

Beyond Oil Digitalization: The Roadmap to Upstream Profitability

Ron Beck, Director of Industry Marketing, Aspen Technology, Inc.

An effective digitalization strategy is much more than data-enabling and IIoT-enabling machines. It involves instrumenting and collecting broader sets of information to achieve process insights.

Introduction

The upstream (exploration and production) industry has responded to the new reality of oil and gas economics through initiatives intended to achieve sustainable profits at any commodity pricing. A key driver is the use of advanced technology to change the profit equation, driving down the break-even cost of producing crude oil and natural gas by up to 30-40 percent.

This trend was highlighted by Daniel Yergin of IHS Cambridge Energy Research Associates in his keynote remarks at CERAWeek 2017.¹ He emphasized the single-minded focus of oil industry executives on driving down production costs. A key initiative showing initial success has been the journey towards the digitalization of the oil asset.

At Yergin's CERAWeek, a special technology vision showcase called "AGORA" was introduced to expose executives to the leading innovations in this area. The vision is that increasing the amount of data collected, and the ability to make decisions based on that data from anywhere, will improve proactive management and decision-making and reduce OPEX.

Early leaders in this digitalization effort have included Statoil in their North Sea fields and Saudi Aramco across their entire value chain. Innovative technology from AspenTech is playing a key role in both of these initiatives. Now other large operators, such as Petronas and ConocoPhillips, have embraced this concept and made it part of their core strategy moving forward.

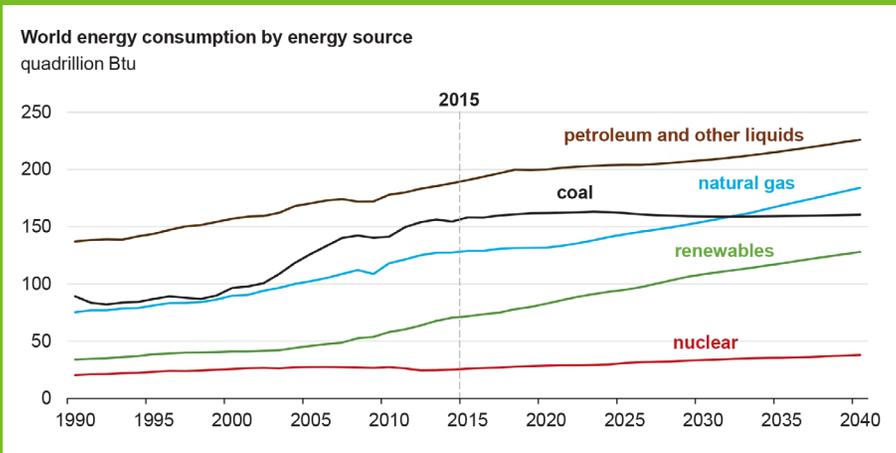
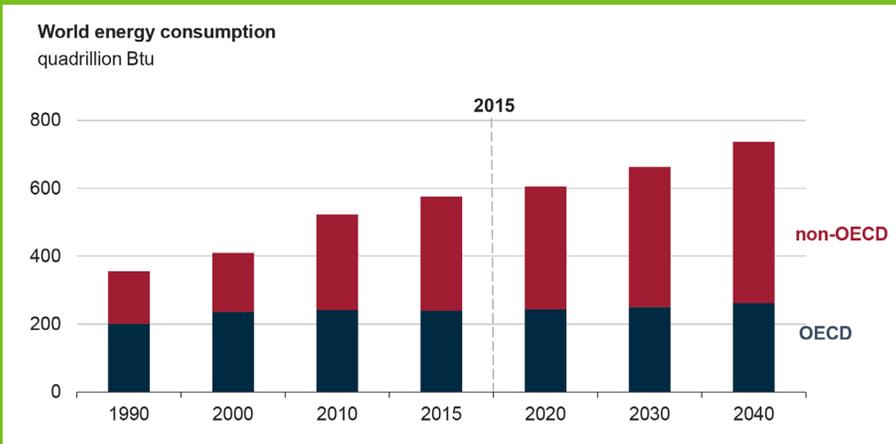
This digitalization of the oil field is exciting, but it is only an enabling step. An effective digitalization requires more than meets the eye. It is much more than data-enabling and industrial internet of things (IIoT)-enabling machines. It involves instrumenting and collecting broader sets of information to achieve process insights.

For the upstream executive, the challenge is to make sense of which technologies match their business priorities the best and how to assemble them into a business solution. This paper will explore how industry leaders are capitalizing on the explosion of data available from producing assets, the lowered cost of instrumenting both new and old assets, and the availability of analytics toolsets to achieve a true competitive advantage in the oil patch. It will also reveal how innovations from AspenTech are helping to lead the way towards asset reliability and profitability.

Four concepts have been converging and provide an opportunity to achieve a better upstream enterprise:

1. The ability to use **powerful data analytics** and visualization to make optimal and rapid operating decisions
2. The emergence of effective **machine learning and automation of knowledge work** to make complex decisions faster and with fewer experienced experts
3. The enabling of **standardized designs** via data- and model-driven reusable designs to both speed up the “time to first oil” and also reduce the overall capital cost of asset development
4. The employment of **model-based analytics** that combine deep process insight with the power of the analytics approach





Figures 1 and 2: Current global energy consumption growth projections.
Source: U.S. Energy Information Administration, International Energy Outlook (September 2017).

Why? The Future of Oil and Gas Economics and OPEX Structure

Long-term energy scenarios, which have been developed and published by leading energy enterprises such as Shell, BP and ExxonMobil, all are consistent with the U.S. Energy Information Agency (EIA) 2017 International Energy Outlook. They show continued global demand for hydrocarbons, but at a flattened rate of growth, suggesting the possibility that prices will remain close to current levels. To sustain this long-term demand, new production from existing and new assets must be brought online. This drives the need for future upstream investments, sustainably, at lower than today's break-even costs.

Because the macroeconomics of oil and gas supply and demand (see Figures 1 and 2) hint that oil and gas prices should not be expected to return to the heights last seen in 2015, structural industry changes are needed. Globally, irrespective of size or scope, upstream companies are pursuing their short- and medium-term capital planning based on the expectation that crude oil prices will remain in the range of \$40–50 USD per barrel of oil equivalent. What are the implications to upstream operators? How is this to be achieved in the long term?

Several basic drivers have emerged which are powering organizations and innovation forward:

- A move towards standardized designs, in place of one-of-a-kind designs, enabled through capture of best-practice unit and module designs via data and models. **ExxonMobil**² has been a leader here, using integrated solutions from AspenTech. This drives down overall CAPEX substantially.
- Increased collaboration between industry players, focusing on better use of people and resources across the execution chain. **Saudi Aramco, Anadarko** and others have driven this collaboration through use of AspenTech's open cost platform across the asset development lifecycle. This provides better alignment between owners and contractors, which has historically been pointed to as a main cause of upstream asset CAPEX overruns.
- Breakthroughs in the use of data to achieve higher summits of reliability — through the combined use of techniques such as machine learning, deep-insight process models and statistical models to turn big data into production-predictive and prescriptive knowledge. This has the promise of significantly driving OPEX reductions.

These drivers are crucial because as proven oil reserves trend towards unconventional and remote resources, there is a focused push towards reducing the CAPEX and OPEX needed to produce those reserves successfully. In the short term, that drive has translated into operators leveraging a “buyers’ market” to drive down supplier and contractor costs.

On the CAPEX side, leading operators are driving engineers toward adoption of lower-risk standardized and modularized asset designs. On the OPEX side, putting buyer pressure on contractors has yielded short-term results. But in the longer term, that is not a sustainable tactic, and instead, fundamental improvements in efficiency, CAPEX designs and reliability are essential.

Breakthroughs in the use of data to achieve higher summits of reliability have the promise of significantly driving OPEX reductions.

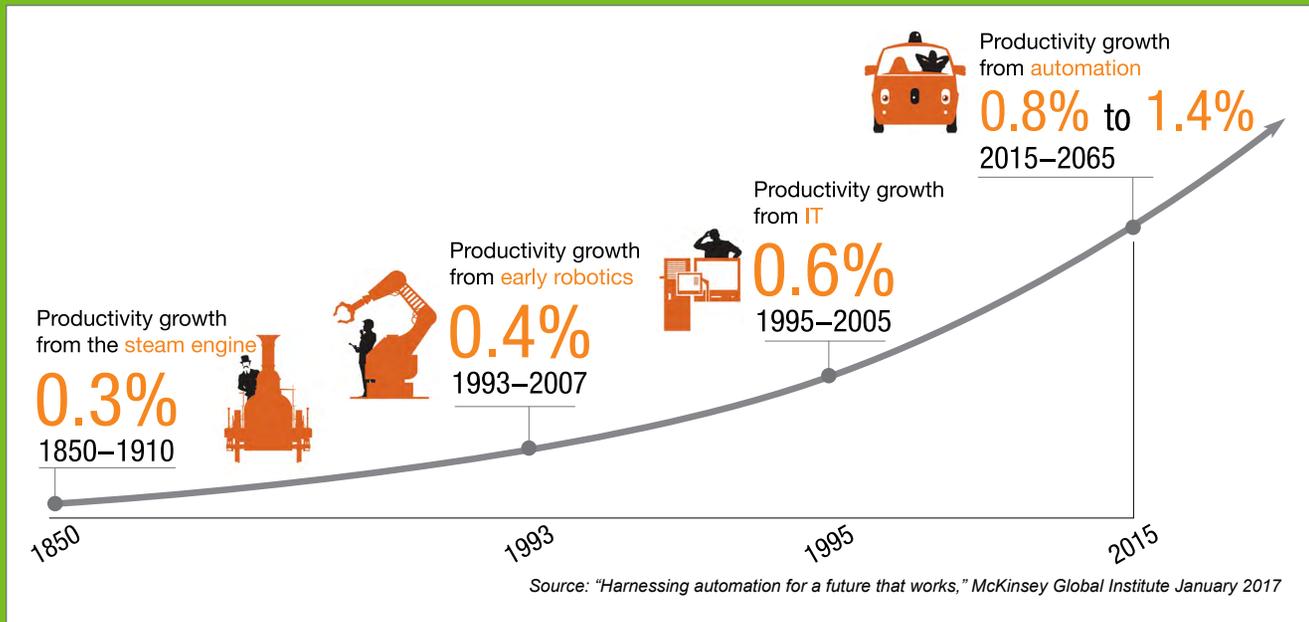


Figure 3:
McKinsey View of Global Productivity of
Industry Over Time and the Megatrends
Causing Those Changes

Efficiency: The Promise of Automation Productivity

Upstream is characterized by its technical complexity, remote production environments, the challenge of developing the experienced technical experts who can guide these dynamic and ever-changing production environments, as well as the expense of putting the technical teams in place at the asset.

Improved productivity is a goal. McKinsey (McKinsey Global Institute, January 2017) has conducted a broad analysis of productivity in industry and in a white paper published this year, has forecasted and projected that current innovations in technology will achieve significant productivity improvements in industry — greater than at any previous time in modern history. This opportunity is available to upstream.

Traditionally, despite industry sophistication in its use of complex geophysical and petroleum engineering data and models, upstream has lagged overall in terms of the types of automation common in other manufacturing sectors. Work has been highly dependent on technical experts. The first area that has recently evolved rapidly is the automation of the drilling domain, specifically advanced directional drilling. Improving asset performance and reliability through technology is the current frontier.

Today's upstream world is ripe to benefit from this productivity growth opportunity, forecast by McKinsey, in several areas.

Addressing Reliability With Powerful Data Analytics and Visualization

Executives are excited, as shown by measurable results that have emerged in the upstream drilling domain, that data analytics can contribute to the reliability of oil and gas production operations.

Where Do Industry Executives Feel the Value Is?

AspenTech has been working with industry leaders to apply analytics to process systems. To understand where executives feel the value is in upstream, we decided to “crowdsource” the industry view of where the biggest benefits are coming from and will come from, in terms of analytics technologies and production data. To that end, we partnered with *Petroleum Economist* magazine to conduct a comprehensive industry survey in April on the views of executives.

This is what we discovered about executive sentiment regarding analytics adoption:

- 51 percent of upstream companies surveyed are using data analytics today, or testing it in pilot implementation.
- 45 percent of all upstream executives expect analytics to have an impact on operational effectiveness in upstream within a year.

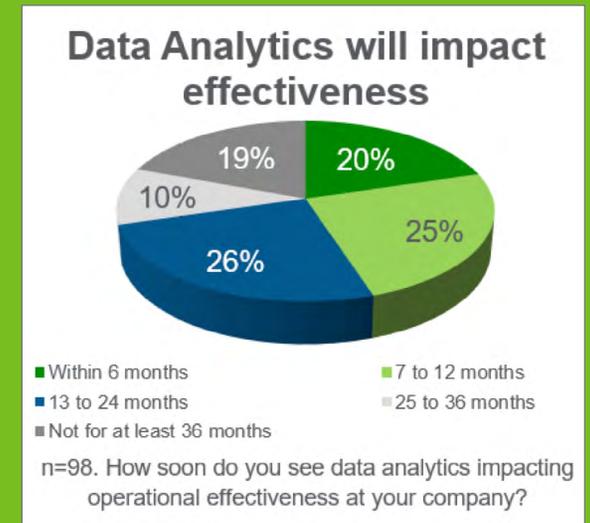


Figure 4:
In an upstream executive survey conducted by AspenTech and *Petroleum Economist* in April 2017, “How Soon Respondents Feel Data Analytics Will Impact Their Business”

When we asked about the different approaches to using data and models to gain insight into upstream operations which will lead to improved productivity, reliability and operating integrity, it was equipment monitoring models, machine learning technology and online predictive models that were most widely viewed as important and practical.

And, since a key aspect of achieving the OPEX reduction and improved reliability promised through data analytics is selecting the most impactful projects, what is the feedback from industry on the most important areas of an asset to focus on? Pumps, compressors and heat exchangers were viewed as the most strategic in this respect.

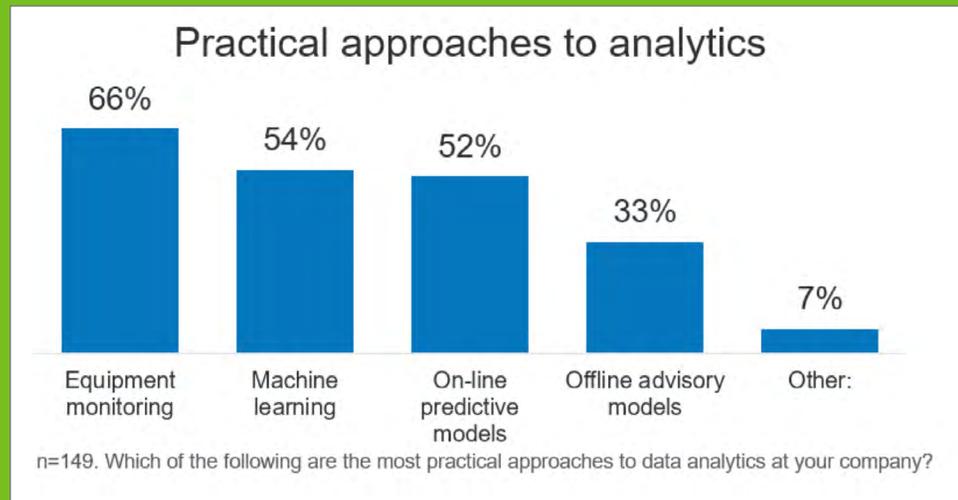


Figure 5: Which Types of Data Analytics Will, From a Practical Viewpoint, Be Implemented and Impact Operations in Upstream? Source: Survey by AspenTech and *Petroleum Economist*, April 2017.

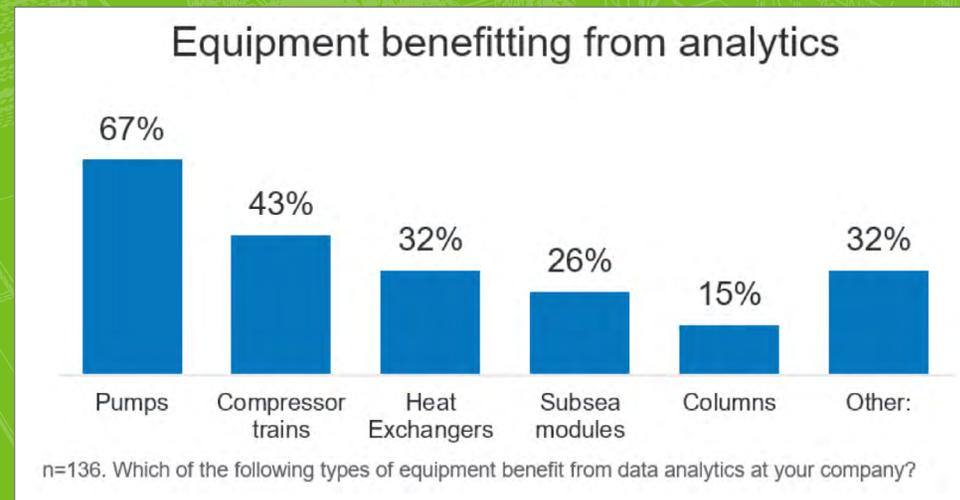


Figure 6: Which Types of Equipment in Upstream Benefit the Most From Data Analytics Advice? Source: Survey by AspenTech and *Petroleum Economist*, April 2017.

Data: The Driver for Digitalization

Many organizations look at the data analytics area for uptime solely in the context of equipment maintenance data. In reality, there is a wealth of information types that provide valuable insights to enable machine learning tools to understand patterns leading to process problems and failure. These are the key types of data that are fundamental to asset optimization:

- Equipment data. This includes embedded sensor data (IIoT), as well as asset history data.
- Process data. This includes process historian-based capture of all instrumentation across a process, unit or site.
- Maintenance data. This includes maintenance history, frequency, severity and equipment lifetime.
- Process safety data. This includes safety and asset integrity incidents associated with equipment and processes.
- Condition data. This includes results of measurements and inspections related to corrosion, equipment degradation, metal fatigue and the like.
- ERP data. This provides a variety of insights into asset performance and yields.

The combination of these data types are all potential inputs to machine learning approaches (such as those employed by Aspen Mtell®) for prescriptive analytics to prevent, avoid and defer maintenance and shutdowns. Through understanding interactions of the hydrocarbon flows, the process and the equipment, prescriptive strategies to modify operating strategies, maximize uptime and minimize maintenance dollars are all possible.



To make future unconventional assets feasible to produce, approaches such as machine learning combined with advanced optimization modeling will be the keys to achieving the economics that are required.

Production Data Abounds, But What to Do With It?

Asset data is proliferating. Strategic equipment, such as turbines and the newest compressors, is being more heavily sensed and instrumented. More data is becoming available from other crucial equipment such as large pumps and subsea modules. However, equipment that can play a spoiler role in production levels and uptime, including heat exchangers, compressor trains and distillation columns, have limitations on the types of information that can be collected and the cost of instrumentation. This leaves uncertainty and makes models that can provide “virtual sensors” to estimate information that can’t be collected much more valuable — and, in fact, crucial.

It is not simply about using data to understand equipment. The equipment interacts with the flowing hydrocarbons and the processes. The complexity and dynamics must be unraveled to optimize the asset. To make future unconventional assets feasible to produce, approaches such as machine learning combined with advanced optimization modeling will be the keys to achieving the economics that are required. Many operators are taking advantage of these technologies to get some early wins, which have been widely publicized, leading to even more hype and interest in this area.



Here are a few technology components that turn data into predictive knowledge:

- **Advanced big-data process data historian and highway.** AspenTech's highly scalable IP.21 data historian has been applied to some of the largest and most complex oil fields, such as the BP Azerbaijan operations, the ConocoPhillips North Slope operations and Statoil's next generation production systems. Applications capitalizing on those data streams include production accounting and allocation, online key equipment monitoring and safety systems.
- **Operations advisory and KPI visualization systems.** AspenTech's open aspenONE Process Explorer™ is a powerful and operator-friendly tool which takes the data power of any process historian and turns it into an asset optimization and reliability advantage. This system is being applied by Statoil to take the people out of remote and expensive-to-staff offshore environments.
- **Machine learning to improve uptime through prescriptive maintenance.** The Aspen Mtell machine learning toolset is a powerful prescriptive tool that addresses chronic uptime challenges presented by compressor systems in remote areas and in LNG operations. A major Gulf Coast LNG operator has dramatically reduced production downtime and increased equipment lifespan associated with their compressor trains.
- **Online data reconciliation.** AspenTech's proven Aspen OnLine® solution rapidly processes, summarizes, fits, tunes and runs models to present valuable KPIs in real time. This removes the technical modeling expert from the critical path.

Automation of Knowledge Work, Machine Learning and Ease of Use

Squeezing the Expertise Gap

During the current trough in the oil market, many experienced experts have retired or left the industry, leaving a crucial expertise gap that is most practically, quickly and effectively replaced through automation of knowledge work. These departing experts, with decades of experience, are being replaced by much younger, though highly trained, professionals who need guidance and further training to make up for the loss of decades of experience.

Automation of knowledge tasks can significantly bridge that gap. Here are a few areas of innovation that are having millions of dollars of impact on the upstream business:

- The DMC3 advanced process control technology, with patented innovations from AspenTech, adapts to changes in the dynamic operating conditions in upstream. With its ability to analyze its own performance and recommend “self repairs,” this exciting technology can be effectively used without the involvement of technical gurus and represents true automation of knowledge work. AspenTech has termed this meaningful innovation “adaptive process control.”

A major Canadian oil sands producer (Alberta, Canada) is using this advanced process control from AspenTech to substitute for teams of experienced operators and achieve up to 5 percent increased production in their Alberta steam-assisted gravity drainage (SAGD) fields, reducing water use and carbon footprint and increasing revenues by millions. This achieves incremental production increases with zero CAPEX.³

Chevron (Houston, TX) is using adaptive process control on offshore production platforms to avoid slugging conditions and increase platform uptime, compressor integrity and production predictability and rates.⁴



Columns, one of the most complex environments in a hydrocarbon facility, can now be analyzed with much more insight, without the benefit of decades of operating experience.

- Activated exchanger design is an innovation area merging two rigorous modeling environments, thus enabling process engineers to optimize processes and heat exchangers concurrently, without the involvement of heat transfer specialists. (AspenTech innovations in this area have also recently been granted patents.) This provides both design and operational advice, leading to optimal operations. It also substitutes for a sub-optimal work flow dependent on very experienced engineering experts.

Chart Industries (La Crosse, Wisconsin) is using this capability to design their high-performance, proprietary plate exchangers to provide solutions for demanding gas processing applications and to evaluate how to adjust operating strategies to improve uptime and extend the reliable life expectancy of exchangers. The business impacts on both CAPEX and OPEX are huge, with heat exchangers representing huge capital investment but also representing one of the biggest opportunities to reduce process energy consumption.

Petrofac (Sharjah, UAE) has employed this powerful knowledge automation approach to arrive at strategies to increase gas field production by greater than 10 percent with minimal CAPEX investment, through identification of the highest-reliability, highest-performance selection and configuration of heat exchangers.⁵

- Rigorous column analysis, with advanced 3D visualization, has enabled operating engineers to understand the implications of operating strategies on column hydraulics. Columns, one of the most complex environments in a hydrocarbon facility, can now be analyzed with much more insight, without the benefit of decades of operating experience. Often, columns such as amine strippers become critical in gas processing, in production fields, on floating production storage and offloading (FPSO) units and in gas plants.

Now process engineers can predict the consequences of operating decisions on column performance and reliability. Companies such as Tupras, Encana and ConocoPhillips are improving column reliability today with these tools.

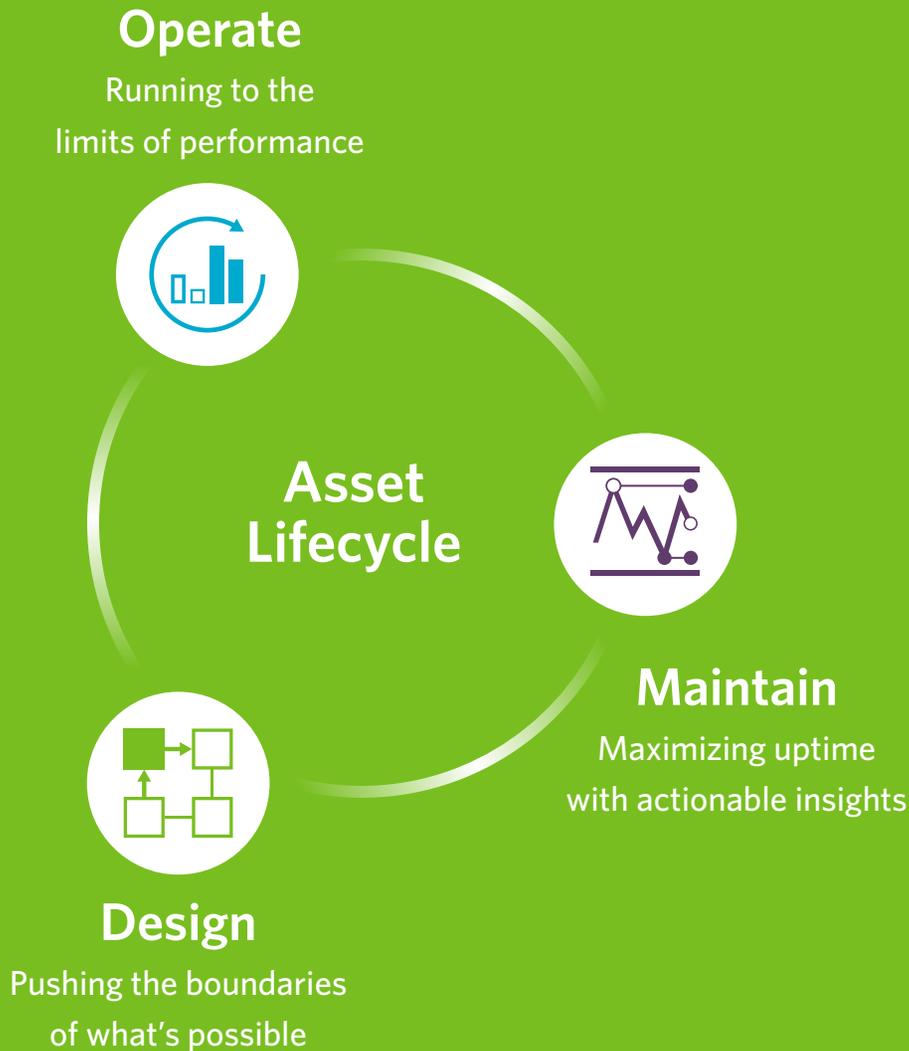
The Role of Model-Based Analytics

Solving the Complexity of Unconventionals

Hydrocarbon resources are increasingly being exploited in unconventional ways, which are both remote and more complex to exploit. This requires flexibility in production processes, as well as better and faster models to advise operations and technology to enable remote decision-making and optimization. Here are two examples:

- Models help operators make better choices. Sensors, digitalization and analytics empower smaller teams of experts to make better decisions in optimization of yields. A major Alaska North Slope operator has worked with AspenTech to unravel the complexities of gas compression in fluctuating ambient conditions, how compressors and air-cooled exchangers interact and how to best re-inject gas to help the in-field operator to make better choices, resulting in significant production benefits.
- Analysis can solve the puzzle of the shale-drilling landscape. With the short-but-productive life of wells drilled into Permian basin and Bakken assets, the ability to sequence and match wells with gathering and processing assets is critical to capitalizing on the profit opportunity. Easy-to-configure hydraulics analysis, which allows technicians to support the dynamics of short-cycle unconventional plays such as in the Permian basin, lets short-staffed technical teams rapidly respond to asset managers and drilling teams. This ensures the right wells are drilled at the right time based on the constraints and possibilities of the gathering networks.





Design: Standardization for Operability and Maintainability

Design, operations and maintenance have long persisted as isolated worlds of automation in the process industry. The current upstream environment demands a different approach.

The concept of re-using standardized, proven designs for known upstream oil and gas processing operations requires a strong lifecycle view of the process and of the asset. An upstream enterprise achieves best practices by continuously improving its assets, to improve operability, maintainability and uptime. To take advantage of that, a feedback loop captures the digital image of that well-operated and optimized asset, to use it in the next similar asset-development project.

Several years ago, in the chemical industry, the Dutch chemical concern DSM developed the concept of capturing complete design and cost information for process modules that could be adopted, on a plug-and-play basis, for new production facilities. AspenTech worked closely with DSM to improve the integration of our preliminary and conceptual design and costing tools to capture libraries of these modules as re-usable template.⁶

ExxonMobil has taken this concept much further, again working closely with AspenTech to develop a fully repeatable fast conceptual design environment. ExxonMobil reported in a presentation in April 2017 that this approach has already enabled them to reduce CAPEX costs for new LNG production facilities of 25-50 percent and reduced the concept design time by months.¹

Further innovations being developed by AspenTech will provide even more insights and capabilities into optimizing designs for operability and maintainability. A few of the key breakthroughs here include:

- **Module-costing models within AspenTech's Aspen Capital Cost Estimator™ (ACCE) system.** These provide a powerful environment to compare modular construction with “stick-built” construction.
- **Volumetric-model-based conceptual estimates in the ACCE system.** ExxonMobil, Anadarko and others are employing this approach to capture completed projects as cost models which can be re-used, through powerful relocation and re-sizing models, that enable a prior project to be re-used in a low-risk way.
- **Integrated economics,** which enables the rapid translation of process models into total installed costs.
- **Enterprise reliability analysis (Aspen Fidelis Reliability),** which enables completely scalable analysis of the reliability of a unit, system, site or enterprise, in terms of cost impact of CAPEX and OPEX investments.

Models: The Knowledge of the Process

With many technical and economic choices — and a continuing dynamic environment, both within the subsurface asset and the production infrastructures — data alone is not able to provide the predictive intelligence that operators and decision-makers require. Models which encapsulate the interactions of the reservoir, the production processes, the equipment and economics provide the opportunity to fully leverage available data.



Rigorous models enable an accurate representation of the actual operating specifications and performance curves. This has proved to be of high value in optimizing operating assets.

The key breakthroughs which are enabling models to be deployed as analytic engines in upstream include:

- **Advanced solvers.** Equation-oriented solution methods for process models are a key breakthrough. AspenTech has been working with a major Alaska North Slope operator to place models of critical gas compressor trains online, calibrating the models continuously with online data and running the models every few seconds, providing intelligent KPIs to understand the compressor performance and the operating levers which can optimize that performance. After running for a few weeks, these easy-to-implement models have already yielded several million dollars in increased production in a few weeks.
- **Rigorous models, capturing operating realities.** Embedding rigorous models within general process models has proved to be a key. In the Alaska North Slope example described above, heat exchangers are a crucial component of the actual performance

of the production system. As with many upstream settings, the heat exchangers are aged. Rigorous models enable an accurate representation of the actual operating specifications and performance curves, not the design specifications, which do not reflect current conditions. This innovative capability, invented by AspenTech to address design needs, has proved to be of high value in optimizing operating assets.

- **Ease of use of dynamic modeling.** Dynamic modeling is crucial to understand the performance of gas- and oil-gathering networks and their interaction with the production systems. For years, this has been a promise rather than a reality, due to the technical and knowledge barriers stopping typical process engineers from applying this powerful tool in operations. Recent breakthroughs, which package the advanced modeler experience into easy-to-use templates for the process engineer, have greatly diminished the barrier for entry for this approach.

Consultants to upstream operators such as the Genesis Group have demonstrated the value in speeding up startup and shutdown of offshore operations, reducing startup times of an offshore operation from days to hours. Each such contraction in operating windows results in incremental revenue opportunities.

- **Integrating flow-assurance and hydraulics tools.** Flow assurance has long been the “black magic” domain of the expert within an upstream company. Recent R&D work by AspenTech has focused on encapsulating flow-assurance thermodynamics, in areas such as hydrate formation and rigorous gathering network hydrodynamics into the general process-modeling environment to provide access to the general process engineer. Indonesia’s MedcoEnergi, in a recent presentation, demonstrated the economic and safety impact of these tools on upstream operations.⁷



Monetizing Best Practices in Upstream Reliability

AspenTech is both a supplier to and a partner with upstream companies in the application of technology to improve upstream design, operations and maintenance. AspenTech products are deeply ingrained in the engineering and operations of upstream assets worldwide. Here are a few examples of publicly reported results of such asset optimization projects:

Statoil: Oilfield Digitalization. Statoil is using aspenONE Process Explorer visualization with IP.21 process historian to support digitalization of their offshore operations, enabling data access remotely and onshore, saving significant OPEX and increasing production.⁸

MedcoEnergi: Dynamic Modeling. MedcoEnergi has employed Aspen HYSYS® Upstream Dynamics to perform process safety analysis on brownfield asset expansion projects. Use of these rigorous models have achieved 10 percent incremental oil field production with existing in-place assets.⁷

Major Canadian Oil Sands Producer: Upstream Advanced Process Control. This has improved steam injection and production settings at its oil sands operations, increasing production field-wide by several percent incremental crude yield.³

Genesis: Dynamic Modeling. Genesis updated and started up an offshore production process control system employing dynamic modeling, with a benefit of production startup that was two weeks faster and \$3 million USD saved.

Chiyoda Corporation: Dynamic Modeling for LNG. Chiyoda Corporation employed dynamic models to achieve 10 percent downsizing of safety systems, saving 20 percent CAPEX on floating LNG assets.



Combining it All to Achieve Reliability

There are many opportunities to achieve significant economic benefits, both in the CAPEX and OPEX domains as well as in incremental production. A few examples have been provided in this discussion, ranging from ExxonMobil's fast conceptual design approach to Statoil's North Sea oilfield digitalization to the incremental production others are achieving through SAGD advanced process control.

All of these opportunities are available to every upstream operator, with real economic benefits close at hand.

The chart in Figure 7 provides a simple roadmap that aids in choosing the toolset for specific reliability and cost improvement projects and prioritize those that will most benefit your organization in the short and medium term.

AspenTech is working with leading upstream operators globally on applying these approaches to improve their business.

Improving Upstream Reliability

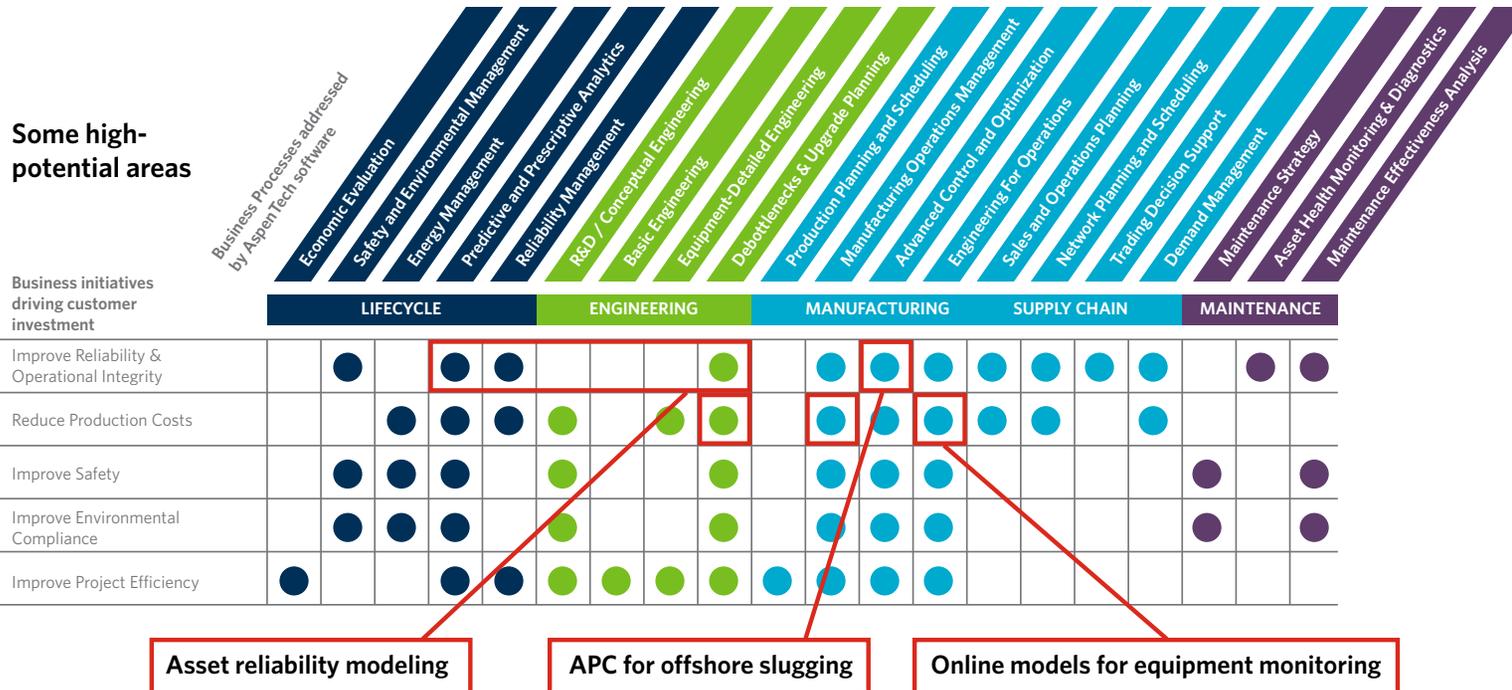


Figure 7: Value Framework Tying Business Initiatives to Business Process Improvement Areas

Next Steps

By collaborating with our upstream clients, the asset operators, we can explore the intersection between technology application and upstream business initiatives to identify areas for extremely significant economic benefits.

If this white paper makes sense in terms of your organization's challenges and strategic direction, AspenTech would like to collaborate with you. We would be glad to engage in a brief executive discussion to identify key areas where technology adoption can impact upstream reliability and incremental production.

Our approach to effectively identifying the highest-importance technology areas, based on business strategies, is focused on simplifying the complexity of an upstream organization's needs and challenges and mapping those to key technologies (as introduced in Figure 7).

Please visit our [Upstream web page](#) to request a free executive workshop with AspenTech on this innovative technology.

Path to Operational Excellence

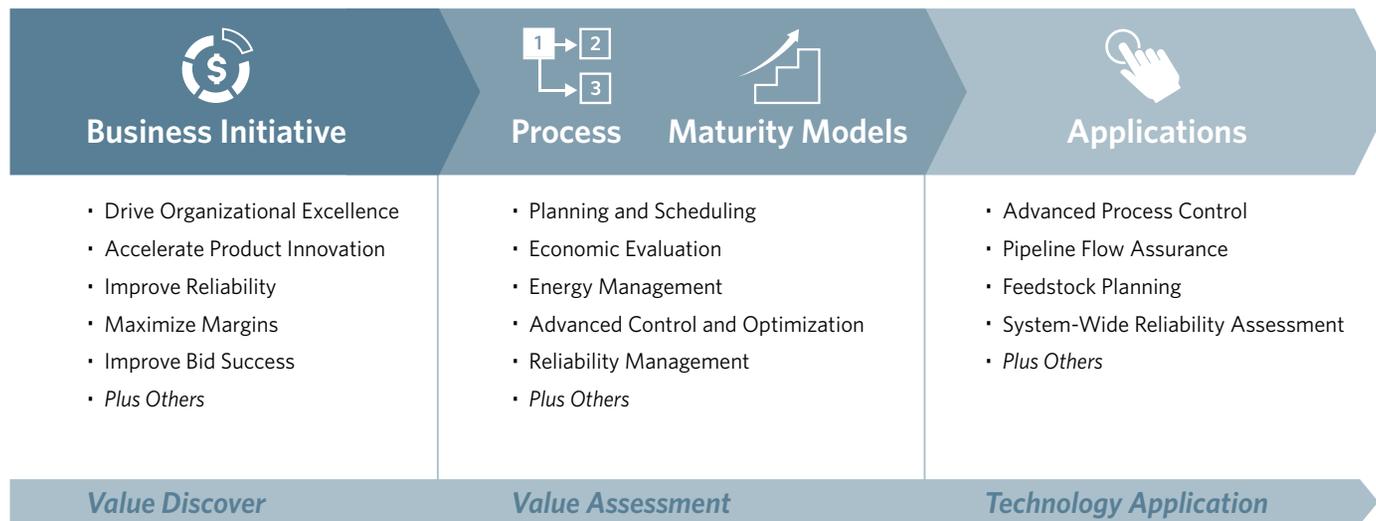


Figure 8:
A Roadmap to Effective Adoption of Key Upstream Reliability Technologies

Sources

¹D. Yergin, IHS, CERAWeek, Houston, March 6, 2017

²D. Victory, ExxonMobil, OPTIMIZE 2017, Houston

³M. Piccolo, Piccolo Controls, Energy Innovation Forum, September 2017

⁴K. Boskovich, Chevron, January 2017, Public Webinar

⁵L. Venkatesh, Petrofac, OPTIMIZE 2015, Boston

⁶M. Eijkenboom, DSM, OPTIMIZE 2011, Washington D.C.

⁷R. Ilhamsyah, MedcoEnergi, Jakarta Energy Innovation Forum, May 2017

⁸"Statoil Seeks Standarization to Optimize Offshore Operations", *Rigzone*, July 25, 2016



AspenTech is a leading software supplier for optimizing asset performance. Our products thrive in complex, industrial environments where it is critical to optimize the asset design, operation and maintenance lifecycle. AspenTech uniquely combines decades of process modeling expertise with big data machine learning. Our purpose-built software platform automates knowledge work and builds sustainable competitive advantage by delivering high returns over the entire asset lifecycle. As a result, companies in capital-intensive industries can maximize uptime and push the limits of performance, running their assets faster, safer, longer and greener.

www.aspentech.com

