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Siemens Pipelines 4.0

An integrated approach to optimizing midstream assets for maximum utilization and investment returns

By providing fully integrated, pretested, ready-to-install pumping/ compressor solutions, Siemens Pipelines 4.0 tames complexity to reduce the time, costs, and risks of bringing much-needed, next-generation pipeline capacity online across North America.

As North America's oil and gas producers continue to successfully unlock energy resources, mostly by unconventional means, pipeline infrastructure capacity must grow to get their production to refineries and markets efficiently, economically, and safely. But, even aside from the inevitable legal thicket of permitting issues, new pipelines still take years and massive capital outlays to move from their first digital drawings through construction into commissioning and full operation.

That's why midstream operators need ways to simplify and streamline bringing new transmission capacity online, while reducing construction time, costs, and risks. And once those new assets are in production, operators also have to maximize their utilization and reduce total cost of ownership over life cycles lasting decades, so they can maximize their returns on such enormous investments.

Despite the pressing demand for new pipeline capacity, operators face a number of challenges in operating their own assets today. These include issues associated with aging infrastructure, intense competition, reductions in CAPEX and OPEX, effective data management, cybersecurity concerns, tightening legislation, regulatory compliance, and the imminent retirement of experienced personnel.

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To help midstream operators address these issues and take full advantage of the demand for new pipelines, Siemens launched its Pipelines 4.0 solution. This is an integrated approach to the engineering, supply, and life-cycle optimization of pipeline assets. All components — including motors, drives, turbines, compressors, e-shelters, and so on — are tailored to meet the needs of North American midstream operators for more operating simplicity, cost-efficiency, reliability, visibility, and decision-support. And these benefits will span decades of service.

In short, Siemens Pipelines 4.0 combines equipment and associated peripherals for pipeline pumping and compressor stations with data analytics, life-cycle services, and cybersecurity. It builds on our extensive pipeline experience, breadth of our product portfolio, and rich domain expertise in rotating equipment, electrification, automation, and digitalization. This paper provides details on how it works and the many benefits it offers.

Pipeline capacity needs may be staggering, but Siemens Pipelines 4.0 can help

To transport all the anticipated production growth in oil, natural gas, and natural gas to processing plants and markets, the American Petroleum Institute (API) forecasts that by 2035 between 27,000 to 45,000 miles of transmission and distribution pipelines with 10 to 12 million horsepower of compression must be replaced or added to today's capacity. What's more, the API expects that between 218,000 to 240,000 miles of additional gathering lines, plus 22 to 29 million horsepower of compression, will be needed to reach upstream production sources and carry their outputs to larger transmission points.[1]

But what's more staggering than these numbers is imagining how all this forecasted capacity can get built in time. That's where the Siemens Pipelines 4.0 solution can help. With it, midstream operators can put their plans for greenfield, new-build infrastructure on a much faster development track. Or, if they want to retrofit and upgrade existing pipelines, it can help them accelerate their project schedules dramatically.

Either way, the reason they can fast-track such complex projects is that Siemens Pipelines 4.0 is not only a highly integrated, sole-sourced solution, but it also arrives onsite ready to install: all components are fully factory-tested, all automation is programmed, and everything is wired for electrification. Drop-in installations can take just a few days, not the weeks or months that a multivendor approach might likely require. That's in large part due to the fact that the number of vendor interfaces to bridge between components is greatly reduced.

In effect, Siemens Pipelines 4.0 can greatly simplify construction of the most complicated phase in pipeline development: the physical plant that keeps oil and gas moving through the pipelines, such as inlet stations at their starting points, compressor/pump stations along the way, and terminals at their end points.

At the same time, Siemens has experience in designing, engineering, and building systems and solutions for the electrification, automation, and monitoring of tank farms, terminals and storage facilities. Plus, with the industry's largest installed base of rotating equipment, Siemens also provides motors and drives, automation, electrification (including e-shelters), digitalization, and SCADA solutions to complement them.

Sole-sourcing via a Siemens Pipelines 4.0 solution also takes the complexity out of multivendor procurement processes, significantly reducing initial costs, effort, time, and risks. And, because it arrives onsite ready for installation, it saves all the work that might otherwise have to be done onsite. This approach eliminates the troubleshooting cycles and inevitable vendor finger-pointing that can occur during testing and commissioning, as would be typical with a traditional multivendor approach. Time savings from this step alone can be in the weeks or even months, depending on the severity of issues.

Siemens Pipelines 4.0 simplifies complexity and variability to cut costs and time

Siemens is one of the few companies in the world able to deliver such complex functionality as a fully integrated solution. First, we have the portfolio breadth of all required components, especially rotating equipment, such as turbines and compressors. Second, we have world-class automation, electrification, and digitalization capabilities and expertise, all developed over decades of serving the rigorous demands of the oil and gas industry as well as the precision requirements of aerospace, automotive, semiconductor, and pharmaceutical industries, among many others. Third, we offer complete life-cycle management (LCM) support and service, backstopped by the financial strength of Siemens as a company that will ensure our viability to support our midstream customers for decades to come.

Let's look at each of these three unique Siemens advantages in more detail:

1. Portfolio breadth. Siemens has 20 models in its rotating equipment family, ranging from 4 – 567 megawatts (MW) in their ratings and featuring industrial gas turbines, heavy-duty gas turbines, and aeroderivative gas turbines. Our worldwide installed base is approaching 7,000 units deployed in all kinds of onshore and offshore oil and gas applications, including pipelines, as well as for power generation and industrial uses.

In our Siemens Pipelines 4.0 solution, we offer two compressor options, electric or gas-driven, each fully integrated, on skids or off, with all its other supporting components completely tested and ready for a fast, drop-in installation:

- **Electric motor-driven compressor package.** This compressor package is pre-engineered for efficient installation and startup, enabling operators to significantly reduce project lead times. It's also designed and engineered to maximize component access for serviceability. Its options extend to an electrification package that includes compressors,

drives, motors, skids, automation, e-shelters, sub-stations, and transformers, enabling operators to further streamline interfaces and reduce risk.

- **Gas-driven compressor package.** Also engineered for efficient installation, startup, and serviceability, this package comes with the 41-MW Siemens SGT-750 gas turbine as its recommended compression unit. This turbine minimizes starting power requirements, but delivers a high starting torque and variable compressor speeds, from 50 – 105 percent. Reliability exceeds 99 percent for maximum uptime. In fact, it's designed, engineered, and built to require just 17 maintenance days in 17 years of service. The SGT-750 also has the highest power and efficiency combined with advanced dry low emissions (DLE) technology that makes it one of the world's most eco-friendly turbines.

In addition to drawing from the wide range of turbines in our rotating equipment portfolio, Siemens Pipelines 4.0 solutions can also provide customized pump stations and modular e-shelters with switchgear and other electrification components aboard, plus automation and control systems.

We have an extensive track record to back up these capabilities with experience and expertise. Recently, for example, we used our Pipelines 4.0 approach in providing 64 ready-to-install pump stations for the buildout of a pipeline network by one of North America's largest midstream operators. Our integrated approached saved the operator months of time in bringing new capacity online. And that's just one of many examples from our base of midstream customers.

2. Digitalization/data analytics. Siemens leads the world in industrial digitalization, supported by more than $10 billion in strategic acquisitions of industrial software and technology companies in the past 10 years. These companies have contributed their applications, expertise, and intellectual property to serve Siemens, customers across a wide range of industries, especially oil and gas.

In our Siemens Pipelines 4.0 solutions, we have focused these resources not only on improving the day-to-day performance and reliability of the products and systems they incorporate, but also to enable us to use the vast amounts of data they generate. For example, a growing number of our oil and gas customers around the world are using the data streams to improve the operating visibility of their equipment assets. They're also employing advanced data analytics to make remote real-time condition monitoring and diagnostics of solution components possible.

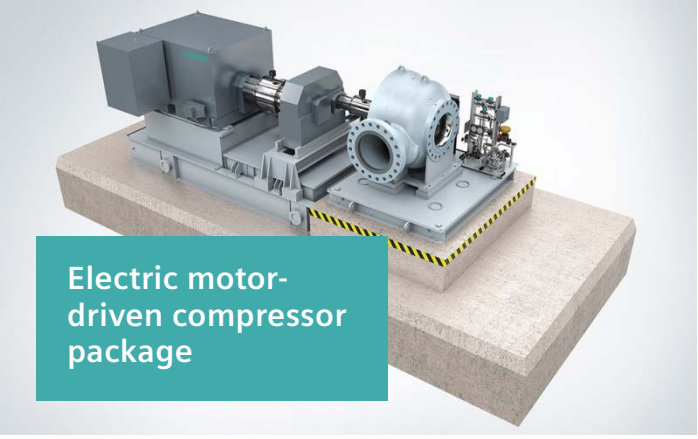
Meet the digital twin. What digitalization brings to a Siemens Pipelines 4.0 solution is a "digital twin" of every component and system. This is a virtual, digital model that coexists with its physical counterpart, whether a single component, subassembly, or complete system such as a turbine. It's possible because manufactured products evolve from initial concepts via advanced 2D and 3D software tools, such as computer-aided design (CAD), computer-aided engineering (CAE), and computer-aided manufacturing (CAM). Likewise, other software tools are used to design and simulate production processes in virtual form.

By adding real-time pipeline performance data to process models — as Siemens Pipeline 4.0 solutions can do — a *performance digital twin* can also be created. This can serve as a baseline for monitoring performance and developing what-if simulation models for performance improvements and decision support. With this performance digital twin, midstream operators can not only drive operational efficiency, but they can also compare simulation and test results with real-world observations.

SmartPumping for smart pipelines. To illustrate this data-driven dimension of our Pipelines 4.0 approach, consider the Siemens SmartPumping software-as-a-service that is in development and eventually part of its capabilities. Securely hosted in the cloud-based Siemens MindSphere IoT operating system, use cases of the SmartPumping application show the potential to help operators cut their utility charges by up to 5 percent, saving many millions of dollars over multi-year periods. By deploying our sophisticated software technologies — including analytics, artificial intelligence, and machine learning, among them — they will be able to improve and optimize pumping operations in terms of load management, power consumption, and scheduling. What's more, they will be also able to better align and fine-tune power consumption and pump performance with the different product batches moving through their pipelines.

This batch optimization will help them avoid paying for unneeded power as well as for ratchet surcharges that come with excessive spikes and peak-power use. In addition, Siemens SmartPumping solutions can provide them with the potential to:

- **Leverage electric utility price differentials** between pump stations, shifting either downstream or upstream some of the power load of one pumping station that's subject to relatively expensive utility rates to another pump station where utility charges are less.



The electric motor-driven compressor package is pre-engineered for efficient installation and startup.

- **Schedule batches based on utility rates** during off-peak hours, avoiding the cost penalties of utility ratchet charges that during peak hours can soar to 2 to 5 times more expensive than standard rates.
- **Ease mechanical stresses** on their systems — such as wear-and-tear on the pumps, seals, bearings, valves, and other moving parts — by reducing or eliminating surge effects with dynamic and predictive tuning of pumping pressures relative to the types of fluid materials and environmental conditions affecting densities and viscosities.
- **Cut carbon emissions,** helping to boost an operator's environmental reputation, if not also providing potential carbon offset credits to sell. In one use case, an operator found that a 1 percent reduction in power usage could potentially translate to 70,000 metric tonnes of CO_2 savings.

Cybersecurity, a priority focus. For Siemens Pipelines 4.0 solutions using SmartPumping's MindSphere cloud connectivity for condition monitoring and decision support, we provide industrial-grade cybersecurity based on rigorous industry standards, such as ISO 27001, IEC 62443 and BSI, the German federal office for information security.

Data at rest is stored on high-performance servers at our cloud partners' highly secure data centers. Those data centers are designed and built to safeguard data against both cyber threats and natural disasters. Data in motion is always encrypted using 256-bit SSL/TLS encryption or better. Of course, MindSphere customers must ensure their own data security measures, too, such as enacting layered, defense-in-depth best practices onsite as well as cloud-specific data safeguards. Our industrial information security team, consisting of the world's top cybersecurity experts, can advise on both.

Notably, MindSphere users own their respective data sets, which are secured against intrusion by other MindSphere users. MindSphere acts as a repository and a custodian of customers' data, while MindSphere customers manage the access rights to that data.

3. Life-cycle Management support and service. To support and service Siemens Pipelines 4.0 solutions, we recommend our life-cycle management (LCM) approach. This takes advantage of the digital twin Siemens keeps on hand for every Pipelines 4.0 solution.

For example, LCM uses an automated, cloud-based, data-driven support model, securely accessible via remote devices, including smartphones and tablets. It provides midstream operators with real-time, condition-based performance monitoring, remote diagnostics, and visibility for decision support. It can compare key performance data, such as turbine or motor vibration and bearing temperatures, with as-tested operating signatures of the specific solution components. Variances exceeding preset limits or other anomalies can be flagged, the right people alerted, and decisions about appropriate responses made.

Asset tracking and preservation. One LCM application that can enhance Siemens Pipelines 4.0 solutions is the tracking and preservation of assets, including parts. One major North American midstream operator saved more than $3 million in project costs with this highly secure, browser-based application, which is accessible on tablets and smartphones and provides:

- Real-time reporting and visibility
- Specific geo-coding capabilities
- Automated workflows
- Remote, mobile access
- Web reporting console
- Fast, easy report generation
- Encrypted security
- Tracking and tracing.

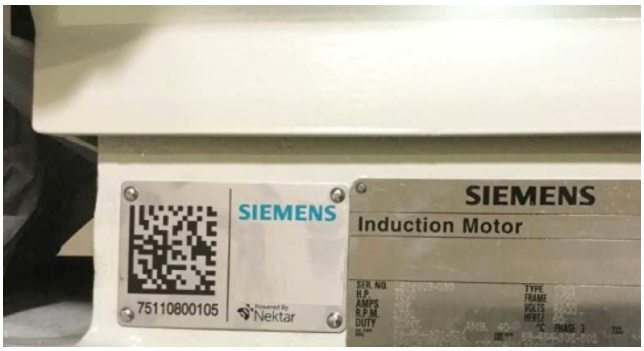


Figure 1. QR codes are used with geo-location to track an asset's physical location, as well as maintenance and service history.

With this application, technicians can make a service call on a piece of equipment and scan a quick response (QR) code on the asset's tag and complete the check boxes on a form in the app using their phone or tablet. The app securely sends the data wirelessly to a cloud-based master database, updating the asset's record with whatever maintenance work that was done. The record shows the asset's location and all completed and pending tasks. Technicians can also upload pictures, if necessary, to document equipment condition.

If an asset, such as a part or even entire piece of equipment has been moved, the app's geo-location feature — accurate to within four feet — notes its new location. If the move was authorized, it is added to the asset's record, creating a chain of custody. If not, an alert can be issued, and an investigation can be immediately started.

Saving time, reducing errors. The app saves time and potential errors by facilitating the ordering of parts. For example, if a part needs replacing, the technician can take a few pictures of it, select the part number from a drop-down menu in the app, and then click on the record. This instantly

sends a secure parts order with all key information, including the part pictures to all of the appropriate people.

These include those who must pull the part from inventory, package and ship it as well as those who just need to know, such as the shipping agents and finance. The automated workflow eliminates the potential for confusion and communication errors. The correct parts are ordered the first time, without the back and forth delays and costs of the wrong parts being pulled and shipped.

Fundamentally, LCM further simplifies the operating complexities of pipelines, especially those that come with the immense scale of these facilities. It eliminates the time, effort, and labor costs of error-prone manual recordkeeping, not to mention the latencies of days or even weeks required to compile, normalize, and analyze data for informed decision-making.

Creative financing solutions to conserve capital.
Siemens Pipelines 4.0 offers several business and financing models, including leasing, debt financing, and equity investments. This takes advantage of not only Siemens financial strength but also its confidence in the future of midstream operators across North America.

From equity and mezzanine solutions to public-private partnerships, tailored project financing, asset-based lending, and construction and permanent facility financing, Siemens offers midstream operators the flexibility to lead, arrange, or participate in projects according to their needs. Whether a pipeline project is a greenfield new-build or an upgrade to existing capacity, Siemens can help Pipelines 4.0 customers develop creative, competitive debt and equity financing solutions with both floating and fixed rate options, off-balance sheet, and long-term payment options.

Siemens Pipelines 4.0: accelerating deployments of North America's next-generation pipeline infrastructure

With Siemens Pipelines 4.0 solutions, North American midstream operators can accelerate deployments of their next-generation of pipeline infrastructure to realize their investment returns much faster. This fully integrated, pre-tested, ready-to-install approach to building the physical plant of new pipelines can simplify and reduce procurement costs, time, and risks.

In addition, one major sole-sourcing advantage is that a Siemens Pipelines 4.0 solution can also eliminate time-consuming cycles of troubleshooting during commissioning, and potential vendor finger-pointing during commissioning. These cycles can add weeks, if not months, to project completions.

But construction is just the starting point for a Siemens Pipelines 4.0 solution's many benefits. During subsequent decades of reliable operation, midstream operators can take full advantage of digitalization, including their solution's digital twin, to conduct condition monitoring and enact condition-based, predictive maintenance programs to save labor and spare parts costs. In addition, the Siemens SmartPumping application can help operators realize dramatic energy savings, lowering their top operating expense.

Taken together, the operating advantages of Siemens Pipelines 4.0 solutions can reduce total cost of ownership by potentially millions of dollars annually. This can expand operators' margins and enable them to share some of those expanded margins with their customers to be more price-competitive.

The Siemens Pipelines 4.0 solution approach is an idea whose time has come, yet is already proven in early deployments with many North American midstream operators. They are already reaping the rewards and will continue to for decades to come.

[1] "U.S. Oil and Gas Infrastructure Investment Through 2035" (American Petroleum Institute, April 2017), p3. http://www.api.org/~/media/Files/Policy/Infrastructure/API-Infrastructure-Study-2017.pdf

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