

Hydro-PRT[®]

KBR's Plastics Recycling Technology for a Green Future

WHAT IS HYDRO-PRT®?

Hydro-PRT® is a differentiated and scalable advanced recycling technology converting plastic waste feedstock into stable commercial hydrocarbon products. It is based on a unique patented process from Mura Technology using supercritical water (SCW).

KBR's Hydro-PRT processes end-of-life, mixed and contaminated plastic waste into hydrocarbon liquid and gas that can be used to produce virgin circular polymers and chemicals. Targeted feedstocks for advanced recycling are waste streams that cannot be cleaned, reused or mechanically recycled.

ENVIRONMENTAL AND ECONOMICAL DRIVERS

Plastic production and consumption are expected to double in the next 20 years. To help circular economy and to achieve net-zero emission goals, recycling rates need to increase, and unmanaged waste streams must disappear. The commercialization of advanced (also called chemical) recycling technologies, like Hydro-PRT, is a crucial milestone to bridge the recycling capacity gap.

KBR's Hydro-PRT can contribute to reach the global sustainability goals by:

Protecting the environment by minimizing plastic waste – on land and in the oceans

Providing feedstock for fully circular plastics and avoiding depletion of fossil resources by recovering the value of plastic waste

Helping to reach the goal of net-zero greenhouse gas (GHG) emissions by providing an alternative to plastic waste incineration or to fossil fuels used for energy generation



A DIFFERENTIATED ADVANCED RECYCLING PROCESS

KBR's Hydro-PRT process is differentiated versus other advanced recycling technologies due to presence of supercritical water (SCW) acting as a heating medium, which is mixed with the plastic waste in the reactor. This guarantees a direct heat transfer compared to other advanced recycling processes (e.g., pyrolysis), where the waste may be heated indirectly. Besides, no catalyst is used in the process, which makes the process less sensitive to contamination coming from the feedstock.

The sorted plastic waste stream is heated and melted in an extruder before getting in contact the supercritical water. The combined fluid flows into the reactor where the hydrothermal conversion occurs. The reactor output is separated into oil products, process gas and supercritical water. In a fractionation column the oil is separated into fractions of various boiling ranges.

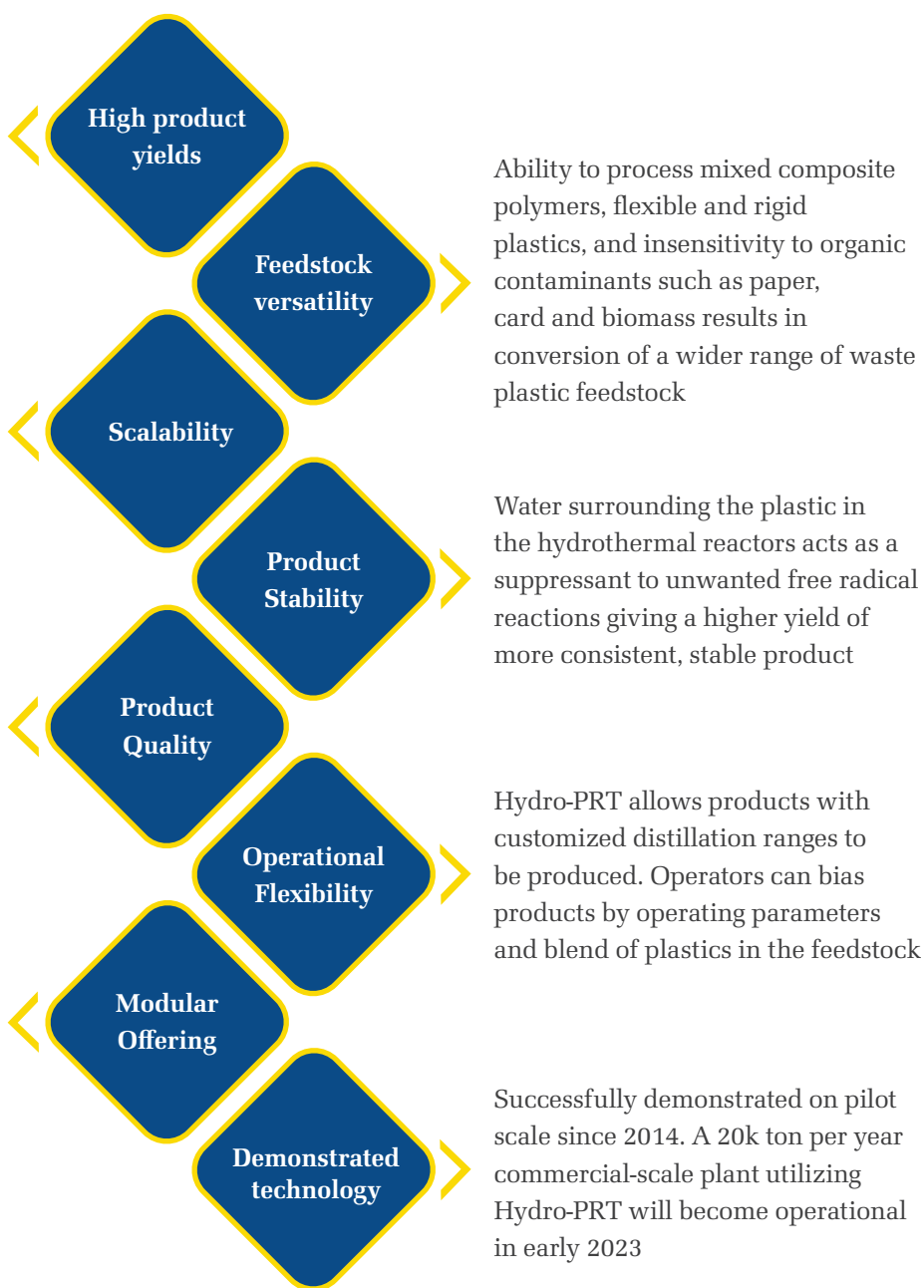
ADVANTAGES

Negligible char or unwanted by-products and the ability to control reaction conditions result in high liquid products yields (>85% liquid)

Direct contact between the plastic and the heating medium (supercritical water) leads to an efficient heat transfer mechanism

Distillation of products allows ready separation of fine solids and particulates from the naphtha into the heavy wax residue. This provides high-quality hydrocarbon oils

Modular delivery of a complete hydrothermal conversion unit will save project time, and costs and reduce project risks

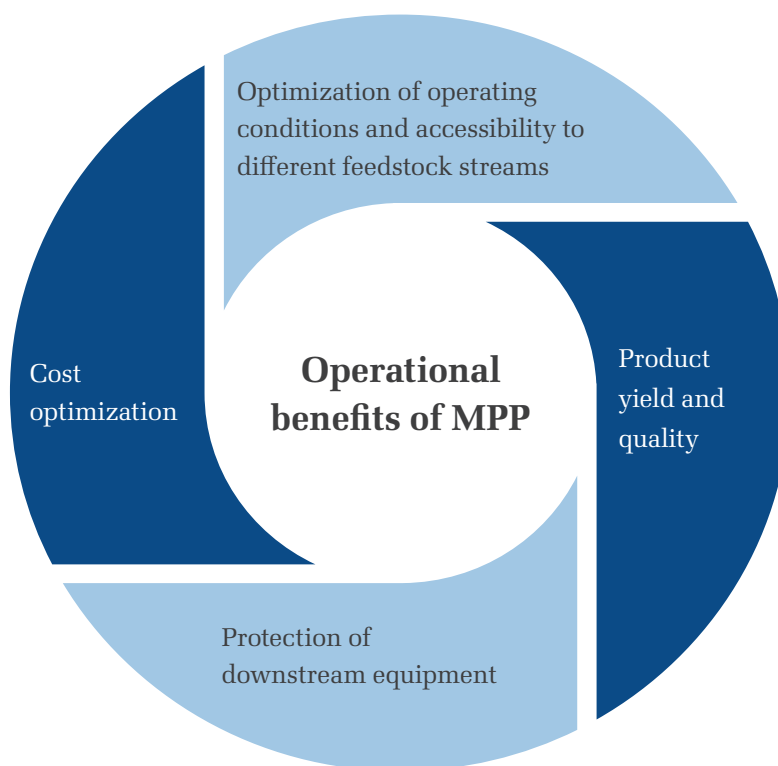


MORE THAN A REACTION - KBR'S HOLISTIC APPROACH

The SCW reactor is the main part of the Hydro-PRT process, however, to ensure continuous operation, high yields and good product quality, KBR defined additional processes – both upstream and downstream from the Hydro-PRT reactor – to offer a holistic approach.

FEEDSTOCK

Before entering the reactor, feedstock should be optimized in a sorting process to minimize the presence of unwanted contaminants. This step takes place in the Material Preparation Plant (MPP).



The targeted waste plastic feedstock stream, before entering the MPP, should consist of high polyolefin content to guarantee high hydrocarbon product yields and minimum contamination.

The key differentiator of the Hydro-PRT is feedstock flexibility as some impurities and unwanted materials are tolerated, including paper, cardboard, textile, or leather as well as non-polyolefinic polymers like PS, PET or PA.

PRODUCTS

The Hydro-PRT products consist of ca. 15% of gas and 85% of liquid hydrocarbon mix. The liquid hydrocarbons can be separated by boiling temperatures into customized fractions. Lighter fractions can be used as feedstock to produce new circular plastics or other chemicals, while heavier ones can be processed further in refineries or used for base oil and wax production or fuel blendstock. The heavy wax residue can serve as asphalt additive or coker feedstock.

KBR OFFERS MODULAR SOLUTIONS

KBR offers modular solutions, for 20kta and 50kta liquid product capacity, with the following benefits:

Cost Reduction

- An **average of 15%** reduction as compared to stick-built
- Better Project returns
- **Improved Cash Flow**



Modules shipped with associated structures, piping and instrumentation diagram (P&ID). Plus, electrical and finished module assembly including painting, insulation and fireproofing

Improved Quality

- Working under **controlled shop environment**
- **Trial fit-up** and match marking
- **One stop shop** solution from design – delivery



Improved Safety

- Majority of fabrication work in shop
- **Less Site work** in active operating



Schedule Reduction

- Improved schedule due to **concurrent engineering**
- Improved by **5-8 months** against standard approach
- **Early start-up** leading to **improved payback**



Risk Reduction

- **Site risk mitigation** – weather disruptions, material sourcing etc.
- Design and fabrication delivery by single party
- **Performance and Mechanical Guarantees by the licensor**





ENVIRONMENTAL IMPACT

Differentiated Hydro-PRT process with its scalability potential can play a significant role closing the capacity gap in plastics waste recycling and contributing to full circularity of plastics. Life cycle analysis (LCA) studies support circular economy targeting net-zero greenhouse gas (GHG) emissions.

Independent LCA studies for Hydro-PRT demonstrate clear environmental technology benefits:

- LCA results demonstrate that circular polymers from plastic waste exhibit less global warming potential (GWP) vs fossil equivalents, especially if renewable energy is used in the Hydro-PRT process. Recycling of plastic waste using Hydro-PRT leads to 90% reduction of consumption of natural resources. The remaining 10% represents the consumption of 'fossil electricity' by the current Hydro-PRT process using the UK grid. Moving to a renewable grid would reduce fossil resource consumption effectively to zero.
- Advanced recycling Hydro-PRT products can reduce CO₂ emissions and if the plastic waste is recycled using the Hydro-PRT process, the carbon footprint of hydrocarbon products (used as fuels to generate energy) is decreased by over 80% vs fossil equivalents.
- Recycling plastics waste via the Hydro-PRT process generates no hazardous waste. The minimal waste produced falls out into the heaviest hydrocarbon feedstock, which can be used, for example, in the construction industry.

KBR'S ALLIANCE WITH MURA TECHNOLOGY



KBR is the exclusive global licensing partner for Mura Technology, the UK-based pioneer of this breakthrough plastics recycling technology.

The partnership has led to multiple licensing agreements from major chemical companies. The deals will play a significant role in supporting our common goal of 1,000,000 tonnes of recycling capacity by 2025.

More recently, the investment of an additional \$100 million in Mura brings KBR's aggregate investment in Mura to 18.5%. This will provide incremental capital to accelerate development of its plastics recycling projects and enables KBR to participate more fully in this sustainability-focused, high-growth sector.

In the first year of licensing KBR got awarded contracts for total capacity of over 150.000 tonnes of plastic waste per annum



With KBR's assistance ReNew ELP, Mura's subsidiary company and the first adopter of the technology, is constructing the first commercial Hydro-PRT plant at the Wilton International Site with an initial production capacity of 20,000 tonnes p.a. to be expanded up to 80,000 tonnes p.a.

The plant will start supplying its first commercial products in early 2023.



ABOUT KBR, INC.

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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