How advances in digitalization provide new opportunities to increase production

Few topics attract quite as much attention as Production Optimization among upstream oil and gas professionals. This begs the question: Is there anything left to say that has not already been said? We at Siemens certainly think so.
Introduction

In this whitepaper, we challenge some of today’s conventional wisdom. We suggest that many of the prevailing views about production are too functionally driven and too narrow, too often dictated by past experiences – and not necessarily with a clear vision to the future. We also think that too many companies are preoccupied with a very tactical view towards optimizing production. And we believe a more holistic, instead of a tactical approach makes better sense long term.

But our goal here is to discuss how advances in cloud computing, IoT, advanced optimization and solutions as a service business models provide new opportunities to increase production without adding new equipment and with minimal impact on staff.

Today’s Approach

In the quest to improve production (reduce deferred production), too many companies today still cannot see the proverbial forest from the trees. The conventional wisdom promoted by many would have us believe that improved production optimization will emerge for those who concentrate on optimizing the different pieces of the puzzle versus looking at the entire oilfield from sandface to sales.

Digitalization is influencing every industry and business sector today. New digital technologies and data-led tools are enhancing business capabilities and are enabling smarter working, better decision-making, and improved business results.

Upstream oil and gas is a sector that is increasingly harnessing digitalization to boost performance, enhance efficiency and reduce costs. This makes the use of a new generation of digital tools particularly advantageous, especially in mature unconventional production fields.

In today’s data-driven world, new methods to provide a full overview of oilfield performance represent an opportunity to optimize production holistically. Today, every operator is using some form of optimization, from straightforward trial-and-error, to in-house developed tools through to high-end specialized software applications. Dynamic modelling and optimization are valuable tools that can unlock the value of upstream data and increase production.

However, while many upstream companies are now increasingly turning to digital tools to more effectively capture and use data, most are doing so with a piecemeal approach. In this bottom-up strategy, digital tools are not systematically implemented. Data (unprocessed facts and figures without any added interpretation or analysis), information (interpreted data) and knowledge (a combination of information and experience) is scattered across tools and staff functional silos.

Attention to each of these separate areas has generated incremental improvement for many upstream companies to be sure. But for many upstream companies, a truly integrated approach to optimization from the well sandface through surface equipment and plants to sales remains elusive. And yet the stakes of having such an integrated approach have never been greater as capital budgets remain constrained.

Rethinking Production Optimization

Siemens’ experience in addressing production optimization suggests that the time is now to leverage the advancements in computing power, IoT, and optimization engines; and combine this with new business models to fundamentally change how production optimization is implemented in the oilfield.

Optimization remains one of the least capital-intensive methods of improving production and is ideal for today’s upstream business environment. Many upstream companies view their field operations quite narrowly and spread the work across various functional groups. This makes it difficult to fully optimize oilfield setpoints from the sandface all the way through to sales. Ultimately, upstream companies need look at their field operations as a dynamic holistic network and not the static network that was defined and then forgotten when the oilfield was developed.

Today, all upstream operators use some level of optimization strategy to help meet their core strategic goals. The most common Key Performance Indicator (KPI) is to maximize production of oil, gas, or condensate. However, one could also focus on other important KPI’s such as the minimization of gas flaring. Individually defined KPI’s (such as Energy, Emissions, Maintenance, Safety) for core oilfield network components are often established at the equipment or plant level but are typically isolated and siloed.

This results in several optimization models being needed for the entire oilfield. Results of one model do not necessarily consider the constraints or outputs of other models. As a result, any optimization-generated oilfield setpoints are localized and sub-optimal.

With modelling and optimization capabilities typically scattered across several separate tools and software packages, significant challenges can emerge. Large-scale operators may find numerous separate tools and packages used for optimization across the enterprise, each with their own separate modelling, visualization and data interfaces. As a result, optimization results are hard to access and visualize across an organization. Data sources are potentially not based on current oilfield information and any optimization setpoint results are less useful when it comes to direct in-field adjustments.
In addition, too many field setpoint changes could be proposed, or it may be that there is no prioritization due to different functional staffs not aligning on the overall goal. Consequently, many of these approaches are not suitable for the regular day-to-day optimization processes needed for the dynamics of mature oilfields. Furthermore, much of this valuable data resource is not accessible to inform and support an impact on operations.

Another area where challenges with current optimization practices exists is when there is a field upset, such as an ESP or compressor failing. Today’s widely used optimization technology is not able to run a new optimization fast enough to help the operating staff maintain the maximum production rates while the upset condition is resolved. By applying state-of-the-art equation-based optimization solutions, operations staff can be provided new, updated oilfield setpoints that maximize production during the upset.

To benefit from the power of big data, it is necessary to digitally capture current operating conditions from the oilfield and other sources. This requires the integration of data from multiple sources in both real time and near real time. Given the innate complexity of such IT/OT architectures and functional silos, so far this has proven challenging.

**Real-Time Production Optimization**

The Siemens Real-Time Production Optimization solution addresses the above challenges and opportunities by leveraging advances in computing, Internet of Things (IoT) and state-of-the-art optimization technology. The gPROMS Oilfield optimization engine is equation-based and leverages advances in computational power to solve full oilfield optimizations in minutes instead of hours or days. By leveraging IoT to capture the current oilfield conditions and feeding these into the gPROMS Oilfield model, a full-field optimization can be run literally at the “push of a button.”

Combining this with a service business model, Siemens RTPO is offering Optimization as a Service. Now upstream companies can increase production without investing in new equipment. By offering Optimization as a Service there is minimal impact on the upstream company’s staff. Siemens maintains the models and the solutions as part of the service.

**Benefits**

Key benefit areas are:

- Increased production without investment in equipment and with minimal impact on staff
- Minimized production losses during field upsets
- Ability to do “what if” scenarios
- Re-optimization at the push of a button
- Incorporation of all aspects of the oilfield from sandface to sales in a single model
- Optimization model reflects today’s operation of the oilfield, not a theoretical model or an AI-trained black-box model
- Simple operator interface allows field staff to make the best decision based on latest information

**Architecture**

The Real-Time Production Optimization architecture is straightforward and comprises three components. First is the gPROMS Oilfield optimization engine, second is real-time IoT field data integration and third is the user interface.

**gPROMS Oilfield Optimization Engine**

At the heart of RTPO Real-Time Production Optimization is the gPROMS Oilfield optimization engine from Siemens Process Systems Enterprise (PSE). This is a state-of-the-art equation-based optimizer that will converge on optimum set points within minutes versus hours compared to other widely used optimization approaches.

Some of the key feature of gPROMS Oilfield are:

- Full equation-oriented approach. The model is treated as a set of equations to be solved simultaneously. This means that solution determination is much faster, making it possible to deploy large, complex models in demanding situations such as online real-time oilfield production optimization. In addition, the equation-based approach handles the inherent non-linearity of oil and gas production systems.
- Simultaneous optimization of discrete and continuous control decisions (Mixed Integer NLP). Now upstream companies can optimize well and pipeline systems simultaneously. By including both continuous (such as gas lift rates) and discrete (such as routing and status) decision variables in a single model, greater improvement in production are achieved.

**Typical improvements in oilfield production range from**

2-8%
• Customization of objective function and constraint equations. With Real-Time Production Optimization, the term optimization means formal mathematical optimization, where the gPROMS Oilfield optimizer searches the decision space for the combination of decision variables that give the best-possible results. This allows optimization of oil and/or oil equivalent production rate, energy consumption, costs, etc.

• Limited Changes Function. In order to provide a workable, immediately implementable solution to the oilfield operations team, Real-Time Production Optimization provides a "limited changes" mode. In this mode of operation, a limit on the number of setpoint changes across the field is specified (such as 10) from the results of the optimization. Real-Time Production Optimization then determines the best optimization based on only the specified number of changes allowed.

Real-Time Data Integration

For the optimization to be relevant, current field conditions must be input to the optimization engine. Also, in the event of a field upset such as a compressor failing, real-time data must be input into the model so that new field setpoints can be determined to maximize production until the field upset condition is fixed. Siemens works with the customer’s IT staff to develop a real-time data integration approach to bring data together from SCADA, well test software, economic models and other relevant sources. Siemens then combines this data either in the cloud or on premise for input into the optimization engine.

User Interface

Siemens works with the customer to provide the appropriate operations decision support displays for integration into the customer’s operations center. Our approach is to keep the displays simple, concise and to incorporate the look and feel of the existing operations center displays.

RTPO will run on premise or in the cloud. The RTPO architecture is shown in Figure 1 below.
RTPO Real-Time Production Optimization Use Cases

- **Strategic Optimization** – run the RTPO optimizer on a regular basis to determine the best set of oilfield setpoints based on a set of specific constraints such as cost, flaring, lift gas usage, energy consumption, etc.
- **“What if” decision support** – use the RTPO optimizer for “what if” analysis scenarios such as shutting in a group of wells, taking equipment down for maintenance, or changing constraints to see the impact on production.
- **Real-Time Field Upset** – re-optimize the field based on an unplanned upset condition to minimize production losses until the upset condition is fixed.
- **Limited changes optimization** – minimizes operator staff workload by allowing the operator to limit the amount of new field setpoint changes generated by the optimization run. For example, the operations team may set a limit of 10 field setpoint changes. Using a second optimization pass, the limited changes function determines optimum set of 10 field setpoint changes to maximize production.
- **Routing Optimization** – for each well, an optimum flow path can be determined within the framework of piping specifications, constraints of separators etc. This unique feature is possible because the optimizer can model and optimize discrete variables.
- **Condition-based production planning** – integration of predictive maintenance input from advanced analytics-based anomaly detection of artificial lift equipment updates the field optimization continuously according to the health of equipment.

**Think Big, Start Small with Proof of Value**

Getting started with RTPO Real-Time Production Optimization is easy. We work with your team to make sure you are fully briefed on the underlying technology and how we have architected the solution. The next step is a Proof of Value.

Siemens’ successful approach to partnering with companies is grounded in collaboration. We do not presume to come to you with “The Answer.” Every company we have worked with is different – organization, culture, experience, and strategies and objectives. They also have different levels of commitment to change. Our goal in the POV is to work collaboratively with our customers to create the best outcome for the POV project to prove the value of RTPO to your organization.

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**Figure 2. Proof of Value Timeline**
As shown in Figure 2, the POV is typically a four-month joint project to validate the RTPO solution in your field operations. We start the process by assembling a joint team and end with a final results presentation of a 60-day field trial. Key steps along the way are:

- Document success criteria for the POV
- Execute three parallel POV workstreams
  - Data integration – identify operating data for model building and real-time operation
  - Model development – build the field optimization model
  - User interface – fine tune the user interfaces for engineers and operators
- Workshop – validate model, checkpoint visualization screens; validate data integration approach; run optimization model and propose new field operating setpoints
- Deploy visualizations to Operations Center and integrate live data for 60-day field trial
- Validate production increases and revenue impacts for final presentation

The POV Project will require the involvement of selected customer staff during the project. At least one staff (POV Champion) will be dedicated to work with us throughout POV project. This is not a full-time role, but more one of guidance and coordinating resources. In addition, other members of team will be required for short periods of time—typically one-hour to two-hour sessions—that could involve an interview, proposing ideas, validating a work process, or reviewing a presentation. Customer Executive involvement, especially in the form of interim report presentations to build awareness of the POV project and benefits will be required.

At the end of the POV, the joint team will prepare a final presentation for all interested customer staff that outlines the POV project and results.
Conclusion

Both internal and external pressures are prompting many upstream companies to rethink their approach to oilfield production optimization. We see this not as a problem, but as a significant opportunity. By transforming how our customers approach production optimization to a more holistic endeavor that includes functional production teams, IT and management, our customers can now increase production without investments in new equipment and with minimal impact on staff.

Siemens has leveraged the trends of low-cost computing, IoT and state-of-the-art optimization software to develop RTPO Real-Time Production Optimization. RTPO enables complete oilfield modelling from the sandface to sales within a single, unified optimization model. Now upstream companies can maximize oil production while minimizing gas lift, flare, energy consumption or other constraints. Typical improvements in production are in the 2-8% range. In addition, RTPO runs fast. This allows quick re-calculation of oilfield setpoints to maximize production in the event of field equipment failure.

Our Challenge

If you say that you are content with your current level of production performance, you do not need us. If you believe there is opportunity for improvement, you should be talking to us.

Real Results

Today, a small oilfield may contain 100+ wells and two to three separators with a significant number of valves, pumps, pipes and equipment involved. Systems with 100+ wells typically will have over one million flow path combinations that are potentially available to select in order to optimize production.

As an example of an RTPO implementation, we will model a field with 120 wells, 3 separators and the associated gathering system with a goal of maximizing production within the constraints of separator capacity and well draw down rates. The control points in the field are well choke settings, gas lift rates and gathering system valve positions.

As discussed, RTPO will optimize both continuous (e.g. gas lift rate, separator flow) and discrete (flow line routing, well on/off) control variables to develop the best optimization settings for the control setpoints. Millions of routing options can be evaluated in a very short period to deliver the best flow path for the oil considering the whole flow line network, including manifolds, separators and facilities.

The following table shows the results of different optimizations using the gPROMS Oilfield optimizer within RTPO.

<table>
<thead>
<tr>
<th>Separator gas rate constraint [MMScf/day] / separator</th>
<th>Oil rate [bbl/day]</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimization (No routing)</td>
<td>Current Technology</td>
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</tr>
<tr>
<td>Optimization (No routing)</td>
<td>gPROMS</td>
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</tr>
<tr>
<td>Full Optimizations</td>
<td>gPROMS</td>
<td>1,030</td>
</tr>
<tr>
<td>Limited changes Optimization</td>
<td>gPROMS</td>
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