AMMONIA

FLEXIGREEN® FLEXIBLUE®

AMMONIA

FlexAMMONIA | SMART-N | HyPURE-N

Take a step towards a greener tomorrow
with Casale's cutting-edge ammonia solutions

CASALE

We are a global partner
in the chemical industry,
offering **integrated technologies,**
engineering, contracting
and construction solutions
for over a century.

Our mission

Contribute to shape a new sustainable planet with our plants for the production of fertilizer, methanol, hydrogen, melamine and derivatives, and help our customers creating value respecting the environment.

We are a global company front leader in the energy transition: a key player in the sustainable transformation of the chemical and energy industry, from a social, economic and environmental point of view.

Our values

INNOVATION PEOPLE CARE **PROFESSIONAL EXCELLENCE**
QUALITY **SAFETY** ETHIC **SUSTAINABILITY**

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FlexAMMONIA

FlexAMMONIA, is the cutting-edge solution from Casale for large-scale green ammonia synthesis plants. Designed with a paramount focus on energy efficiency, FlexAMMONIA stands as a forefront solution in sustainable ammonia production.
It utilizes hydrogen derived from water electrolysis with renewable energy and pure nitrogen from an air separation unit.
FlexAMMONIA boasts a remarkable capacity rangeability and the ability to operate reliably, even with fluctuating renewable power supplies. This is achieved through advanced control logic solutions, plant optimization techniques (Casale Optimizer), and dynamic analysis (Casale Dynamic Analysis Model), effectively mitigating the adverse effects of cyclic operation and fatigue.
The seamless integration of performance, mechanical integrity, and flexibility sets FlexAMMONIA apart.
To maximize performance, we highly recommend Casale-Clariant proprietary Amomax®-Casale synthesis catalyst, renowned for its superior performance compared to other catalysts available in the market.
A further advantage is its adaptability to meet the specific requirements of each client.

Enviromental Impact

The operation of the ammonia synloop is emission free.

Capacity

- Best suited from **300 MTD** to **7'000 MTD** of ammonia

Performances

- Clean Syngas consumption, per ton of ammonia produced: **~2650Nm³** (equivalent to less than **2000 Nm³** of H_2)
- Reaction heat recovery, per ton of ammonia produced: more than **600'000 Kcal**
- Plant turndown range: **10-100%**
- Ramp-up/down rate: up to **3%/min**

Benefits

- Very low energy consumption
- Reduced Low Cost of ammonia (LCOA)
- Compact lay-out, with all sections arranged in a way to reduce the overall footprint as well as minimize the connections across the different sections of the plant
- The design can be customized to specific Client's needs and integrated with other sections
- Possibility to optimize of other sections of the green ammonia plant

Casale technical assets

- Casale Axial-Radial® ammonia converter
- Loop's waste heat recovery train
- Amomax-Casale catalyst
- Casale electric Start-up heater

PROCESS OUTLINE

The fresh make up gas is compressed in a centrifugal compressor (typical) up to required pressure for ammonia synthesis and recycle gas stream from the circulator is added.
Before entering the ammonia converter, the combined stream is fed to the hot gas-gas heat exchangers, where it is heated by the hot converter effluents.
The preheated gas then enters the ammonia converter, in which it reacts over an iron-based ammonia synthesis catalyst, in particular the Amomax®-Casale catalyst can be used to improve the activity and increase the resistance to poisoning.
The ammonia converter is the well proven Casale Axial-Radial® type incorporating three adiabatic, beds, with intermediate cooling by two inter-bed heat exchangers.
At the converter outlet, the product gas is cooled in the hot waste heat recovery train, generating either saturated or superheated steam (according to specific needs) and then in the hot gas-gas heat exchangers. The produced steam can be used to generate el. power in a steam turbine generator (STG), thus increasing the energy efficiency of the unit.

The product ammonia is condensed first in a water cooler, then in the "cold" gas-gas exchanger and lastly in the ammonia chillers.
A considerable amount of ammonia is condensed in the first coolers leveraging the high ammonia concentration obtained in the highly efficient Casale ammonia converter thus limiting the energy consumption of the refrigeration section.

The use of a Casale electric heater inside the converter (instead of a traditional fired type) for the converter start up further enhances the sustainability of the process.

WASTE HEAT RECOVERY TRAIN

The recovery of the reaction heat downstream of the ammonia converter is contingent upon the design of the steam system. While many plants employ a waste heat boiler, alternatives include a steam superheater or, in some cases, a boiler feed water (BFW) preheater.

One notable advantage of Casale's design is that the waste heat boiler or superheater or BFW preheater is flanged directly to the converter outlet nozzle. This feature eliminates the need for a large and expensive connecting gas outlet pipe, which could be prone to nitriding due to the hot, high-pressure converter effluent, and therefore it improves the safety of the loop.

CASALE OPTIMIZER

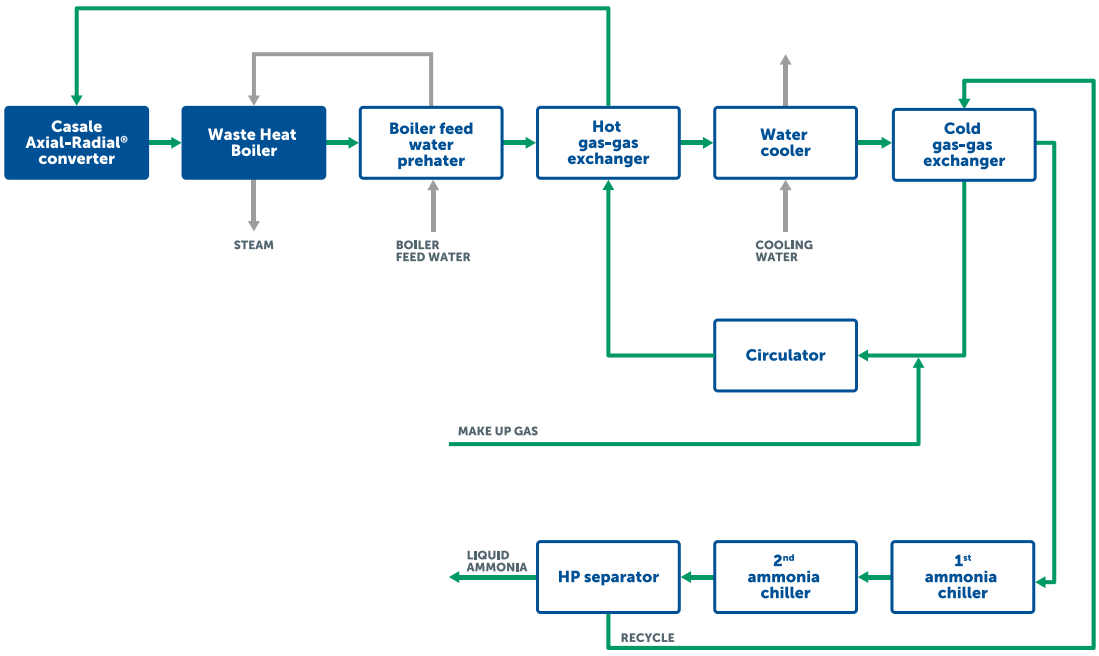
This tool optimizes the variable renewable energy utilization, minimizing the so-called "curtailed energy", and the pre-sizing of the whole plant components, including the SMART-N, the hydrogen storage and the water electrolyzers. It also optimizes the overall process control so that the plant operates at the highest possible output and the lowest possible Levelized Cost Of Ammonia (LCOA). Optimization takes account of the yearly profiles for the renewable power unit and exploits the flexible design features of Casale's SMART-N ammonia plant.

CASALE DYNAMIC ANALYSIS MODEL

This tool is a dynamic process model of the plant which can simulate the process using scenarios from real fluctuations in the renewable power profile. It allows fine tuning of the system, troubleshooting and scheduling.

The tool can dynamically analyze and determine the following:

- renewable power profile
- grid power, if available, although 'off grid' island mode generation can also be an option
- electrolysers: specifies their optimal size
- hydrogen storage: including sizing, control philosophy and plant integration
- ammonia plant: its unique and independent controls
- nitrogen generation: suggests the optimal N_2 profile.



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SMART-N

SMART-N is Casale sustainable solution for small green ammonia synthesis plants, whose feedstock is hydrogen produced via water electrolysis using renewable energy and pure nitrogen obtained in an air separation unit. This process scheme can be easily customized to meet specific Client's needs and adapted also for other applications such us in case of small blue or turquoise ammonia plants.
A distinctive feature of this process lies in its wide capacity rangeability and, if required, it can reliably operate with an erratic renewable power supply so to avoid or minimize the negative effects of cyclic operation and fatigue. Main feature of the Smart loop is to minimize the number of equipment required for green ammonia production (the minimal configuration is requiring 5 item).
Minimal Capex and plot plan are thus obtained.
The process scheme is extremely flexible and can be used to produce pressurized or atmospheric (cold) ammonia.

Capacity

- Best suited up to **300 MTD**, typically

Performances

- Loop turndown ratio, from **10%** to **110%**
- Energy consumption: about **300 kWh/MT**
- No demi-water consumption

Benefits

- Simple arrangement
- Compact lay-out
- Reduced CAPEX
- Production of either pressurized ("hot") ammonia or atmospheric ammonia ("cold")

Casale technical assets

- Casale Axial-Radial® ammonia converter
- Electric Start-up heater of the ammonia converter
- Ammonia washing unit (if required), to remove the water possibly present in the fresh make-up gas
- Casale optimizer
- Casale dynamic analysis system

Enviromental Impact

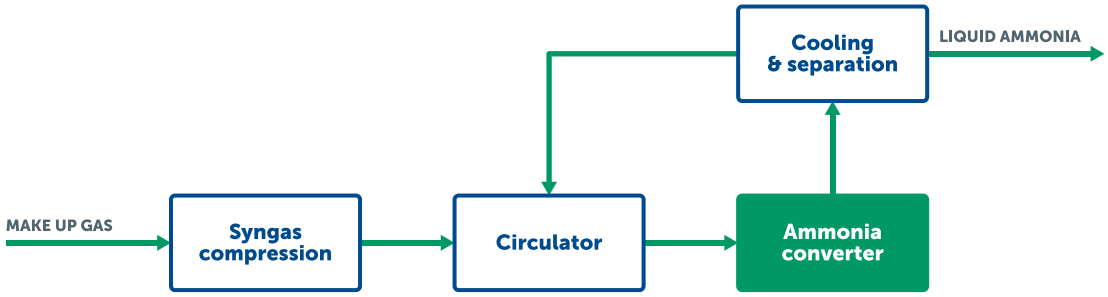
The plant has no CO_2 emissions if all renewable energy is used.

PROCESS OUTLINE

The make-up hydrogen and nitrogen are supplied at 3 to 1 ratio, compressed up to final loop operating pressure and then mixed with the recycle unreacted gases.
The mixture is fed to the Casale ammonia converter in which the gas is pre-heated to the final reaction temperature before flow through the catalytic beds. The converter incorporates the well-known Casale Axial-Radial® technology for all the catalytic beds. An electrical heater housed inside the converter is used for cold start-up and during catalyst activation.
The hot converter effluent is routed to the 1st downstream cooler, which in a typical arrangement is an air cooler. This is followed by a water cooler where the final ammonia condensation is obtained.

The liquid ammonia is then first separated in high pressure separator then depressurized and sent to Battery Limits, while the unreacted gas is recycled back to the synloop circulating compressor.

The liquid ammonia can also be produced at atmospheric pressure ("cold" ammonia). In this case the ammonia vapors are recovered in a dedicated small refrigerant compressor.



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HyPURE-N

Casale has embraced the energy transition challenge focusing on developing sustainable technologies for the production of various base chemicals, including blue ammonia from Natural Gas resources. Drawing upon proprietary technologies, HyPURE-N represents the latest step forward for the large-scale production of ammonia with a greatly reduced environmental impact thanks to the optimization of the energy consumption, the reduction of the natural gas required thus generating, as a consequence, a lower amount of emissions. All CO_2 is captured, and it is sent to sequestration or to other utilizations.

Capacity

- Best suited from **3500 MTD and above**, but can be applied also for lower capacities

Performances

- Energy consumption: as low as **7.4÷7.6 Gcal/MT LHV basis**, including utilities and final CO_2 compression at Battery Limits
- CO_2 recovery: **as high as 99%**

Benefits

- Low energy consumption
- Reduced LCOA (Levelized Cost of Ammonia)
- No steam/power import or export is required

Casale technical assets

- Auto Thermal Reformer (ATR) including burner
- Casale Axial-Radial® prereformer
- Casale Axial-Radial® HT and LT shift converters
- Casale Axial-Radial® ammonia converter, with proprietary nozzle-to-nozzle connection between the pressure vessel and the downstream waste heat boiler
- Advanced waste heat recovery train in the synthesis loop
- AmoMax®-Casale ammonia synthesis catalyst

Enviromental Impact

Total CO_2 emissions per ton of ammonia produced:

- from 0.08 to 0.02.

PROCESS OUTLINE

HyPURE-N is a single-train process optimized to produce ammonia on a large scale with very low carbon intensity. Virtually all CO_2 generated in the front-end is captured and compressed up to (for instance) 200 bar g for sequestration or other utilization purposes (e.g. Enhanced Oil Recovery).
Such high level of decarbonization is achieved through the adoption of a pre-reformer and pure O_2-blown Auto-Thermal Reforming (ATR) front-end, operated at high pressure and with a low Steam to Carbon ratio.
This peculiar and patented reforming scheme is central to obtaining large capacities, high energy efficiency whilst reducing the generation of high temperature heat (limited only to pre-heating purpose), which is the main responsible for the high carbon emissions through the stack in traditional "grey" processes.

The main steps of the process are:

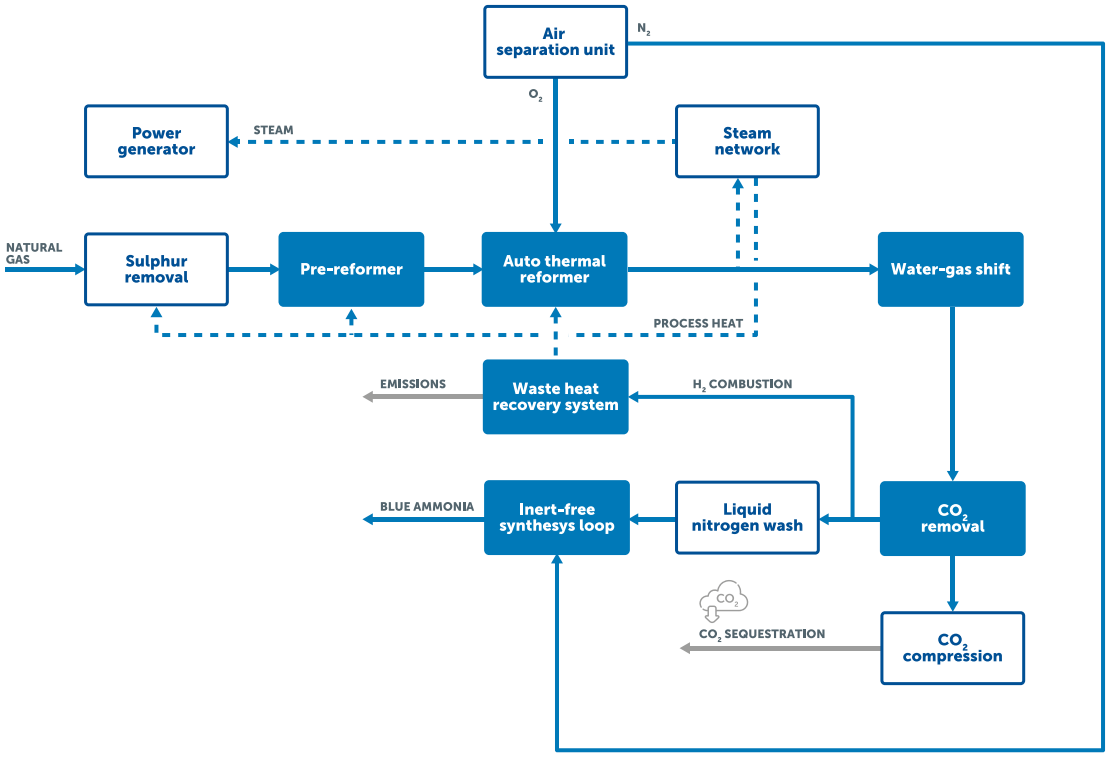
Auto thermal reforming - The feed natural gas is first desulphurized in a conventional cobalt-molybdenum unit and, after subsequent preheating, it is transferred in a Casale Axial-radial® prereformer reactor.
The partially reformed gas is mixed with O_2 and the routed to the autothermal reactor (ATR) where it is catalytically converted into a mixture of H_2, CO and unconverted methane.
The O_2 necessary is obtained with a conventional Air Separation Unit, which also generates the N_2 required by the synthesis of ammonia in the back end of the plant.

High-Temperature (HT) CO Shift – After cooling in a waste heat boiler generating high-pressure steam, the bulk of the carbon monoxide (CO) content of the synthesis gas is converted to CO_2 and H_2 by reaction with steam.

Low-Temperature (LT) CO Shift – After further cooling, the CO shift reaction is completed in a LT shift stage. Casale Axial-Radial® flow internals are used in both the HT and LT shift reactors.

CO_2 removal – After cooling and condensing the surplus steam, the gas next passes into the absorption column of a highly-efficient regenerative CO_2 removal system. The CO_2 is recovered in a concentrated form and sent to other uses or final sequestration.

Syngas Purification – The traces of oxygenated compounds, other ammonia synthesis catalyst poisons, and inerts are removed through a suitable purification system, including for instance trough Liquid Nitrogen Washing. Nitrogen necessary for the ammonia synthesis reaction is also added at this stage.



Ammonia Synthesis - After adding with N_2, the purified, inert-free syngas is compressed and directed to a Casale ammonia synthesis loop, equipped with a Casale Axial-Radial® ammonia converter, where low-carbon, cold ammonia is produced. The high efficiency of the converter and the reactivity of the inert-free gas ensure that equipment sizes in the synthesis loop and refrigeration section are within the limit of industrially proven references.

With the only exception of the syngas and the refrigeration compressors, which are driven by steam turbines, all other movers utilize electrical power generated within the plant.

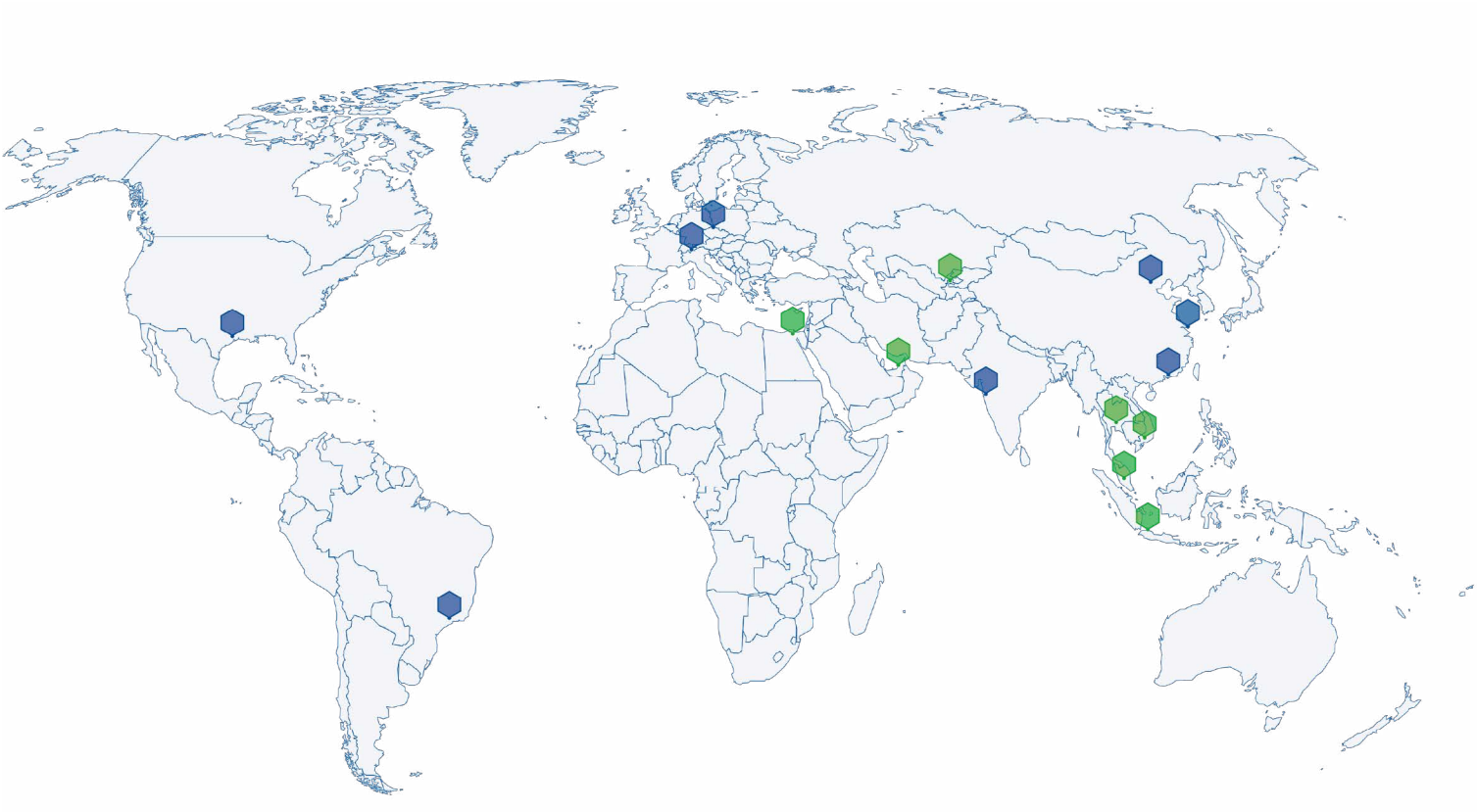
Most importantly, HyPURE-N, process leverages a specific pre-combustion philosophy that utilizes part of the carbon-free syngas generated plus other off-gases for all fuel requirements and that is central to meet the distinctively low environmental impact target.

The process is extremely flexible and may be tailored to specific needs in terms of carbon capture requirements and energy consumption.

Explore our full range of ammonia technologies

Visit our website

Casale in the world



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