A Yokogawa Company

Why digitalization is only scratching the surface, and how deeper integration of engineering silos can increase production

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SEPTEMBER 2019

Overarching objective

Everyone developing new gas processing and LNG capacity wants to:

- Engineer, procure and construct the facilities as cheaply as possible, within schedule, whilst still meeting the performance specifications of the Process Licensor;
- De-risk commissioning / start-up activities; and
- Speed up time from commissioning / start-up to profitable operations to start paying down as much debt as possible

Whilst the gas market is currently over-supplied and only expected to balance sometime in the early-mid 2020s, having a production-centred plant is the biggest enabler for achieving optimal positioning on the cost curve. A production-centred plant is one that places priority on Efficiency, Availability and Reliability; Safety & Security; and Human Reliability:

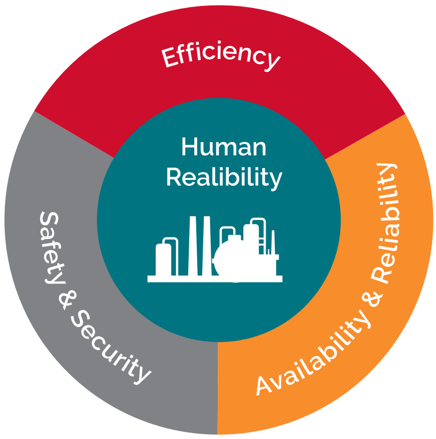
Production Priorities

Efficiency

- Improve total energy efficiency and reduce CO_2 emissions
- Ensure profitable operation by optimizing asset lifecycle and supply chain
- Realize flexible and lean production

Safety & Security

- Achieve zero incident operations
- Improve overall HSSE management
- Comply with legislation, regulations and standards



Human Realibility

- Capture and transfer knowledge
- Build autonomous and intelligent expert system
- Create better workforce-development training

Availability & Reliability

- Eliminate unplanned outages
- Maximize plant uptime while minimizing lifecycle costs
- Realize predictive operation andmaintenance

Engineering Priorities

- Improve project economics
- Mitigate project risks
- Optimize delivery schedule
- Realize flawless engineering
- Flexibly manage changes
- Comply with industry standards

Figure 1: Production-centered plant priorities

The degrees of freedom available for optimized production are, to some extent, influenced by how plants are engineered. Once the plant is built there are limited opportunities available for optimization to meet market demand before further capital investment is required to upgrade, debottleneck, etc.

How can value engineering of the plant facilitate and drive asset and supply chain optimization once the plant has become operational?

Bang for your buck

First of all, we need to look at where the dollars are being spent on these projects. The chart below shows how many of these projects have an upstream component to deliver the gas to the plant that is of a similar magnitude to the liquefaction plant itself. These upstream costs are driven by the scope of the facilities required to treat and transport the gas from the reservoir to the liquefaction plant, e.g. the Ichthys project had a major offshore FPSO and 890 km pipeline to shore. The cost of the offshore pipeline has been stated at around $2bn.

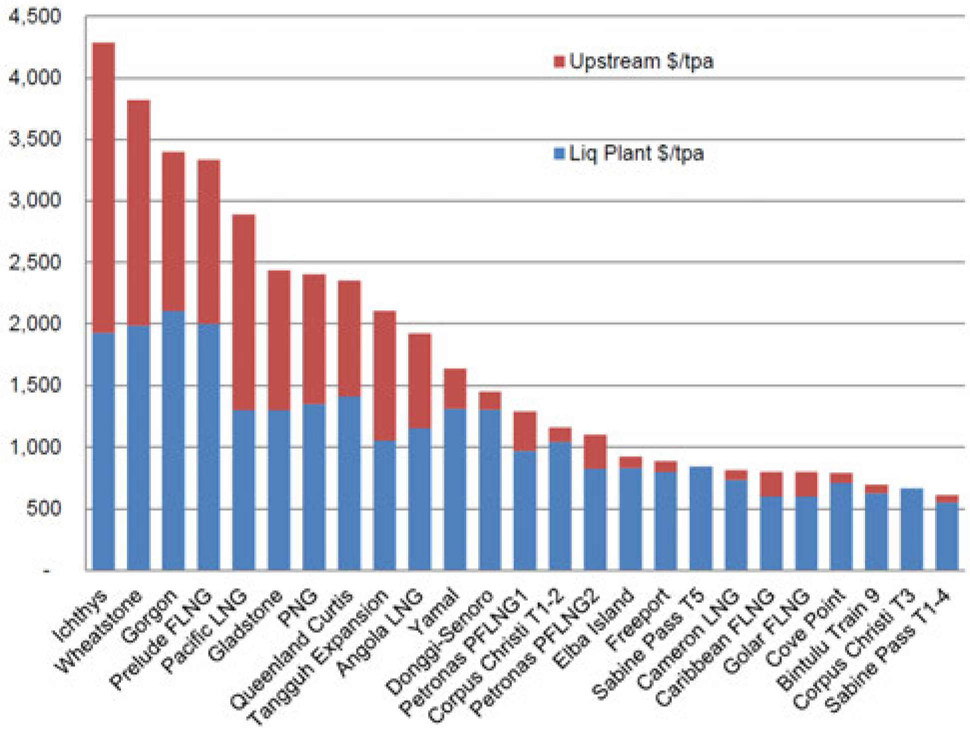


Figure 2: Overall Project Capital Costs $/tpa Constructed 2014-2018
(Source: The Oxford Institute for Energy Studies)

The upstream and downstream components are inextricably linked. Fortunately for many plants, particularly in the US, the upstream component is a lot smaller and only requires relatively short interconnecting lines to transport pipeline quality gas from the natural gas pipeline system.

Regardless of the scale and complexity of upstream and downstream components, the industry has very complex and iterative work processes for delivering these projects, with many teams operating in their individual silos:

1. Reservoir team. They live in a stochastic world of probabilities and are primarily concerned with (a) number and locations of wells and (b) producing the design point (desired flow rate at specific pressure for each well).
2. Drilling teams. Their focus is on how to drill the well; the optimal method of drilling and well design.
3. Facilities people. Their focus is on how best to achieve the design point given to them by the reservoir engineers through the facilities.
4. Well teams. Live in a world of maximizing well production and minimizing well damage.
5. Commercial people. Focused on maximum revenue generation as a function of system availability to drive flow rate / day multiplied by offtake pricing. Pricing can vary depending on export optionality to other 3rd party hosting production systems. Production penalties which oblige the operator to produce at certain flow rates can be a major determinant on the sparing philosophy for the facilities and hence available design space / weight of structures.

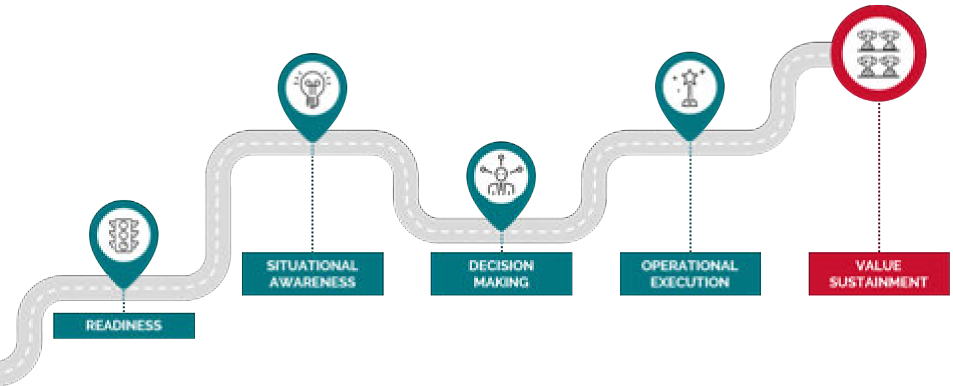
One of the biggest challenges, from a facilities perspective, is the way a deterministic design point has to be produced by reservoir engineers from a world of stochastic probabilities. This is problematic because multiple factors need consideration (and behave in a non-linear manner) for optimization:

- Reservoir changes over time – reservoir production potential / profile – flow
- Reservoir fluid composition (characterization / pseudo-components) changes over time – gas, oil, water
- Changing power demands (with increasing produced water) yet limited power generation flexibility
- Right flow regimes and pipe diameters to control slugging
- Type, size and cost of associated production and export facilities

How can the net absolute design point be derived along the deliverable flow rate continuum to determine the optimum integrated operating case / facility which considers the above factors?

Think digital

The answer is Digitalization. Digitalization is in itself a process, an enabler, the means to an end - not the end itself. It enables achievement of engineering and production priorities faster, more efficiently and effectively. The secret is to do it cross-discipline from the start and eliminate bias.



Upstream reservoir engineers simulate downhole conditions using models which have a heavy dependency on data-driven, correlation-based analytics rather than rigorous first principles-based models. Correlation-based analytics tools are typically convenient, simple to set up, and quick to generate an answer. The consequence of this approach, however, is the intensive and continuous exercise of using spreadsheets in an attempt to update the correlations against reservoir history, before they lose their predictive validity.

Conversely, process and production engineers who are focused on the facilities understand the value of first principles simulation models to design and operate the asset. They know that chemical and physical interactions and dependencies must be respected in order to draw safe and meaningful conclusions.

Therefore, while reservoir engineers are very comfortable playing within ranges of probabilities (P50, P75 etc.), process and production engineers have an inherent and valid dislike of correlation-based analytics, due the lack of precision. As a result, major siloes exist between subsurface and facilities organizations. These two worlds don't speak the same "language", yet the business's success relies on their ability to interact and cooperate with each other.

In order to unlock trapped value, more precision is needed in subsurface reservoir engineering, involving unification of first principles and correlation-based analytics. Whilst this is the case, topside process/production engineers must relax their quest for ultra-precision within the small operating window of what's happening today and look to the next 1-24 months.

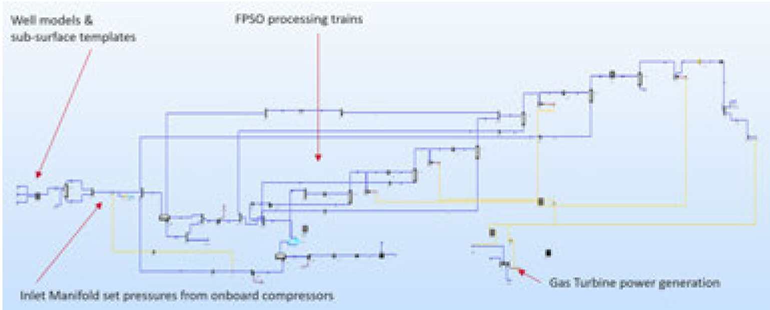
When looking forward over this time frame, the operating window may be much wider than today's operation requiring the rigor of simulation, but many possible futures may need to be explored requiring the convenience of correlation-based analytics. These two disjointed worlds need to come together using the 'ensemble' approach of an integrated asset model (IAM) that is neither reservoir-centric or facilities-centric.

The IAM must mix physics models with data driven models in digital environments with secure data access and reconciliation and corporate asset models.

The compelling event for this unification of subsurface and facility operations worlds is Digitalization. It is upstream's 'electric car' moment. An IAM enables more effective economic evaluation and portfolio management decisions to be made, taking a much more holistic approach to deliver the required return on capital. This approach will create the major cultural change that will see a step change in profitability once projects advance into the operations phase.

Case Study

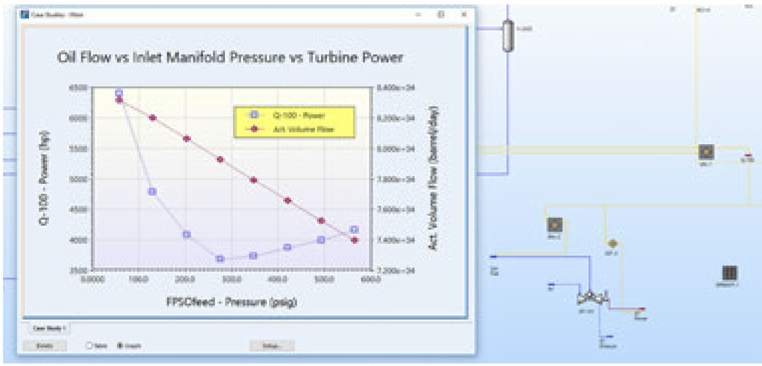
- 20+ wells feeding a "self-powered" FPSO
- FPSO has processing capacity of 90,000 b/d of oil, 10-20 MMscfd of fuel gas handling and treated water injection rates of up to 30,000 b/d.



This particular case demonstrates how matching well deliverability to topside power generation and compressor availability was able to boost FPSO production by 9,000 b/d and deliver incremental asset value increase of $180 million per annum...all in a single modeling environment.

Results

The results of the study showed that there was no CAPEX investment needed, used only onboard equipment, matched sub-surface to surface pressure, flows, first time power-production balance implemented. When tested on the physical asset, the new production regime confirmed and production rates and value attained.



Key aspects of this approach are:

- Workflow integration across disciplines to massively improve engineer productivity and efficiency during design.
- The integrated model can rigorously represent the whole asset, not individual components, e.g. from wellhead through topsides facilities into liquefaction plant of any scale and complexity. Changes made in the design of one aspect or part of the project can be made knowing the impact to the performance of the entire asset.
- Digital combination of data and physics.
- With all these components in one single environment and modelling of engineering work flows, data transfer among its various components is seamless and invisible to the user - there is no need to use multiple products to solve pieces of the problem thereby reducing errors and the time involved in jumping between different products and cutting and pasting data from one to the other.

- One integrated model with consistent thermodynamics / flash calculations (including. rating and costing) of equipment throughout, thereby ensuring right-sizing for all future anticipated operating scenarios. This also includes native integration of specialized models (such as reactors, heat exchangers, pipelines and risers, multiphase and electrolyte thermodynamics, aqueous corrosion models, and cost estimation tools), thereby allowing for detailed design of the individual components without breaking their dependence on all the other assets to assure most efficient and best possible design.
- With all this, there is de-risking of commissioning / start-up activities and reduced time to complete design and transition to profitable operation.

Once the models have been built to support engineering activities, they can be operationalized for operational performance management and optimization … with automatic model output synchronization with the OSIsoft PI historian to allow the integrated asset model to become a true digital twin driving operations.

Traditional Simulator	VS	Digital Twin
An accurate representation of a particular operating case	➡	An accurate representation of the asset over its full range of operation, all the time
Static provision of a snapshot in time	➡	Captures the full history and future of the asset
Built on an ad-hoc basis to answer a question	➡	Automated, regular model runs. Built-in to business workflows
Owned and used by isolated groups on an ad-hoc basis	➡	Centralised single version of the truth, used by everyone, outputs delivered directly to the business, strong governance systems

Always aligned with and drives business data model

The integrated asset model is designed to automatically validate mass balances and reconcile process data with all model outputs available for consumption through the OSIsoft PI System and various other analytics and visualization tools. All model outputs are written to a fully historized relational database and using the natively integrated data querying engine, users can mine the data and explore different database cases. This constitutes a rich source of process data on which to base other analytics initiatives.

As well as being able to consume real-time data from the OSIsoft PI System and other historians, the integrated asset model can write all outputs back into the PI System in real time to amplify the quality of data in the PI System.

This allows the integrated asset model to both serve as a molecular-enabled digital twin for monitoring and surveillance and then underpin supply chain optimization and other advanced applications and services by having an always-validated model available.

Through this mechanism, the integrated asset model can provide a single source of the truth across the full stream for how molecules and operating conditions behave at the unit- and asset-wide level; thereby providing actionable insights into production activities that can drive convergence in decision-making and action across organizational silos.

Conclusions

The integrated asset model used by the different disciplines means any changes in one part of the complete system are instantly reflected in the designs for the other disciplines. There is significant value of this completely integrated sandface to facility modelling using a single engineering tool, and this revolutionizes engineering workflows in design and operation. This deeper level of digitalization allows everyone developing new gas processing and LNG capacity less risky, cheaper and faster to profitable operations.