BECHTEL

ENERGY

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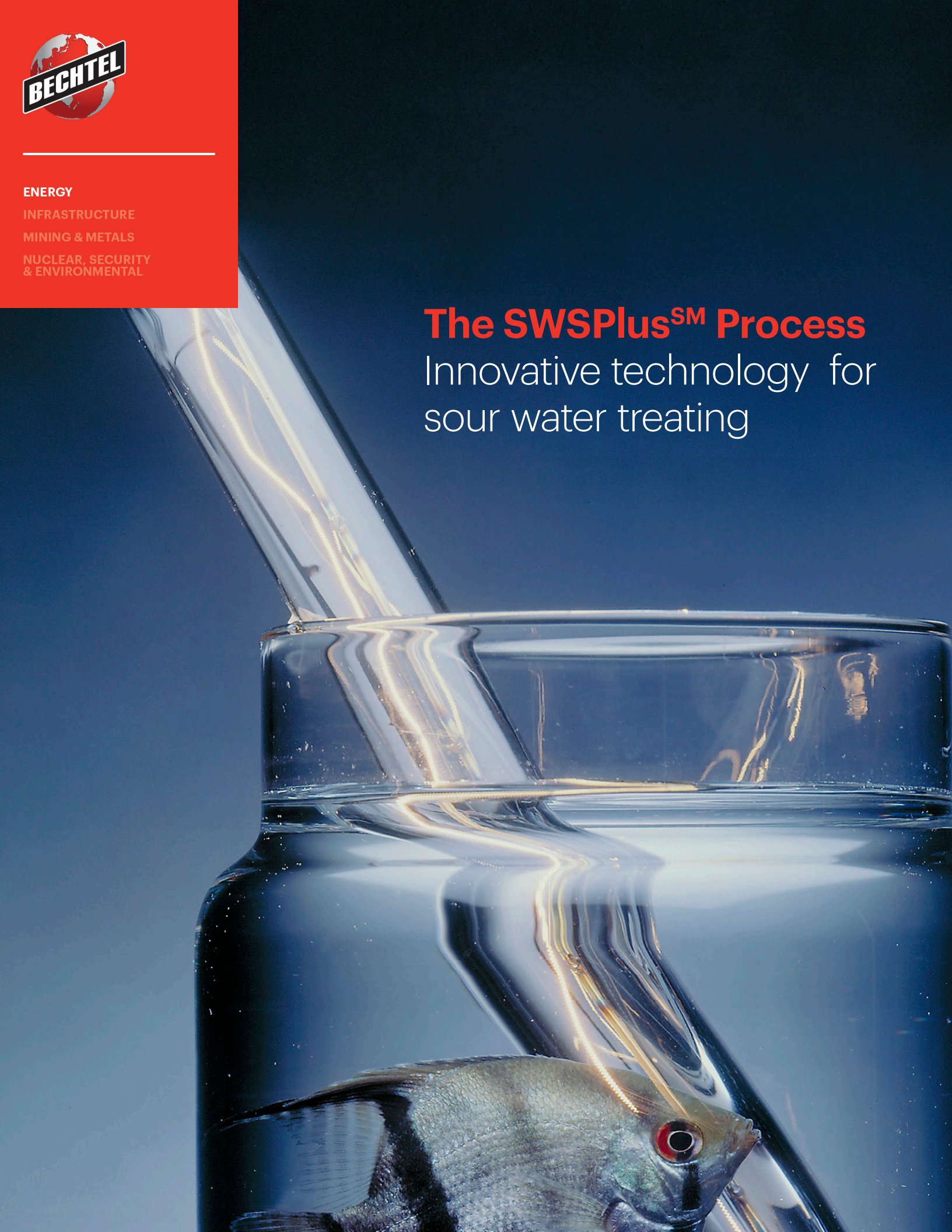
The SWSPlus℠ Process

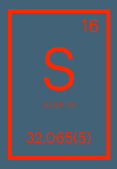
Innovative technology for sour water treating

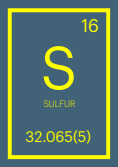


A Sulfur Recovery Unit (SRU) is meant to convert hydrogen sulfide (H_2S) into a salable elemental sulfur product.

$$H_2S + {}^1/_2\, O_2 \longrightarrow {}^1/_x\, S_x + H_2O$$

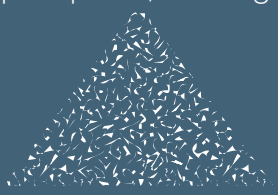
NOT





$$NH_3 + {}^3/_4\, O_2 \longrightarrow {}^1/_2\, N_2 + 1\,{}^1/_2\, H_2O$$

Unsurprisingly, an SRU **does not** convert NH_3, CO_2 and other non sulfur species into **sulfur**. If NH_3 is not destroyed in the SRU Reaction Furnace (as it is in all Bechtel-licensed Sulfur Plants), then it will precipitate, forming



solid ammonia salts.
These can cause the unit to experience an **unplanned shutdown.**

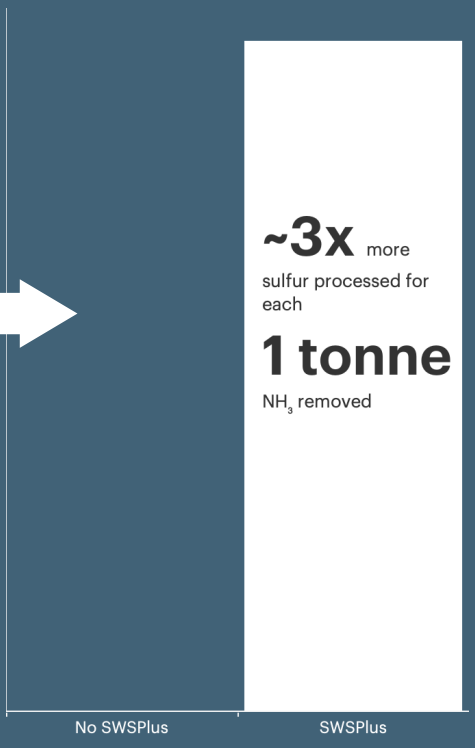
To avoid this, all good licensors will properly specify the SRU reaction furnace to destroy the ammonia, resulting in a (difficult to control)

MINIMUM FLAME TEMPERATURE

and a proprietary burner. In fact, properly combusting NH_3 requires

50%

more oxygen than H_2S.



Wouldn't it be simpler to remove NH_3 at the source?

(We thought so too.)

Introducing the SWSPlus℠ Process from Bechtel.

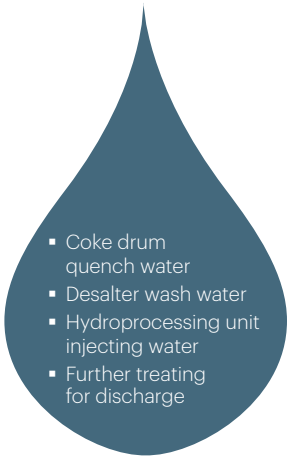
The SWSPlus℠ Process

Expands the capacity of your Sulfur Plant.

Make **blue** ammonia from a waste stream.

Reduce SOx, NOx and PM emissions.

The commercially proven SWSPlus℠ technology separately recovers hydrogen sulfide (H_2S) and ammonia (NH_3) from sour water. The innovative two-stage stripping process yields acid gas with less than 50 ppmw NH_3 and a high purity gaseous or liquid NH_3 product. The produced stripped water is of excellent quality, making it suitable and sustainable for reuse as:



For every **1 ton** of NH_3 removed, an incremental **3 tons** of sulfur can be processed in the downstream Sulfur Recovery Unit (SRU). Removing NH_3 allows for effective debottlenecking of the SRU train and increased reliability.

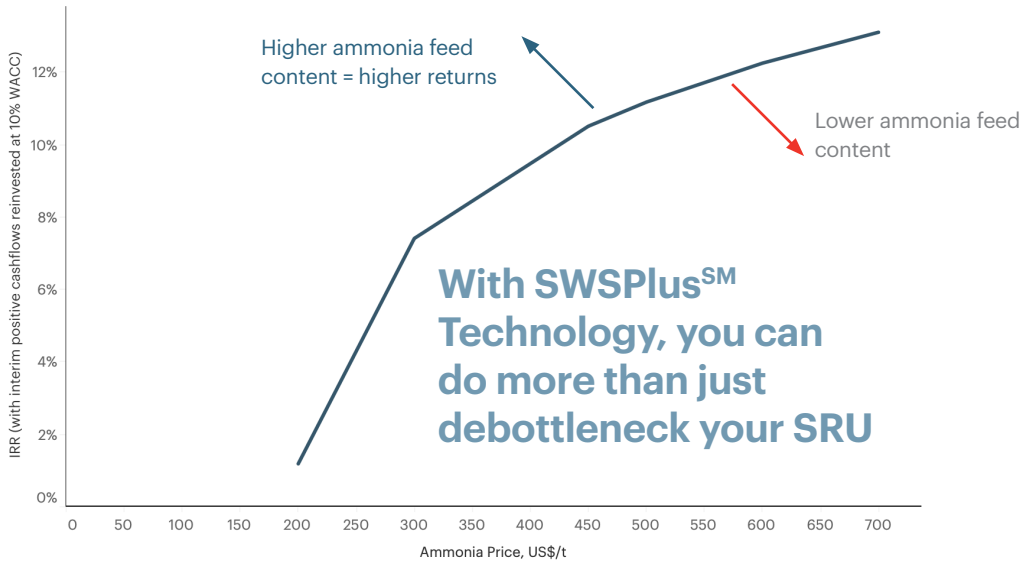
Alternatively, SWSPlus℠ can be used in lieu of a new SRU train.

Bechtel provides a tailor-made SWSPlus℠ design that fits your specific water processing requirements. Stripped water specifications are readily achieved, typically ranging from 10-50 ppmw NH_3 and 1-25 ppmw H_2S.

By recovering NH_3 and H_2S separately, air pollution compliance problems associated with SO_X, NO_X, and particulate emissions caused by conventional SWS offgas incineration are reduced.

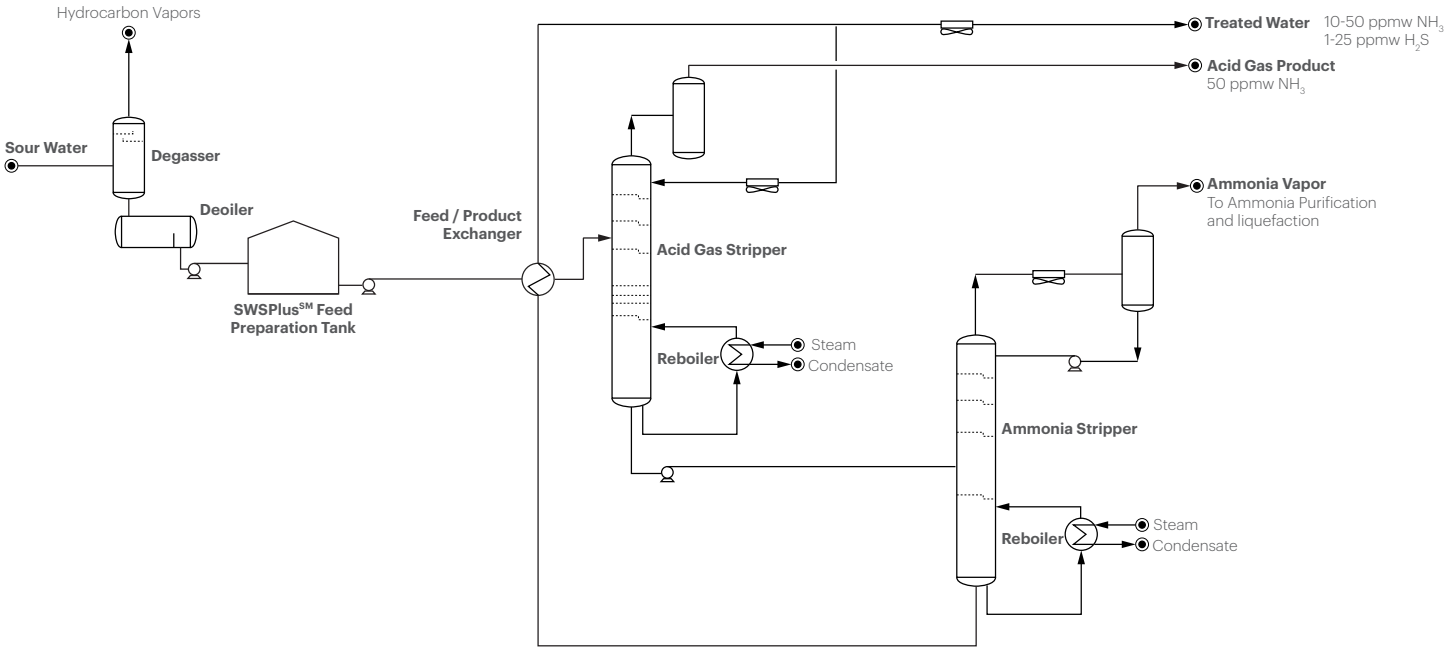
Refiners using crude feedstocks with increasing nitrogen content are having to accommodate operational challenges due to NH_3 based salt deposition in the SRU. Salt deposits lead to a more complex and costly SRU reaction furnace and burner design. The SWSPlus℠ process eliminates this issue by addressing the root cause: NH_3 in the SWS acid gas feed.

SWSPlus℠ provides salable anhydrous or aqueous NH_3 for use in the chemicals and fertilizer manufacturing industries. It's a simple and elegant solution to a significant industrial problem.



The Technology

The SWSPlus[SM] process consists of four main processing steps:



1. Degassing and Feed Preparation

Sour water feeds from a single or several sources are cooled and passed through a Degasser where dissolved hydrogen, methane, and other light hydrocarbons are removed. The degassed sour water is pumped to a SWSPlus[SM] Feed Preparation Tank, which serves to attenuate flow rate and composition changes while also providing the opportunity to remove entrained oil and solids.

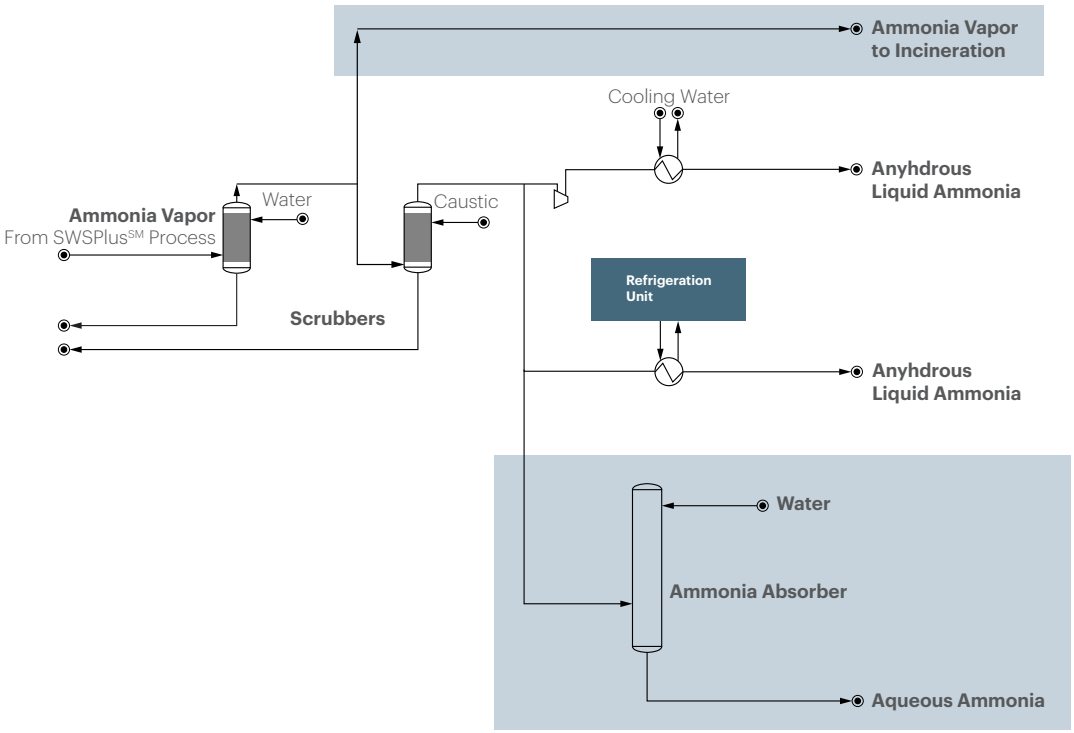
2. Acid Gas Stripping

From the SWSPlus[SM] Feed Preparation Tank, the degassed sour water feed is pumped to the Feed / Product Exchanger and fed to the steam-reboiled Acid Gas Stripper. H_2S and CO_2 are stripped to the overheads and a water wash is used to reduce NH_3 contamination. The resulting acid gas is of high purity and is an excellent feed for an SRU or a sulfuric acid plant. It contains negligible ammonia (less than 50 ppmw) and very little hydrocarbons since the plant feed has been degassed. The acid gas is available at roughly 100 psig and 100°F.

3. Ammonia Stripping

The Acid Gas Stripper bottoms, which contains ammonia and some acid gas, are fed directly to the Ammonia Stripper. The Ammonia Stripper is a steam reboiled, refluxed distillation column. In this column, essentially all ammonia and acid gas are removed from the water, which leaves as the column bottoms stream. After being heat exchanged with the feed and cooled, this stripped water is suitable for many plant reuse needs or may be discharged. The stripped water H_2S and ammonia content is tailored to individual client requirements and is typically 10-50 ppmw ammonia and 1-25 ppmw H_2S.

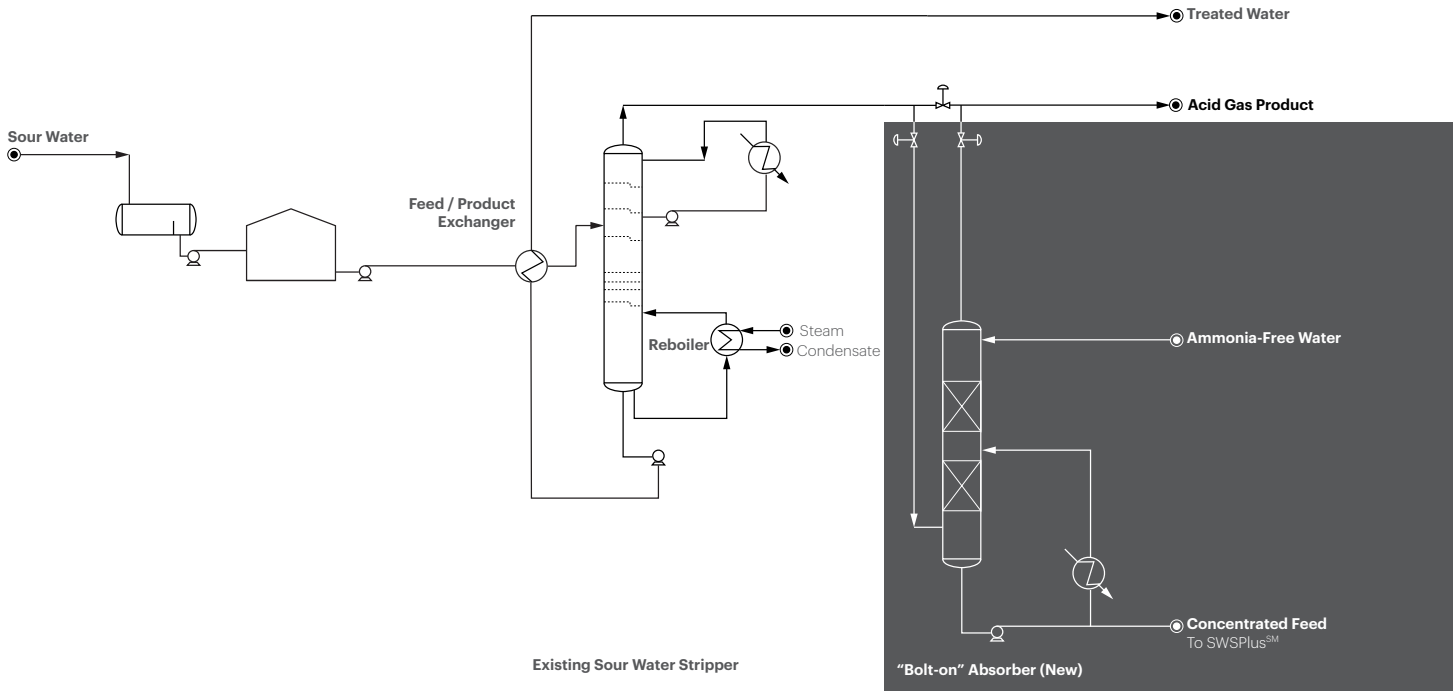
Stripped water from SWSPlus[SM] plants can be used in hydroprocessing unit injection water, crude unit desalter water, for coke drum quenching or may be sent to effluent treating for discharge.



4. Ammonia Purification and Liquefaction

The NH_3 and H_2S stripped from the water in the Ammonia Stripper are passed through an overhead condenser and are recovered as a vapor and liquid. The liquid is used as column reflux. The vapor product is an NH3-rich gas, which may be handled in a variety of ways. For small plants where NH_3 recovery is not desired or economic, the overhead product may be incinerated. However, in most cases, the choice is to purify the gas and produce either anhydrous or aqueous NH_3 suitable for sale.

For production of anhydrous NH_3, the gas is passed through a two-stage scrubbing system to remove residual contaminants; and is then liquefied to produce the anhydrous NH_3. For production of aqueous NH_3, a one or two-stage scrubber may be used to remove the contaminants, depending on purity requirements. The NH_3 gas is then dissolved in water to yield the desired product grade.



A Real Plus: The Bolt-On Absorber

Since Bechtel acquired WWT from Chevron in 2012, several improvements have been developed and patented. These changes were so important to our customers that we changed the name of the technology to SWSPlus℠.

One such improvement is the use of a "Bolt-On Absorber" sometimes called a "Pre-Absorber". This allows the use of SWSPlus℠ as an addition to existing sour water systems and results in a more concentrated sour water feed to the new SWSPlus℠. The concentrated sour water feed allows a typical reduction in CAPEX of about 20-40% plus reductions in OPEX of about 15-35%.

The "Bolt-On Absorber" concept changes the SWSPlus℠ feed source from the sour water to the sour water stripper acid gas of an existing SWS. That SWS equipment is already in place and operating as a cost of doing business. Therefore, its capital and operating costs should be viewed as sunk costs. The product gas from that unit, the sour water stripper acid gas, is contacted with recycled water from the SWSPlus℠ processes, producing a SWSPlus℠ feed that has a high concentration of ammonia. At the same time, about half of the hydrogen sulfide, carbon dioxide, and hydrocarbons normally present are not re-absorbed into the SWSPlus℠ feed stream and simply pass through the "Bolt-On Absorber" to the SRU as before.

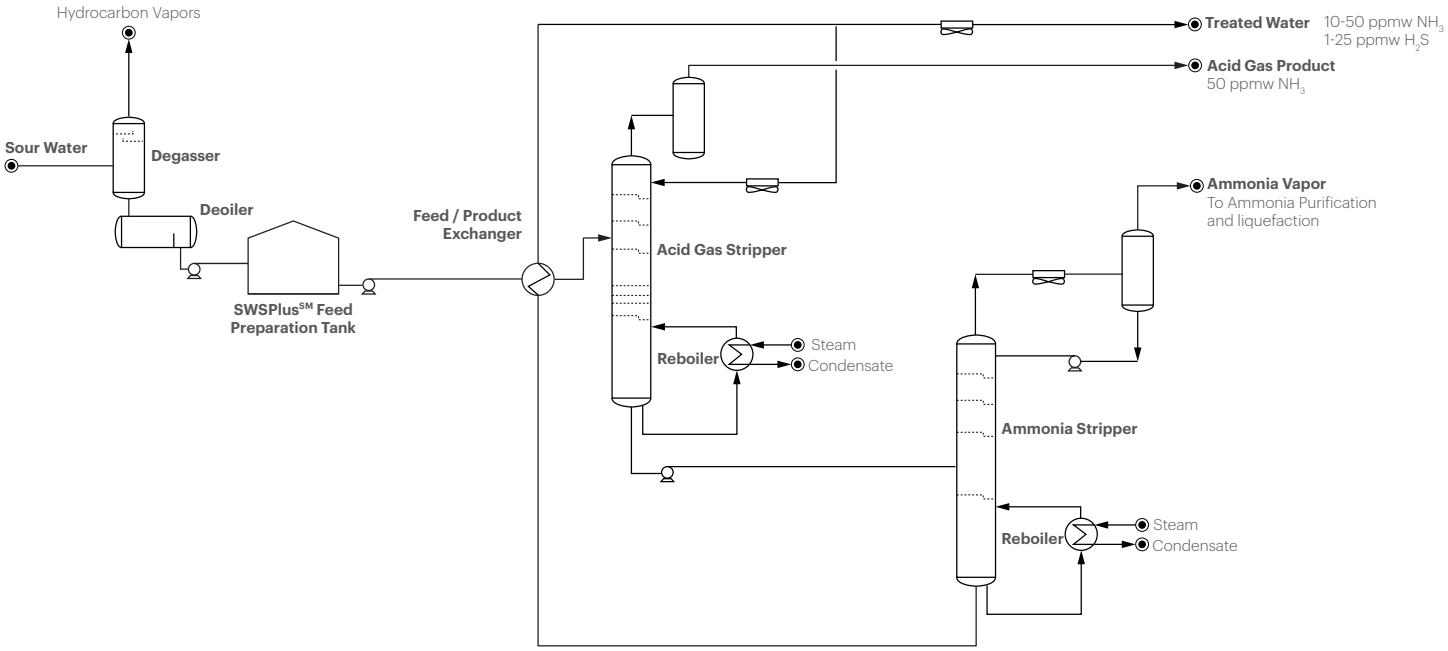
The objective is to significantly reduce the sour water feed rate to the SWSPlus℠ unit while keeping the ammonia out of the SRU.

Due to the heat of absorption of ammonia (and subsequent reaction with hydrogen sulfide and/or carbon dioxide), a circulating water stream with a cooler is used. Proper water optimization will produce any concentration of sour water that is desired. Very low ppm levels of ammonia in the overhead gas can be achieved with relative ease.

A strong advantage of this approach is that the tie-ins can be installed at any turnaround and the new SWSPlus℠ unit built at any convenient time. **SRU expansion has never been easier.** Best of all, if there is a unit upset, the isolation valves can be switched and the SWS sends all vapor product to the SRU as before. There will be no upset to the SWS.

Process Parameters

Properties	
Feedstocks	Sour Water with dissolved NH_3 and H_2S
Products	Stripped Water for reuse Low ammonia content Acid Gas to SRU Ammonia (Gaseous / Anhydrous / Aqueous) to sales
Operating Pressure Range	50-200 psig (350-1400 kPag)
Operating Temperature Range	40-350ºF (5-180ºC)
Acid Gas	
NH_3 Content	< 50 ppmw
Water Content	0.5 wt. %
Temperature	100-120ºF (38-50ºC)
Pressure	100-180 psig (690-1200 kPag)
Stripped Water	
NH_3 Content	10-50 ppmw (Tailored to client specifications)
H_2S Content	1-25 ppmw (Tailored to client specifications)
Temperature	100-200ºF (38-93ºC) (Tailored to client specifications)
Pressure	As needed
Ammonia as Commercial Grade Anhydrous Product (Higher purities are achievable)	
H_2S Content	< 5 ppmw
Water Content	0.4 wt. % maximum
Temperature	100ºF (38ºC)
Pressure	200 psig (1,379 kPag) minimum
Ammonia as Aqueous Product	
Sulfur Content	2 ppmw maximum
Water Content	72 wt. % (or as required)
Temperature	100ºF (38ºC)
Pressure	35 psig (241 kPag) minimum



Phased Options for Flexibility

SWSPlus℠ processing when and where you need it.

For optimized project economics, the SWSPlus℠ process can be phased-in by constructing the Ammonia Stripper first and operating the unit as a conventional Sour Water Stripper. The unit can subsequently be converted by adding the Acid Gas Stripper and associated ammonia purification and liquefaction facilities.

Additionally, a conventional Sour Water Stripper can be converted to the SWSPlus℠ process as an effective means of debottlenecking the SRU or addressing ammonia salt deposition challenges.

Removing NH_3 has other benefits.

With SWSPlus℠ Technology, you can do more than just debottleneck your SRU:

1 It's more sustainable.
NO_X , SO_X and PM are reduced in the Sulfur Complex's Thermal Oxidizer when using SWSPlus℠ because the firing rate is lower.

2 Upcycle a waste product into blue ammonia.
Salable ammonia can be turned into fertilizer or used as a petrochemical feedstock.

3 Attractive Economics.
As described above, proven financial returns can be realized from a 1500 gpm grassroots SWSPlus℠.

Call Bechtel today for an evaluation of your project.

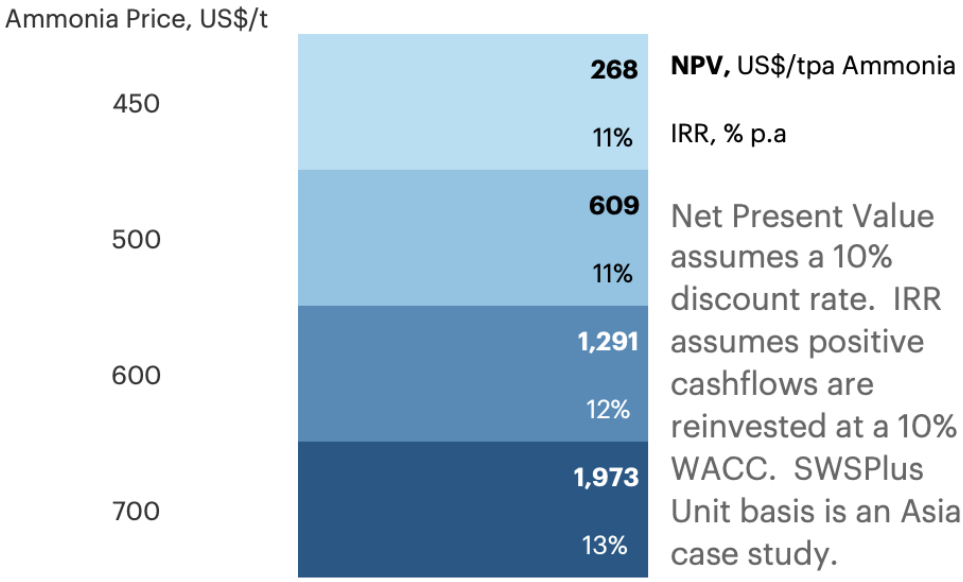
Global Experience

The SWSPlus℠ Process has been proven in >20 leading refineries worldwide since 1966 with capacities ranging from 2 gpm to over 1,500 gpm.

nearly **6,500 gpm** of superior sour water processing using the SWSPlus℠ Process.

The Math is Simple:

For each MSCFH of sour water stripper acid gas processed, 8 tonnes of CO_2 emissions can be avoided.



451 MSCFH of acid gas = avoiding CO_2 emissions from 481 homes/year*

Upcycle a waste stream to high value **blue** ammonia = better project ROI.

*Compared to producing ammonia through the conventional Haber-Bosch process. The CO_2 emissions per tonne of ammonia for SWSPlus ammonia are 2.06 tCO_2/t ammonia produced. A typical Haber-Bosch process emissions are 2.164 tCO_2/t ammonia.

Process Design Package Options

Fit for customer needs

Deliverable	Basic Package	Extended Package
Process Design Basis	■	■
Process Description	■	■
Process Flow Diagrams	■	■
Heat & Material Balance	■	■
Material Selection Diagrams	■	■
Equipment List	■	■
Process Data Sheets	■	■
Chemical Summary	■	■
Utility Summary	■	■
Effluent Summary	■	■
Critical Instrumentation Process Data Sheets	■	■
Preliminary Piping & Instrument Diagrams (P&ID's)	■	■
Plot Plan (Unsized equipment; typical)	■	
Plot Plan (Comprehensive)		■
Start-up and Operating Guide		■
Line Designation Table		■
Instrument List		■
Utility Flow Diagrams		■
Inside Battery Limits Utility Distribution P&ID's		■
Control & Shutdown Philosophy		■
Cause and Effect Diagrams		■
Relief Scenarios and Relief Valve Data		■
Relief Load Summary		■
Hazardous Area Classification		■
Electrical Load List		■

Delivering Net Zero with Bechtel

Helping customers accelerate their decarbonisation goals

Our Bechtel Energy Technologies & Solutions (BETS) group provides technology and subject matter experts focused on delivering for our customers as they tackle the challenges of the Energy Transition. Bechtel delivers optimised solutions to help our customers realize lower capital costs, shorter times-to-market, and projects with lower carbon emissions.

Supported by world-renowned experts, our depth of technology experience and technology development capabilities, and a suite of in-house licensed technologies , we examine innovative solutions and identify the optimal solution for each customer's needs. We have the breadth and depth of expertise to evaluate and integrate proven technologies, emerging technologies, and innovative combinations of both to lower carbon emissions for our customers.

How we help

We apply technology, economic analysis and complex process systems analysis to the energy transition challenge including concept definition, emerging technology advice and selection services, feasibility studies, technology licensing, process design basis and pre-front-end engineering and design (pre-FEED) services in olefins, chemicals, water treatment, advanced fuels, sulfur, carbon capture and hydrogen.

For more information,
please contact Bechtel at:

MJ Rahman
Sr. Business Development Manager
+1(713) 235-4180
imrahman@bechtel.com

Martin Taylor
Technology Manager — Sulfur
+1(713) 235-5234
mataylo1@bechtel.com

F202111007