INTRODUCTION
Within a coil-wound heat exchanger (CWHE), several layers of tubes are helically wound around a large central tube, known as a mandrel. This tube bundle is enclosed by a pressure vessel to ensure sufficient flow on the shell side. LINDE CWHEs are very flexible and can process more than five different process mediums.

Due to their special “spring-like” design, CWHEs are extremely robust. They can be operated at a temperature range between -269°C and +650°C and can handle much larger temperature and pressure differences than other types of heat exchangers. The tube bundle simply shrinks or expands during start-up or shut-down, for instance, to accommodate these large changes in temperature.

This robust design makes CWHEs ideal for a wide range of cryogenic applications. In particular, they are often used as core equipment in mid- to world-scale LNG plants. For liquefaction capacities of up to 1.5 million tonnes per annum (MTPA), a single mixed-refrigerant cycle is typically deployed as it is the most economic process in this case. The CWHE consists of three tube bundles installed above each other within one shell. This is referred to as a “rocket design”.

REASON FOR SEPARATE VESSELS
Depending on the location, mainly for Chinese on-shore LNG facilities inland, there are very strict transport restrictions regarding length, diameter, and weight. A CWHE design with separate vessels, each containing one LNG bundle, was developed to overcome this challenge.

COST IMPACT
The following graph shows a comparison between one- and multi-vessel designs. The cost of the design with separate vessels is almost identical to the rocket design. This is especially true for the Chinese projects. In addition, local scope (e.g., interconnecting piping and steel structure) is increased at similar plot space.

DESIGN OPTIMIZATION
In addition, separating the structure into three vessels optimizes the design of all CWHEs. The Joule Thompson expansion of the mixed refrigerant stream for the Precooler and Liquidifier bundle is routed in the vessel above. This allows a new distributor type to be utilized and increases the residence time for mixing to create thermodynamic equilibrium.

Using computational fluid dynamics (CFD), this new shell-side distributor system provides ideal separation of liquid and gas and perfect distribution to the bundle below. This design also shortens cool-down time during start-up by up to 20%.

MANUFACTURING & SCHEDULE
For each vessel, central tube sheets can be used instead of radial ones. This accelerates mandrel manufacturing and simplifies the support system. Additionally, for the rocket design, up to three parts have to be transported separately due to shipping limitations. The separate parts must be welded together on site and a pressure test is required afterwards. The separate vessel design eliminates the need for final assembly and a pressure test on site.

CONCLUSION
Economical design as well as fabrication factors have been taken into account by LINDE during development. Compared with the rocket design, separate vessel designs have the following advantages:

- Smaller CWHE vessel size for compliance with transport requirements
- Lower CWHE costs
- Overall cost similar despite extended Chinese scope
- Improvement of shell-side flow
- Faster fabrication due to simpler design
- No on-site pressure test required
- Faster cool-down during start-up

REFERENCE PLANTS
Two LNG plants with separate vessel design are already in operation and performance test run was successful. Two other plants with capacities of up to 0.7 MTPA are still under construction.

Customer: Tongkr
Capacity: 0.32 MTPA
Location: Bachiou, Sichuan
Commission: 2016

Customer: Huagang Gas (PetroChina)
Capacity: 0.45 MTPA
Location: Jinqeng, Shashi
Commission: 2016

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