CAPITAL INVESTMENT DECISION MAKING FOR LNG PROJECTS - OPTIMIZING DESIGNS AND SCOPE THROUGH INTEGRATED USE OF TECHNOLOGY

For the business decision maker, it is essential to be presented with the key options and trade-offs as to which contracts to negotiate, technologies to select and which capital investments to approve for development. The separate environments that the different analysts work in an organization interfere with reaching the best decisions quickly. An altenative approach based on the inter-operability of software used during screening and FEED studies can enable a better decision making framework. This article describes how this can be achieved.

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Exploitation of new gas reserves or increasing the throughput of existing LNG operations involves a number of competing technical, market and economic factors. Processes are screened with simulation models and spreadsheet tools. Contractual, pricing and supply chain information is analyzed with financial spread-sheeting. Capital costs are estimated with estimation systems. And resource and timing constraints are evaluated via planning and project management tools. The business leader is then left with the results of these different analyses that he needs to weigh based on "dueling PowerPoint" presentations.

A better approach can be based on the interoperability of software used during screening and FEED studies which now can enable a better decision making framework. In particular, an innovative capability that we have introduced to the market embeds accurate economic models in the process modeling environment. This allows the process modeler who is screening options to derive accurate and comparable operating and capital costs during his modeling studies. These very early economics are particularly useful in the comparison of alternatives. He can efficiently include economics (capital and operating costs) in the technical, energy and yield tradeoffs that he is considering.

Challenges

LNG producers face numerous challenges to characterize the capital and operating costs and risk early enough to be used making investment decisions. Greenfield production facilities are increasingly in the mega-project category; comprising gas processing facilities, liquefaction and loading. In addition to new projects; in any of these three asset areas there could be opportunities to leverage existing facilities that will involve debottlenecking projects. Screening of these projects involves complex interaction between technical and facility cost parameters weighted against commercial negotiation factors and logistical constraints, all in the context of the business goals for a project. The concepts discussed here will focus on the LNG liquefaction end but are applicable to all major capital projects in the value chain.

If a stable process can be designed, will it be cost-effective, make best use of capital and achieve the business and revenue objectives of the project? To answer these questions confidently and rapidly, it is now possible to use powerful technical models, link them to economic ones, rapidly screen alternatives, and further link them to Excel "front ends" which can give broader access to operation of models beyond the realm of the model experts.

Early Concept Workflow

Since early process screening usually involves small teams, automation of this workflow has not received the attention that the detailed design workflow (usually involving large teams) has. However, integration of this workflow, to remove the need for data re-entry and copying, is valuable in enabling the process screener to look at more alternatives in hopes of arriving at the optimal choice.

The typical workflow resembles the simplified one shown in Figure One. In particular, the last three steps are improved through the integration of simulation models and economic evaluation systems.

Process and Energy Optimization

The chemical process simulation model is a key tool in the design of LNG facilities, both on the liquefaction and re-gasification side. While frequently process engineers only model portions of a proposed process for schedule or effort expediency, there are many advantages to building the complete model. Rigorous models can be built much more quickly and efficiently than organizations often realize [2]. Some recent advances in simulation modeling include integration of energy analysis (that enable system-wide balancing and optimization of energy

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sources and uses), integration of dynamics with steady state models to simplify the development and analysis of process dynamics, and the addition of reporting tools to account for carbon emissions. All of these developments mean that the process engineer can rapidly evaluate several alternatives and optimize for yield, energy cost and use, and carbon emissions. By incorporating dynamics, the model becomes an invaluable tool for understanding and improving startup conditions and avoiding instabilities. As an example, Osaka Gas was able to apply dynamic modeling to understand and solve LNG fractionation tower instabilities, resulting in pre-construction design revamps that increased process efficiency and reduced production costs by $3 million per year. [3]

By integrating heat exchanger rating models with the general process simulators, the heat exchanger aspect of an LNG facility, usually the dominant one in terms of the energy balance of the process, can be analyzed with much greater accuracy during screening studies. ConocoPhillips [4] reports that they Have been able to achieve optimized design and improved operations through their accurate modeling of brazed aluminum heat exchangers within the simulation model and heat exchanger model environment, using each tool to its best advantage.

Institutionalization of the Model at the Business Level

Once conceptual design is complete, the process model itself should be a valuable asset that has lasting benefit, both for the startup and operation of the facility but perhaps more subtly, for follow on capital investment decisions around process improvement, commercial negotiations, debottlenecking and expansion.

Use of an Excel "modeling executive" is a proven way to make technical models of LNG assets available for and range of purposes. This involves running the model in the background, while using the familiar Excel interface as the way that the casual user can entering the scenario conditions and otherwise interact with the model. In this way, business analysts and process engineers can run scenarios involving debottlenecking, energy use, pricing and other scenarios.

British Petroleum is an example of one organization that has implemented such an Excel interface layer to broaden the availability of models of existing assets for decision-making, both at a technical level in operating assets and at a business level for operating strategies, enabling revenue optimization. [5]

Let's take a typical debottlenecking project. An existing LNG plant usually has been modeled fairly completely by at least steady state models during the design and sometimes dynamic models are added during startup stage. When debottlenecking activities are studied, often a different team is involved who may have a learning curve in re-using these existing models or else be unfamiliar with the details of the model. This is where a spreadsheet interface can be invaluable, to enable a screening team to access a model and use it for alternatives evaluation, without concerning themselves with the details of model creation.

Incorporation of Relative Economics in the Decision making Process

Estimators have long used unique rigorous "engineer-in-a-box" class of estimating software tools for conceptual estimating of hydrocarbon facilities, both greenfield plant sites as well as brownfield upgrades and debottlenecking projects. These tools can be calibrated by to achieve better than 20% accuracy time after time. For instance ConocoPhillips reports moving to this approach between 2004 and 2006 and during that timeframe reducing the % variance of their estimates from actual from a starting point of greater than 35% variance to less than 15% variance [6]. But these tools are too specialized and complicated, in their native form, for the process engineer to use.

The innovation required to embed this powerful tool within the process simulation environment is fourfold. First, some of the power of the estimating tools (which enable the estimators to calibrate the tools) must be hidden so that the process engineers are not required to see that complexity. Second, engineering rules need to be incorporated in the interfacing activity, to map the simulation blocks to equipment types that can be estimated and to size equipment and bulks based on the model's heat and material balance. Third, operating cost items – such as feed costs, utility costs, and product pricing – need to be captured from the model. And finally, fourth, the tool is automated to run "behind the curtains" so that by simply pushing a button, the process engineer accesses the estimation cost engine. All of this workflow and engineering rules innovation has been accomplished over the past three years by our organization.

This tool has been effectively adopted and used by several enterprises to achieve economically superior process designs and improved capital predictability. Kuwait Oil Company [7] has used this integrated economics approach to rapidly evaluate two dramatically different options for a gas dehydration unit. Using this approach, the counter-intuitive alternative, complete unit replacement, proved to be an economically superior option, saving 50% of the total costs, for a savings on that project of almost $20 million. The key to achieving this was the ability to generate both capital and operating costs so that lifecycle business impacts of design alternatives could be measured fully.

Technip [8] has used the integrated economics capability to improve their ability to make bidding decisions and to study tradeoffs in selecting designs. Technip reports an ability to increase design flexibility, achieve maximum energy efficiency and optimize designs from a cost point of view. They employed this integrated approach on designs for Technip proprietary technology for gas processing. They are able to achieve economically superior designs and detailed proposals in one tenth of the former time. Technip now incorporates training in use of integrated economics during early conceptual design as a core competency for their North American process engineers.

Business Modeling

Once the economics have been derived, the resulting capital and operating forecasts can be easily brought into a master spreadsheet, where the business factors such as product transportation costs, contract values, royalty schedules, reserves over time, and the like can be taken into account. Several major LNG producers are currently considering this approach to improve capital decision-making.

Design Standardization

One of the characteristics of LNG processing plants is the repeatable nature of the designs. Large scale LNG liquefaction plants usually involve multiple identical process trains, and LNG facilities bear many similarities from a process point of view. This can be taken advantage of to create libraries of re-usable design elements, both from the process point of view and from the economic modeling point of view.

This general approach has been described quite clearly by one organization, DSM [2], who has gained significant competitive advantage in reducing time to market for new processes. DSM broke down commonly re-used processes into libraries of "design fragments" that were built up into simulation models and the associated economic models.

Samsung Heavy Industries [9] has proposed such a library approach for the rapid FEED design of LNG FPSO topsides. Their goal, during pre-FEED, is to rapidly estimate the total cost, weight and layout of a LNG FPSO facility. In their analysis of the repeatable design problem, Samsung concluded that the process units could be divided into those that are common across all LNG projects and those that vary with the type of source gas being processed. In the case of Samsung, a benefit of this approach is to enable them to begin to penetrate the FEED phase of these projects, from their traditional strengths in the areas of fabrication and detailed design.

Next Steps: The innovations described in this article provide tremendous opportunity to rethink the way that early process design is conducted. The next areas of innovation will most likely involve applying the new usability paradigms, common to mobile devices and the web, to the technical engineering modeling domain. Social media tools will present additional opportunities for sharing of best practice modeling ideas within organizations and, with the appropriate intellectual property protections, across them.

Summary: With the fast pace and dynamic nature of the LNG market place, the pressure to make capital decisions better and faster is increasing. The technical groups supporting these decision-making processes are hard pressed to keep up. One of the reasons is the highly-manual process by which information is distributed between groups and the fragmented way in which the different engineering and economics aspects of the problem are often tackled. Figure 3 indicates the typical, traditional approach that is taken, highlighting the ad hoc nature of the communications and data handoffs between the groups. What we have described in this article are a number of innovations which change the game in terms of the ability to make these decisions better and faster. By incorporating equipment sizing, energy analysis, and rigorous economic modeling, within the world of the process modeler, the technical organizations can respond more quickly and with better choices and financially superior designs. Figure 4 provides a simplified summary view of the approach that we have been discussing. Measureable benefits as described by Kuwait Oil, Osaka Gas and others in the examples above are just the tip of the iceberg. The potential payoff of adoption of these new approaches is high.

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