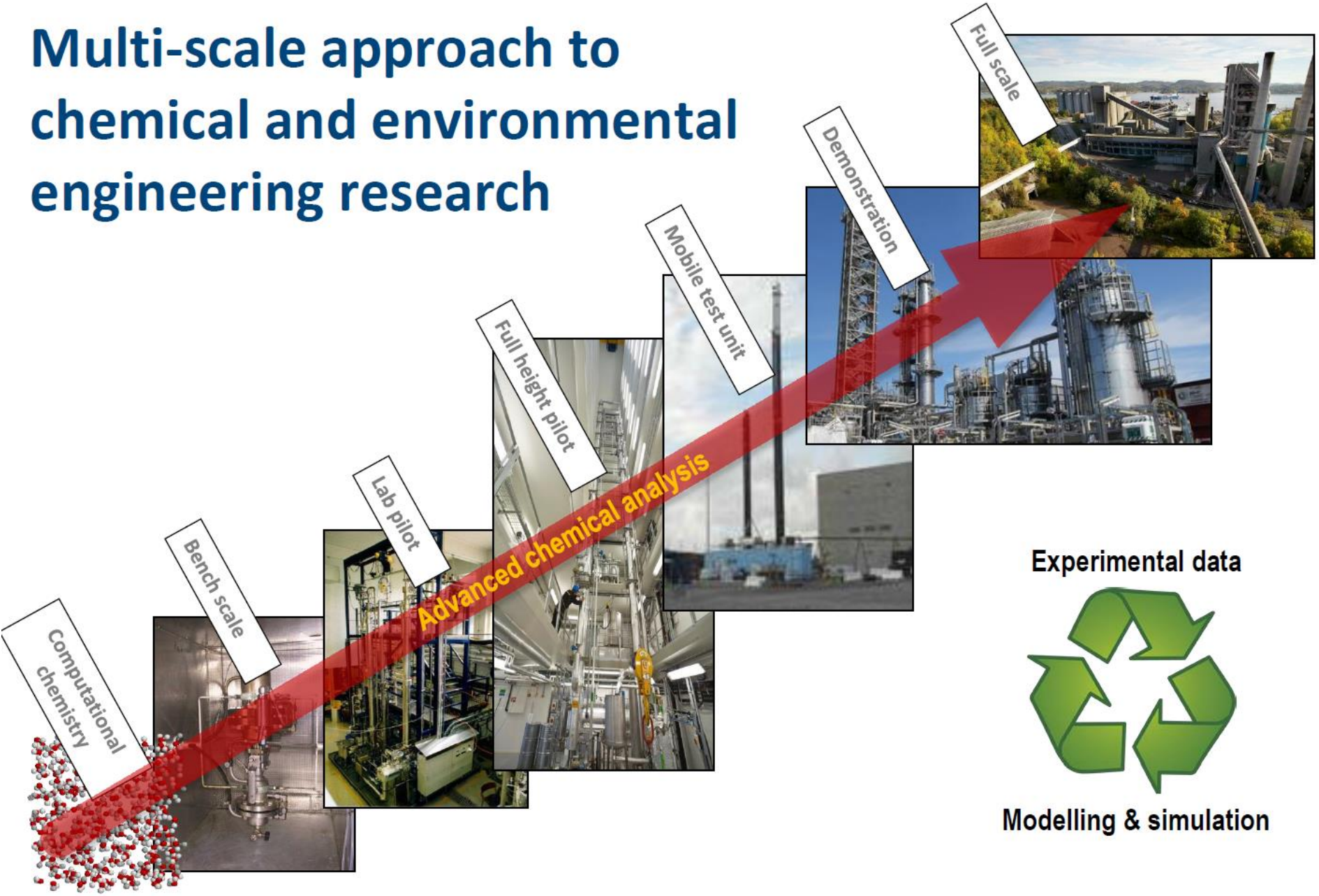
Technology status - Aker Solutions

Based on SOLVit and other spin-off activities Aker Solutions can offer:

- Green solvent (as green as an amine solvent can be) with:
  - Improved HSE characteristics
    (non-toxic, nonhazardous for aquatic organisms, ready biodegradable, etc.)
  - Improved energy consumption
  - Low degradation and waste (robust)
  - Minimum corrosion
  - Efficient reclamation (HSS removal ~90%)
- Carbon capture plants with:
  - Minimum emission (best in class)
  - Minimum liquid waste (robust solvent and efficient reclamation)
  - Less energy requirement (- 35%)
  - Cheaper materials, lifetime >25 years
  - High availability (93% at TCM campaign)
  - Technology and process validated through long term operation in industrial scale plant
- Qualified for large scale application

Multi-scale approach to chemical and environmental engineering research



Experimental data

Modelling & simulation

- **Norge gjennom forskningsrådet, Gassnova og TCM har investert ca. 10 milliarder kr i teknologiutvikling.**
- **Aker Solutions har investert 400 millioner kr i forbedret fangstteknologi og resultatene er gode**
- **CCS teknologien er klar til bruk i stor skala**

- **La oss få gjennomført et miljøprosjekt i Norge!**

Vi er klare!

AkerSolutions™

Contact details

Oscar Fr. Graff

Manager & CTO

Carbon Capture and Storage (CCS) Department

Aker Solutions

Snarøyveien 20

NO-1360 Fornebu

NORWAY

Mailing address: PO Box 222, NO-1326 Lysaker, Norway

Phone: +47 67 59 50 00

Fax: +47 67 51 35 90

E-mail: oscar.graff@akersolutions.com

Read more about CCS in Aker Solutions:

http://akersolutions.com/what-we-do/products-and-services/carbon-capture-and-storage/

Test Center Mongstad (TCM)

- Video at youtube:

https://www.youtube.com/watch?v=adu4-ahLE_0&feature=youtu.be

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