ION Engineering: Redefining Carbon Capture

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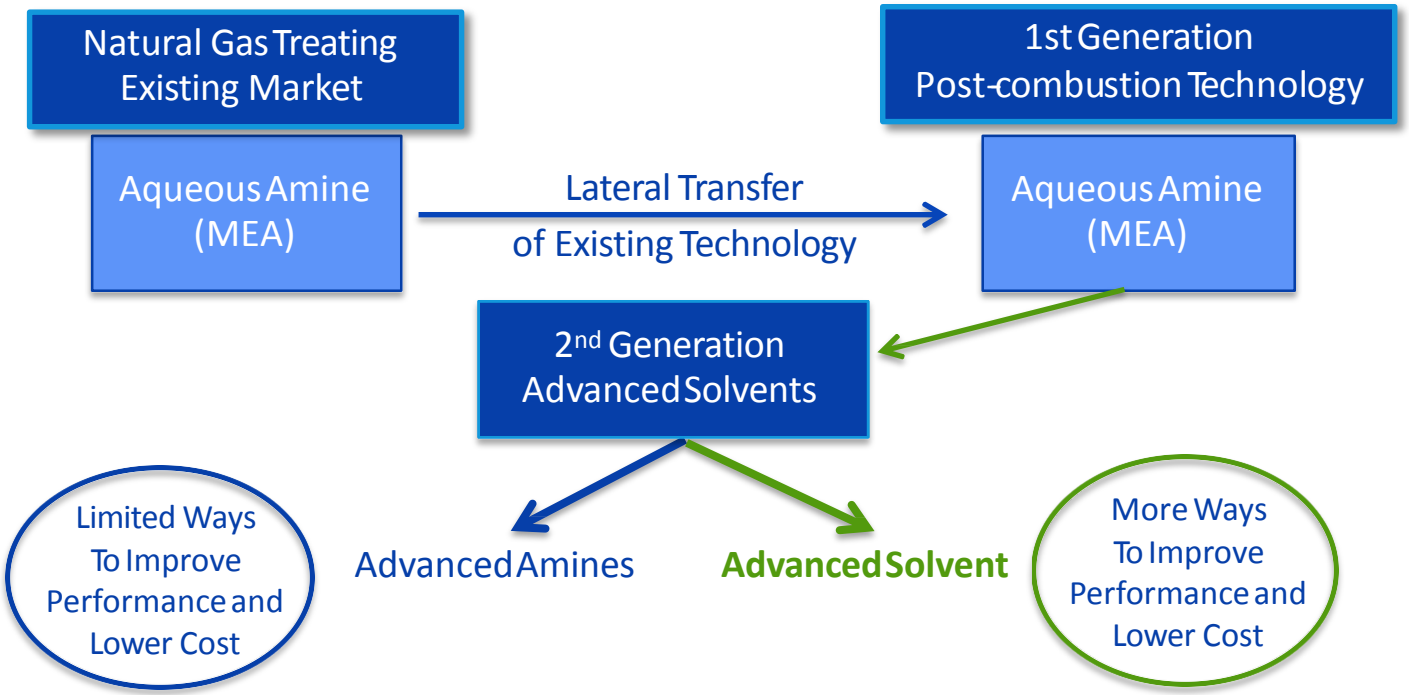
ION Engineering

- Founded in 2008 in Boulder, CO, USA
- Mission: To reduce carbon emissions globally by producing the most environmentally responsible, cost-effective, post-combustion CO_2 capture process
- Markets: Existing large point sources - coal, natural gas & refinery gas

Innovation

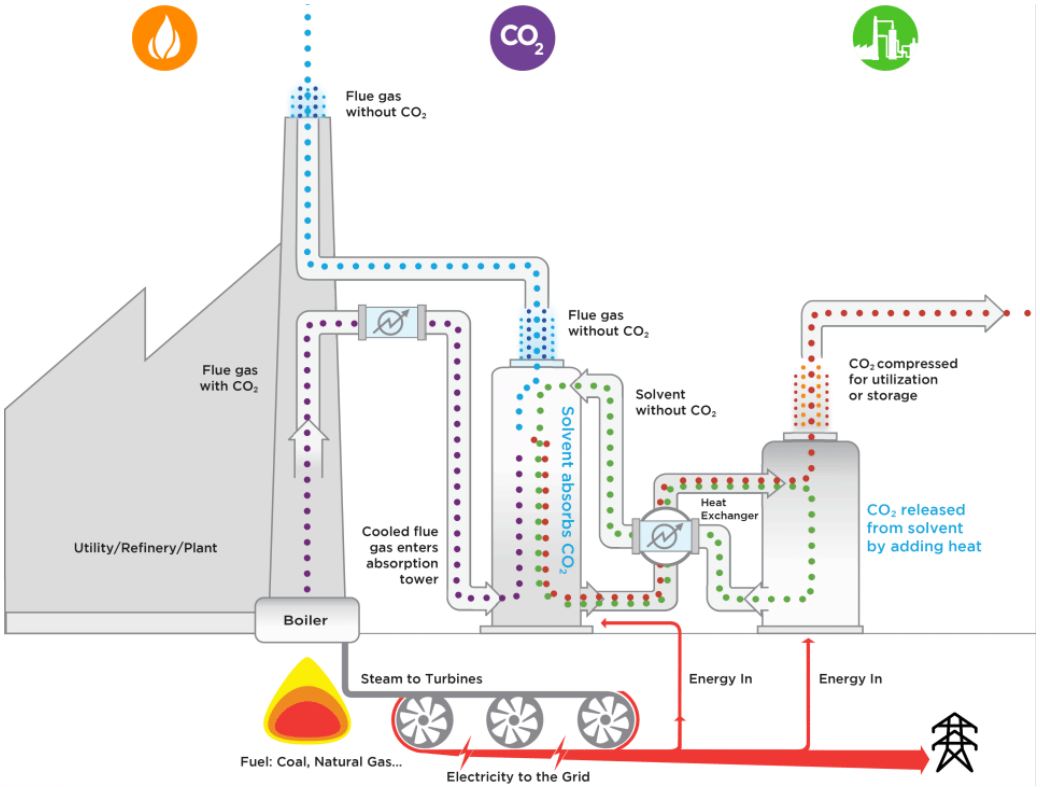
ION has developed a patented liquid absorbent technology that produces a more efficient & lower cost way to capture CO_2 than traditional methodologies



ION Technology

Faster kinetics resulting in higher working capacity

- **Reduced CAPEX**
  - Smaller footprint
- **Reduced OPEX**
  - Lower energy requirements
- **Lower parasitic load**
- **Scalability**
  - Established engineering process
- **Performance**
  - < 1,090 btu/lb CO_2 captured



Proof of Concept: ION Engineering

Funding Provided by: US DOE, NETL, ION Engineering, EPRI

- $4M Bench award
- Proof of concept
  - Thermophysical & kinetic properties
  - Initiated rate-based simulation modeling
  - 0.05 MWe pilot operations
- Completed 2012

Location: Boulder, CO

Proof of Principal: Energy & Environmental Research Center

Funding Provided by: US DOE, NETL, ION, EERC, CO_2 Capture Project, Univ. Alabama

- $2M Proof of principal award
- Existing 0.25 MW pilot unit
- Multi-fuel capability
  - Coal & Natural Gas
- Significantly improved rate-based simulation modeling
- Best in class performance
- Completed 2013

Location: University of North Dakota

Pilot: National Carbon Capture Center (NCCC)

Funding Provided by: US DOE, NETL, NCCC, Southern Company, CLIMIT, Nebraska Public Power District, Univ. Alabama

- $14M Project
- Existing 0.6 MWe pilot
- On-site at Southern Company's Plant Gaston (880 MWe)
- >1,100 hours continuous testing
- Real process environment
- Validated Rate-Based simulation model
- Initiated solvent degradation and corrosion studies
- Completed August 2015

Location: Wilsonville, Alabama

Demonstration: Technology Centre Mongstad

Funding Provided by: US DOE, NETL, Technology Centre Mongstad, Gassnova/CLIMIT, Nebraska Public Power District

- $16M Project
- Existing 13 MWe Facility
- On-site at Statoil Refinery with CHP Plant
- Multiple Flue Gas Types
  - CHP & Refinery Gas
  - Simulated coal performance
- Timeline for Testing:
  - Q3 2016 – Q2 2017

Location: Mongstad, Norway

ION'S COMMERCIALIZATION PLAN

ION's Strategy

Building Capture Units and Utilization Opportunities to Offset CAPEX and OPEX

- Multiple CO_2 capture units per site to allow for scale up over time
- Sizes ranging from 25-200 MWe depending on customer need
  - Match commercial markets with CO_2 supply
  - Large scale commercial deployment by 2024

Carbon Capture, Utilization & Sequestration

Petra Nova - NRG

- 90% Capture – 240 MWe
- $1 Billion
- Multi Owner Structure
- Utilization: EOR via Pipeline

Boundary Dam – SaskPower

- 90% Capture – 110 MWe
- $1.3 Billion
- Utilization: EOR Site <8 miles away

Lessons Learned

- COE
- Regeneration Energy
- Solvent lifetime
- Solvent reclamation
- Process optimization
- Process automation
- Emissions monitoring
- Solvent monitoring
- Solvent resupply costs
- Plant emission mitigation
- Plant operations
- Environmental conditions
- Environmental regulations
- CO_2 transportation
- CO_2 markets
- TCB
- FOAK
- GEP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