

K-Boost™ – KBR Technology Solutions to enhance capacity and energy efficiency of your ammonia plant

Making the Future Happen Faster



Revamp to thrive

KBR has the know-how to upgrade ammonia plants to peak performance. Our reliable engineering solutions like KRES™, Purifier™, Ammonia Converter upgrade with high pressure steam generation in the synloop have proven track record for ammonia plant revamp to:

- Increase plant capacity by as much as 25-50% compared to current capacity
- Reduce specific energy consumption by 5-15%
- Decrease maintenance cost
- Debottleneck existing key equipments such as primary reformer, waste heat boiler, synloop equipment, which will be operated at milder condition and have their life extended
- Improve productivity, flexibility, and reliability
- Increase profitability and achieve attractive project paybacks, in as low as three years
- Reduce your plant's carbon footprint and NOx emissions for meeting environmental standards

Why partner with KBR...

A leading ammonia licensor and innovator since 1944, KBR has licensed more than 250 grassroot ammonia plants and completed more than 200 revamp studies and projects.

Assess, identify and improve

Each plant is unique and your plant is quite different from the one that was commissioned – over years of operation, in fact, modifications happen, parts wear out, get replaced and feedstock mixes change.

Every revamp project begins with KBR team collecting plant data and conducting a thorough process study of the existing plant, simulating your current operation to:

- Determine sustainable capacity
- Pinpoint bottlenecks
- Assess energy consumption and equipment performance
- Identify areas of improvement

A number of revamp process options are considered, and the costs and benefits of each are carefully weighed to find the most cost-effective solution for your requirements.

Engineer and execute

Once the revamp scheme is defined and selected during the study phase, the KBR design team can develop the basic engineering design package (BED). After BED is completed, KBR will support project execution, including but not limit to proprietary equipment (PEQ) and catalyst supply, critical equipment vendor design review, detailed engineering review, equipment fabrication check and inspection, catalyst loading, pre-commissioning activities, commissioning, start-up, performance test.

Our experience in revamping encompasses plants both KBR and non-KBR original design. The latter typically offers more opportunities for improvement.

Flexible revamp technology solutions

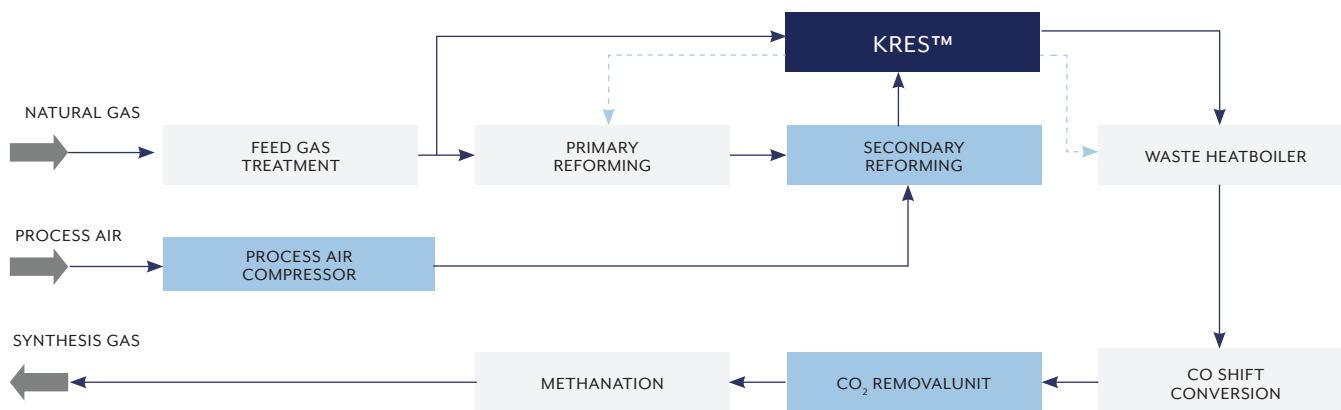
SMALL CAPACITY INCREASE (15-20%)
+ IMPROVED ENERGY EFFICIENCY

- Optimize key process parameters such as S:C ratio, pressure profile, synloop operating parameters
- Revamp major machinery with modern internals and optimize cooling
- Reformer furnace
 - Re-harp with higher ID reformer tubes
 - Optimize heat recovery in convection section
- Dry loop with KBR syngas dehydrator
- Improve hydrogen recovery, heat recovery and ammonia recovery
- Retrofit CO₂ removal unit to increase capacity while reducing energy consumption
- Cost benefit analysis for each revamp option

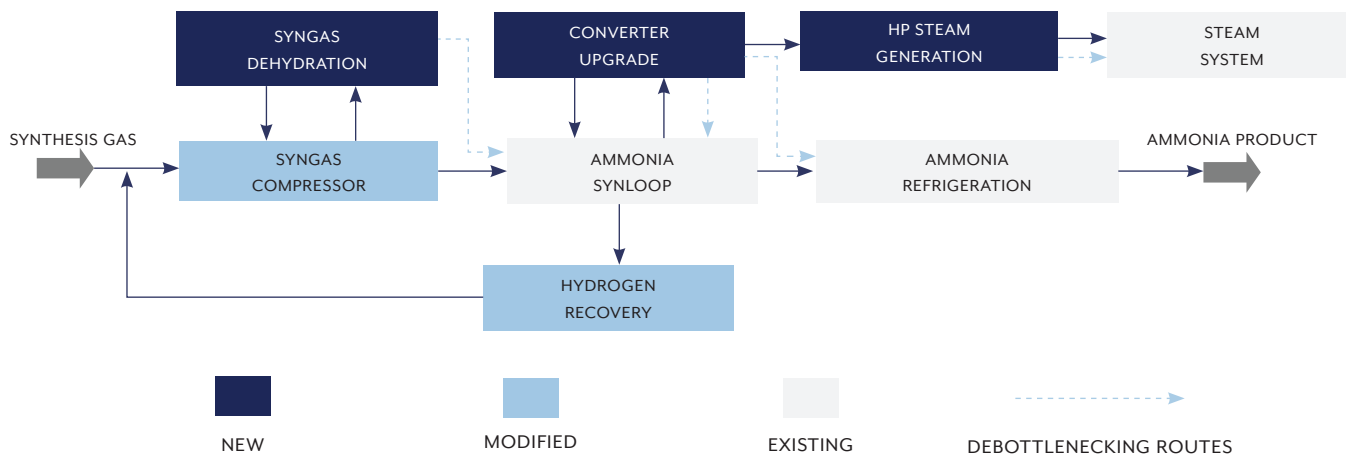
MAJOR CAPACITY INCREASE (UP TO 50%)
+ IMPROVED ENERGY EFFICIENCY

- Similar changes as per small increase
- New KBR floating head waste heat boiler design
- New KBR Reforming Exchanger System (KRES™)
- Revamp CO₂ removal units for high capacity increase and energy saving
- Add-on ammonia converter (or new ammonia converter) + new HP steam generator
- New KBR Purifier™ package to debottleneck ammonia synloop

Front-End Revamp (Example)



Back-End Revamp (Example)



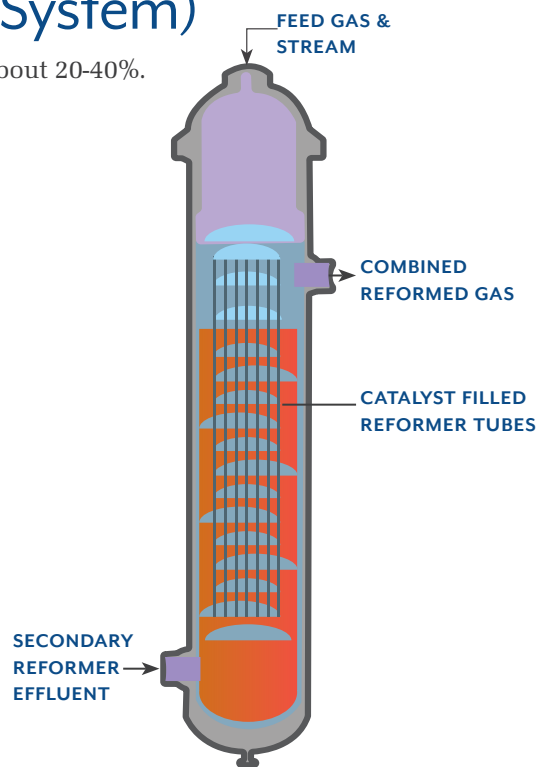
KRES™ (KBR Reforming Exchanger System)

KBR offer KRES™ revamp to increase reforming capacity by typically about 20-40%.

KBR's proprietary Reforming Exchanger System features:

- Effluent gas from the reformer provides heat for the reforming reaction occurring inside the catalyst-filled tubes
- Tubes are open-ended and hang from a single tube sheet at the inlet cold end to minimize expansion problems
- Easy catalyst load through a removable top head
- The tubes are accessible and removable as a bundle for maintenance

KBR provides expertise and experience on how to physically install and connect the reforming exchanger with the existing secondary reformer and waste heat boiler, which was implemented in similar KRES™ revamp projects.



The benefits of KRES™ revamp

Reduce load in primary reformer. The primary reformer operates at milder conditions than current operation

Reduce inlet temperature and heat load on the waste heat boilers. The boilers thermally operate at milder conditions

Utilize heat from the reformer to generate synthesis gas. This reduces natural gas energy consumption and decreases CO₂ emission in the flue gas

Eliminate pressure drop increase in the reforming section

Shorten shut-down period as the reforming exchanger can be installed in advance

WASTE HEAT BOILER

KBR offer the well-proven and reliable floating-head design waste heat boiler to replace existing boilers for large capacity revamp or maintenance replacement. This new boiler, featured in all new KBR Purifier™ ammonia plants, improves reliability and maintenance, shortens turnaround and decreases pressure drop.

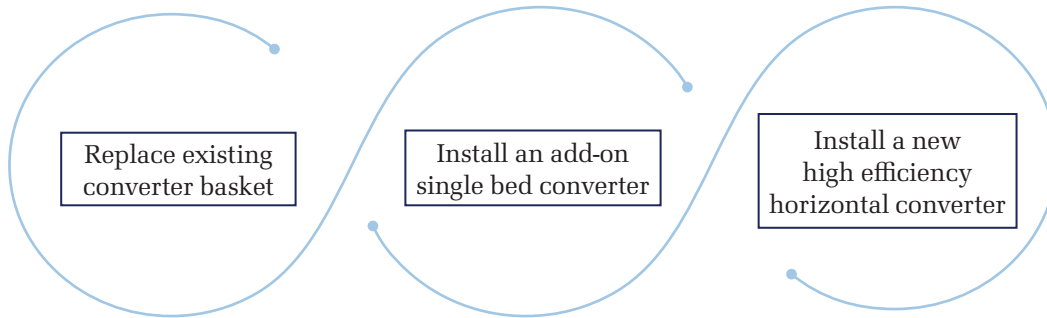
KBR Floating Head design features

- Dual-layer refractory shell
- Process gas on shell side, entering two-third from top tube sheet
- BFW/steam on tube side
- Floating head design accommodate thermal expansion growth



AMMONIA CONVERTER REVAMP

KBR offers for the revamp of the ammonia synthesis converter three options, depending on the existing configuration, capacity increase and energy efficiency targets:



SINGLE-BED VERTICAL ADD-ON AMMONIA CONVERTER

This is typically used downstream of the main converter to boost per-pass ammonia conversion to maximize capacity as well as energy efficiency.



HORIZONTAL AMMONIA SYNTHESIS CONVERTER

The KBR horizontal converter features a removable basket that can be rolled out of the converter on tracks for easier loading and unloading of catalyst. This new modern ammonia converter replaces existing vintage converter for higher capacity, higher conversion per pass at lower pressure drop.



With KBR ammonia converter revamp solutions, only minor or no change to existing refrigeration system is required.

HIGH-PRESSURE STEAM GENERATION IN AMMONIA SYNLOOP

In addition, coupled with a new add-on converter or a new horizontal converter, KBR can introduce HP steam generation in synthesis loop, which significantly increases plant energy efficiency while debottlenecking existing steam system.

PURIFIER™ REVAMP

In some applicable cases, KBR offers its proprietary cryogenic purifier technology, that removes all the methane and 60% of the argon leaving a nearly inert-free syngas. Used alone or in combination with a KRES revamp, our Purifier process can increase plant capacity up to 50% and combined with other improvements can reduce plant energy consumption as low as 6.3 Gcal/t.

Success stories

Some of the key revamping projects are included in the following table. A full list of projects is available on request

Client	Location	Year
Acron, Novgorod #2	Russia	Ongoing
Acron, Novgorod #3	Russia	Ongoing
SAFCO IBB	Saudi	2021
Acron, Dorogobuzh	Russia	2019
Potash Corp.	Lima OH USA	2015
Chambal (CFCL) #2	India	2010
Chambal (CFCL) #1	India	2009

— Case Study 1: Dorogobuzh, JSC (Acron Group) – capacity increase of 20% and energy saving of 9% —

Project outline

In 2017, Acron set the ambitious goal to achieve the highest possible capacity on all its operating plants. The revamping of its TEC ammonia plant in Dorogobuzh was selected as a pilot case and KBR technology was selected for the project. The project implementation period was very ambitious, targeting completion by 2019. The successful execution of the project convinced Acron to select KBR technology solutions for the revamping of two more existing plants, with even higher capacity targets.

Revamping Solution

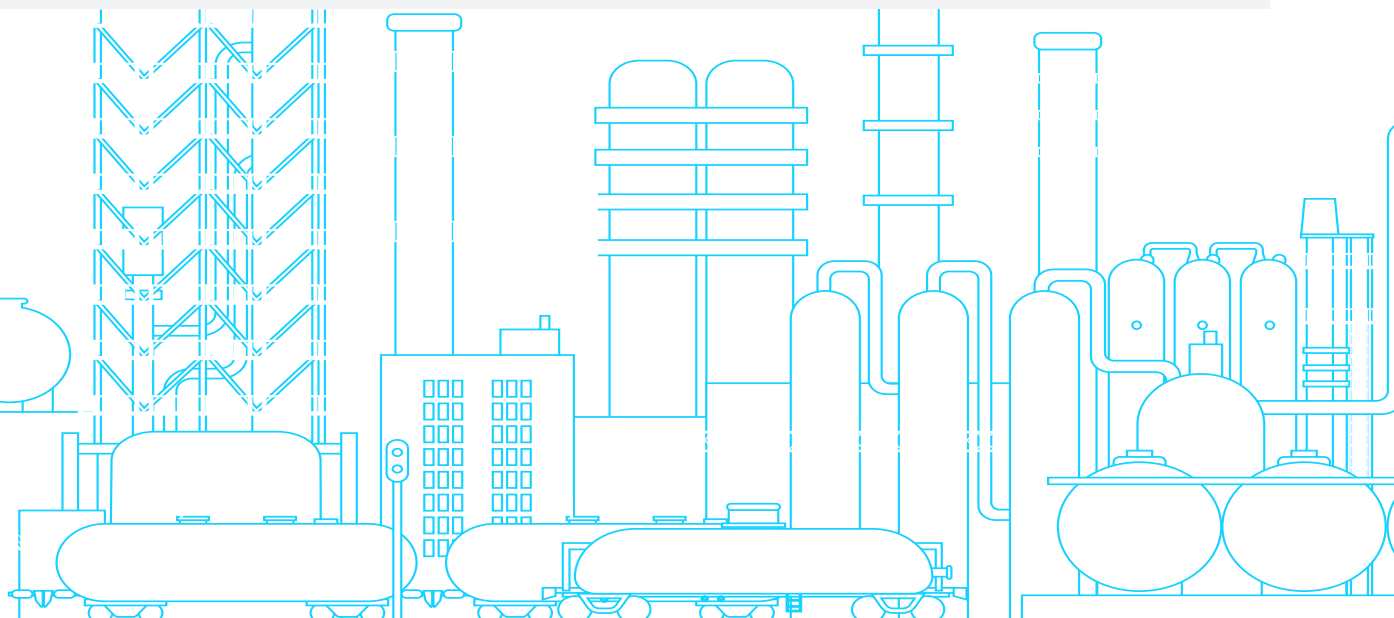
KBR applied its state-of-art design solutions including KRES™ and the cold-wall add-on ammonia converter with HP steam generation.

Timeline

Project was completed within 30 months from entering BED contract. Most of fabrication and installation works was performed during normal plant operation. The tie-in of new equipment was done during a normal 42-day plant turnaround.

Figures	Units	Base 2017	Guaranteed	Test run
Ammonia capacity	MTPD	1745	2100	2107
Total natural gas consumption	Nm ³ /MT	1111	1042	1006
	Gcal/MT	9.03	8.5	8.2
	MMBtu/MT	35.8	33.7	32.5
Ammonia quality	wt.%		min. 99.8	99.85

The plant reliability was enhanced as demonstrated by uninterrupted operation of the plant since start-up



Digitalization solutions for Ammonia Revamp

The **KBR Digital Sustainability Suite** leverages KBR's decades of industry and domain expertise to offer a set of integrated digital solutions covering the entire asset life cycle of revamped plants, that enable our ammonia clients to establish profitable and energy-efficient operations and realize opportunities to reduce operating costs.

KBR INSITE® – a cloud-based licensor service to enable our clients maintain optimal operation of their revamped plants through performance monitoring and provision of expert advisory services, based on tracking and analysis of key performance indicators (KPIs).

KBR Predictive and Prescriptive Analytics Solutions – artificial intelligence and machine learning (AI/ML) solutions focused on both process and equipment health, which detect anomalies early, avoiding unplanned shutdowns and allowing the revamped plant to operate at peak performance.

KBR Competency Development Solutions – high fidelity operator training simulators (OTS), based on proprietary models of the revamped plant and integrated training service (ITS) programs including training scenarios.

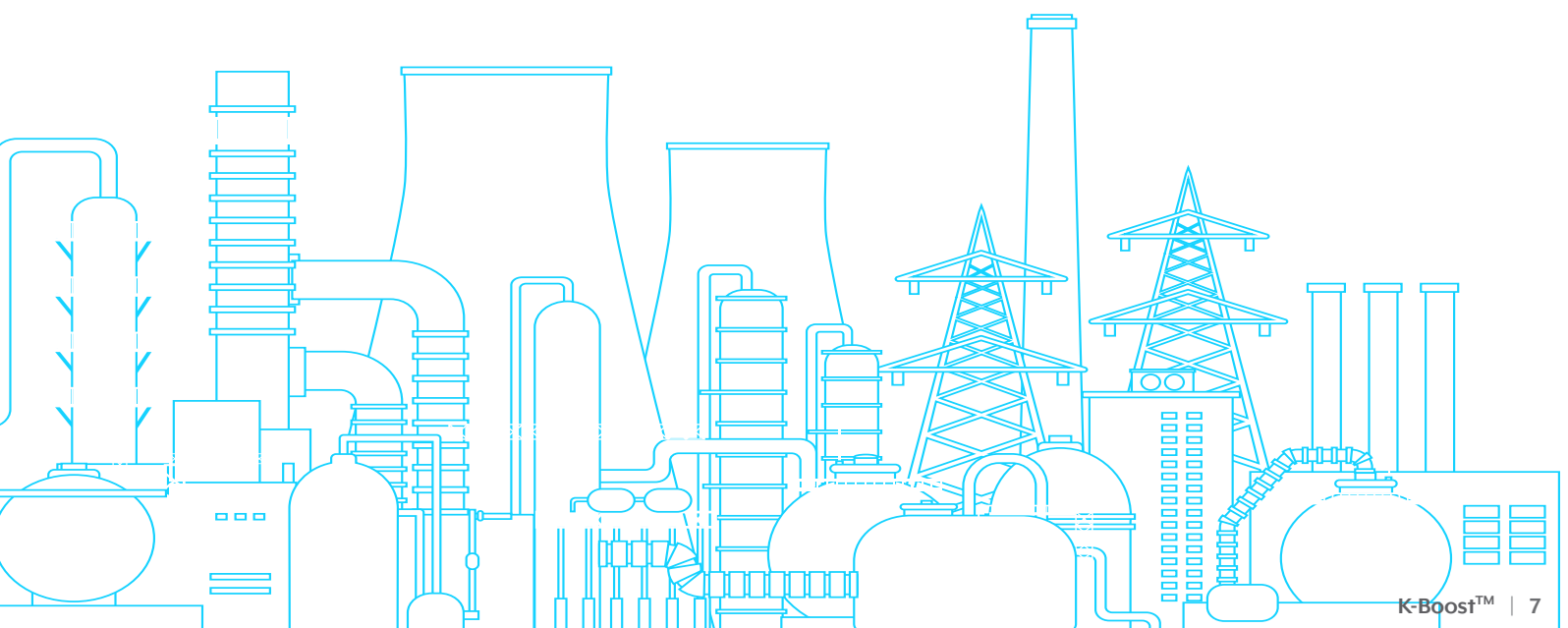
KBR Advanced Process Control (APC) Solutions – full turnkey APC solutions, leveraging our rich history in ammonia process technology and early experience in the application of advanced control for the ammonia production process, achieve optimal and stable operation of revamped ammonia plants.

KBR Dynamic Simulation Solutions – based on proprietary first principle process models, to establish equipment specifications and a robust control system for the entire operating range of the revamped plant.

Significant, multi-million-dollar savings are expected from the optimization of an ammonia plant turnaround schedule due to the extension of the catalyst residual life.

KBR utilizes rigorous kinetic models and domain expertise to estimate the catalyst residual life given the plant's throughput, reactor space velocities, sulfur poisoning, moisture ingress, and catalyst bed operating conditions. Based on predicted reactor yields, plant economics, spare parts inventory availability, supply chain constraints and contractual production commitments, our client was able to determine the optimum turnaround schedule using KBR digitalization solutions.

KBR ENGINEERS CAREFULLY CONSIDER EVERY ASPECT OF THE PROJECT – FROM CRITICAL EQUIPMENT AND SYSTEMS TO START-UP AND SHUTDOWN AND CLIENT CONTINUES TO RECEIVE TECHNICAL SUPPORT FROM CONCEPT TO REALITY. A TEAM OF KBR AMMONIA EXPERTS IS AVAILABLE TO PROVIDE COMPLETE ON-SITE COMMISSIONING AND START-UP SERVICES.



ABOUT KBR

We deliver science, technology and engineering solutions to governments and companies around the world. KBR employs approximately 28,000 people performing diverse, complex and mission critical roles in 34 countries.

KBR is proud to work with its customers across the globe to provide technology, value-added services, and long-term operations and maintenance services to ensure consistent delivery with predictable results.

At KBR, We Deliver.



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