

Overcoming environmental challenges to the implementation of post-combustion CCS

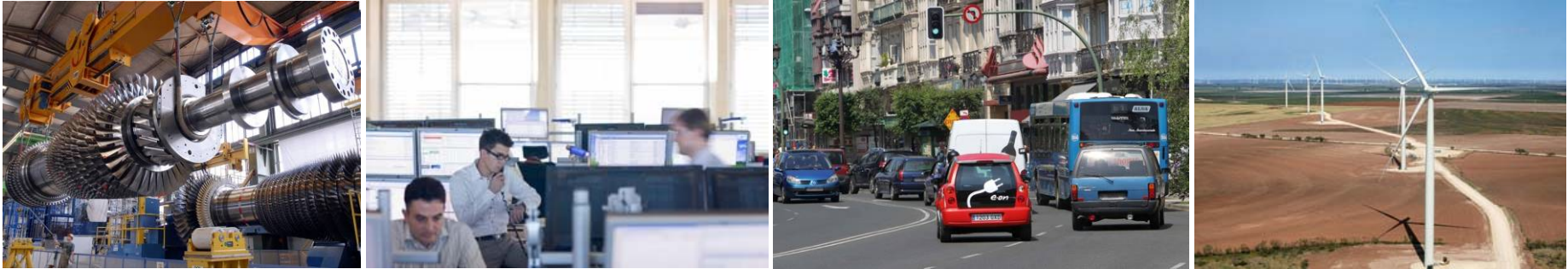
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The E.ON Group: An overview



- We stand for cleaner & better energy and are a global, specialized provider of energy solutions.
- Across our locations in Europe, Russia and North America, our more than 79,000 employees generated just under €113 billion in sales in 2011.
- Wherever we are active, our aim is for the world of energy to be cleaner & better as a result of our involvement.

E.ON & CCS

- E.ON maintains an active CCS programme
- Ensuring CCS applicability in future
- Significant proportion of R&D work delivered by E.ON New Build & Technology
- Main topics:
 - Screening of technologies
 - Pilots
 - Transportation and storage infrastructure
 - HSE issues
 - Legal and regulatory framework
 - Technical support to projects
 - Carbon Capture Ready (CCR) studies

Realising E.ON's cleaner & better strategy

E.ON New Build & Technology

We work safely within a proactive performance culture delivering solutions for our customers internationally.

Technology & Innovation



We are E.ON's knowledge base and process & execution engine

- We invest 50% of E.ON's innovation budget
- Our innovations will deliver a value (NPV) to E.ON of twice the amount invested

Major Asset Projects



We develop and execute E.ON's Major Asset Projects

- We develop and execute more than 50% of E.ON's major investments budget
- We will improve the net present value of E.ON's projects by 10% from plan to execution

Asset support



We are E.ON's high value & strategic engineering services provider

- We deliver solutions with a portfolio penetration > 75% across fleets
- Customers who choose our service will save three times our cost

Targets 2015

Key challenges to the implementation of CCS

- Financial/Economic
 - Policy/Legal
 - Regulatory
 - Public Acceptance
 - Environmental
 - Technological
- } Often more visible
- } Must not be overlooked

But...

Many environmental challenges need technological solutions

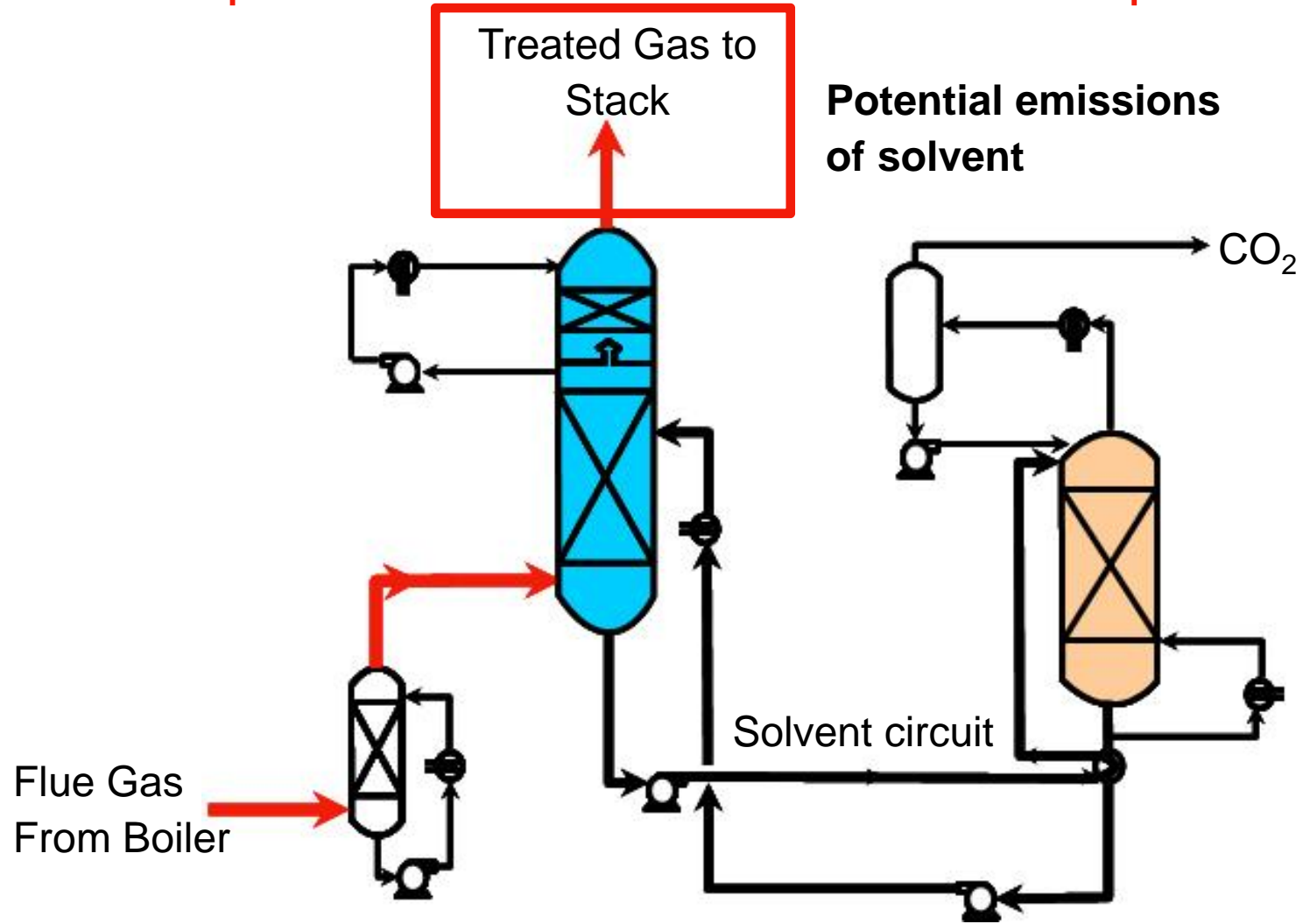
Why is addressing environmental challenges important?

- Project progress



- Ability to deploy technology
- Developing technical solutions is the right thing to do

An example: Potential emissions from PCC plant



E.ON approach to overcoming this challenge

- Collaborative research
- In-house emissions measurement capability
- In-house solvent chemistry expertise
- Work with technology suppliers
- Operational experience on our pilot plants

E.ON has supported the development of technical solutions over the last 8 years

Compound	Unit	Inlet Abs	Outlet Abs	After WW
MEA	mg/Nm ³	<0.1	0.7	<0.3
DEA	mg/Nm ³	<0.2	<0.3	<0.2
Formaldehyde	mg/Nm ³	<0.1	0.7	<0.1
Methylamine	mg/Nm ³	<0.2	<0.3	<0.2
Acetamide	mg/Nm ³	<0.6	<1.0	<1.0
Ammonia	mg/Nm ³	<0.1	23	20

EU FP7 CESAR
Esbjerg pilot results
showing affect of
Water Wash

Source: Presentation at IEAGHG workshop on environmental impact of amine emission during post combustion capture

Some examples of ongoing work...

WHV pilot plant

- Approx. 100 tpd CO₂ plant (E.ON & Fluor partnership)
- Site: E.ON 800 MW station in Wilhelmshaven, Germany
- Slipstream of 16,000 m³ of gas
- Fluor's Econamine FG PlusSM
- Began operation in June 2012

- Contributions to overcoming environmental challenges:
 - Direct experience
 - Detailed, long term information
 - Development of expertise within E.ON
 - Supporting the ROAD demo project

WHV pilot plant

FLUOR[®]



CATO-2



- Dutch national R&D programme for CO₂ capture
- Supports a TNO pilot plant at Maasvlakte, Netherlands (E.ON)
- Considers full CCS Chain

- Contributions to overcoming environmental challenges:
 - Dedicated pilot testing and investigation
 - R&D of novel solvents & solvent chemistry
 - Locally supports ROAD project

CATO-2 pilot



- Approx. 6 tpd CO₂ pilot plant with experience testing a range of solvents



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OCTAVIUS



- 13.5 MEUR EU FP7 project started in March 2012 for 5 years
- 16 partners from 8 EU nations plus Russia & South Africa
- Key objectives: To prepare for CCS using 1st generation solvent technologies & to demonstrate 2nd generation technologies
- Use of 3 major pilot plants (TNO, ENEL, EnBW)

- Contributions to overcoming environmental challenges:
 - Verify measurement techniques
 - Develop, improve & demonstrate effective countermeasures
 - Study of emissions behaviour
 - Fundamental studies of emissions and degradation

ENEL pilot, Brindisi



Courtesy of ENEL

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- Approx 100 tpd CO₂ pilot on coal flue gas

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SOLVit



Aker
CleanCarbon™



SINTEF



NTNU

- 40+ MEUR collaboration between ACC and SINTEF/NTNU
- Funded by the Norwegian Gov. through Gassnova SF
- Phase 2 with E.ON and EnBW
- Wide range of R&D activities
- Deploys two pilots: Tiller & MTU

- Contributions to overcoming environmental challenges:
 - Development and implementation of novel countermeasures
 - New solvents
 - Environmental & toxicological studies
 - New analytical methods
 - Pilot plant studies

- ACC's technology is part of the Test Centre Mongstad

Tiller



Aker
CleanCarbon™



SINTEF



NTNU



- Approx. 250 kgpd CO₂ full height
- Utilises propane burner to provide flue gas
- Can simulate coal or CCGT flue gas
- Housed in purpose built facility
- Heavily instrumented

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Benefits so far...

- Deployable technological solutions
- Fundamental understanding
- Operational learning
- Knowledge and experience of measurement
- Good relationship with a range of partners
- E.ON as an informed buyer and potential operator of CCS

Wider learning

- Working with research partners is important – fundamental knowledge
- Collaborating with technology suppliers is essential – deliver commercially available solutions
- Pilot scale testing - realistic evaluation
- E.ON's expertise – choosing most suitable CCS technology for power plant
- Tackling issues promptly - keep the technology progressing

Conclusions

- Environmental/technical challenges must continue to be considered
- Technical solutions for potential solvent emissions have been (and continue to be) developed
- Collaboration required to overcome challenges quickly and effectively
- Approach ensures we maintain CCS technologies that are deployable

Thanks for listening

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