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WHITE PAPER

Digitalizing onshore wellheads, pipelines and terminals



Small, medium and large producers can all improve results and safety through digitalization of the onshore hydrocarbon chain

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Introduction

The world is in the middle of a fourth industrial revolution and the onshore sector is not exempt.

Many companies have thought the benefits from digitalization best served the offshore sector whose operations are particularly complex and costly. This is simply no longer the case. In today’s environment where digital products and services are more cost-effective than ever before, the onshore sector is poised to reap great benefits.

Historically, onshore operators, particularly at the wellhead, have tried to drive their operations by looking through the rearview mirror – basing decisions on data typically 30 days old, manually collected during routine inspections by a large dedicated task force.

When prices were high, time lags were not a big issue. Also drilling low value wells made sense, less so in a time of uncertain commodity prices. Today, margins matter more than ever.

Companies that exercised discipline through the downturn can now leverage digital opportunities for the upturn to maximize results.

Oil & gas (O&G) production fields, transportation pipelines and storage and distribution terminals that are better connected have the potential to greatly improve effectiveness, safety and security.

Digitalization sees smart devices exchange timely data in ways which help transform performance through the use of analytical programs which guide operational decision-making to increase efficiency and profitability, safely. In the onshore upstream sector, it involves measuring devices, actuators and sensors in items like drilling rigs and production wellheads that use information to make decisions autonomously or under the supervision of operators who are now better informed. Enhanced monitoring, remote management and collaborative operations are already delivering significantly more productivity at reduced costs and risk.

Indeed, unless onshore operators embrace the Industrial Internet of Things (IIoT), they risk delivering disappointing shareholder returns in the near term. And, over a longer time horizon, those who ignore digitalization’s potential risk jeopardizing their future viability. They are likely to be outmaneuvered by companies who use digital technologies to gain competitive advantage by using better insights to guide more timely and effective decision-making.

There are benefits to be had regardless of company size and starting point on the digital journey. Using ABB’s experience with digitalizing the onshore sector, the aim of this white paper is to provide onshore operators some thoughts and pointers to guide their efforts.



A continuing digital momentum

By now, traditional approaches towards the oil price crash, such as personnel layoffs and rig shutdowns, have largely been exhausted. More is needed if onshore operators are to be viable over the long term. That ‘more’ is digital.

There is a growing realization of digitalization’s potential to transform performance. This could be in the form of optimizing well-design and modeling reservoirs through to enhancing artificial lift performance and maintenance. Improving pipeline flows and security along with increasing terminal margins and throughput is also achievable.

Today, only a few large players are pursuing integration from wellhead to pipeline to terminal. Most segments are operating as independent silos and, even within each segment, further silos exist within and across sites.

Connectivity at the wellhead has been a particular challenge given that assets tend to be widely dispersed, often in remote locations. Additionally, some well operations need extremely reliable and fast data exchange which can be difficult to achieve in some areas.

That said, digitalization offers companies an unparalleled opportunity to integrate and

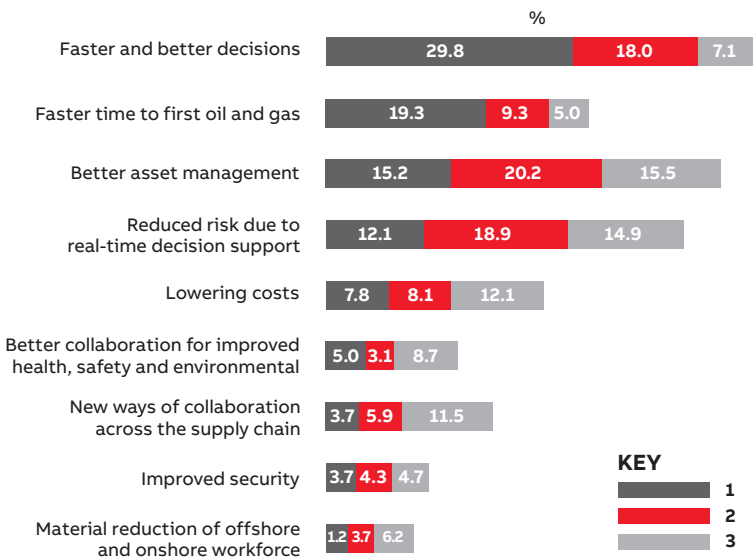
optimize the entire value chain, including certain less time critical applications at the wellhead. Widespread cloud computing is a big enabler. It is much easier to do integration in the cloud where computing, storage and connectivity resources are plentiful and inexpensive.

Digital investments are already on an upwards trend and delivering value. According to the Accenture and Microsoft 2017 Upstream Oil & Gas Digital Trends Survey:

- Over half of respondents, compared with 40 percent answering a similar question two years ago, see digital’s value and are looking to increase their investments.
- In 3 to 5 years over 70 percent say they intend to invest “more” or “significantly more” in digital and, during that timeframe, 73 percent think most O&G fields will be fully automated.
- 27 percent say digital technologies are delivering at least \$50 million in value today to their businesses.

Respondents also said the top benefits are faster, better decision-making along with shorter time to produce O&G (up from fifth to second place versus 2016 survey), better asset management and less risk through real-time decision support. See figure 1.

Figure 1. Accenture and Microsoft 2017 Upstream Oil & Gas Digital Trends Survey answer to question “What are the top three areas you believe digital can benefit your company?”



Technologies the respondents are most investing in today are mobile devices, cloud technology and big data analytics with over 70 percent saying one of the following was their top area for analytics investment: Asset management/ maintenance, drilling and completions, capital project management and production optimization. Investment in big data is expected to jump to the number one investment spot within 3 to 5 years.

While estimates vary depending on what is measured, the upside potential of getting digitalization calls right is significant. The World Economic Forum, in collaboration with Accenture, suggests that the upstream O&G sector could see \$600 billion in value created between 2016 to 2025 and £100 billion for midstream. Ninety percent of the upstream value is expected to come from optimizing drilling and production, and from the power of advanced analytics which crunch the data received from end-to-end connected assets. Resource productivity is expected to improve as are costs from non-productive time.

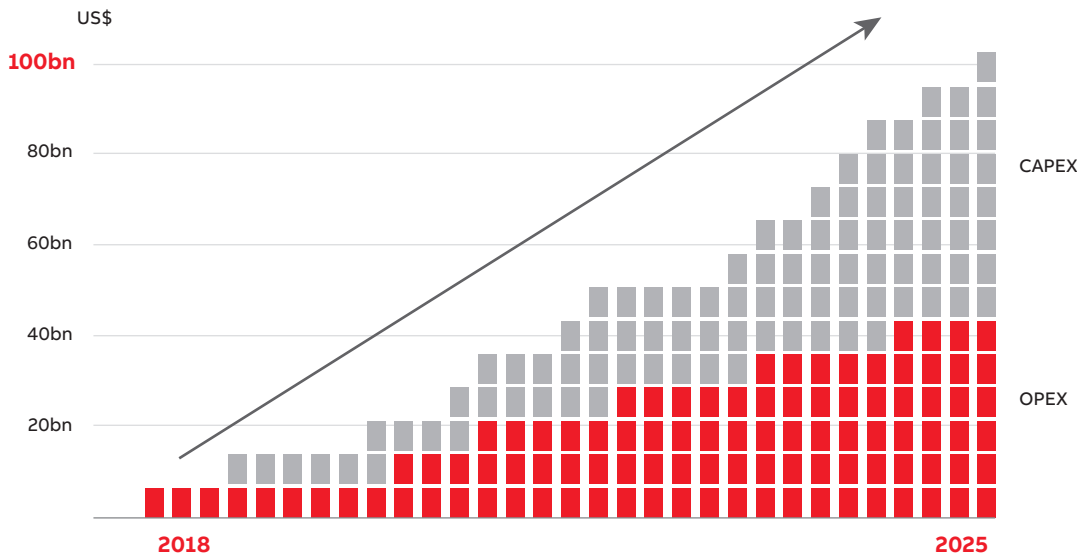
Over a similar time period PwC’s Strategy& estimates the cumulative savings in the global upstream sector could be as high as \$100 billion in terms of operating expenditures (OPEX) and capital expenditures (CAPEX). See figure 2.

All the above statistics notwithstanding, however, many companies are still struggling to find their way with digital. There remains a significant amount of uncertainty around what digitalization can deliver and how best to implement it. For example, nearly a third of respondents in the Accenture and Microsoft 2017 Upstream Oil & Gas Digital Trends Survey “do not measure” or “don’t know” the value digital is adding to their business. And, in the midstream sector, Deloitte suggest only 50 percent of US companies see existing data management as a high priority.

Also noteworthy is the fact nearly 40 percent said the biggest risk from not investing in digital was becoming uncompetitive versus their peers.

Figure 2. Estimated cumulative savings in global upstream using digital technologies.

Source: PwC’s Strategy& March 2018 video, Drilling for data: Digitising upstream oil and gas.





Challenges facing the onshore oil and gas industry

The drive towards digitalization in the onshore sector, and indeed the wider hydrocarbon value chain, is being driven by a range of external and internal challenges.

External challenges

Fewer new discoveries

As of the end 2017, the volume of new O&G discoveries was the lowest it has been since the early 1950s – see figure 3. While some of this is due to a dip in funds available for exploration due to the price crash, a large contributing factor is that many of the easily accessible deposits have already been explored. New reserves are more technically challenging to extract and are often located in remote or politically complex regions.

Uncertainty and continuing relatively low oil prices

The sharp oil price drop in 2014, and expectations that prices would stay lower for longer, rocked the industry. Reasons for the initial drop included weak global growth, shifts to alternative energies and considerable spare supply. For example, Chinese economic growth slowed considerably and OPEC members consistently overshot their production ceilings to protect their market share, while US oil production from shale extraction nearly doubled versus 2008.

With already heavily indebted oil, gas and chemical (OGC) companies seeing their market capitalization plummet by over 25 percent in 2014, they operated closer to break-even points than ever before. The situation was particularly difficult for upstream and integrated oil companies in Brazil, Argentina and Canada. Given the previous, historically high prices, companies there had begun pursuing resources such as pre-salt and oil sands, which are among the most expensive to bring to market. Being locked into pursuing these plans, which are hard to start and stop, these companies needed to ensure costs were minimized, most likely through technological innovation and better deployment of resources, to survive low-priced oil.

Many large CAPEX projects were put on hold as the industry tried to sweat existing assets more effectively but this appears slowly to be changing as an increasing number of new projects are getting the go-ahead.

Figure 3. Global volumes of new discoveries in oil and gas.

Source: Rystad Energy: Strategy& research as reported in "Oil and Gas Trends 2018-19"

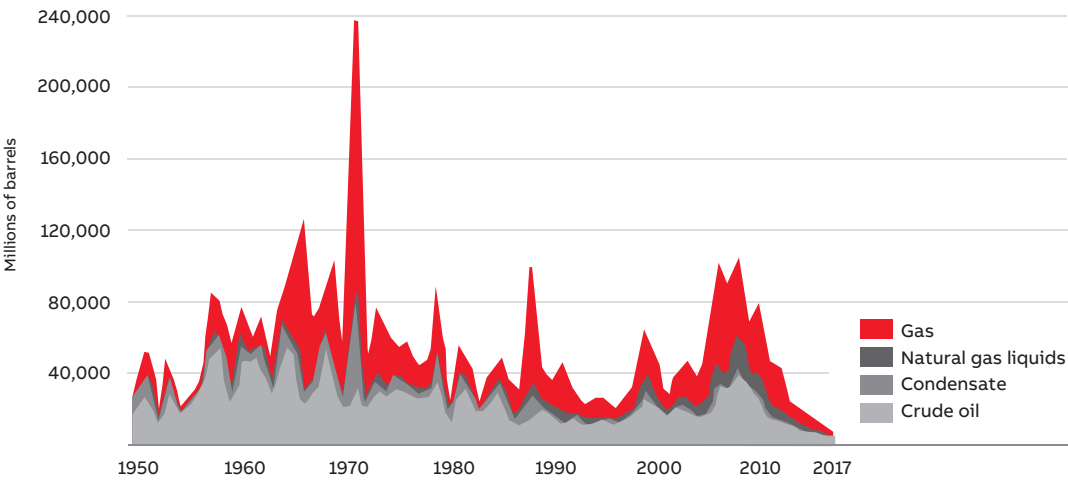
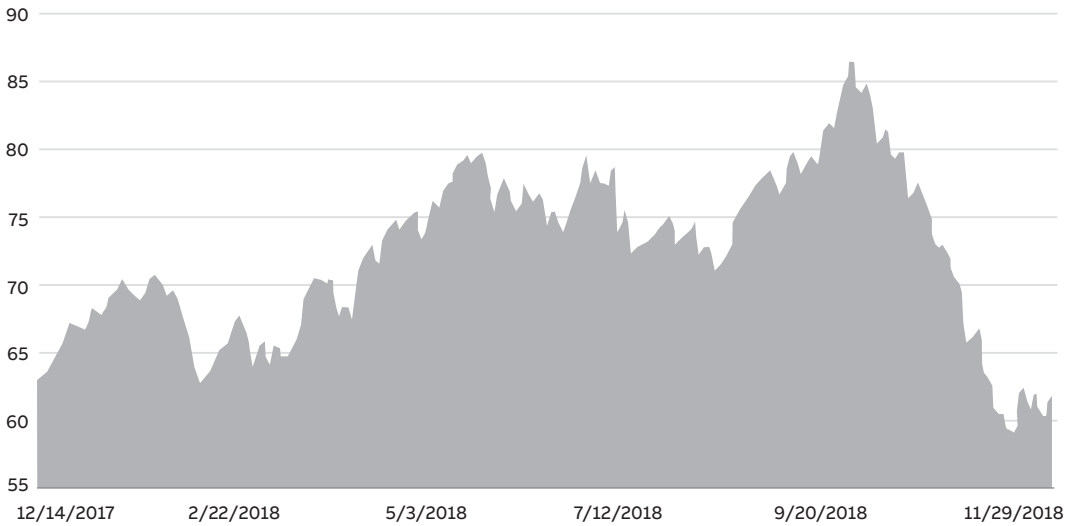


Figure 4. 1 year oil (Brent) price MarketInsider chart accessed 14/12/2018.



More recently, oil prices have recovered somewhat but they remain low and somewhat unpredictable as outlined in figure 4.

There is also a tremendous amount of geopolitical uncertainty which is further clouding the horizon. These include the US-China trade war, Brexit, significant political changes in major oil producers (Brazil and Mexico), the Venezuelan implosion and China hitting its lowest growth rate in a decade at 6.5 percent, to name but a few elements.

Supply glut or crunch?

Some are predicting a supply crunch. Reasons given include muted exploration spending and supply disruptions caused by unanticipated shutdowns from deferred maintenance to cut costs during the crash as well as distress in

traditional markets such as Venezuela and Libya. In existing oil fields production is declining at a rate of around four percent per year with spending to discover new fields considered insufficient to offset this decline. Concerns are also being raised about whether the recent round of job shedding will hamper production by having stripped the industry of too many skilled workers while at the same time making it less attractive for new hires. They suggest new shale oil will not provide enough output to counterbalance declines in conventional production.

Most, however, expect that growth in unconventional sources will keep prices low given the considerable investments now being made throughout the world, particularly North America and Argentina. See figure 5.

Figure 5. Global expenditures in unconventional.

Source: Rystad, ABB analysis.

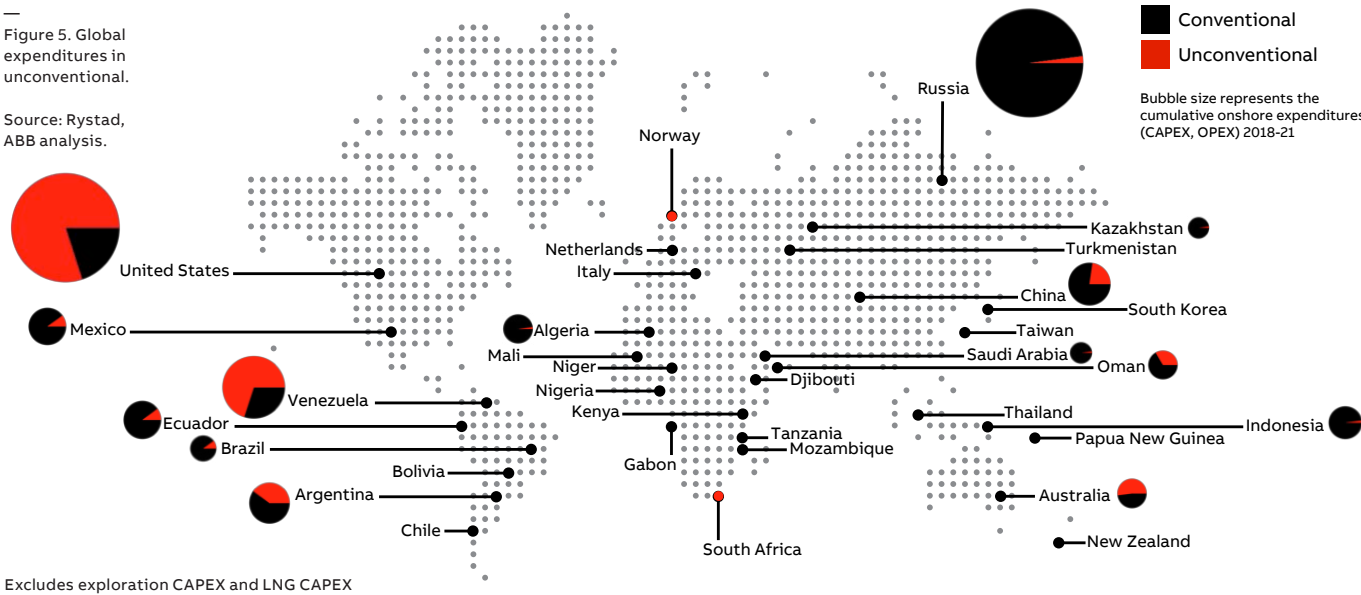
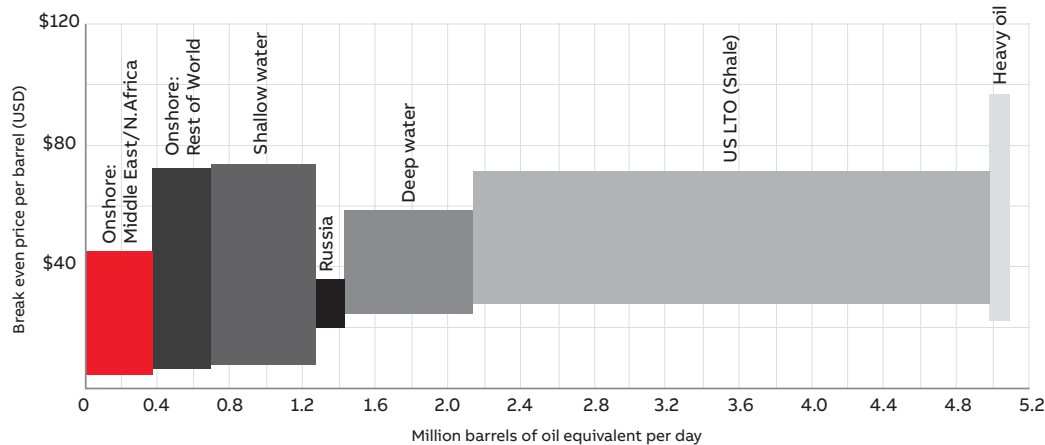


Figure 6. US light tight oil (Shale) is the new swing producer. Medium term incremental yearly supply curve.

Source: Accenture Strategy, Energy analysis.



Shale: Goldman Sachs has observed that, if the three main US shale projects continue to improve their output, breakeven points for new wells could fall to \$50/bbl by 2020. This means that global demand growth for the next decade could be met entirely by US shale oil and OPEC alone. This could make up to a trillion dollars’ worth of production projects uneconomic. Indeed, in January 2018, BP said it would only approve new projects which were profitable at under \$40/bbl.

An analysis by Accenture suggests that for the next five years US light tight oil (shale) is positioned to be the global swing producer that will set oil price floors and ceilings. See figure 6.

Increased shale production complicates matters further for traditional oil companies since shale investment cycles are much shorter and less capital intensive. From beginning the drilling process to having an operational well only takes two to four months at a cost of only \$8 million to \$12 million per well. This makes this form of

production much more flexible in response to changing market conditions than an offshore project which could take two to five years to produce first oil. However, shale’s short lifecycle brings with it a certain amount of risk as poor decisions could lead to large opportunity losses or stranded assets.

Liquefied natural gas (LNG): As seen in figure 7 LNG has been growing. In China and Southeast Asia, for example, it is worth noting that there has been an increasing shift away from coal as an energy source towards more and more LNG import terminals which are absorbing North America’s production.

Looking ahead, LNG supply is expected to continue growing as new plants and more trains come online such as in the Pacific Basin. BP sees global demand for LNG doubling by 2025 from 250 Mtpa in 2015 to 500 Mtpa which is in keeping with EIA projections predicting five percent growth over the next decade.

Figure 7. LNG Trade Volumes, 1990-2016 as documented in the International Gas Union’s 2017 World LNG report using HIS Market, IEA and IGU as sources.

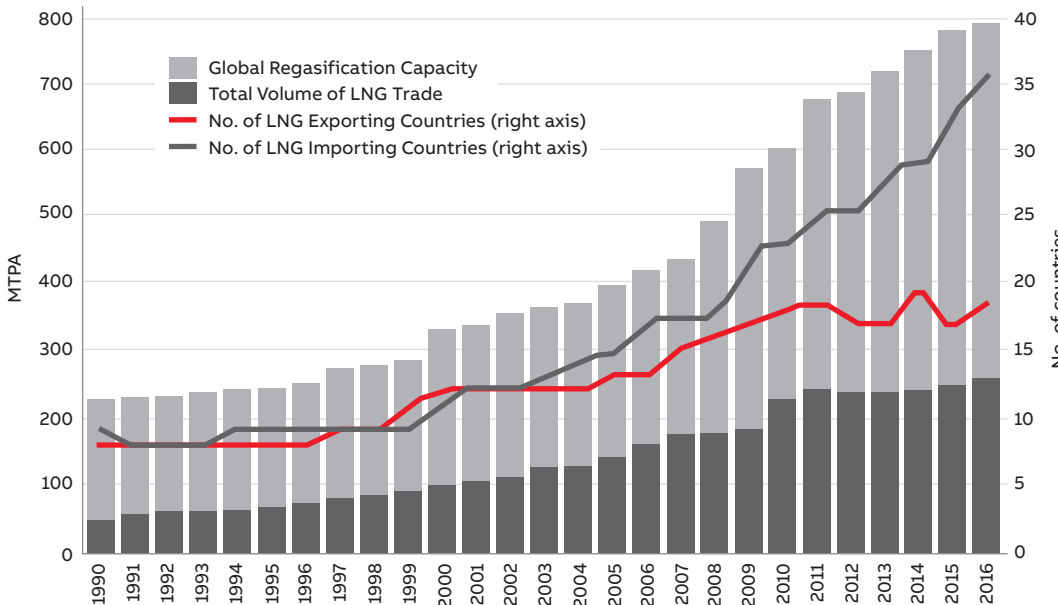
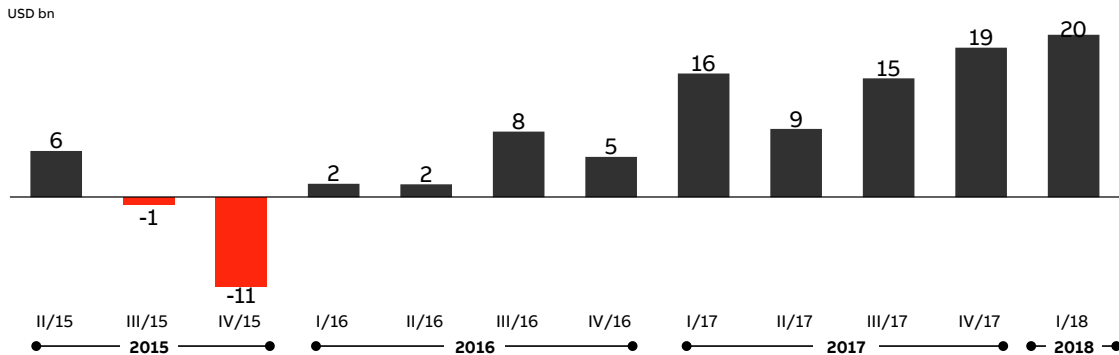


Figure 8. Net income by quarter for 6 supermajors¹, last 3 years.

Source: CapitalIQ.



¹BP, Chevron, ExxonMobil, Royal Dutch Shell plc, Total, and Eni

However, despite the relatively low oil prices, increase in unconventional supply and market uncertainty, thanks to a range of initiatives including various cost-cutting measures and shutdowns, the market is back to solid profit levels. See figure 8 outlining net income by quarter over the last three years for six of the supermajors.

That said, while marketplace conditions have improved, as shown by the net income results in Figure 8, it is also clear that the industry is not going back to the old ways of working where growth and production were prioritized over cost-containment. According to DNV GL and Goldman Sachs, 63 percent say that cost-cutting measures from 2014 are permanent, 39 percent of organizations have an increased focus on digitalization and 49 percent say they their organization must embrace digital technologies to remain competitive. Additionally, 73 percent report that projects are facing scheduling delays.

The new energy ecosystem

There are considerable and increasing concerns around energy security, equity and sustainability which are driving significant changes across the hydrocarbon chain. There is a concerted push by consumers and governments for more eco-friendly alternatives sources of power and transportation as seen in the push towards solar power on homes and the growing preference for electric vehicles. See trend chart in figure 9.

The current energy mix is 85 percent fossil fuel. Over the next 25 years, its share will probably decrease to 50 percent and be primarily used for transport (ships and trucks). The most likely scenario, put forward by Rystad and Bloomberg, has coal declining first. This has already started in many regions and will likely gain momentum after 2025. Liquids will follow in early 2030s as light transportation converts to electric and more power generation shifts to wind and solar. Last to start falling will probably be gas towards the end of the 2030s, as it will pick up from coal in the short to medium time frame.

Figure 9. US energy consumption by primary fuel 1949 to 2015.

Source: ©2017 WTRG Economics.

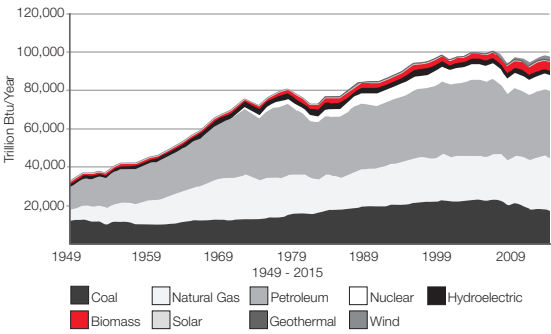
As a result, the future oil price window is likely to remain in the \$40-\$60/bbl range. This should further drive investments to lighter, faster return onshore developments.

Indeed, such is the importance of this change, that recently ABB integrated its power generation and oil & gas business units into a new operational unit to mirror the fact that oil and gas companies are integrating renewable energy resources more and more and are becoming energy companies rather than oil and gas companies.

For a more detailed look into how these evolving energy companies can adapt their operations to thrive in this evolving environment, please read ABB’s guide, “[Innovation to transform the energy future: How digitalization enables O&G operators to transition to a new energy ecosystem](#)”.

Continued strong demand over the long term

Even if renewables are added to the energy mix, not only will the shift to these technologies take time to become mainstream but also, they cannot replace hydrocarbon’s use in a variety of products such as plastic bottles and various types of clothing. Demand for such products is projected to rise particularly as consumers in developing countries begin to exhibit similar spending patterns to their peers in the developed world.



Internal challenges

On top of the external challenges explained earlier, the industry must wrestle with numerous internal difficulties. Operators need greater efficiency, for example, in supporting an ever growing well stock without increasing operational headcount or bringing new pipeline projects to fruition. Reliability is also a concern in the face, not only of aging infrastructure, but also of accessing information and expertise in remote locations with an unreliable power supply and

lack of general infrastructure. Dealing with the large volumes of required and produced water while avoiding water supply contamination – not to mention other types of problematic leaks and emissions – is also a headache. Fortunately, digitalization can help address many of the onshore sector's problems as explored in more detail by the following table.

Challenge	Issues	Benefits of a technological approach
Delivering large scale projects on time, on budget, on schedule and with minimized risk	<ul style="list-style-type: none">As of mid-2018, 48,310 miles of pipeline projects valued at \$310 billion are in the planning and construction phase64% of projects today face cost overruns and 73% also report schedule delaysLeading to a significant impact on profitability in terms of actual costs incurred and foregone revenues from projects delivered lateCost overruns of 20-30% range are commonAs many as 30% of loops fail on commissioning due to errors in the engineering processPrimarily in the data from EPCs	<ul style="list-style-type: none">Helps streamline labor intensive activities, reducing opportunity for human error and speeding up schedulesAutomated data management, standardization and cloud-based workbenches, for example, can:<ul style="list-style-type: none">Consolidate new project execution activitiesSimplify documentation requirementsReduce engineering man hoursPave the way for virtual commissioning resulting in fewer on-site changesStreamline equipment and shrink required footprintConfigurable I/O reduces marshalling and hardwiring significantly, generating large time and cost savingsBetter project execution can cut CAPEX and OPEX 20-30% while speeding up schedules by 25% and needing 40% fewer start-up and installation hours
Improving safety and security through better prevention and quicker ability to address problems effectively	<ul style="list-style-type: none">High target areas for thieves and mischief-makersIt is estimated \$133 billion worth of fuels are illegally stolen, adulterated or defrauded from legitimate operatorsPipelines are particularly vulnerable given the vast distances involvedUp to 400,000 barrels of oil stolen daily in Nigeria , a 675% increase to over 5,500 illegal taps on Mexican pipelines from 2010-2015 and one theft a week detected in UK pipelines in 2014Unstable, dangerous political environmentsNaturally hazardous areas with potential for explosions and oil spills along with possible machinery accidents, often in remote areasGeographically dispersed wells help make driving the top cause (18%) of O&G fatalities in the US300 killed in highway accidents in 10 yearsVersus other sectors, workers are 8.5 times more likely to die on the job in motor vehicle accidentsWith most of the US new wells to be drilled via fracking in next decade this is likely to get worse<ul style="list-style-type: none">Fracking requires millions of gallons of water per well with some estimating 500 to 1500 more truck trips needed per well compared to traditional drilling	<ul style="list-style-type: none">Pipeline monitoring for quick leak and theft detectionLeak prediction could help US pipeline companies avoid a potential annual cost of \$30 billion per year with the savings being used instead to fund nearly half the midstream CAPEX needed by 2030Cuts downtime, insurance costs and litigation, while improving employee retention, recruitment and morale by reducing injuries and fatalities<ul style="list-style-type: none">Digital solutions can mean employees do not need to go out to sites as often, thereby minimizing risk of injuries and fatalities from the dangerous environment as well as from drivingIt is estimated overtime fees paid to upstream field workers can be reduced by 20% through digitalizationAlarm and safety systems identify hazardous situations and help prioritize responseCapturing information from many sources: Test reports, online measurement, shutdown reports, alarms, work permits etc. to see how well and how safe the plant is operating, ensuring critical safety barriers are maintainedAutomated identity and security management programs that centrally track employees' access rights, location, duration, training, safety certification, permissions and compliance to tighten securityCybersecurity systems and services to ensure asset integrity and performanceAn analysis by the World Economic Forum and Accenture suggest workplace accidents and injuries will be reduced by:<ul style="list-style-type: none">3% through advanced analytics and modeling6% via automation13% from 'connected workers' using wearables and smartphones along with connected products that help them work more safely and efficiently
Overseeing complex, often remote and geographically dispersed	<ul style="list-style-type: none">Information overload<ul style="list-style-type: none">Chevron's daily internal IT traffic alone is 1.5 terabytes a dayA single drilling rig can generate 1 terabyte of data per dayBP says petabytes of data are now more commonInsufficient visibility of key information<ul style="list-style-type: none">Only 1% of information collected is being made available to the key decisionmakersEngineers spend 70% of their time looking for and manipulating dataUnreliable power supplies and lack of general infrastructure	<ul style="list-style-type: none">Better information available onsite and from distant, centralized control rooms or headquarters facilities<ul style="list-style-type: none">With everyone viewing the same real-time data to facilitate effective decision-makingDumb data is turned into analytic intelligence with the right information being channeled to the right person at the right time in a prioritized manner<ul style="list-style-type: none">Enabling employees to focus on the issues that matter, allowing the smart equipment to take care of the restPotentially boosting production by 6-10% or up to 1.6 million barrels a day

Challenge	Issues	Benefits of a technological approach
Overcoming disjointed communication and information silos	<ul style="list-style-type: none">Many independent pieces of equipment and systems, each with its own data and interfacesHard to share information and expensive to upgrade<ul style="list-style-type: none">A gas company with thousands of wells looking to upgrade its SCADA system to deal with growing information complexity had to pay the new supplier to develop a driver to enable the old system to talk to the new one, at cost of \$180,000 per driver per siteDuplicated activities and costs (e.g. procurement)Difficulty making timely, effective decisions to manage disturbances due to lack of common visualization at a field, pipeline and plant level as well as throughout the entire enterpriseTechnology has grown in a diverse and chaotic way resulting in fragmented automation where:<ul style="list-style-type: none">Operators and control room staff see different screens and view separate pieces of informationManagers feel they are drowning in data but are unable to find the answers they needInsufficient real-time informationOver-reliance on operator skill	<ul style="list-style-type: none">Easier information sharing to facilitate better business decisionsCollaborative operations leveraging open standards can help future-proof investments through easier upgradesIt is estimated that better connected field workers could be up to 15% more productive than those without access to support on demand, access to enhanced virtual-reality training opportunities etc.Changes how O&G employees view and interact with their operations and markets<ul style="list-style-type: none">Allows greater visibility by integrating information technology with that of operational technologyFor example, information from sensors on refinery equipment can empower technicians to optimize decisions by quickly working through robust scenario planning, factoring in the different crudes available along with pricing, availability, delivery and inventory informationThroughput maximized given operators can now use technology to juggle many more variables than beforeMore strategic and better integrated procurement programsEnables O&G players to be more responsive and flexibleEnhances delivery performanceAs a result, O&G companies can benefit from:<ul style="list-style-type: none">Increased production and revenueReduced operations cost and improved marginsBetter return on capital employed
Leveraging collaboration across the entire supply chain	<ul style="list-style-type: none">Elements of the supply chain are isolatedSuppliers, customers and partners rarely interactO&G teams in remote locations hardly ever talk with a central control roomMissed opportunities to develop novel approachesInsufficient best practice sharing: Reinventing the wheel	<ul style="list-style-type: none">Enhances productivity and performanceHelps resolve common issues more quickly and effectively<ul style="list-style-type: none">Shared knowledge can result in more accurate plans (e.g. forecasting)Potentially builds customer loyalty and may identify new revenue streams<ul style="list-style-type: none">Due to technology, innovation and R&D being shared more easily and frequently throughout the company and with partners, suppliers and customersAccording to McKinsey, oil companies are using digital to optimize pricing models and improve the efficiency of supply and distribution networks by using geolocation analytics to inform location planning and route optimization :<ul style="list-style-type: none">Such efforts have already lowered costs by 10% and increased revenue by 3%
Dealing with an aging, difficult-to-replace, workforce	<ul style="list-style-type: none">Difficult to retain competent staff to work in or travel to remote, geographically dispersed locationsEstimated as much as 50% of the O&G workforce will retire within the next decade<ul style="list-style-type: none">Transferring their knowledge and experience to the new generation is a challenge, especially as the experts are spread across many sitesRoughly 440,000 jobs were lost in the oil sector between mid-2014 and the end of 2016, with a 1/3 of these being from the US<ul style="list-style-type: none">Jobs closest to the wellhead have been among those hardest hit; 2015 saw exploration and production companies shed around 1/5 of Texas' workforceUS midstream companies (e.g. pipeline and energy transport) were relatively unscathedStagnant recruitment pool and an average of five jobs for every candidate<ul style="list-style-type: none">The skills shortage issue will get increasingly acute the more oil prices shift upwardsBy 2025 Accenture Strategy predicts a 10,000 - 40,000 shortage of upstream 'petrotechnical' professionals (e.g. geoscientists and engineers in drilling, completion, production and maintenance) with US operators likely to experience the skills crunch firstAlready 12,000 data scientists are estimated to be needed immediately to develop algorithms and to analyze the petabytes of data now coming from field sensorsToday's recruits have different expectations and attitudes and, with them, O&G has an image problemHistory of layoffs, tough working conditions and environmental impact concernsAccording to a 2016 Accenture Strategy survey only 2% of US college graduates see O&G as their top employment option	<ul style="list-style-type: none">Knowledge is captured and delivered to the right workers at the right time through remote coaching and augmented reality thereby expediting execution to generate higher productivity, safety and quality while improving marginsOptimizes expertise of global workforces through virtualization, training simulators and remote operationsPromotes an optimized management setup with centralized organization and reduced cost structure via efficient and rapid decision-makingMakes O&G appear an attractive career option for high-tech graduates by making industry appear relevant for the current digital age and by demonstrating industry focus on corporate responsibility and environmentalism<ul style="list-style-type: none">Ability to work remotely from less hostile environments could also help recruit more workersWith less reliance on human operators, digitalization could help even out the boom and bust cycles of hiring and firing, making job prospects for those entering the sector more attractive and sustainable

Challenge	Issues	Benefits of a technological approach
Managing aging assets to minimize downtime risk and its impact on profitability and workforce safety	<ul style="list-style-type: none">According to an Economic Intelligence Unit report of global process industry executives, three quarters of which were from the oil, gas and chemicals industry, 77% stated that aging infrastructure impacted operations in terms of time and costAnd O&G executives said that roughly 50% of maintenance projects in mature oil fields are caused by aging infrastructureAlso, 40% of natural gas and crude oil production comes from fields operating for more than a quarter of a century with some 175 fields delivering output for over 100 yearsIn the Middle East 35% of its O&G output comes from fields that have been producing for over 50 yearsIn the US alone, 55% of 135,000 miles of pipeline is almost 50 years old and the average age of the country's 2.7 million miles of pipelines is 20 years meaning there is a high risk for safety incidentsWhich, considering 2/3 of Americans live within 600 feet of a pipeline, is worryingThe cost of decommissioning facilities has risen from \$18 to \$52 million since 2008With most operators keen to extend the lifetime of their facilities as much as possibleThe operational cost of an hour's downtime in an O&G central processing platform (CPP) facility is over \$100,000 and \$30,000 for a field compression station (FCS)The reputational damage of major incidents, e.g. spills and explosions, can be significant, and have a dramatic effect on the bottom lineReactive and time-based maintenance are dominating maintenance strategies<ul style="list-style-type: none">As a result of a fragmented, often manual, approach to asset managementLack of data acquisition systems and real-time data complicates more proactive strategiesIsolated from other business planning functions	<ul style="list-style-type: none">Reduces expense and downtime through real-time condition and health monitoringAssets are instrumented, interconnected and intelligent, reporting their location, status and other key metrics remotely and automaticallyFacilitates preemptive condition monitoring using systems with predictive data modeling to trigger maintenance orders and prevent breakdowns before they happenHelps determine the optimal way for these assets to behave and interact with each other by providing a view of the entire asset management life cycleAsset management is integrated with other business functions and systems, such as enterprise resource planning and documentation, thereby enabling better control over costsEstimates for the upstream sector suggest digitalization can :<ul style="list-style-type: none">Cut costs for maintenance by 20% and material by 10%, with a reduction in spare parts inventory of 20%Reduce downtime by 5% through predictive analytics and boost production in conventional land operations by 3%In the midstream sector, Deloitte estimate that digitalization can reduce annual downtime by 70% and lower unplanned costs to 22% of the total, compared to 50% currently
Coping with energy volatility and sustainability concerns	<ul style="list-style-type: none">Increased government regulations globally:<ul style="list-style-type: none">Paris AgreementAustralian Emission Trading SchemeEuropean Union Emission Trading SchemeKyoto ProtocolManual management of carbon, water, energy and waste with currently little automation or integrationWater is a particular issue for onshore operators with considerable quantities to be dealt with not only during production but also during frackingOnshore O&G often faces unreliable power supply and general lack of infrastructure in remote areasPerception industry is environmentally unfriendly with concerns about fugitive emissions, spills, pollution, gas leaks and water supply contaminationLittle or no integration between the processing and power parts of many operations, making it difficult to determine where energy is actually used	<ul style="list-style-type: none">Helps reduce energy expenditure and regulatory costsTracks and monitors carbon, water and fuel from end to end, extending to footprint management, waste management, ecosystem risk management, well closure and re-habitationProcesses, information and analytical tools are used proactively to manage environmental and energy consumables, such as modeling carbon trade-offs, carbon trading, water management, fuel optimization and waste controlTighter compliance with regulations and reduced costs of meeting/monitoring regulationsA joint analysis by the World Economic Forum and Accenture predicts that between 2016 and 2025:<ul style="list-style-type: none">Automation will result in 66,000 fewer barrels in spills from upstream operations and 43,000 fewer in pipeline spills, while advanced analytics and modeling will also deliver spill reductions of 54,000 and 65,000 barrels in each area respectivelyAnd, across oil & gas as a whole, a reduction of 1,300 million tons of CO₂-equivalent emissions and some 800 million gallons of water consumption

The digital wellhead

Of the onshore sector, the wellhead is probably the least developed segment in terms of digitalization. This has been due to the difficulty in providing the communications bandwidth required to transmit the digital data given that large proportion of offshore wells are geographically dispersed over wide, remote unpopulated areas.

The potential benefit, however, is large. And, while the digital wellhead concept is not new, the recent price crash and continuing low prices – coupled with the consumer technology boom making sensors, storage and connectivity more affordable– has encouraged operators of all sizes to consider it more seriously than before.

In North America alone there are two million wellheads and the distances between them is often considerable. Many are marginal, producing under 10 barrels per day of oil. At an industry level 2P reserves having an extraction certainty of 50 percent make up around half of the industry's 1P reserves. There are also well over a thousand tired or low volume wells up for sale globally; indeed, some 100-year-old assets have been on the market for over three years. Digitalization can help make the finding and operating of wells more targeted, more efficient and safer by

helping prioritize efforts and decreasing the interventions required by employees in the field. It also helps optimize performance at aging, dispersed assets with a poor general infrastructure and unreliable power supply. All while improving safety and sustainability issues.

As opposed to offshore assets which generate high volume output for long periods of time, in onshore environments companies are faced with a declining asset from the day drilling starts. This asset decline is often further accelerated by the fact that different companies' wells are often drawing from the same reservoir. Onshore operators embracing digitalization are more likely to be able to pinpoint the best performing assets while at the same time potentially taking a greater slice of the finite reservoir as compared to digital laggards.

Remote visibility into equipment on the well pad can decrease the time field operators spend driving between wells to do maintenance checks as they prioritize routes based on real need and potential upside. This saves cost but, even more importantly, improves safety considering motor vehicles are the top contributor to workplace injuries and fatalities.



Digitalization can also ensure any actions taken are optimal for a given well’s set of conditions since analytics and cloud computing can help local and/or remote production specialists better assess what is going on and thus choose the best solution based on the available data. Field supervisors and management can instantly view production statistics and make real-time decisions about investments.

Nowadays, applying technologies, such as wireless telecommunications, on non-time critical applications means that historical data limitations interfere less with the ability to optimize operations. In the cloud, data volume is relatively limitless. And, the information which can be aggregated and considered is not limited to sensor data like pressure transmitters on the wells. Instead, thousands of data points – information in databases, inspection statistics, subject matter input safety and financial data etc – can be analyzed to ensure optimal decisions are made.

Digital platforms exist to simulate and analyze outcomes such system degradation, failures, process efficiency etc. Thousands of simulations can be run to integrate inbound data to determine the state of the system overall as well as each component and sub-system. Analytical programs can evaluate and filter out noise in the data use identify trends using varying predictive algorithms. Diagnostics on current conditions and predictions for the overall system, every component and sub-component can be delivered along with predictions and recommendations based on the cause of the predicted outcome or diagnosed state at an enterprise level.

For example, there are high-cost maintenance tasks associated with a rod pump. By collecting data, analyzing it and putting a predictive analysis package on that, companies can predict where there might be a potential failure. They can then take timely actions to mitigate things before the rod breaks and heavy costs are incurred.

Another example, of many, can be seen in the automation of chemical injection processes. Typically, operators set a flow rate and expect that sufficient optimization occurs. However, it could be beneficial to adjust flow rates based on other factors such as local weather conditions. While it would be uneconomical for operators to install a lot of weather stations, there are many existing weather services they can tap into to receive accurate information which can then be implemented into the overall control strategy to fine-tune performance.

Key questions to ask are: what are the influencers and how can we create more value with additional information to really drive a significant change to production outcomes? The answers to this are evolving every day as operators work more closely than ever before with suppliers like ABB to write the future of the relatively uncharted territory of the digital wellhead.

“We have 1 person assigned to 20 wells today. We need 1 person per 100 wells in the future.”

Chevron

Digitalization can also help operators produce more with fewer, less experienced workers. During the downsizing process brought on by the price crash, expertise has been lost. This has increased the importance of data-based decision-making to help those remaining, or joining the industry, to still make good decisions. Digital technologies, such as augmented reality and/or access to centralized subject matter experts, can also be used to help engineers perform their tasks even more safely and effectively while also freeing them up to work on more value-added tasks.

The enablers for digitalization at the wellhead and elsewhere are automation, cloud platforms and collaboration but, to be effective, companies need to take a holistic view of the overall ecosystem. It is about more than just a sensor, an RTU and the SCADA host. Everything is related and interconnected from all the sensors, the data and the people.

Human expertise will remain at the core of this new, more connected and digital, world. For the short to medium term at least, the goal is to use mobile technologies to allow fewer people to look after a greater number of production sites – as opposed to fully autonomous production. See figure 10.

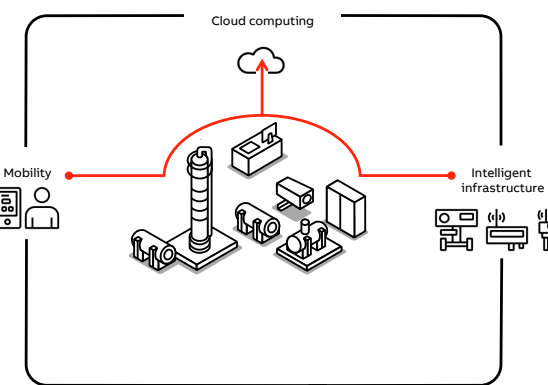


Figure 10. Mobile technologies allow for better visibility and control of entire infrastructure.

To that end, the data needs to be available wherever it is of most value and not in a single location. It must also be in the form where it can be of best use, whether that be in a desktop computer, tablet or smartphone for example. Access to experts needs to be quick and easy. The more data people see, the better able they are to manage efficiencies. Mobile technologies will thus be increasingly critical as they will allow for enhanced visibility and control of the entire infrastructure.

It is worth noting, however, that the benefits offered at the digital wellhead will evolve over time and the prioritization of each may be influenced by producer size.

At the smaller end of the spectrum, companies with 10 to 50 wells, or those just getting started, tend to have bought their wells from the companies that opened them. As such they are likely to be looking for ways to get more output from what is still left from a tired well. Here, basic, cloud-enabled monitoring is probably enough for their objectives.

Of interest to all operators, but historically most within reach and of greatest interest to companies with over 50 wells, is digitalization’s ability to enable maximize production while minimizing the costs of existing wells. This helps produce a sufficient and predictable cash flow to fund further exploration programs.

Leaving aside costs associated with failure and repair, it has been estimated that optimizing production via digitalization in a 100-well project can generate annualized cash flows of \$20 million (approximately \$20 billion at an industry level).

Here, sensors and analytics are particularly useful in prioritizing activities, such as maintenance, on the most productive wells. Technology can minimize the rate of asset decline while maximizing output not only in absolute value but also versus competitors drawing from the same source.

Artificial lift is an example of how digitalization can increase production. Nowadays hydrocarbons are only rarely brought to the surface by reservoir pressure alone. Enhanced oil recovery (EOR), such as gas lift or mechanical pumping, can push or draw the hydrocarbons out of the reservoir. However, as EOR usage increases, so too does the need for automation and electrification. Achieving maximum output requires a critical velocity to be reached. This can be most effectively delivered by sensors and technology which provide better data input. It is also worth noting, however, that gas lift and pumping systems create their own back pressures. Digitalization can be used to manage these pressures and keep output flowing to desired levels.

ABB DELIVERS...

Optimized artificial lift with digitalization: Remote management to improve results

Start Evaluation

!Warning

Fault Detection

Detects the faults present in the plunger in order to optimize the well production.

Activate

More Information

Start Evaluation

Bar chart and gear icon

Optimization

Optimizes the well production by analyzing the plunger and displaying averages of critical fields.

Activate

More Information

Start Evaluation

Person with tablet icon

Operator Training System

Provides a training simulation for the users to understand the ecosystem of plunger analysis.

Activate

More Information

Status quo

Currently most companies set up a manual-based set point and walk away. Under such situations there is the risk companies will gas off the wells, hurt the formation, underperform by under-injecting or washing out the valves.

Digital enhancement

Through SCADA and various web user interfaces, vendor agnostic, pattern recognition software can be used to analyze key trends. Injection set points can be adjusted based on incoming live-fed data with liquid loading used to open mandrel valves or gas-assisted plunger lift (GAPL) to inject the right amount to make the well do the most work.

Benefits already seen in solutions delivered by ABB

- Optimization: Use loading cycles history and data to recommend setpoints and identify deficiencies in well performance as well as help enhance closed loop tuning
- Fault detection: Find variances in transmitters, flow rates, arrival inconsistency to well e.g., bad sensor, potential holes in tubing
- Operator training: Help new operators learn to plunger lift without putting the well at risk or incurring downtime, as well as perform “what if” scenario analysis

Unsurprisingly, supermajors with over 500 wells across multiple regions are the most advanced in terms of using technology to maximize value via data extraction from digitalized wellheads. Like smaller producers and mid-sized players focused in a particular region, large companies are also interested in maximizing production to finance exploration. However, they also look to optimize output at a fleet level worldwide to focus efforts where the markets are the most profitable.

Historically, even such large producers have only been able to monitor a proportion of their wells. Now with associated costs dropping so significantly, keeping close tabs on all their wells globally is becoming a more realistic proposition. Fitting IIoT sensors and running analytics allows operators to determine which wells are the most valuable, with digital investments prioritized accordingly:

- High-value wells will warrant the full suite of smart equipment, advanced sensors and access to remote collaboration centers to provide a detailed picture of what is happening underground and at the surface.

- Medium-value wells could do with having sensors to monitor rotation, vibration and temperature etc on valves, pumps and other equipment to enable a predictive maintenance program with selected access to remote monitoring
- Low-value wells only receive standard monitoring and automation technologies

The impact of changing market conditions can be mitigated when performance is tracked and adjusted across locations using data to help executives decide where to invest finite resources for maximal returns. By quickly and effectively aggregating large volumes of operational information, digitalization makes it easier to compare regions and prioritize investments.

Operational metrics, as opposed to predicting where the best price will be achieved, are the current focus area. By the time a well has been drilled, companies will already have spent so much it makes sense to keep output flowing irrespective of price. That said, knowing when to cut one's losses is also valuable and analytics can potentially help reach that decision sooner.

ABB DELIVERS...

Optimized artificial lift with digitalization: Better prioritization of interventions

Status quo

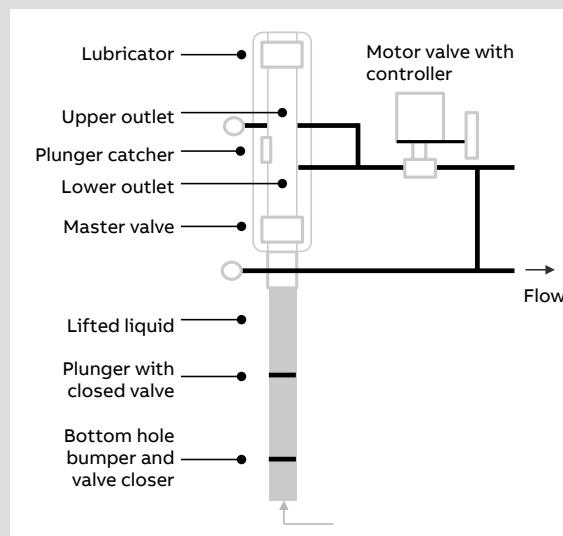
Plunger lift systems are an economical choice to enhance oil recovery but without digital prioritization current maintenance practices require high labor costs and unplanned downtime reduces the profitability.

Digital enhancement

A field level cause and effect-based predictive-prescriptive analytics solution can monitor and evaluate all key sub-systems and associated components. It can predict system, sub-system, and component-level failures, prescribe mitigating/preventative action(s), and can be deployed at site, aggregation point, remote locations, and/or cloud.

Benefits already seen in solutions delivered by ABB (results vary on a case by case basis)

- Technicians perform manage by exception visiting wells identified as needing attention, thereby reducing man-hours and mileage – for example, daily mileage dropping from 200 to 80 miles
- One company went from 40 wells to 240 covered per person while another drilled an extra 411 wells but only added two heads
- Field operators order replacement parts ahead of predicted failure window, reducing unplanned downtime by 35-45 percent as well as deferrals
- Production efficiency increases of 20-30 percent and reduced injections of 30-40 percent have also been observed
- Prescriptive capabilities allow technicians to prevent catastrophic failure, increasing the life of each plunger lift system, keeping gas flowing to sales



Large producers are also using digitalization for the purposes of predictive maintenance. By having advance notice of potential problems with equipment, maintenance activities can be directed to those wells whose shutdown would be most costly. For examples of this, see the boxed item below and the case studies at the end of this document.

The good news, however, for small and mid-size players is that digitalization is helping to level the playing field somewhat. In the past the scale of capital investment required to create a suitable communications infrastructure was particularly prohibitive. It is becoming increasingly possible to offer SCADA software as a service such that analytics are run in the cloud and, instead of heavy upfront capital costs, smaller companies can pay a more manageable monthly subscription.

Telecommunications as critical infrastructure: a new imperative for long-term success

In today's greenfield projects, putting in a digital communication infrastructure should be the first critical step taken in these capital investments. By building the network as the well pad is being cleared and as they drill, companies set themselves up for the evolving digital future and save considerable cost too.

If the well site is on the network before the drilling crew arrives, the drilling team can avoid using expensive satellite for data services. And, when the drilling team moves on, the mesh router

can remain meaning the subsequent teams – e.g. fracturing and completions crews – can also take advantage of the network when they are onsite.

Similarly, for production the mesh network can provide backhaul connectivity for RTUs, PLCs, and video etc. Thousands of dollars in communications costs can be saved in the drilling phase. Tens of thousands over the life cycle of the well pad.

Going wireless offers a lot of advantages. Companies can save thousands on cabling and installation costs for each facility. Low transmit power reduces the noise floor and enables more reliable communication at short distances. Radios with onboard I/O can send 4-20mA and 1-5VDC values to the RTU while the Emergency ShutDown (ESD) network can be autonomous on sub-1GHZ.

Basic components to include are a pole, wood or Rohn-style self-supporting tower (30 feet), mesh router, solar panel/battery pack and cabling. See figure 11 which shows a complete modern wireless architecture for onshore production.

Caveats

With the state of technology available today, not all wellhead operations are currently suitable for cloud-enabled optimization. Real-time applications such as keeping temperature, pressures, flow and levels are best handled in the onsite remote terminal unit (RTU). Until there is instantaneous cloud-connectivity which is 100 percent reliable, the safety risk is too high.

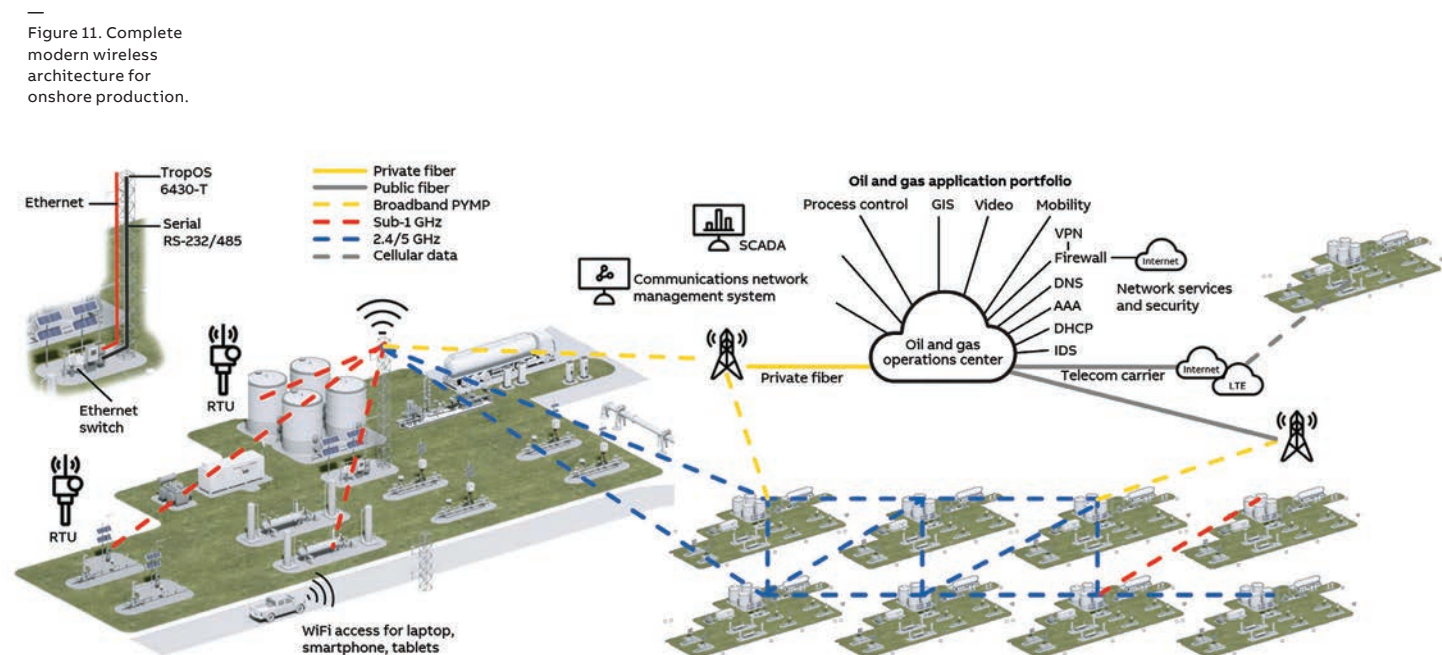


Figure 11. Complete modern wireless architecture for onshore production.

The digital pipeline

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Figure 12. 1994-2013 Significant pipeline incidents.

Source: US DOT. Pipeline & Hazardous Materials Safety Administration.

Many midstream operators already deploy a substantial number of digital components with advanced measurement devices such as data-intensive, intelligent pipeline intervention gauges (PIGs). However, there is still room to optimize operations further through the better distillation of the data they currently collect to generate new insights and by gaining additional information through the deployment of drones to conduct pipeline flyovers where regulations permit.

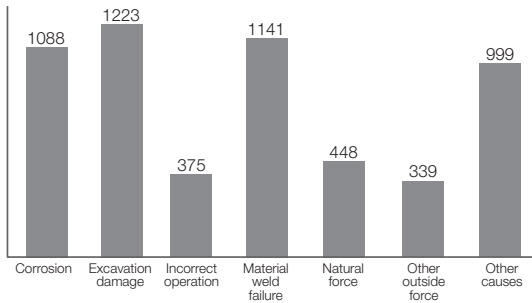
Additionally, the market has changed a lot with the growth in unconventional energy which needs to be transported, particularly in the form of liquid petroleum gas (LPG) and natural gas, from well sites to refineries, processors or storage facilities. Midstream players will need to expand capabilities or adapt aging infrastructure to track and optimize greater flows of an increasingly complex array of product from and to a variety of new locations.

Cloud-based systems can be used to track and manage thousands of kilometers of pipelines. Machine and sensor data, weather information, geolocation data can be more effectively mined to improve predictability and performance.

Better deployment of technology will help companies use pipeline data to optimize routes to market and react quicker to changing volumes and fluctuating prices. For example, careful surveillance of electricity market indicators may signal increased future demand for gas. Leveraging insights from big data models will help savvy operators steal a march on competitors slower to read the market signals due to an outdated method of forecasting.

On the supply side, it may be that by analyzing flow history and better tracking existing conditions, midstream companies may become better at predicting where and at what pressure and volume the product to be transported will arrive. Improved forecasting algorithms will mean they can better optimize their configuration plans and increase revenues from their assets.

It will also help with theft protection and leakage detection, thereby improving finances and safety.



Theft from pipelines and other sources costs billions globally. Given a tanker can be filled in less than 15 minutes, prompt illegal tap detection through accurate, real-time monitoring, is a useful tool to keep revenues where they belong.

Detecting and deterring illegal tapping can also save lives. In one of many examples, an oil pipeline explosion in San Martin Texmelucan, Mexico in 2010 caused by inept thieves killed 27 people, injured another 52 and destroyed over 115 homes.

Other risks that the Internet of Things can mitigate are undetected leakages or spills which not only add to operator costs but result in more stringent regulations for everyone else.

As outlined in figure 12, pipelines can fail for a variety of reasons, many of which can be minimized through increased automation and real-time surveillance.

In short, midstream companies will increasingly use advanced analytics to improve profit margins through initiatives such as better pressure monitoring, more efficient transportation fuel cost management, more precise forecasting and a better view of overall operations.

ABB DELIVERS...

Enhanced pipeline visibility
ABB is using fiber-optic based technology to monitor the 1850 km long TANAP pipeline for intruders, leaks and pig tracking. ABB is also applying the same technology for the very first time on the subsea section for leak detection and other events such as anchor drag.

The digital terminal

As with the other parts of the onshore hydrocarbon chain, terminals can use digitalization to increase profits and performance by increasing throughput at their sites, improving the use of resources and reducing risk. Agile, updatable terminal management systems can help companies more easily adapt to evolving conditions e.g., changing legislation.

Historically, terminals have relied heavily on manual labor. Digitalization makes it possible now to increase efficiency by better balancing and/or reducing inventory needs. It can thus make operations more flexible and minimizes downtime. At the same time digitalization can reduce the hardware fingerprint by using cloud solutions (no local servers required), smartphones (no need of local identification devices or workstations), etc. Additionally, the real-time control of product delivery made possible through digital technologies lessens the potential for human error meaning it is less likely that incorrect quantities of product will be loaded. Communication between local terminals and headquarters facilities can also be made more effective.

While digitalization can add value across a range of terminal areas, the most visible of these is in its potential to automate processes. On the one hand digital technologies can be used to facilitate faster loading thereby increasing revenues. On the other hand, costs can be decreased by minimizing errors and using a smaller workforce to deliver this increased output.

For example, many companies still receive orders via fax or email. This, in turn, necessitates time-consuming and thus costly human interventions with potential for mistakes. Instead, digitalization means orders can be processed automatically. The relevant information is quickly and directly fed into the company's enterprise resource planning (ERP) system. This delivers faster processing and reconciliation which is also error-free.

Site access to pick up orders can also be sped up. Long waits for manual verification of and entry permissions for trucks, barges and rail wagons can be reduced, or even eliminated. Instead, automated access control technology can allow quick terminal entry and exit without jeopardizing security. Valid access is granted through card readers such as iris scanners, radio frequency identification (RFID), etc. or even using smartphones as identification devices.

Once inside the terminal, digitalization can accelerate the tasks needed to load and unload products. These include verifying orders, generating transaction documentation and monitoring volume changes. Product and additive recipe calculations can be automated to improve speed and avoid manual errors during the loading process to ensure enhanced profitability and safety. The generation and printing of bills of lading can be automated for even greater efficiency.

Furthermore, inventory balancing can be improved. Product inflows and outflows are dynamic. Digitalization can help companies to accurately calculate the difference between expected yields and actual values. This is done by maintaining a real-time record of all terminal operations, calculating the theoretical product quantities and doing product reconciliations in a timely manner to determine product gains and losses.

ABB DELIVERS...

Fully automated terminals to maximize throughput
ABB is helping Spain's Compañía Logística de Hidrocarburos automate its 40 terminals, helping the company to increase its revenues significantly as more trucks can enter its sites per day. This has also helped CLH tighten its grip on product inflows and outflows, cut labor costs and reduced mistakes.

Empowering the onshore ecosystem: ABB's technologies and approach

As discussed throughout this white paper, digitalization offers the onshore sector a wide range of potential benefits, particularly if changes are adopted throughout the value chain and the various elements are treated as part of an interconnected ecosystem. We have also highlighted some of the uncertainties and struggles onshore operators face when trying to put the various pieces together.

Having ABB as a partner can simplify much of this complexity to ensure onshore operators exploit fully the promise of the fourth industrial revolution both in terms of transforming performance and adapting to the rapidly evolving energy environment. ABB not only has the oil and gas domain expertise and technologies necessary to improve bottom-line results but also the insights, solutions and partnerships to help companies more smoothly evolve their energy transition strategies, thereby improving profitability and sustainability.

Only when things, services and people are in sync will real change occur. And, with an installed base of over 70 million connected devices and more than 70,000 digital control systems across a range of industries, ABB understands how to make this happen. Indeed, knowing just how critical it is for the right people to have the right information at the right time, ABB has gone a step further for customers by partnering with Microsoft to develop one of the world's largest industrial cloud platforms. This partnership gives customers new insights to empower faster, more astute decision making.

Additionally, ABB's preference for open, as opposed to proprietary systems, means its solutions tend to be easier to integrate in the short term and to upgrade when obsolescence becomes a concern.

Likewise, ABB has partnered with Hewlett Packard Enterprise (HPE) to combine ABB's deep domain expertise in operations technologies (OT) with HPE's leadership in information technologies (IT). ABB and HPE are delivering joint industry solutions that merge OT and IT to turn industrial data into insights and automatic action. They are combining cloud platforms like Microsoft Azure with IT systems running in corporate data centers and OT systems at the edge of the network closest to where the raw data is being collected. By helping customers employ the right mix of IT platforms and serving their OT data more effectively into those IT systems, ABB is helping customers accelerate data processing and enabling effective control of industrial processes across multiple locations.

It is particularly important for companies to optimize the routing of their data via the most appropriate method. Information which is not particularly time sensitive should be shared via an IoT path which is easier and relatively inexpensive to set-up and run. Here, some of the data can even be pre-processed at the site over minutes or days before going into the cloud, reducing by a significant factor the amount of data going into the cloud and minimizing the associated costs.

On the other hand, where sub-second timing is needed, data should be shared via a control system path. For example, an ABB Ability™ Smart Sensor on a motor analyzing vibration and temperature etc, to identify pending problems needs fast sampling rates so it is not suitable for running in the cloud. ABB has experience helping a wide range of companies set up these parallel paths in ways which optimize costs, safety and performance. Figure 12 shows both routes.

And, to help improve edge analytics, ABB Ability™ EdgeInsight, a new service offering which runs on HPE Edgeline hardware, is being piloted at a number of oil, gas and chemical customers. The new software collects data from field devices / gateways / PLCs in OT systems, converts the various field protocols into one common protocol and serves the standardized output to the IT infrastructure while simultaneously guaranteeing no access to the field network. Data can thus be shared efficiently beyond individual sites while protecting site assets from potential outside interference. Data is merged close to field level ensuring the same timestamp and context across vendors and protocols. By unifying complex industrial languages at the edge, it saves up to 75 percent of the data normally sent through control system databases and avoids data gaps due to control system updates, downtime or faults. Analyses which used to take days are now being done in minutes. See box below for more detailed

results from pilots within the hydrocarbon sector.

Running on HPE Edgeline Converged Edge Systems, ABB Ability™ EdgeInsight ensures quick, quality data – even when dealing with a range of old, legacy systems – and is a key enabler for digital services such as ABB Ability™ Condition Monitoring which can move up to 97 percent of maintenance from site to office.

ABB DELIVERS...

Faster, more cost-effective performance with ABB Ability™ EdgeInsight

ABB has improved electrical maintenance for a large O&G company. Using ABB Ability™ EdgeInsight for data collection and ABB's wider insight portfolio for dashboards and analytics, ABB moved 830 of 915 hours of offshore work to onshore and eliminated 30 hours, improving safety and cost.

In another O&G project, analysis went from days to minutes and achieved a 10 percent increased drive power rating and forecast annual savings of 9460 MW/h and 160 tons of CO₂. Without it, if there was a voltage dip, they had to manually gather event data and send it off for analysis. Now instant automatic analysis, with precalculated key performance indicators, enables faster decision-making. Before compressor tests were annual and, if decreased performance was seen, further analysis required shutdown. With continual assessment, issues are now spotted earlier meaning less shutdown likelihood.

Collaborative operations: A proven four-angled approach to cut costs, reduce schedules and minimize risk through properly integrated digitalization

ABB's collaborative operations approach addresses the need to use big data and data analytics to realize the potential of the IIoT. ABB consolidates data to manageable levels whereby people can take decisions, helping to improve coordination between functional silos by providing greater visibility and real-time system integration.

Collaborative operations is a proven operating mode which facilitates effective business transformation. It is made up of four elements:

- **Intelligent engineering:** An integrated digitally-powered approach which covers the processes, tools and standards that take project execution from a traditional multi-vendor approach to one which streamlines equipment to reduce human error, risks, labor and CAPEX costs. It also

Figure 13. Data routing in a digital facility.

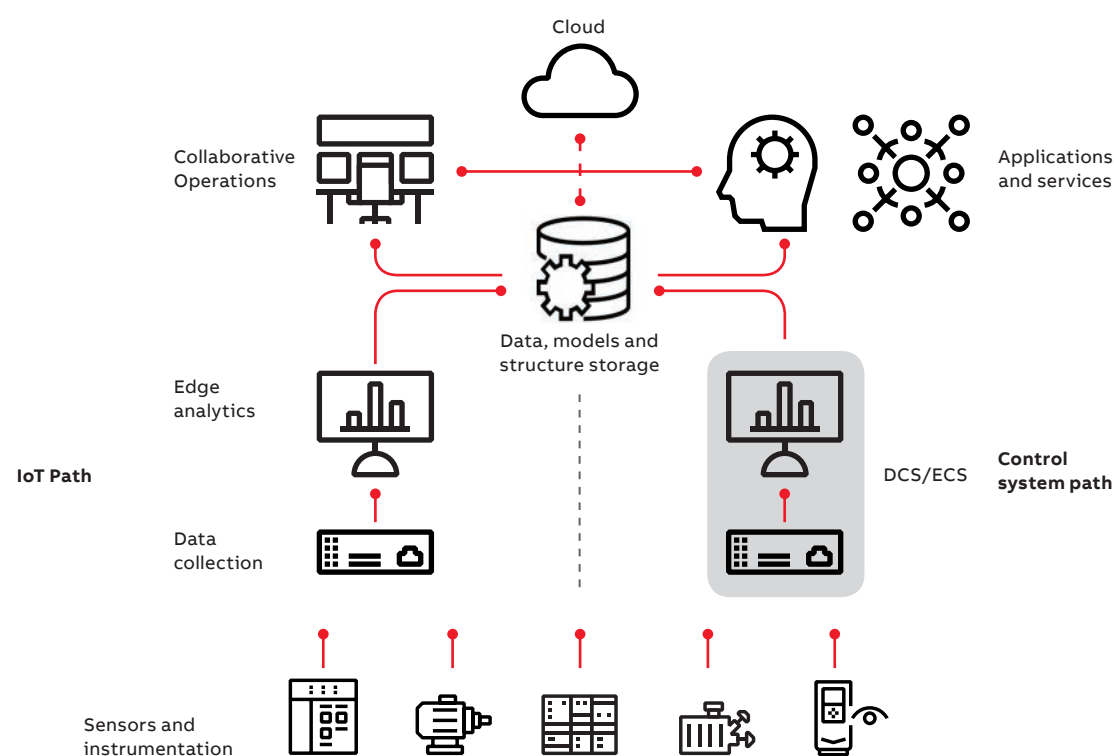


Figure 14. Closing the communication loop: Fully collaborative operations.

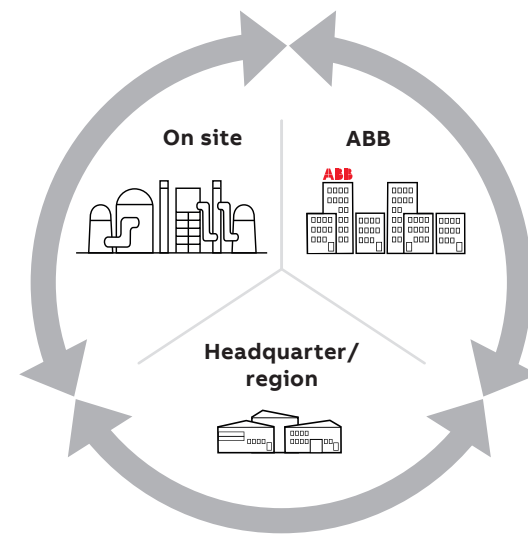
provides single-source accountability for extra peace of mind and shortens completion times.

- **Intelligent infrastructure:** Having an intelligent infrastructure which seamlessly integrates process control, safety, power, automation, telecoms and electrification systems into one collaborative system is the backbone of many operations. By leveraging digitalization where possible and optimizing how machines, applications and people communicate ABB, when used as a single-source supplier, has proven that companies can significantly reduce CAPEX and OPEX expenditures while simultaneously improving production.
- **Intelligent applications:** Are software and system components that help improve efficiencies and optimize performance across the enterprise. They ensure the intelligent infrastructure reaches its full potential to deliver sustainable profitability. To that end ABB offers a suite of applications designed to enhance day-to-day equipment efficiency, promote safe and secure production and make it easy to access expert guidance whenever and wherever required.
- **Intelligent services:** Minimize downtime and improve employee effectiveness through a mix of human intervention and technological solutions which enable companies to move from costly reactive or unnecessary time-based maintenance to planned and predictive tasks based on actual equipment needs to ensure a cost-efficient and extended equipment lifecycle.

The first two elements provide the foundation on which performance improvement and cost containment rely while the other elements ensure that initial engineering and infrastructure benefits continue. Our approach is scalable such that companies can join in where it makes sense – though full benefits will only accrue to those opting for the totally integrated solution.

Greenfield

Here companies benefit from combining intelligent engineering with intelligent infrastructure, the first two. The former simplifies and accelerates project execution while the latter helps to further reduce initial CAPEX expenditures by streamlining the equipment required and reducing required footprints. We call this Intelligent Projects™. In addition to cutting costs by 20-30 percent, it can shorten schedules by a quarter. That said, the benefit goes beyond the initial design and build phase; an intelligent CAPEX investment here enables higher OPEX savings once the project is up and running.



Brownfield

For existing operations, companies may prefer to start their digitalization journey at an asset level which is fine so long as they do so with the end goal of enterprise-wide digitalization in mind. If they do not take such a long-term view, they risk continuing to develop islands of intelligence of an insufficient scale to deliver significant value and they will increasingly find themselves at a disadvantage to other players who create a larger digital ecosystem. Of course, the magnitude and nature of the ecosystem will vary by size of company.

Ultimately, they should be striving to close the communication loop more fully and as best suits their business size. Larger players, for example, should be looking towards having onsite operators liaise more closely with headquarter locations and suppliers such as ABB who can work remotely or in proximity with local employees to make operations and services more efficiently. In fact, at its various Oil, Gas and Chemicals Collaborative Operations Centers located throughout the world, ABB has created digital hubs that allow IT and OT experts to work very closely together to solve customer issues in real-time. These centers gather data drawn from assets across the customer's production sites and translate this into intelligence, before transferring it back to each plant's operations center on-site and to management at headquarters. See figure 14.

Using the ABB Ability™ platform, based on Microsoft's Azure, data from instrumentation, switchgear, motors, drives and other smart sensors, for example, are channeled through analytics which undertake condition monitoring,

remote diagnostics, performance monitoring, cybersecurity and condition-based maintenance. Depending on customer needs, a full suite of experts can man the center 24/7 meaning project teams to address crises can be quickly assembled. There are even high security Armor rooms for working directly on customers' own networks.

Delving deeper into ABB's sector offering

In terms of oil, gas & chemicals specifically, for over five decades ABB has been at the forefront of equipping companies across the full hydrocarbon chain, offshore and onshore, with a wide range of technologies and services to support some of the world's largest and most challenging projects including:

- Motors, drills, drives and telecommunications on the largest float-out ever built, ExxonMobil Hebron, Canada
- Automation, electrification and telecoms for the world's first coal seam gas to LNG plant and its associated pipelines – Queensland Gas Company (QGC)
- PMS, electricals and analyzers for Shell Pearl, the world's largest gas to liquids facility
- SCADA, telecoms, pipeline monitoring and security systems for the largest ever fully integrated control and security system on one of the world's longest pipelines – for Trans-Anatolian Natural Gas Pipeline - (TANAP)
- Automation and instrumentation for largest petrochemical complex ever built in a single phase – The Sadara Chemical Company

More than that, ABB is one of very few companies which not only integrates electrification, control, instrumentation and telecommunications (EICT) but also has a proven record of providing seamless solutions saving the hydrocarbon sector 20-30 percent in CAPEX and OPEX. ABB

knows how to deliver practical technology solutions which optimize operations, improve efficiencies and increase production potential while reducing risks to schedules and safety—even in historically low-tech environments like the wellhead.

Through its onshore upstream ecosystem pyramid in figure 15, ABB offers a full portfolio of solutions to address wherever companies would like to evolve their digital journey.

At a device layer, ABB can integrate many different elements, such as measurement and analytics (e.g. valve positioners, fire and gas detectors, vibration sensors), electrical devices (e.g. transformers, switchgear, drives, motors) and telecommunications and security-related devices (e.g. VoIP, CCTV cameras, access control points, intruder detection equipment).

At the control layer, ABB can integrate a wide range of automation equipment such as RTUs and remote modular controllers, flow computers, local HMI panels, wireless gateways, PLCs and/or DCS programmable controllers. Also included here are edge devices and programs such as ABB Ability™ EdgeInsight mentioned earlier.

From a communications network perspective, ABB offers a wide range of solutions such as wireless meshed networks and fiber optic-based networks, using the latest technologies such as DWDM and satellite-based backup communications.

At the operations layer, ABB can provide field-wide SCADA and DCS solutions, with fully designed and equipped centralized main and backup control center solutions, ergonomically designed to industry standards, such as EEMUA 201 and ISO 11064.

Figure 15. ABB's Onshore upstream ecosystem pyramid: integrated solutions to meet needs at all levels.

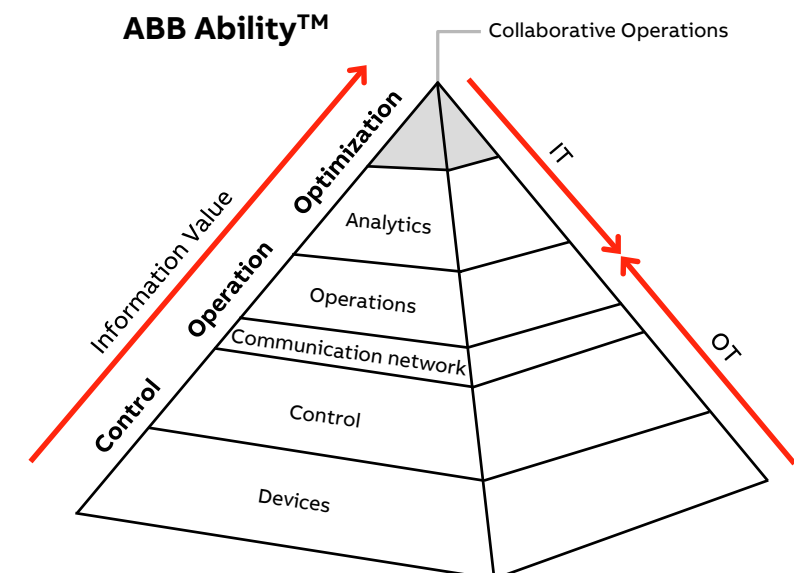


Figure 16. ABB's pillars of digital analytics.



On the analytics front, ABB has an extensive portfolio of digital products and solutions designed to optimize production, uptime and reliability, energy consumption and field operations. Our digital solutions are designed to be scalable and can run on edge computing devices situated locally at the wellhead, pipeline or terminals, on servers at control centers, in private or public clouds or in any combination of these alternatives.

Digital analytics produce actionable insights; Collaborative Operations amplifies these actions through people. We help turn control centers into Collaborative Operations Centers as explained on page 22 and in figure 17.

It is also worth noting that, in addition integrating stand-alone elements ABB can also offer a range of packaged solutions such as metering systems (fiscal, custody transfer, LACT), containerized ehouses, local equipment rooms and electrical skids.

Figure 17. Empowering people to amplify results through ABB Ability™ Collaborative Operations.

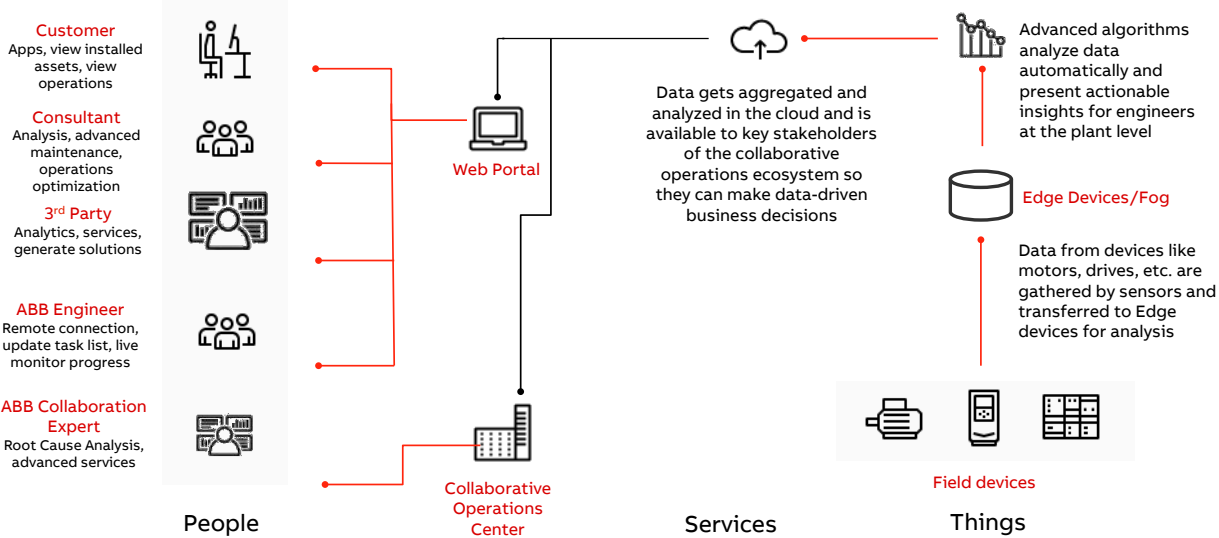
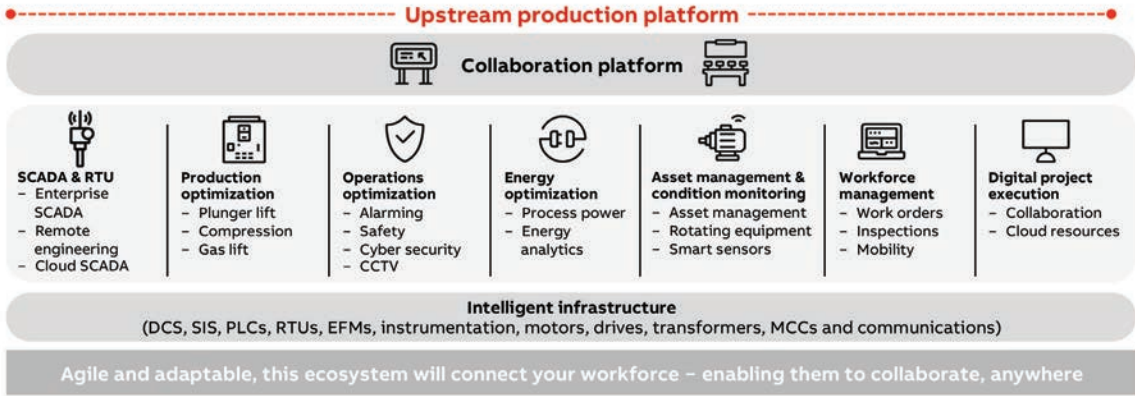


Figure 18. Overview of the ABB Ability™ Onshore Upstream Production platform for smaller operators.



Rolling things up together using onshore upstream as an example of solutions ABB can tailor for different-sized companies, ABB recently launched ABB Ability™ Onshore Upstream Production platform for smaller operators. More specifically it is a rapidly deployable automation solution for companies which may not have the size and resources to deploy a traditional SCADA or DCS solution for their automation needs. This cloud-based automation system platform combines the top three layers of the pyramid shown earlier into a cloud-based offering software-as-a-service solution which is ‘evergreen’ and does not require updates. It can be accessed by a wide variety of mobile devices and does not depend on any operating system so it can be

seamlessly integrated into any environment without an expensive associated infrastructure to set up. It helps smaller companies optimize operations, reduce cost, minimize risk and maintain or improve schedules. Agile and adaptable, it enables people to collaborate effectively – anywhere and with better results than previously achievable. See figure 18.

Of course, the above represents only one of many solutions ABB can offer the onshore sector. We welcome discussions with all sizes of companies, be it at the wellhead, pipeline or terminal. Given the depth of our experience and the breadth of our portfolio, we are likely to have a suitable solution to deploy, regardless of size or situation.

The value ABB brings to the onshore sector

Easily integrated, modular solutions	Optimized production	Increased speed	Improved safety
<ul style="list-style-type: none">One interface through integrated solutionsRugged, high quality products intentionally designed for their specific usesTrusted partner with over 50 years experience	<ul style="list-style-type: none">Standardized, repeatable design that is built to last and scales to simplify field, pipeline and terminal expansionOptimized start-up and ongoing production with ABB Ability™ digital solutionsMinimized downtime through digitally-enabled predictive maintenance, intelligent 24/7 servicesEnterprise-wide visibility and access to expert support	<ul style="list-style-type: none">Digitally-powered, integrated solutions, including third party options, allowing wells, pipeline and terminal projects to be brought online faster<ul style="list-style-type: none">E.g, Easily configurable to add wells daily from a centralized control room or other remote locationModular solutions for quick production and increased throughputScalable, multi-tiered options to match application needs	<ul style="list-style-type: none">Telecommunications solutions that keep people, assets and data securely monitoredGreater ability to identify, prioritize and resolve risks before they happenDigital technologies eliminate safety risks e.g. by prioritizing alarms, reducing the need to physically drive to sites or manually staff/check wells, pipelines or terminals

Optimizing the onshore hydrocarbon chain in practice

Oil and Natural Gas Corporation Ltd, (ONGC) India

Challenges solved

To support the company's geographically dispersed production and drilling facilities, ONGC wanted to have a centralized system to monitor, control and manage key information, linking oil basins, processing plants and other assets. The company also sought to replace aging instrumentation and establish connectivity with legacy systems.

How

In collaboration with ABB, ONGC deployed a three-tier SCADA architecture for drilling and production spread across 19 assets, including 600 servers, 1300 HMI stations, 250 RTUs and a telecommunication infrastructure. As a result, ONGC has increased drilling efficiency and optimized production by enabling decision-makers to use real-time, accurate data, for more efficient planning, production and analysis. Managers also receive detailed and summarized aggregate information which can be delivered anytime, anywhere to facilitate more informed and quicker responses than previously possible.

Background

ONGC is the largest crude oil and natural gas Company in India, contributing around 70 percent to Indian domestic production. It ranks twenty-first on Platt's 2018 Top 250 Global Energy Company Rankings.

EOG Resources

Challenges solved

EOG was interested in reducing the driving needed to oversee their production assets which are spread across the very large shale fields of Eagle Ford/Permian/Bakken. The company also wanted to provide its operators with remote access to SCADA and measurement software applications. EOG also sought real-time polling of RTUs and PLCs in the field. Additionally, its legacy

900 MHz-only radio system was slow and susceptible to heavy interference.

How

ABB helped design secure broadband wireless mesh networks for applications spanning the entire life cycle of EOG's North American assets. Real-time SCADA and drilling rig communications and diagnostics were also provided along with well pad video monitoring and a connected emergency shutdown and recovery system.

EOG now enjoys enhanced network resiliency and performance at a lower cost. The company has an increased monitoring capability to digitize its entire production environment. It has achieved significant communications cost reductions by eliminating the need for satellite and cellular services. EOG can also quickly add video cameras and environmental sensors for real-time visual monitoring of critical process points. Software applications for decentralized decision-making are also being used and driving times have been reduced.

Background

EOG Resources, Inc. is one of the largest independent (non-integrated) crude oil and natural gas companies in the United States with proved reserves in the United States, Trinidad, the United Kingdom and China. EOG's total worldwide production in 2017 was 222 MM Boe.

Queensland Curtis LNG (QGC), Australia

Challenges solved

Integration of automation, electrification and telecommunications makes it possible for a skeleton crew to oversee a complex operation consisting of a 540 km pipeline and over 6000 wells spread over 3500 km² in Australia.

How

The ABB Ability™ System 800xA enables the integration of the entire plant meaning that fewer

than four people using a single operator interface are required to manage an operation the size of a country like Ireland since the real-time analytics can be viewed from anywhere.

- A 24-hour control room in Chinchilla lets QGC operators monitor and regulate the operations of wells, processing facilities and the pipeline
- The information is shared with the monitoring center in Brisbane which also oversees the operations in Gladstone where the two train liquefaction plants are located.

The fact that the automation, electrification and telecommunications systems are fully integrated helps QGC:

- Minimize operational costs, including travel, and allows real-time decisions to be made to optimize production parameters and respond quickly to alarms.
- Maintain reliable and stable energy supply through load shedding, load sharing, generator control and synchronization.
- Ensure the physical safety of personnel and sites via a full range of CCTV, intruder detection and hotline services enabled by a highly resilient fiber optic infrastructure.
- Protect assets from deliberate or accidental cybersecurity incidents through a secure system architecture with advanced user control, host-based firewalls, continuous security patches and a secure-by-design philosophy.

Background

This is the world's first project to turn coal seam gas into liquified natural gas (LNG). There are two train liquefaction plants producing up to 8.5 million tons of LNG per year.

It is estimated that 250 trillion cubic feet of gas reserves lie beneath Queensland and New South Wales - enough to power a city of one million people for 5,000 years. Also, coal seam gas produces up to 70 percent fewer greenhouse gas emissions than coal and 20 percent less CO₂ than oil when burned to create the same amount of electricity.

The project, which started construction in 2010, started producing LNG in 2013 and continues development today. ABB has worked over 750,000 hours, or the equivalent of 400 man-years, without any lost-time incidents. Over 2500 wells of the 6000 expected during the project's lifetime are already operational.

Trans-anatolian natural gas pipeline (TANAP)

Challenges solved

To deploy an integrated automation, safety and security solution which can seamlessly manage and protect the gas flow of one of the world's largest pipelines (1850 km) and ensure more product reaches intended destinations safely and cost-effectively.

How

ABB is providing the following: pipeline application system, pipeline monitoring system, integrated security system, pipeline SCADA, block valve RTUs, communications backbone, main and backup control room buildings.



ABB are using a fiber optic based technology (DAS – Distributed Acoustic Sensing) to monitor the entire pipeline for intruders, leaks and pig tracking. ABB are also applying the same technology for the very first time on the subsea section for leak detection and other events such as anchor drag.

Integrated pipeline-wide communication is being facilitated by ABB's sophisticated point of control (PoC) technology available via ABB Ability™ System 800xA control system.

- The TANAP system will be fully automated with main and back-up control centers to meet the requirements of gas transmissions and associated environmental and safety considerations.
- A SCADA for overall control and monitoring of the pipeline from a remote Main Control Center (MCC) has already been provided. ABB also designed and delivered the MCC building.
- PoC allows the transfer of authority to operate parts of the pipeline to be passed between central and local HMIs, while automatically maintaining the integrity of the system. Using PoC, engineers will thus be able to quickly and safely transfer control from the central control room to local operational staff on request. The central control room will retain view-only access until the control is transferred back.
- The robust site communication system uses TETRA and interfaces with all sites via the IP telephony system. PAGA systems integrate to the TETRA and IP telephony system, including 2,900 speakers.

Sophisticated leak detection and pipeline monitoring systems are being deployed. ABB is

installing a single comprehensive integrated security system, which monitors the external and internal CCTV cameras and the perimeter detection system of every site. The pipeline intruder detection system covers every meter of pipeline. The project involves 1300 cameras and 650 access control points. There are two leak detection systems, one using information from the same system delivered as the fiber optic based pipeline intrusion detection systems and one is model based. The SCADA system interfaces to both the fiber optic sensing system and to the model systems. The fiber based system is also used for pig tracking information.

- Laser pulses sent down a cable will report changes using a technique known as coherent optical time domain reflectometry (COTDR), and algorithms on the servers can interpret the data, pinpoint where the leak has occurred and verify it using other data, such as the pressure wave that usually accompanies a break in the line.
- Intruders will be detected in the same way as leaks, with laser pulses. All the pipeline's stations, manned and unmanned, will be surrounded by fences, and all the fence lines and surrounding areas will be fitted with a fiber optic cable that are automatically monitored 24 hours a day.
- If any suspicious activity is detected, the system can attempt to verify it using CCTV. If the system thinks it 'sees' something untoward, it can sound the alarm, present the operator with the evidence and even suggest what standard operating procedures the operator should follow next.
- For extra security, the data collected will be shared via the ABB Ability™ System 800xA

through firewalled connections, but separate from it, with its own dedicated servers.

- Indeed cybersecurity is such an important issue ABB uses a defense-in-depth approach that involves multiple layers of security controls placed throughout the system. Cybersecurity is a critical factor in all phases of the system lifecycle and it is an integral part of the SCADA and telecoms solution. ABB addresses it at each stage of the project – from design and development to operations and maintenance.

Background

The TANAP pipeline is the largest section of the \$45 billion 3500 km Southern Gas Corridor, which will transport gas from the Shah Deniz 2 field in the Caspian Sea through Azerbaijan, Georgia, Turkey, Greece and Albania, to join the European network in Italy.

- TANAP is a company formed for the execution of the project, with SOCAR of Azerbaijan, BOTAS of Turkey and BP as shareholders.
- The \$11 billion TANAP pipeline will interconnect with the South Caucasus Pipeline (SCPx) at Turkey's border with Georgia and the Trans Adriatic Pipeline (TAP) at its border with Greece.
- The project consists of a 56" and 48" diameter onshore pipeline system of 1814 km in length with a 21 km offshore section beneath the Marmara Sea comprised of two parallel 36" diameter pipelines.

The first phase, 'Gas to Eskisehir' officially opened in early summer 2018, ahead of schedule. The TANAP pipeline is scheduled to complete by June 2019.

—
TANAP control room monitoring pipeline for performance and security.



Compañía Logística de Hidrocarburos (CLH)

Challenges solved

CLH sought to optimize the efficiency of its terminal network and minimize the need for manual processes.

How

Using ABB's terminal management system, it is making all 40 of its terminals entirely unmanned. Site access now features truck RFID verification and driver magnetic card scanning meaning that, through digitalization, a process which used to take up to 60 minutes can now be done in under half that time. Trucks go to their designated loading area for automatic filling with the product matching the order they have been assigned to collect.

By automating the generation of bills of lading generation and the communication with the relevant tax authorities to authorize the product movement, digitalization has sped things up by around 10 minutes.

A handful of offsite employees use integrated CCTV to monitor terminal activity remotely. When needed operators can interact with drivers via voice over internet protocol (VoIP) enabled by integration with the ABB Ability™ System 800xA.

By totally automating its terminals, CLH is able to increase its revenues significantly as more trucks can enter its sites per day. Plus, CLH has reduced its labor costs, lessened its potential for error and has tightened its grip on product inflows and outflows.

Background

CLH is a leader in storage, transport and distribution of petroleum products in Spain. It is also one of the largest private companies in its sector at an international level. The company's main business involves receiving oil products – mostly gasolines, diesels, fuel oils, aviation fuels and biofuels - and then transporting and storing these materials. CLH then delivers these products to its customers through its tank truck loading facilities. It owns an oil pipeline network of 4,000 kilometers (km) which enables it to transport output to various storage and distribution centers, before sending the product on to a range of end users such as marine ports and airports.



© CLH

Conclusion

As outlined in this white paper, digitalization is no longer a ‘nice to have’ but instead ‘need to have’ for the onshore sector. It facilitates the kind of integration which drives value. The more connected a company’s operations are, the easier it is to make real-time decisions on operations and improve profitability.

Those onshore operators who embrace the potential digitalization offers them today will be the ones that tomorrow will leapfrog their more traditionally-minded competitors, some of whom may no longer be viable in the new market environment.

Already technologies exist that can save onshore companies of all sizes costs both on project development and operations. Cloud-based solutions can provide complete visibility and control from anywhere. By using communications networks and routing their data through the right

channels, onshore players can increase situational awareness to improve decision-making as well as reduce unnecessary downtime and decrease risk to assets and personnel.

The question is what the best approach is given each company’s starting point and how fast they would like to proceed with their digital journey.

Eventually boundaries between individual rigs, pipelines and terminals will no longer exist. Instead, they will be interconnected across multiple sites or even geographical regions scaling production up or down as best suits the current market conditions. Companies need to ask themselves how ready they are for this fast-evolving future. Hopefully, this white paper has provided significant food for thought and practical insights into factors which should be considered when planning for onshore’s digital future.



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