

# Methanol synthesis

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## ***Step-wise Technology Pathways to Decarbonization***

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Achieving deep decarbonization of large-scale chemical production assets poses a significant challenge, as existing plants are capital-intensive, and deeply integrated into complex value chains. While fully greenfield solutions offer the highest theoretical emission reduction potential, they are often limited by technology readiness, infrastructure availability, and economic constraints. As a result, step-wise technology pathways that enable gradual impactful emission reductions are emerging as a pragmatic and scalable approach towards net-zero.

This presentation discusses three representative industrial examples in which decarbonization can be implemented incrementally rather than through a single, disruptive transition. The first example focuses on methanol production, where a green hydrogen electrolyzer is added to an existing grey steam methane reforming (SMR)-based syngas plant. By partially substituting fossil-derived hydrogen with renewable hydrogen, CO<sub>2</sub> emissions are reduced while key assets such as large-scale methanol synthesis and downstream processing remain unaffected. Such hybrid configuration enables early deployment of electrolysis, supports learning curves and reduces risks, and can be scaled further as renewable power availability grows.

The second example addresses steam cracking, one of the most energy- and carbon-intensive processes in the chemical industry. Instead of full electrification, a single conventional fired furnace is partially replaced by an electrically heated furnace within an existing cracker complex. This selective electrification approach allows significant direct CO<sub>2</sub> emission reductions, while maintaining operational flexibility and minimizing retrofit risks related to power infrastructure, plant availability, and capital expenditure.

The third example illustrates feedstock decarbonization through the gradual introduction of pyrolysis-oil-based feedstocks derived from plastic waste into a conventional steam cracker. Due to feedstock availability, and process constraints, full substitution is neither realistic nor necessary in the short to medium term. However, even limited co-feeding enables meaningful fossil feedstock displacement and supports circular carbon pathways.

Together, these cases demonstrate that step-wise decarbonization strategies can deliver substantial and credible emission reductions today, while preserving asset value and enabling continuous technological and infrastructural evolution towards fully decarbonized chemical production chains.