European Carbon Dioxide Capture and StoragE Laboratory Infrastructure

Enabling low to zero CO₂ emissions from industry and power generation

Implementation and operation of ECCSEL

www.eccsel.org

E-mail: volker.rohling@ntnu.no
Vision and Objectives

IEA 1.5 degrees low carbon path

- Nuclear 8% (8%)
- Power gen. efficiency and fuel switching 3% (1%)
- Renewables 21% (23%)
- End-use fuel switching 12% (12%)
- CCS 17%
- End-use fuel and electricity efficiency 42% (39%)

Reduction needed to keep global warming within 1.5 °C

Reduce global warming
Reduce CO₂ emissions
Close the knowledge gaps

www.eccsel.org
Vision and Objectives

ECCSEL vision:
*Enabling low to zero CO₂ emissions from industry and power generation*

The main objectives of the ECCSEL initiative

- Establish and operate a world class distributed Carbon Capture and Storage (CCS) research infrastructure in Europe
- Integrate and upgrade existing research facilities and supplement with new ones
- Enhance European science, technology development, innovation and education in the field of CCS
- Enable spin-off activities and generation of new business
What is ECCSEL?

ECCSEL is implementing and operating an European distributed, integrated Research Infrastructure (RI) based on a selection of the best research facilities in Europe for CO2 capture, storage and transport research.

- Establish and maintain the **most advanced CCS research facilities**, resources and related services to set **standards** in science and technology **beyond the state-of-the-art**
- **Promote** and pursue **research projects** selected according to scientific criteria and/or techno-economic potential and for de-risking CCS technologies
- CCS research with future options for **tail-end usage** of CO2 (CCUS - narrow definition) where relevant
- Offering **open access to advanced laboratories** for talented scientists and visiting researchers to conduct cutting-edge research
- **CCS research for** power generation and industrial processes (i.e. iron and steel, cement, chemicals, refining, gas processing, paper, biofuels, aluminum, etc.)
What is ECCSEL?

ECCSEL is
• A dedicated research environment,
• striving to close specific knowledge gaps,
• pushing the forefront of technological development beyond the state-of-the-art,
• and thereby accelerating the commercialisation and deployment of CCS.

ECCSEL will coordinate necessary infrastructure investments thereby reducing overcapacity and cost at a European scale.

ECCSEL past
ECCSEL present
ECCSEL future
ECCSEL has focus on all CCS technologies

**Capture and transport**
- Post-combustion CO$_2$ capture
- Pre-combustion CO$_2$ capture
- Oxy-firing
- CO$_2$ transport

**Storage**
- Onshore and offshore
- Storage site characterisation & capacity assessment
- Efficient and safe operations
- Monitoring and verification
- Safe long term storage and associated modeling

Focus is also on integrational aspects of the whole CCS value chain

CCS for Industry and Power Generation
ECCCEL Benefits

Benefits to be part of ECCSEL

- **Prioritised & easy access** to the best laboratories in Europe
- Increase **Industry competitiveness** for CCS (with USA / China etc.)
- **Cooperation** with and **cost sharing** among many partners in Europe
- **Commercial spinoffs** across the CCS chain, implying business development and job creation
- **Increased research facility utilisation**
ECCCEL Benefits

Benefits to be part of ECCSEL

- Valorisation of capital by sharing investments and risks
- Admission to the comprehensive ECCSEL research facilities ensured by agreed common access rules
- Possibilities to attract joint funding of research projects making use of world-class laboratories and expertise
- Topical leadership in European research towards the wider deployment of CCS
- Knowledge sharing supporting research, education and innovation
- Insight and influence on the complete ECCSEL operation, and opportunity to generate cost effective cooperation related to investments and knowledge sharing
- Sustain own excellence in CCS by attracting distinguished scientists and leading industry to domestic ECCSEL facilities, and maintain insight about state-of-the-art CCS research
ECCSEL Timeline

Events

- ECCSEL on the ESFRI roadmap
- FP7 pre project granted
- H2020 implementation granted
- ECCSEL on the ESFRI 2016 Roadmap
- ECCSEL to be converted into a legal entity (ERIC)

Funding

- Project funding PP1/PP2
  - EC FP7: 2.5 MEUR
  - RCN/CLIMIT: 1 MEUR
  - Other partners: 1 MEUR
- Horizon 2020 Infradev-3 funding
  - 3.3 MEUR
- Infrastructure investments (until 2030)
  - 200+ MEUR
    (Funded by EU, member states, funds, industry...)
ECCSEL - the past

ECCSEL PP1
ECCSEL PP2
ECCSEL Transitional phase
ECCSEL - the present

- Horizon 2020 Infradev-3 Project
- EU sponsored Transnational Access to 43 facilities
- Scaling up operations
- Access to those and other facilities also available (managed by ECCSEL)
- Update of list of required facility upgrades and required new research facilities
- Industrial Advisory Group (IAG) of ECCSEL
  - Active in supporting the industrial alignment with ECCSEL CCS research infrastructure
  - Create an Industrial Community Platform
  - Raise awareness of the ECCSEL objectives across the industry group
  - Become an effective interface between the industry group and the ECCSEL community
ECCSEL - the present

ECCSEL Implementation

WP1: Central Management & Coordination of Access
- Operations Centre
- National Nodes
- Peer review of access projects
- Quality management

WP2: Business Case Consolidation & Enlargement of Membership
- Member consolidation
- Enlargement
- Funding model
- Industrial engagement

WP3: Implementation & development of ECCSEL RI
- Enhance technical architecture
- Common standard

WP4: Long-term Research Strategy
- Exchange best practices
- User needs mapping
- ECCSEL Roadmap

ECCSEL Initial Operation

WP5: Capacity Building
WP8-21: Transnational Access

WP6: Outreach - Dissemination
- Training of users
- Outreach of users
- Uses access facilities

WP7: Project Coordination
- Research and Innovation activities
- Dissemination
Horizon2020 INFRADEV-3-2015: Individual Implementation and Operation of ESFRI projects

Financial Support for Implementation and Initial Operation activities (ECCSEL 3 Mill EURO):

- Enlargement of membership
- Enhancement of technical architecture
  - Development of final prototypes, implementation plans
  - Development of methodologies, protocols, instrumentation
- Central Coordination
  - Setting up and initial running of the central coordination office (Operation Centre)
  - Organization of logistic support for researchers
- Transnational Access
- Data Management (open access to data)
- Training, Outreach
- International Cooperation
- Research and Innovation Activities
Implementation

9 countries
14 partners

ECCSEL preparatory phase

- Legal & governance
- Financing strategy
- Infrastructure development plan
- Access Policy & IPR
- Communication
- Outreach strategy
- Business Plan

H2020 Infradev3 Consortium (2015 - 2017) with 43 research facilities/installations
Implementation and Transnational Access

By category/science area

Capture Labs
- Absorption Labs
- Membrane Labs
- Solid Sorbent Labs
- Cryogenics Labs
- Combustion Labs

Transport Labs
- CO₂ characterization Labs
- Material integrity Labs

Storage Labs
- Rock characterization Labs
- Field Labs

HORIZON 2020

www.eccsel.org
Transnational Access

43 Fact sheets (web)

- Organisation name
- Installation name
- Location (Google map)
- Category, Science area
- Short description
- Pictures
- Calendar (availability soon)

Fact sheets (non-EU_TA) of other facilities also be added
Transnational Access (funded by the H2020 Infradev3 Project)

- **Start/End**
- **“Open” CALL published early 2016**
- **Application made by Potential Users**
- **Pre-Screening of Applications**
- **Successful Projects/Users access the Infrastructure**
- **HSE and Practical Local Training**
- **Dissemination**
- **Peer Review Committee**
ECCSEL the future

- ECCSEL ERIC established end 2016
- More partner countries
- More facilities part of the ECCSEL RI
- Innovation Management system fully implemented
- Cooperative research projects
- Industrial partners
Ministry meeting for ECCSEL, Schiphol, 4th February 2016

<table>
<thead>
<tr>
<th>ECCSEL ERIC application timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meeting – Governmental Rep Group at Schiphol / Amsterdam</strong></td>
</tr>
<tr>
<td>Finalising application documents based on input from meeting and by communication with possible founding members</td>
</tr>
<tr>
<td>Obtaining formal commitments from at least three founding members</td>
</tr>
<tr>
<td><strong>Send step 2 (final) application to the Commission</strong></td>
</tr>
<tr>
<td>Continue obtaining formal commitments from founding members</td>
</tr>
<tr>
<td>Commission Decision (6 - 8 months)</td>
</tr>
<tr>
<td><strong>First formal General Assembly of ECCSEL ERIC</strong></td>
</tr>
</tbody>
</table>
Functional organisational structure of ECCSEL

- **General Assembly**
  - **ECCSEL Operations Centre**
    - Director, Management & Administration
    - **Nat. Node 1**
    - **Nat. Node 2**
    - **Nat. Node 3**
    - **Nat. Node n**
  - **Entry point**
  - **Research facilities**
  - **Research institutes**
  - **Universities**
  - **Industry**
  - **User groups**
    - RCN, E21, Gassnova, GCE, DECC CATO, CIUDEN
  - **Owners (seats)**
    - Nat. Node Norway, UK, Netherlands, Spain, Greece, France, Switzerland, Italy, Poland
  - **Binding access rules**
    - HSE, IPR
  - **Peer review**
    - Scientific
    - Industry
    - Ethics & Environment
  - **ECCSEL RI Coordination Committee**
  - **ADVISORY COMMITTEES / Boards**

- **NATIONAL STAKEHOLDERS**
- **OWNERS** (seats)

- **Facility operators / owners**
Overall ECCSEL ERIC Operations Centre responsibilities and tasks

Operations Centre (OC)

Executive Director

Administration
- Finance
- Accounting
- Legal
- HR
- HES & Q
- IT
- ...

Strategic scientific and technical planning and coordination

Operations

Development

Community building, Outreach, Promotion and Education

Lean organization:
- 4-6 employees
- Annual budget ≈ 1 MEUR
Including in-kind contributions

Location:
NTNU/SINTEF Campus
Trondheim, Norway
Future Infrastructure Investments

Gap analysis – main conclusions

- **Capture and transport:** Need for up-scaling promising solutions and testing at more severe experimental conditions (pressure, temperature, gas compositions, ..)

- **Storage:** Need for a variety of test/pilot sites throughout Europe

[Image of various stages of infrastructure development: Simulations, Lab pilot, Full height pilot, Mobile test unit, Demonstration, Full scale]
## Future Infrastructure Investments

### New Capture Facilities (Extract)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Priority</th>
<th>Category</th>
<th>Budgeted investment cost in million €</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Mobile unit (container size) for testing of CO₂ capture from flue gases by absorption/desorption (~1000 m³/h)</td>
<td>High</td>
<td>New</td>
<td>3-5</td>
</tr>
<tr>
<td>14</td>
<td>Facility for testing (pilot scale, 1-10 m²) of inorganic membranes and modules for oxy- and Pre-combustion applications</td>
<td>High</td>
<td>New</td>
<td>3-4</td>
</tr>
<tr>
<td>15</td>
<td>Experimental facility (small pilot) suitable for CO₂ purification of gas mixtures originating from oxy-combustion processes as well as CO₂ / H₂ separation, for pressures up to 110 bar and temperatures -70 °C - +50 °C. The test rig should be highly instrumented to monitor the operation of heat exchangers and non-equilibria operations, and be built to handle the HSE requirements of H₂.</td>
<td>High</td>
<td>New</td>
<td>3-4</td>
</tr>
<tr>
<td>16</td>
<td>Aerosol counter measure development facility: demonstration of suitable countermeasures for aerosol formation during post-combustion capture at different scales. Lab pilot: special demisters, wet electrostatic precipitator (WESP), impactor. Pilot scale (real flue gas): wet electrostatic precipitator.</td>
<td>High</td>
<td>New</td>
<td>2-3</td>
</tr>
<tr>
<td>17</td>
<td>Experimental facility for adsorption techniques capturing CO₂ from flue gases at atmospheric pressure. The facility should preferably be located to an industrial site where a realistic gas mixture can be provided. A mobile unit serving various purposes is preferred.</td>
<td>High</td>
<td>Medium</td>
<td>New</td>
</tr>
<tr>
<td>18</td>
<td>Facility for testing (pilot scale, 1-10 m²) of inorganic high-temperature CO₂/H₂-separating membranes and modules (pre-combustion power plant and industrial type applications). This facility should allow testing of high-temperature H₂S removal.</td>
<td>Medium</td>
<td>High</td>
<td>New</td>
</tr>
<tr>
<td>19</td>
<td>Experimental facility for testing of CO₂/H₂-separation at pressures up to 110 bar with auxiliary refrigeration at temperatures down to at least -60°C. Test rigs are further needed to be built to handle the HSE requirements of H₂.</td>
<td>Medium</td>
<td>New</td>
<td>2-3</td>
</tr>
<tr>
<td>20</td>
<td>Experimental facility to investigate heat transfer and pressure loss in heat exchanger channels for CO₂ mixtures.</td>
<td>Medium</td>
<td>New</td>
<td>1-2</td>
</tr>
<tr>
<td>21</td>
<td>Experimental facility for efficient laboratory screening and characterisation of absorption solvents at higher pressures. (Low CO₂ partial pressure and higher total pressure equilibrium measurements and high-pressure kinetics.)</td>
<td>Medium</td>
<td>New</td>
<td>2-3 or upgrade existing</td>
</tr>
<tr>
<td>22</td>
<td>Experimental facility for membrane technology capturing CO₂ from flue gases at atmospheric pressure. The facility should preferably be located to an industrial site where a realistic gas mixture can be provided.</td>
<td>Medium</td>
<td>New</td>
<td>4-6</td>
</tr>
<tr>
<td>23</td>
<td>Experimental facility (pilot &gt;3 MW thermal) for Chemical Looping Combustion (CLC) for solid fuels.</td>
<td>Medium</td>
<td>New</td>
<td>10-15</td>
</tr>
</tbody>
</table>
# Future Infrastructure Investments

## New Storage Facilities (Extract)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Priority</th>
<th>Category</th>
<th>Budgeted investment cost in million €</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>A pilot scale research facility for injection into a fracture to study migration and attenuation processes during migration through the overburden. Challenges could be site identification and permitting. ➔ Hontomin and Svalbard may be possible candidates.</td>
<td>High</td>
<td>New or upgrade existing</td>
<td>3-8</td>
</tr>
<tr>
<td>26</td>
<td>A large (i.e. metres-scale) true tri-axial cell to enable cap rocks. Such a cell will give us the realistic stress testing for reservoir and opportunity to investigate more realistic stress distributions. For example, we could run fracture propagation tests which are not possible in existing equipment due to boundary effects.</td>
<td>Medium</td>
<td>New</td>
<td>2-3</td>
</tr>
<tr>
<td>27</td>
<td>Well scale testing facility at well (with realistic diameter) for evaluating in-situ a range of in-situ potentially damaging processes specific to CCS wells (temperature changes, pressure changes, low pH conditions...). This implies: cement-rock bonding, casing-cement bonding, casing boundaries, remediation technologies, borehole monitoring.</td>
<td>Medium</td>
<td>New</td>
<td>3-5</td>
</tr>
<tr>
<td>28</td>
<td>Engineering facility to develop new low-cost, advanced, drilling techniques for site characterisation and monitoring. ➔ Svelvik may be a potential candidate</td>
<td>Medium</td>
<td>New</td>
<td>2-4</td>
</tr>
<tr>
<td>29</td>
<td>Facility to simulate leakage for developing models and integrated monitoring technologies for offshore storage. ➔ No storage site needed.</td>
<td>High</td>
<td>New</td>
<td>3-8</td>
</tr>
</tbody>
</table>

In Process to be updated by the Infradev-3 Consortium
# New (Cat 3) Transport Facilities

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Priority</th>
<th>Category</th>
<th>Budgeted investment cost in million €</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>Experimental facility to test various properties of CO₂ and mixtures with CO₂: phase behaviour including hydrate formation, liquid phase density, viscosity, thermal conductivity, speed of sound in liquid phase, surface tension, diffusion coefficients and heat capacity. Large span of temperature and pressure.</td>
<td>High</td>
<td>New</td>
<td>5-8</td>
</tr>
</tbody>
</table>
**Expansion**

**ECCSEL Membership Development Plan**

**Preparatory Phase**
(2011-2014)
- **Norway (host)**
  - NTNU, SINTEF, RCN
- **France**
  - IFPEN, BRGM
- **The Netherlands**
  - TNO
- **Germany**
  - Universität Stuttgart
- **United Kingdom**
  - BGS
- **Switzerland**
  - ETH Zürich
- **Spain**
  - CIUDEN
- **Italy**
  - OGS, ENEA
- **Greece**
  - CERT, ISFTA
- **Poland**
  - PGI-NRI

**Implementation**
(2015-2016)
- **Norway**
  - (Operations Centre)
- **The Netherlands**
- **Spain**
- **United Kingdom**
- **Poland**
- **Italy**
- **Greece**
- **France**
- **Switzerland**
  - (ERIC observer)

All have signed Letter of Intent to join ECCSEL and transition MoU agreements until an ERIC is established

**Expansion**
- **Germany**
- **Czech Republic**
- **Other member states**
- **Bilateral agreements with oversea states, institutions, industry**
Thank you for the attention!

www.eccsel.org