SYNGAS CLEANUP
WDP - WARM DESULFURIZATION PROCESS

"A CAPABLE AND ECONOMIC GAS CLEANUP OPTION."

CASALE

SYNGAS CLEANUP
WDP WARM DESULFURIZATION PROCESS

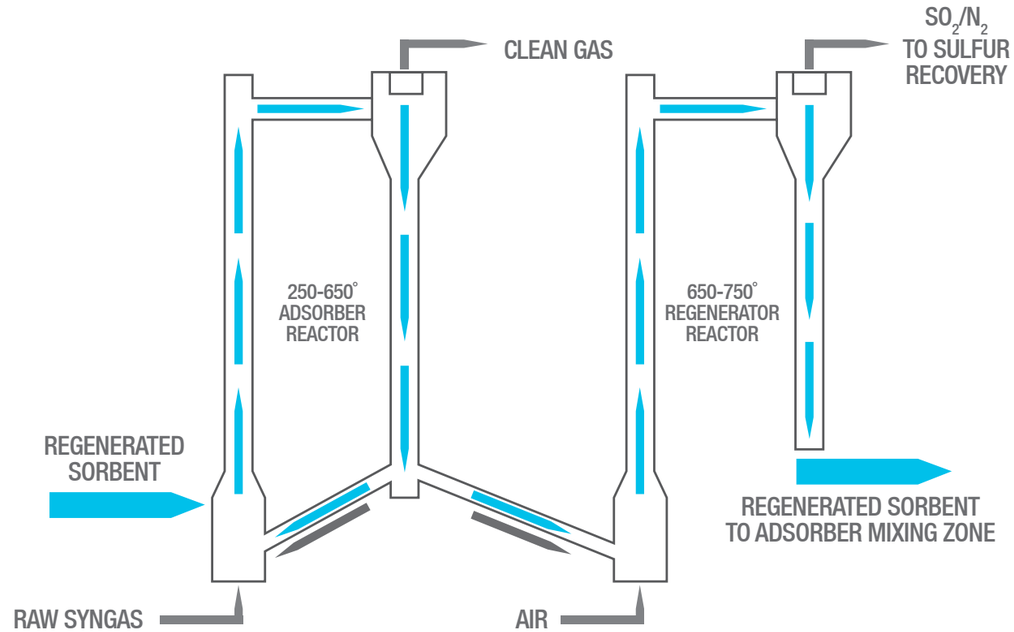
WDP is a unique gas cleanup technology - based on a solid sorbent operating at elevated temperatures - that enables production of cleaner energy and chemicals from coal and other high-sulfur feedstocks at substantially lower costs and higher efficiencies than conventional gas cleanup technologies.
WDP is a technology developed by RTI International; Casale is the exclusive sublicensor for WDP worldwide.

KEY FEATURES

- Effective sulfur removal (up to 99.9% of H_2S and COS) at temperatures up to 650°C
- Pressure independent sulfur removal
- Integrates with most CO_2 capture processes
- Improved process flexibility by decoupling sulfur and CO_2 removal
- No need for COS hydrolysis
- Reduction or elimination of need for substantial gas cooling and expensive heat recovery systems
- Compared with conventional gas cleanup technologies, WDP offers potential for:
  - Lower capital costs (20-50% less)
  - Lower operating costs (up to 30-50% less)
  - Improved overall process efficiency (up to 10% higher).

The WDP technology is based upon two key proprietary components:

- A unique process technology based on dual transport reactor loops, and
- A regenerable, high-capacity, rapid acting, attrition-resistant sorbent.



UNIQUE PROCESS TECHNOLOGY

The WDP technology is based upon the use of dual transport reactor loops (similar to fluid catalytic crackers except operating at elevated pressure). In the first loop, up to 99.9% of the sulfur contaminants in the warm gas stream are chemically adsorbed in a few seconds, thanks to the highly active sorbent for sulfur adsorption. By utilizing only a fraction of the sorbent's total sulfur capacity, the process can instantaneously respond to process upsets while maintaining stable and robust desulfurization performance.
The sulfur-loaded sorbent is then separated from the gas stream and recycled back to the adsorber. A portion of the recycled sorbent is separated and sent to the second transport loop where it is regenerated by combustion of the sulfur to SO_2 using air or oxygen. The regenerated sorbent is then sent back to the adsorber loop. Fines from sorbent attrition are captured by filtration of the gas streams exiting each loop.

ATTRITION RESISTANT SORBENT

Key to WDP technology is a novel regenerable, high-capacity, rapid acting, attrition-resistant solid sorbent based on unique, highly-dispersed nanostructures.

The sorbent has exhibited exceptional performance across a wide range of operations, which included lab, bench, pilot, and demonstration scales.

The sorbent has a high capacity for sulfur and adsorbs it as either H_2S or COS and even other sulfur forms (i.e. no need for upstream COS hydrolysis).

The sorbent also has rapid kinetics for both adsorption and regeneration and can be regenerated through repeated cycles for as much as three years without a substantial decrease in overall sulfur capacity.

In addition, the sorbent has very low attrition rates, considerably lower than rates typically observed for fluid catalytic crackers.

The sorbent has already been produced at commercial scale.

OPERATING EXPERIENCE

WDP operating experience consists of about 7,000 hours of combined pilot and demonstration testing with coal- or petcoke-derived syngas using commercial-scale sorbent.

Over this testing, the sorbent maintained stable and reliable sulfur capacity and adsorbed close to 99.9% of the total H_2S and COS present in the syngas with low attrition losses.

PILOT PLANT TESTING

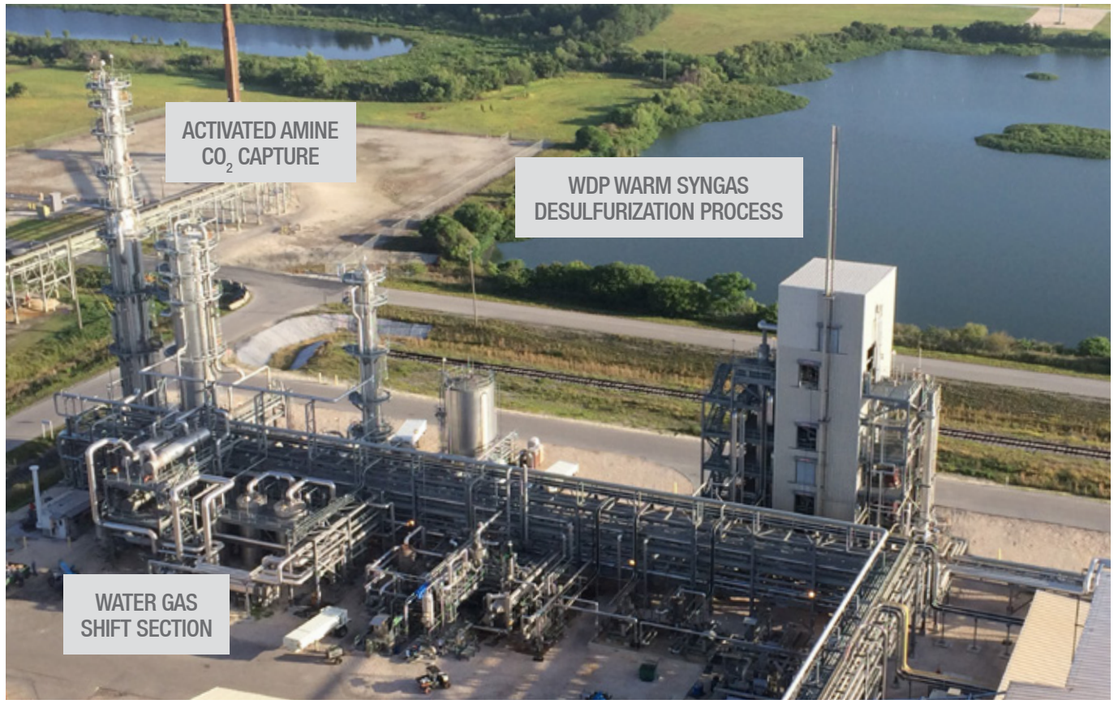
WDP was pilot-plant tested for over 3,000 hours at Eastman Chemical Company's coal gasification plant in Kingsport, Tennessee (pictured on the left). Parametric testing across a wide range of conditions, including operating pressure, showed consistent and excellent desulfurization performance.

PRE-COMMERCIAL DEMONSTRATION OF WDP TECHNOLOGY

The WDP technology was tested for over 3,500 hours at Tampa Electric Company's Polk 1 IGCC facility in Florida, which gasifies a mixture of high-sulfur coals and petcoke. Typically, inlet syngas H_2S levels ranged from 10,000-12,000 ppmv and inlet COS levels ranged from 600-900 ppmv. The demonstration unit treated ~20% of the total syngas produced from the gasifier (~54,000 Nm3/hr or ~50 MWe).

In addition to WDP, the demonstration facility also included water-gas-shift and activated amine (BASF's OASE®) processes to demonstrate >90% carbon capture. WDP consistently removed up to 99.9% of total sulfur, and in combination with the activated amine system was able to reduce syngas sulfur to sub-ppmv, suitable for many coal-to-chemicals applications, such as fuels, hydrogen, ammonia, methanol, or substitute natural gas.

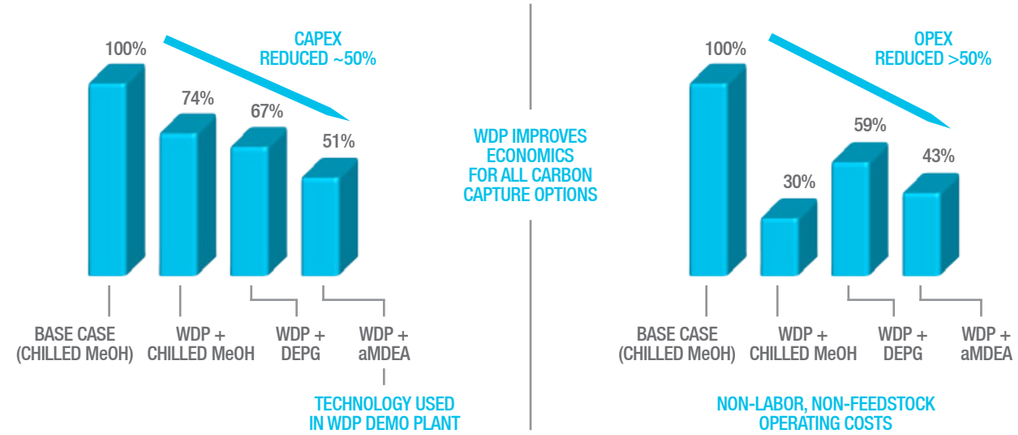
The clean syngas was successfully fed to the IGCC turbine and SO_2 off-gas from the WDP regenerator was successfully fed to an existing sulfuric acid plant. The unit performed very well and convincingly showed that WDP technology is ready for deployment at commercial scale.



TECHNO-ECONOMIC EVALUATIONS OF WDP

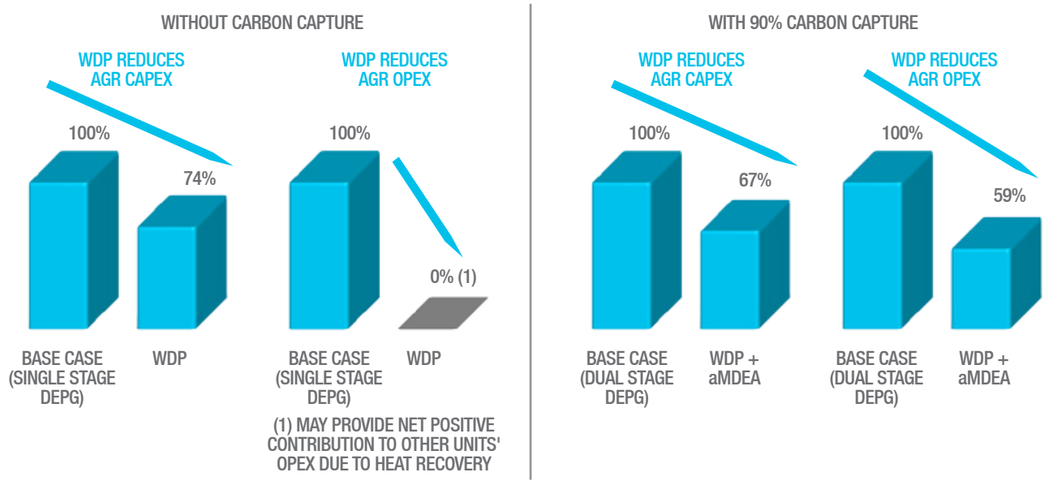
TECHNO-ECONOMIC ANALYSIS: COAL TO METHANOL CASE

(2 x 300-MW_{equiv} Shell-type solids-fed gasifiers with Shenhua Mix or PRB coal)



TECHNO-ECONOMIC ANALYSIS: COAL TO POWER (IGCC) CASE

(2 x 300-MW_{equiv} Shell-type solids-fed gasifiers with Shenhua Mix or PRB coal)



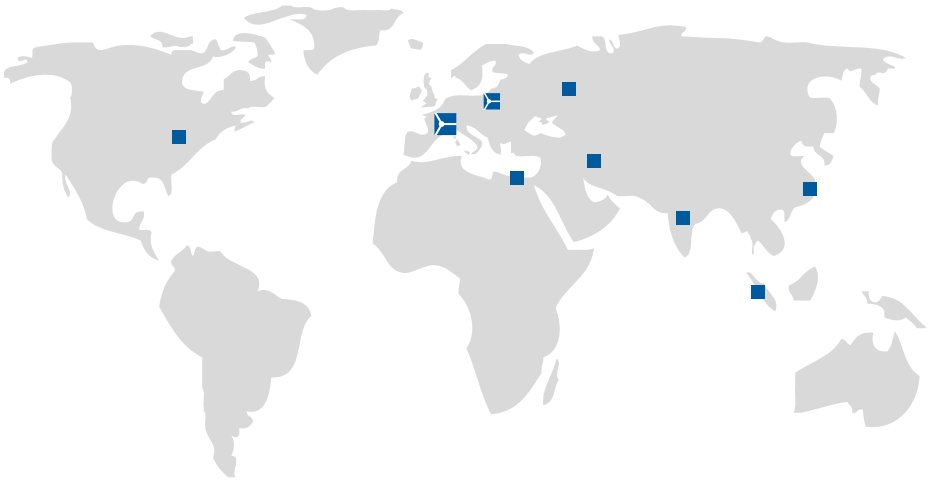
AGR = ACID GAS REMOVAL • **aMDEA** = ACTIVATED AMINES • **CC** = CARBON DIOXIDE CAPTURE • **DEPG** = DIMETHYL ETHERS OF POLYETHYLENE GLYCOLS
MeOH = METHANOL • **PRB** = POWDER RIVER BASIN • **SRU** = SULFUR RECOVERY UNIT • **WGS** = WATER GAS SHIFT

MARK-THING.IT

CASALE

Via Giulio Pocobelli, 6 | 6900 Lugano | Switzerland (CH)
tel. +41 91 6419200 | fax +41 91 6419291
www.casale.ch | info@casale.ch

In the world



Sister company

CASALE PROJECT
Prague, Czech Republic

Network of Representatives

China | Egypt | India
Indonesia | Iran
North America | Russia