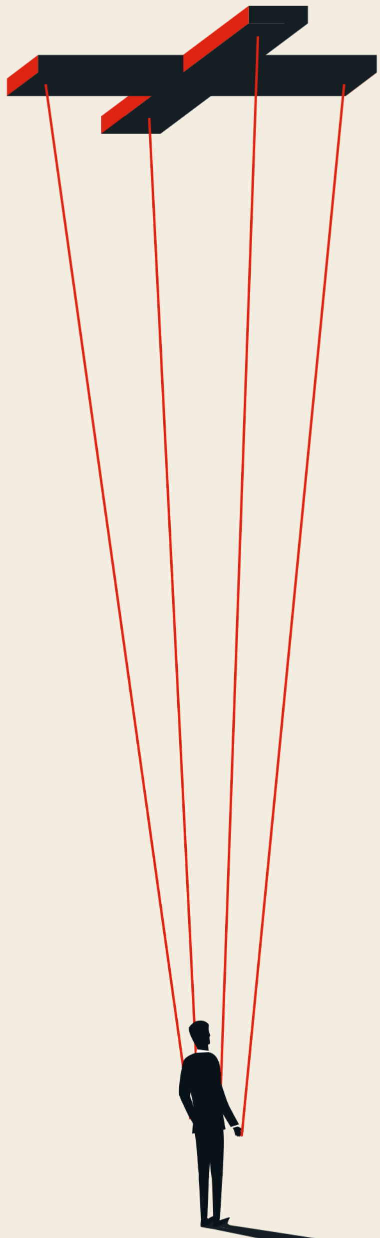
# Influencing optimisation



**Paul Dickerson and Dr. Jennifer Worthen, Emerson, USA,** discuss building pipeline capacity to plan for a cleaner, optimised energy future.

Calls for new and improved critical infrastructures globally are being tied more and more often to the modernisation of energy transportation for a cleaner, more sustainable future.

To meet demands while figuring out the short and longer-term planning and problem-solving aspects, in consideration of this cleaner energy transition, there is much discussion to be had in regards to the potential performance, capacity and throughput of liquids and gas pipelines.

The analysts envision a novel blend of repurposed oil and gas pipelines and networks, as well as the development of new pipeline systems, compressor stations and storage reservoirs. These efforts will support expanding industry requirements to sequester carbon while effectively transporting, storing and moving hydrogen-enriched natural gas.

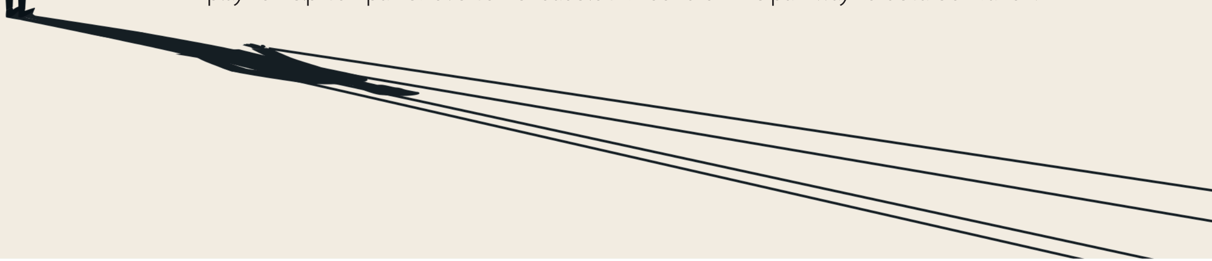
Expected to take several decades, the move away from carbon intensity and toward net-zero emissions won't be swift. By and large, it will be dependent on the build-out and optimisation of such energy related pipelines, storage hubs and infrastructures. A considerable amount of cooperation will be required as governments, policymakers and forward-thinking organisations consider the legal and regulatory frameworks that have already been or will need to be constructed, to launch a contemporary and more interconnected era of energy production, transmission, and distribution.

Added to this list of complexities are tests related to outcroppings of geopolitical issues and socioeconomic concerns associated with rising demands around different parts of the globe for greater energy independence, energy security, and more access to renewable forms of energy.

There has been a global increase in demand for products being transported by pipeline, including natural gas, carbon dioxide ($CO_2$) and hydrogen. Part of this is being fuelled internationally by carbon capture, utilisation, and storage (CCUS) projects, hydrogen blending, and similar decarbonisation-related activities in Europe, the US, and other parts of the globe.

For pipeline operators, the cleaner energy transition must come to pass concurrently with keeping everyone safe, protecting one's corporate reputation, and seizing on opportunities to stay on top of design, engineering, and operational scenarios, in addition to increasing pipeline profitability by optimising movement cost.

It would be difficult to overstate the role reliable, built-for-purpose technologies will play to help companies overcome roadblocks found on the pathway to decarbonisation.



The overarching question for many draws back to, "How can we meet future demands for more energy, with lower costs and fewer emissions, while taking a more sustainable approach that is responsible, reliable, and adds value across the entire pipeline supply chain?"

## The chain

From an operations standpoint, one quandary is to better manage and optimise pipelines amid increasingly diverse sets of product flows – by ensuring the capacity is available to plan and perform – and deliver.

Pipeline networks go far beyond point A to point B; there are numerous supply points, delivery points and interconnections. Pipeline operators also routinely deal with fluctuations in demand that require near-constant re-evaluation of consumption rates that change on a daily, hourly, or minute-by-minute basis.

Pipeline assets are managed as part of an overall supply chain – with products making their way to buyers from the production site to pipelines, and finally to distribution points. To optimise the movement of products and improve both profitability and flexibility of the pipeline, operations must be planned in the most efficient way possible. They must not only satisfy the demands of shippers, but also maximise internal efficacies.

View this from the perspective of a food trucking company hired to deliver assorted produce, including the logistical responsibility of caring for many different types of fruits and vegetables while they are being transported both from and to their respective pick-up locations and drop-off points.

From this point of view, getting the correct products to the right market while still ripe and on-time requires certain sets of preplanned actions, perhaps starting days in advance. There is logistical aptitude involved as products are both categorised independently and taken into account as a whole.

At a certain point, these types of premeditated actions may become so common that it feels as if they could be automated – the various tasks that must be performed to allow for the trucking, shipping, and delivery of goods to continue.

In this same vein, pipeline operators and energy companies are seeking to leverage immense amounts of raw data via investments in tech-enabled software – helping automate the evaluation of delivery capacities within networks. This trend will help ensure operational successes as end users become more dependent on robust and timely access to sufficient supplies of energy resources, such as hydrogen and natural gas.

## Effective overall

In the long-term, what can be done to plan for and optimise both the design of pipelines, as well as pipeline operations and product flows, as more carbon sequestration and pure or enriched-hydrogen projects shine through?

How do I make the most efficient use of a new energy pipeline or expand an existing network to move product? What is the appropriate diameter of pipe and the potential need for additional pressure on my systems? Can I keep construction costs low while meeting capacity requirements? How do I determine the amount of energy needed to drive gas from a line or electricity to drive compressors?

In short-term planning, supply chain issues must be met head-on, day-to-day, while remaining vigilant by preparing for peak season demands, as well as contingencies such as cold snaps, prolonged freezing temperatures, major weather swings, or excessive heat waves. Drains on the power grid caused by an unforeseen circumstance or a peak-season weather event have been known for knocking out power, sometimes for days or weeks.

Such extremes are being reported on more often and on a more granular level with greater attention being called to events, such as requests to limit power, rolling planned outages, and prolonged power outages that can impact residential, commercial, and non-profit communities.

What could go wrong? What could go right?

Emerson has been enabling oil and gas companies to mitigate and overcome related challenges. Its PipelineStudio software has a singular focus – provide solutions to planning, engineering, and design problems. It was developed to support the ongoing decision-making processes of pipeline owners and operators by giving them the confidence to act.

It has been used as an application to achieve favourable business outcomes, firstly from an engineering applications point-of-view and secondly from an operational applications perspective. As a design, planning and analysis tool, the software combines graphical configuration and reporting devices with simulation engines.

Pipeline operators are tasked daily with maintaining optimal operating conditions to satisfy demand while considering all pipeline constraints. From an economic comparative standpoint, software such as PipelineStudio, as one example, can help determine the appropriate equipment – and associated costs – for looping a pipeline or adding pump or compressor units to improve throughput.

The software was engineered to provide design analysis of networks, line size and capacity studies, as well as deliverability analysis, which may be used to determine whether a given network can meet increasing future demand, either with or without additional equipment.

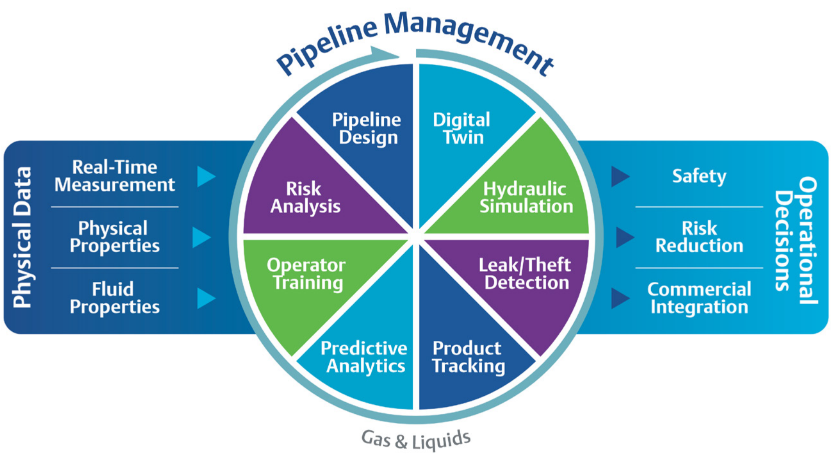



Figure 1. Companies able to leverage raw data via simulation software such as Emerson's advanced pipeline applications will benefit from greater network capacity to transport both existing and newer energy products.

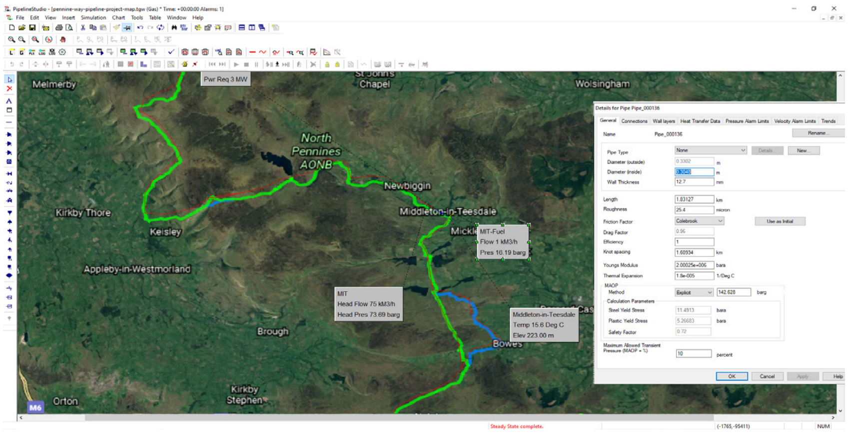



Figure 2. **Emerson's PipelineStudio allows companies to accurately predict future capacity based on simulations generated from available data to proactively manage nominations, maintenance, etc.**

An example of this is the determination of maximum throughput, which requires calculation of the largest possible flow increase without violating a minimum delivery pressure. Users can compare and evaluate different operating scenarios such as variable flow and delivery pressures over specified time periods.

Rapid configuration and simulation of various supply/demand scenarios makes way for determining the most economical pump strategy. When the associated performance curves and detailed operating specifications are provided, the software allows for detailed calculations and a report for each unit, including the power used during the operation.

At times, cyclical flow conditions in some pipelines cause certain pump or compressor stations to operate below peak efficiency. Shutting these stations down and shifting the load to others enables the user to maximise the available horsepower and thus conserve energy or power.

Using a fixed configuration of the network, PipelineStudio is supplied with flow and pressure boundary conditions from a pipeline system. Nominations, provided by a gas load forecaster, are used to create a transient scenario. Steady-state and transient simulations run automatically at the start of the gas day. Essentially, it is a decision-support application designed to complete a faster-than-real-time simulation of the pipeline for the next gas day – with results presented to the operator. This helps identify any problems associated with the nominations and provides information ensuring that the pipeline is operated safely, all while satisfying contractual obligations.

Pipeline systems operating during peak season can be analysed to determine whether the system can meet increasing future demands, or whether additional equipment is necessary. Maintenance of key pressures in the network, line pack analysis, and manipulation of supply or delivery setpoints can each be performed.

## 2050 blend

The Heartland Institute reported that in the US alone, total liquids pipeline safety incidents have decreased by 17% over the last five years, including a 31% drop in incidents impacting the environment or people. That's good news for pipelines and operators as they are still considered among the safest, most economical methods of transporting oil and natural gas.

CCUS is attractive because it can reduce emissions from existing oil and gas production capacity quickly through retrofits, and can enable large-scale dispatchable hydrogen production. By 2030, the total length of hydrogen pipelines globally will need to quadruple to >20 000 km, according to the International Energy Agency (IEA) and their Net Zero Emissions (NZE) by 2050 initiative.

Interest in projects that combine CCUS with conventional technologies is on the rise, yet the ability to reach hydrogen-strategy targets will rely on faster development of hydrogen transmission systems. The IEA data suggest fast action is needed in the next 10 years to meet projected net-zero targets, and recent analysis of the current project pipeline had proposed that only ~18% of this demand would be met.

Total hydrogen demand from industry, the IEA stated, is expected to expand 44% by 2030. This will occur alongside the increasing importance of low-carbon hydrogen – amounting to 21 Mt in 2030.

Large-scale hydrogen deployment will need to be buttressed by an effective and cost-efficient system for both storage and transport. The goal is centred on the strategic design and positioning of such critical infrastructures to connect supply sources to centres of demand, in turn establishing a highly liquid market. The scale-up to meet global demand, reduce costs and make improvements in efficiency, lifetime or process integration will also include technologies such as electrolysers, fuel cells and CCUS-equipped hydrogen production.

## Optimisation equations

The optimisation of both renewable and non-renewable sources of energy are key factors for many pipeline operators, including those closely monitoring the correlation between investments in technologies and desired business outcomes. The industry has embraced optimisation, including various optimisation tasks that exist from design to operation in all stages of the pipeline sector. The focal point is on the ability to reduce pipeline costs.

Frictional resistance is the main reason for energy loss, and how to reduce it while retaining delivery capacity is one of the primary concerns. Polymetric drag reduction application techniques are essential for energy optimisation and emission reductions initiatives in the transmission and distribution market. Known as drag-reducing agents (DRA), these long-chain hydrocarbon polymers have properties that reduce friction and allow increased throughput and flow volume. The chemical additive is in high demand as it allows for the pumping of greater quantities of product through pipelines.

DRA optimisation considers pump schedules, flow rates during specified times, and suggested DRA injection rates designed to meet user-defined target throughputs. Multiple variables including different boundary conditions, product properties and devices in the configuration will have an impact on the probable solution.

There is a price associated with the energy consumption to transport a barrel of oil, as well as the cost of DRA utilised. Cost vs production movement is of special interest to pipeline operators who find value in figuring out the sweet spot for options to

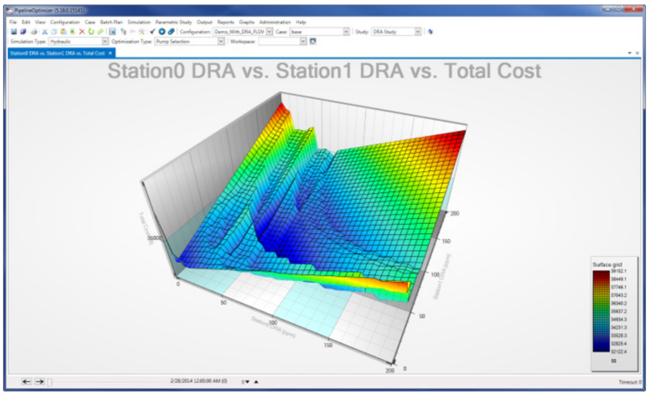



**Figure 3.** **Emerson's PipelineOptimizer software simulates the hydraulic and thermodynamic behaviour of fluid to optimise station DRA usage and minimise costs.**

minimise the total cost to move each barrel of oil from origin to destination.

Pipe size, the scale of pipeline lengths, velocity, viscosity, the spacing of pumps and compressor stations, the cost of electricity, the cost of DRA, minor frictional losses, and other variables may all influence optimisation outcomes, and may be included in the final analysis.

DRA, however, does not work alone. Pumps in the pipeline, for example, are still needed at various stages to increase compression. Timing is also super critical to both peak and off-season pricing, as well as when figuring out a more cost-effective way to run at a higher flow rate overnight, or to meet spikes in demand because of unforeseen events. The scope of demand can change on a dime.

In other words, it is possible for unrealistic capacity estimations to be generated based on inaccurate DRA performance predictions, meaning more than one solution may be required to make adequate assessments. Furthermore, empirical data have proven that DRA degradation is unavoidable. One of the things that means is that more volume will be required to produce the same amount of energy.

There is automation available that allows for very simple analysis and clearer achievement of the desired results. Emerson's PipelineOptimizer software is designed to simulate the hydraulic and thermodynamic behaviour of fluid in a pipeline network. It was built to catalyse liquid pipeline hydraulics and operations by way of understanding and minimising operational costs.

These governing laws of fluid flow are solved many times during an optimisation simulation, potentially tens of thousands of times, before generating data that is output in reports, trends, and graphs. The result is an accurate representation of the fluid dynamics in the pipeline system, allowing the user to analyse the effect of various pipeline routes, pump station locations, and pump unit selections.

The features built into PipelineOptimizer software automatically choose the best pump combinations and DRA usage for a pipeline system, including the effects of new facilities or changes in available pipes and pumps. Built-for-purpose software can also simulate a full line of products at various target flowrates, allowing for greater optimisation of DRA usage based on flow rate.

These solutions rely on good, clean source data as optimisation modules can choose which pump units to operate, what speed variable-speed units are operated at, and where and how much throttling should occur – so that operational costs can be kept to a minimum while running in accordance with a variety of user-input operating rules.

## CCUS and hydrogen

The IEA lists energy efficiency, behavioural change, electrification, renewables, hydrogen, hydrogen-based fuels, and CCUS as key pillars of decarbonising the global energy system. The importance of hydrogen in the 2050 emissions initiative is reflected in its increasing share in cumulative emission reductions.

Strong hydrogen demand growth and the adoption of cleaner technologies for its production enable hydrogen and hydrogen-based fuels to avoid up to 60 Gt of $CO_2$ emissions, based on estimates from the 2021 to 2050 net-zero emissions initiative, representing 6% of the total cumulative emissions reduction.

Hydrogen has the highest energy per mass of any fuel. However, the low energy density of hydrogen by volume when compared with natural gas (approximately four times less energy dense) means that advanced, large-volume transportation and storage methods with higher capacities will additionally be needed to compensate – to get the same amount of energy.

The ability to achieve optimal operating conditions to satisfy demand, while considering all pipeline constraints, is one example of how the determination of maximum throughput is essential in pipeline operations.

In the lean towards natural gas to produce electricity as part of the clean energy transition dynamic, it is noteworthy to consider that pipelines can be used to store power. The push toward net-zero emissions targets, while considering both current and future energy demands and critical infrastructure, is certain to include new pipelines, repurposed pipelines, and the enhancement of existing commercial systems.

Such value decisions are important as they can have a big impact on the degree of operational execution that is possible. Where and how big to build? To and from where to extend? The best location for pump units or compressor stations? What are the effects of pump drive size on capacity? How long will it take for product to get there? What can be done to better ensure the successful flow of single-phase fluids from the reservoir to the point of sale?

There will be more questions. And more answers to come.

The IEA frames the NZE as a "normative IEA scenario that shows a narrow but achievable pathway for the global energy sector to achieve net-zero $CO_2$ emissions by 2050, with advanced economies reaching net-zero emissions in advance of others."

Purveyors in the newly emerging landscape that's trending heavily toward cleaner energy prerogatives are also becoming more dependent on their ability and capacity to both plan and optimise. Operators want less unscheduled downtime, greater pump and compressor efficiency, a better understanding of capacity inefficiencies, and the overall optimisation of throughput.

In light of corporate emission minimisation strategies, they are on the hunt for solutions to help offset utility and compliance costs – in tandem with a reduced number of flaring events, fewer reportable environmental events, and greater thermodynamic proficiency.

It is widely accepted that reliable simulations and automated solutions will be even more representative – both offline and online – of the real-time technologies used to bolster competencies in association with the optimisation of pipeline operations, and the future of pipeline systems and networks overall.