This paper describes how onshore oil and gas compression stations can be built most efficiently and economically using sole sourcing, further supported by advanced digitalization and expert project management execution. The digital twin concept is explained. Ultimately, the concepts and principles covered by this paper can help owners and operators of onshore compression stations reduce costs, risks, and time while ensuring maximum investment returns.

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Fifty kilometers north of Abu Dhabi, one of the world’s largest and most modern gas compression stations — the Taweelah Gas Compression Plant — opened in late 2018. Owned and operated by the Abu Dhabi National Oil Company (ADNOC, the facility comprises three Siemens compression trains, each with a processing capacity of 225 million standard cubic feet per day (mmscfd). Two operate at any one time, with the third on standby, giving the plant 450 mmscfd of total production throughput.

Not only is the ADNOC plant’s size remarkable, but also how fast it was built: just 16 months for a full turnkey works, including engineering, procurement, and construction (EPC, with no major safety incidents during more than 5 million man-hours of construction time. Siemens was the project’s prime contractor, overseeing its entire construction and numerous subcontractors.

As part of the EPC contract — facility design, construction, and commissioning — Siemens also supplied three Dresser-Rand DATUM compressors; three electric variable frequency drives; a 33 kV electrical substation; a 10-kilometer 33kV cable corridor; four kilometers of pipelines for sales gas suction and discharge; a control building; auxiliary equipment and systems; utilities; a flare tower; and safety and control systems.

To accelerate the project schedule, Siemens brought its global scope to bear by putting its Singapore offices in charge of engineering and project management and coordinating with extreme precision the work and scheduled deliverables of more than 140 suppliers. Overall, approximately 30 percent of the project involved Siemens equipment. This included outputs from many Siemens worldwide centers of competency that were responsible for the following major subsystems, components, and services:

- **France**: Gas compressor trains
- **Turkey**: 33 kV gas-insulated switchgear (GIS); 11kV air-insulated switchgear (50kA); and low-voltage switchgear
- **Germany**: Distribution board, meters, and gauges
- **Italy**: 240V AC uninterruptible power supply for the control building
- **China**: Valves used throughout the plant
- **UAE**: Telecommunications; piping; fittings; and civil engineering

The speed of construction underscores how the complexities and inherent project risks of building a large onshore compression plant can be best managed by sole-sourcing project responsibilities to a competent, experienced resource. Alternatively, Siemens does provide other customers — end-users and EPC consulting firms — with compression solutions that range from powerful turbines to complete drive trains, if they prefer to build their own plants.
Deploying advanced digitalization and experienced project execution

Although the ADNOC gas compression plant’s completion speed was noteworthy and possibly record-setting for a project of such a size, it was not an exceptional result of having extraordinary resources focused on an aggressive schedule, plus the good fortune to have all the right circumstances line up. Instead, it was highly representative of a distinctive approach that Siemens brings to large, complex projects across the oil and gas industry: advanced digitalization and experienced project execution.

Digitalization of large, complex oil and gas projects, such as onshore compression plants, starts at the FEED stage. That’s when concepts to address project requirements begin to be sketched out collaboratively by the design and engineering teams of the customer and Siemens.

The use of 2D and 3D software tools, such as computer-aided design (CAD) and computer-aided engineering (CAE) applications, means that all the project’s many components, sub-systems, and major systems first take form in virtual space. These can then become the basis for what are called digital twins, which are software proxies for the physical counterparts that will eventually be fabricated.

As 3D virtual proxies, digital twins can illustrate and animate just about every plant dimension. For example, engineers can expand their views from extremely granular detail of a turbine’s components and sub-assemblies to larger views of the turbine itself and the entire compression train, even the entire plant. With such comprehensive virtual representations, they can conduct a wide range of simulations to evaluate their FEED concepts, pre-empting the time and rework of design and engineering in later stages.

Of course, for our customers seeking onshore oil and gas compression plant solutions, Siemens already has available the design and as-built 2D and 3D drawings in the software of every model of our rotating equipment for compressor trains in operation worldwide.

Even more, for thousands of those units, we have operating data going back years, so we can help our customers conduct their simulations with data representing actual operating conditions. Those conditions can vary from arid desert climates, such as the operating environment of the ADNOC Taweelah compression plant, to steamy jungle climates or harsh Arctic winters.

Finally, digital twins can help onshore compression plant owners/operators cut weeks, if not months, from commissioning time. That’s because the plant’s digital twin can be used to verify design interfaces, develop and test operating and safety procedures, and train operations and maintenance personnel in the virtual environment instead of waiting until the physical structures are complete and operational.

To facilitate global, interdisciplinary cooperation and a systems-engineering approach to onshore compression plant projects, Siemens offers a range of sophisticated software tools. We use these ourselves when acting as the prime contractor on projects such as the ADNOC compression plant.

One example is our COMOS integrated engineering management software suite. COMOS is a centralized cross-disciplined database and integrated toolset for plant engineering, operations, and maintenance throughout the life cycle of the asset — from process design through decommissioning — that supports process engineering, P&IDs, electrical, instrumentation, and control engineering.

Although digitalization offers significant benefits during design and build project phases, its biggest contribution to a project’s return on investment is during the operations and maintenance (O&M phase by maximizing asset availability and utilization and optimizing maintenance activities. The digital twin of the compressor station enables O&M personnel to visualize an asset’s performance in near-real-time, as well as its as-is engineering data and maintenance history.

In addition, predictive diagnostics, on both Siemens and third-party equipment — including those related to a plant’s electrical, automation, instrumentation, process, and utilities dimensions — alerts operators to when key indicators are out of the normal range, so they can plan condition-based rather than time-based maintenance campaigns.

Last, but most importantly, digitalization reduces OPEX and improves safety by enabling onshore compressions stations to be operated from a central operations hub, with fewer or even no personnel physically located at the facility.

Designing and engineering new transmission capacity with the latest innovations

Today’s professionals in charge of the design, engineering, and construction of new onshore compression stations — or retrofits and upgrades of existing ones — have many more options and tools to ensure new infrastructure can be built, commissioned, and begin full operation more quickly, economically, and with less risk than more traditional approaches might allow. Among those innovations are:

Sophisticated hydraulic modeling software that can take into account highly variable parameters across a wide range of use-case scenarios that can affect pipeline flows to determine optimal numbers and sizes of compression drive trains along with capacity under failure analysis.

Station designs using large power blocks reduce the number of compressor trains required while operating more efficiently and economically over a wider range of power loads than small power blocks.

Sole-source provisioning of compression drive trains with the compressor and gas turbine arriving from their factories as fully integrated and fully tested units with attributes like remote I/O, pre-flushing to reduce site works.
Remote diagnostics and analytics for condition monitoring and condition-based maintenance to ensure maximum uptime and availability after installation and commissioning. Mid-life and full-life overhauls can be extended to improve train availability. This approach can also help operators avoid the need for spare trains — and their associated capital and operating expenses.

Maximizing investment returns on onshore oil and gas compression stations

Whether new onshore compression stations are sole sourced through Siemens or use Siemens’ compressor trains, turbines, and supporting infrastructure, owners and operators can cut costs, risks, and time. Advanced digitalization, especially as manifested in the use of digital twins, can help accelerate deployments as well, especially via virtual commissioning.

In addition to these benefits, compression station operators can take full advantage of digitalization over their facilities’ entire lifecycles to conduct condition monitoring and enact condition-based, predictive maintenance programs to save labor and spare parts costs. In addition, digital applications can help pipeline transmission operators optimize their batch throughput runs to ensure maximum asset utilization and to realize dramatic energy savings. For many owners, this capability can lower their top operating expense and save significant costs.

These reductions in the total cost of ownership (TCO can help operators expand their margins and enable them to share some of those expanded margins with their customers. This can enable them to become more price competitive. At the same time, the TCO savings from operating efficiencies can also improve the returns to compression plant owners on their invested capital for decades to come.

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