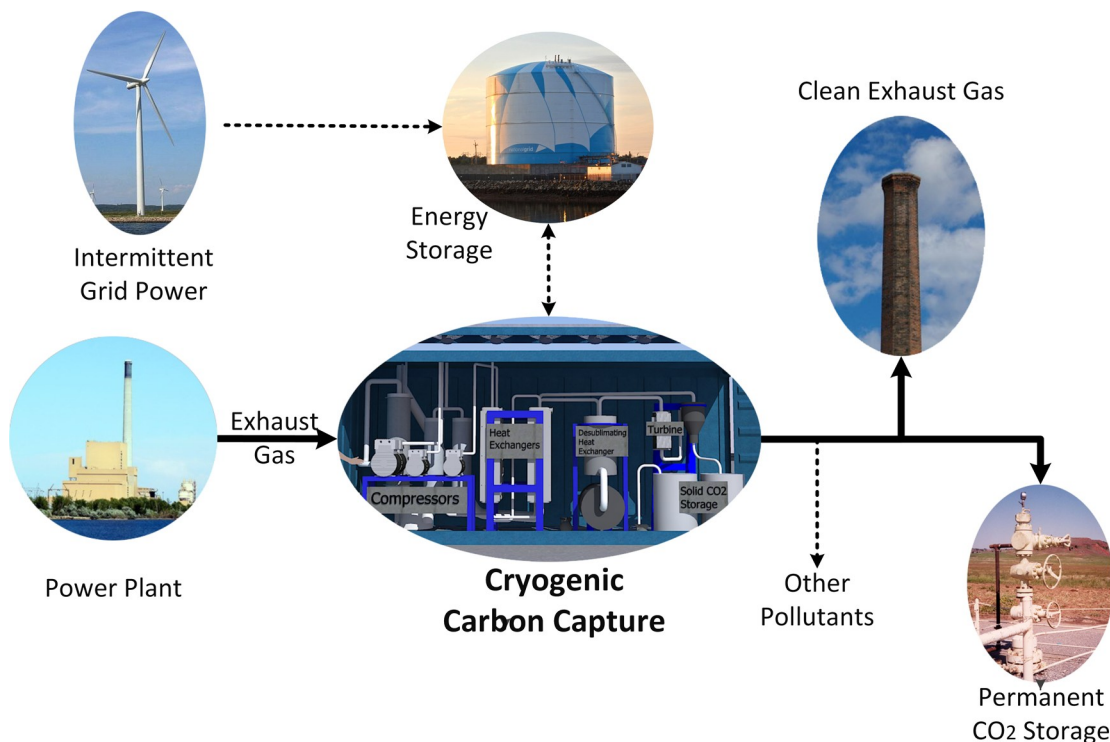


# Cryogenic Carbon Capture

## Fossil-Fuel Energy for a Changing Market



Sustainable Energy Solutions (SES) is developing a cost and energy effective way to produce low-emissions energy from fossil fuels. The Cryogenic Carbon Capture (CCC) process is a post-combustion process that can be applied to many new or existing stationary sources of emissions and largely uses common industrial equipment. Secondary benefits to the process include the option of grid-scale energy storage, removal of other pollutants, and further cost and energy savings through plant integration.

### Process Highlights\*

- Greater than 90% CO<sub>2</sub> capture
- Approximately 35% increase in levelized cost of electricity
- Less than 15% parasitic load
- Additional cost and energy savings when retrofitted to existing plants
- Successfully demonstrated at small scale
- On-site demonstration planned for 2013
- Uses scalable equipment that is familiar to the power industry

### Additional Advantages

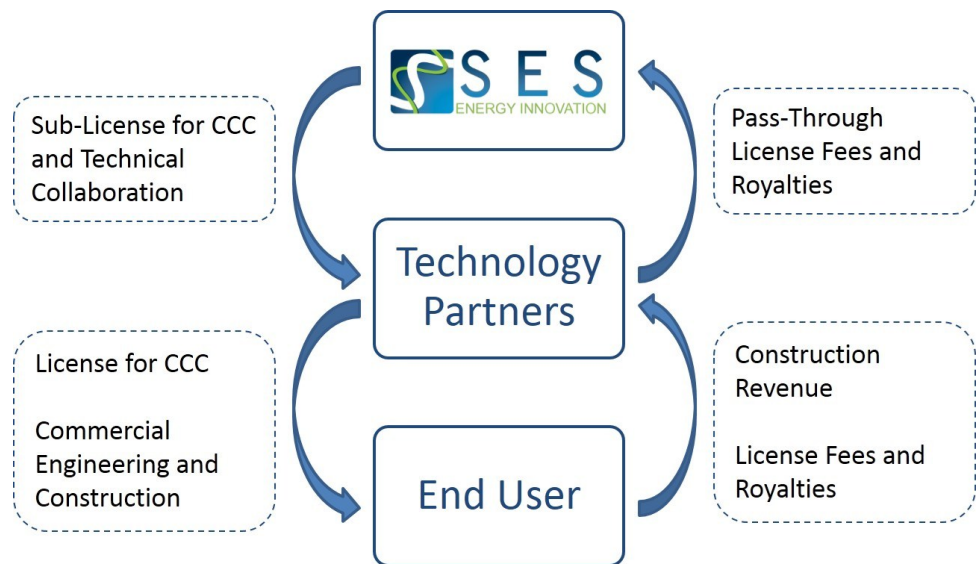
- High-efficiency energy storage may be incorporated into process resulting in no parasitic load during peak-demand hours and better grid integration with intermittent, renewable power sources
- Captures mercury, SO<sub>x</sub>, NO<sub>2</sub>, and other harmful pollutants resulting in even greater cost and energy savings to the plant
- Captures and uses about 90% of flue-gas moisture

\*Numbers refer to installation on a new coal-fired power plant.

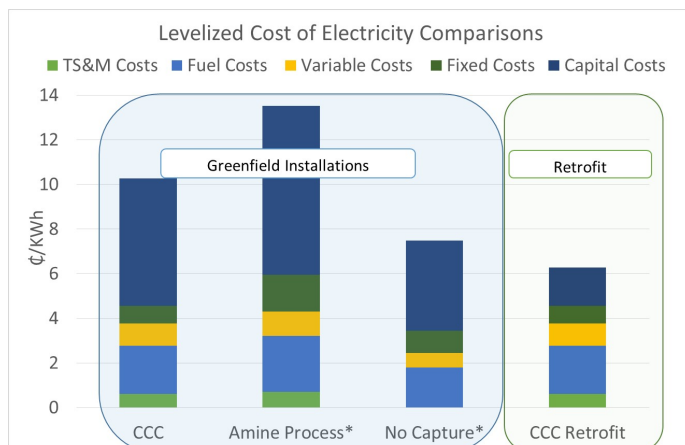
## SES Ideas Factory

SES operates as an “ideas factory”, specializing in creating innovative solutions to sustainability problems in the energy industry then partnering with companies that can assist in taking those solutions to market.

## Cryogenic Carbon Capture Path to Market



**Cost:** A greenfield installation of the CCC process results in about a 35% increase in the cost of electricity when compared to a plant with no capture, less than half of the reported increase for an amine process. The increase in the cost of electricity is reduced even further if the CCC process is applied to an existing power plant because of the ability of the process to leverage the existing capital. Parasitic load for the CCC process is also about half of that of the amine process.



LCOE comparison of four scenarios;  
TS&M is transport, storage and monitoring of the CO<sub>2</sub>. \*from DOE, 2008.

**Natural-Gas Application:** The CCC Process can be used in natural gas processing to remove sour gasses and natural-gas liquids in preparation for pipeline transportation. The process has the potential to accomplish all of this for less than the current cost of an amine-based scrubbing system.

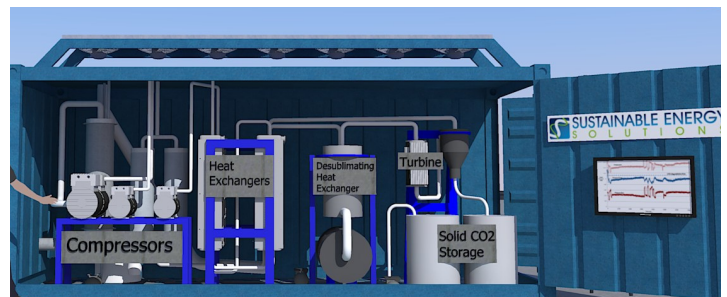
Lab Validation  
2008-2010

Bench  
Demonstration  
2009-2012

Skid  
Demonstration  
2012-2014

Pilot  
Demonstration  
2014-2017

**Development Status:** The CCC process has been demonstrated at lab scale and at several bench scales. The first skid mounted, portable prototypes are under construction and will be demonstrated at several locations. The next stage of development for the process is a stationary, commercial-scale pilot demonstration that will be used to demonstrate full-scale operations, economics, and parasitic load.



Rendering of skid system

**Intellectual Property:** Sustainable Energy Solutions has filed several patents five of which are directly related to the CCC Process. Claims in the patents cover two different variations on the overall process and several key pieces of equipment including desublimating heat exchangers.

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