

Managing Gas Assets through Simulation and Scenario Planning

*Presented at the
International System Dynamics Conference
Wellington, New Zealand*

Mani Vannan

Chevron Corporation
1300 Beach Blvd
Le Habra, CA 90631
USA

(562) 694-7817
mtva@chevron.com

Will Glass-Husain

Forio Business Simulations
San Francisco, CA 94111
USA

(415) 440-7500
wglass@forio.com

Abstract

This paper discusses the introduction of system dynamics modeling and scenario planning into the planning process at Chevron. These techniques can help planners by providing an integrated, quantitative perspective, filling a gap between the detailed micro-analysis of spreadsheets and the holistic, but static forms of decision analysis. Specifically, system dynamics simulations can help planners to manage uncertainty and view the consequences of investment decisions in alternative futures.

In this paper we discuss lessons learned from the creation of a pilot simulation focused on gas asset management in Chevron's Nigeria operations. We briefly look at the process by which we built the system dynamics model. We discuss possible ways these types of simulations might be used in the future at Chevron and in the oil & gas industry. Finally we close by presenting several key lessons learned from the pilot at Chevron that could contribute to the success of disseminating these methods across an organization.

Introduction

During the spring of 1998, the Gas Asset Management group at Chevron Nigeria Limited developed a prototype scenario planning simulation to assist in long term planning of Nigerian operations. This simulation was designed to complement other Chevron planning processes by providing a means to evaluate the impact of alternative business opportunities and new technologies on the return on Chevron's investments in Nigeria.

Chevron's revenue from gas production in Nigeria has historically been significantly smaller than the revenue from oil production. Chevron's current oil production yields a significant amount of associated gas. In order to generate revenue from this gas, it must be marketed for local consumption or converted into a sellable product such as Liquefied Natural Gas (LNG) or synthetic diesel fuel for export markets. Local demand for gas is very small even at extremely low prices. A significant amount of capital infrastructure is required to process the gas and transport the product for any export market. Gas that is

not processed must be disposed of by either reinjection into the reservoirs (which is difficult to do in Nigeria for geological reasons) or burning it in a flare (resulting in significant political and financial penalties).

In the past few years, Chevron has begun to implement a number of different options to utilize and gain revenue from this gas. Two large initiatives that are in the early stages of implementation are the Gas Processing Plant (EGP) and the Gas To Liquids (GTL) plant in Escravos, Nigeria. The EGP processes the produced wet gas to yield the required dry residue feed gas for the GTL plant which converts the gas to various synthetic liquid petroleum products. The synthetic petroleum products vary from premium diesel to high quality lubes targeted for the European market.

Making good investment decisions in this area is critical for the success of Chevron in Nigeria. Many of the opportunities have no historical precedent. These decisions are complex because the behavior of the future markets is partially determined by Chevron and the investment opportunities are not independent of each other.

Decision Analysis and System Dynamics

In order to make the most effective set of investment decisions in the Nigerian gas business, Chevron planners must confront the following questions:

- What are the possible market opportunities and how will they change over time?
- What actions will competitors take that may influence potential Chevron supply or demand?
- What are the possible impacts of changes in government regulations, particularly with regard to taxation and penalties for gas flares?
- Given the above, which investment decisions have the highest Net Present Value (NPV)?

Chevron primarily uses decision analysis (DA) techniques for evaluating opportunities requiring large investments. The fundamental objective of the evaluations is to recommend the right course of action by considering several alternative strategies and understanding the risks associated with implementing them.

Chevron follows a structured dialogue approach to ensure high quality decisions. High quality decisions can only be achieved by conscious and deliberate choice of action made by empowered and committed work team and decision-makers working together. It is imperative to understand that good decisions do not guarantee good outcome nor good outcome does not mean a quality decision was made. Quality decisions are made when all components of decision quality are achieved. The six components of decision quality that governs the structured decision process are illustrated in Figure 1. It is also critical to note that the process emphasizes appropriate level of communication between the decision-makers and the work team during a decision process cycle.

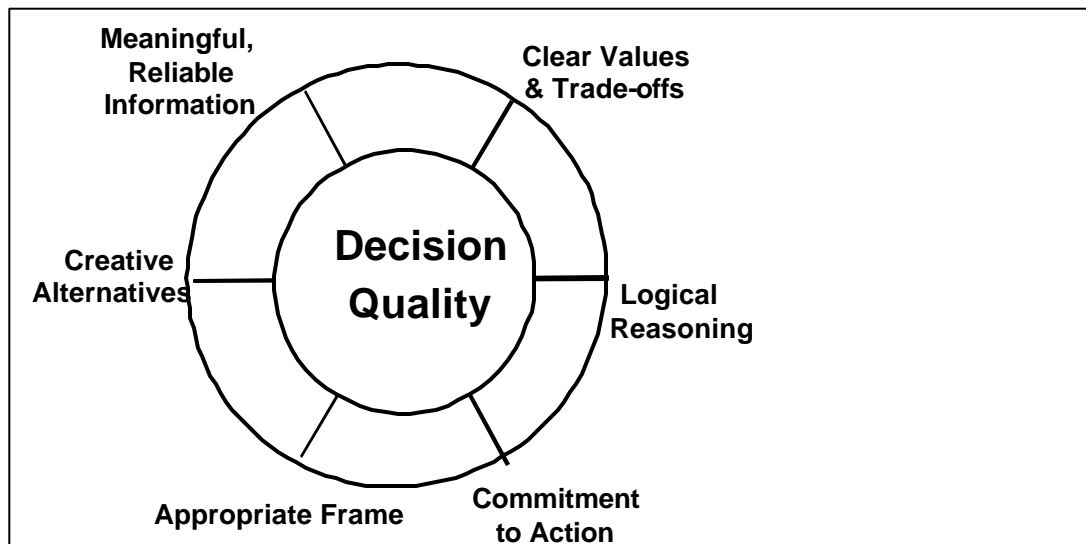


Figure 1: Components of decision quality

The first step is problem structuring where all related issues are considered and the business drivers, critical decisions, uncertainties and value measures are clearly identified and implementation strategies formulated. In the second step, an economic model (typically spread sheet) is built to determine financial measures (NPV, IRR, DPI etc.) for each alternative strategies identified in the first step. Using 10-50-90 range for each uncertainty, a sensitivity analysis is performed to identify those that have the most impact on the bottom line metric (typically NPV). The third step is to build the probabilistic decision tree using the most critical uncertainties selected from the sensitivity analysis performed in step two. The most critical task in this step is to get the appropriate assessment of the probabilities of occurrence for each uncertainty modeled. Solving the decision tree gives the expected values (expected NPV), a range of outcomes and corresponding probabilities of occurrence for the alternatives considered in the analysis. The fourth and final step is the appraisal where the analysis is critically reviewed for proper assessment of probabilities as well as the appropriateness of the results. A course of action is typically recommended to the decision-makers by presenting the alternatives and their exposure to risks and the criteria used to arrive at the best alternative to implement.

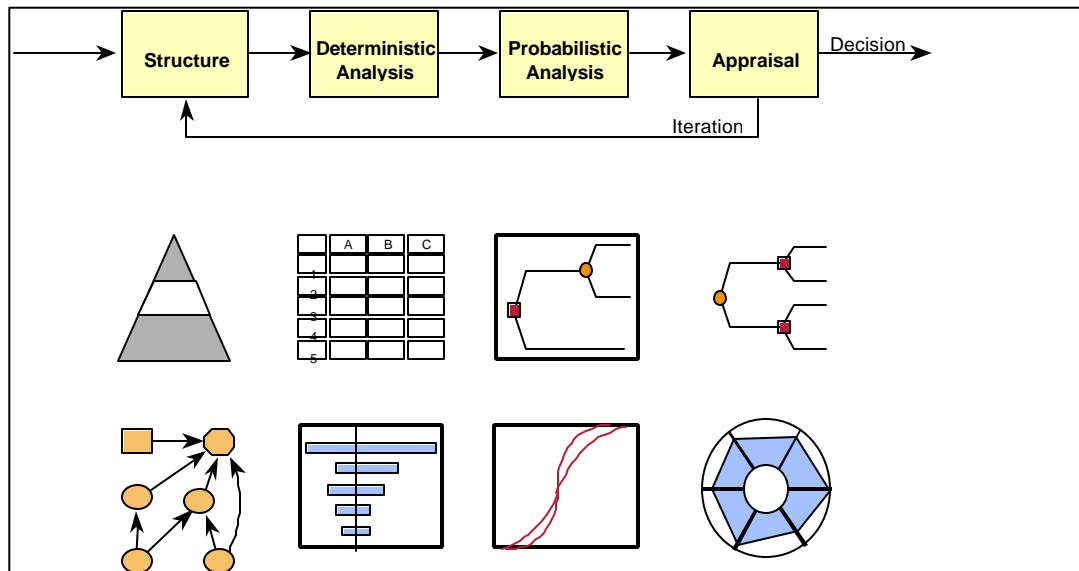


Figure 2: Structured decision process and tools used

More details of the decision analysis process discussed in greater detail in Mathesen (1998). Keeney (1996) provides a very useful perspective on decision analysis principles.

The process steps used in DA are not very unlike the ones used in a typical framing of a SD problem. Perhaps, the major difference between the two is that DA as explained here is probabilistic but static and SD is deterministic but dynamic. There are times where dynamic modeling is used in a decision analysis setting where repeated decisions in time are analyzed dynamically. However, these techniques often lead to very complex modeling and analysis and the results are difficult to communicate and thus make it difficult to be adopted to solve decision problems.

In this pilot project we used system dynamics, a new methodology in Chevron, to build a computer simulation to help examine the impact of Chevron's strategies upon the Nigerian gas business. System dynamics offered Chevron an integrated yet quantitative perspective. A scenario planning simulation, built on top of a system dynamics model, would allow Chevron to view the consequences of its business decisions in several alternative futures. A system dynamics model would capture the complex links between multiple investment and market opportunities, possibly uncovering previously unseen weaknesses or strengths of alternative proposals. Most importantly, all assumptions in the system dynamics model are explicitly represented, allowing managers to learn why scenarios might evolve in particular ways.

Simulation Conceptual Design

The first phase of our simulation building effort involved determining the initial focus, key issues, and key relationships for our model. We did this in a series of facilitated meetings with a small group of US-based staff members responsible for long-term Nigerian gas planning.

Our simulation was built to demonstrate the utility of a system dynamics scenario planning simulation as a planning tool within Chevron. Consequently, we quickly set our model focus to a fairly narrow scope, focusing on the processing and marketing of gas-derived products in Nigeria.

Using a set of colored hexagons, we brainstormed issues, sorting them into issue clusters and generating a list of key variables. (Hodgson 1994). A sample issue cluster and variable list is listed in Figure 3.

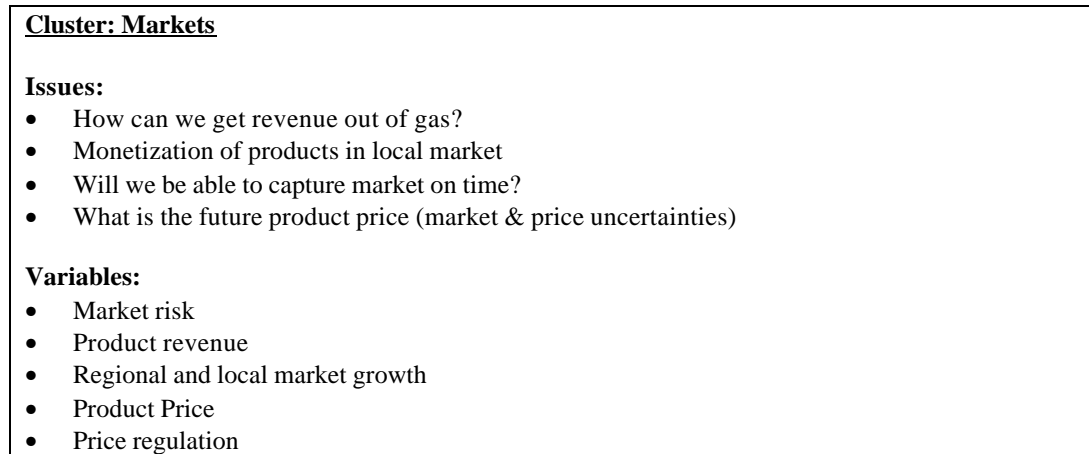


Figure 3: Sample issue cluster

We then created a first cut at a causal loop diagram (excerpted in Figure 4), summarizing the key interrelationships at a high level.

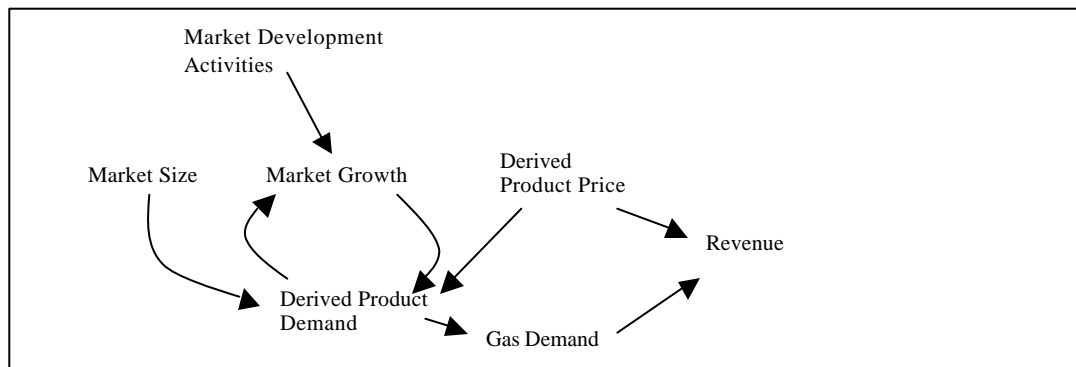


Figure 4: Initial Causal Loop Diagram (Excerpt)

Finally, to further focus our modeling efforts, we listed out two detailed scenarios that we wanted to study. One scenario was a success story for the Gas-To-Liquids plant. The second scenario involved a significant increase in government regulation and competitive pressure.

Building the Simulation

We built our model with the model subsystems shown in Figure 5. Rather than explicitly build out the rate of gas production, we used the Dynamic Data Exchange (DDE) connectivity capability of Constructor to load in the data from an external spreadsheet.

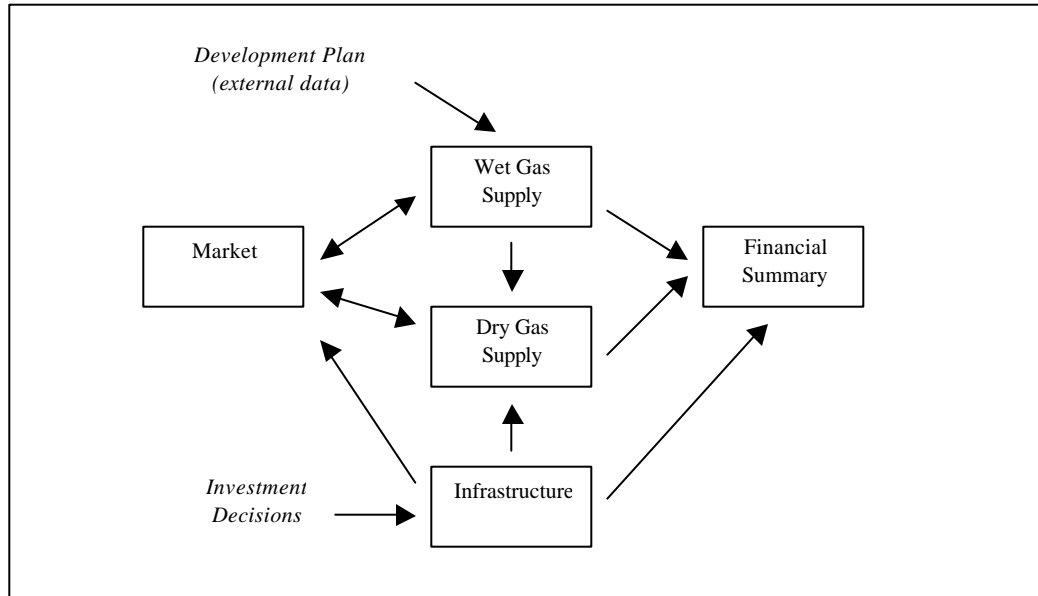


Figure 5: Model Subsystems

As we finished building the model we created a user-friendly interface in Constructor. This interface allowed us to see an overview of the model as the simulation proceeded (Figure 6) and to change our assumptions and investment decisions (Figure 7).

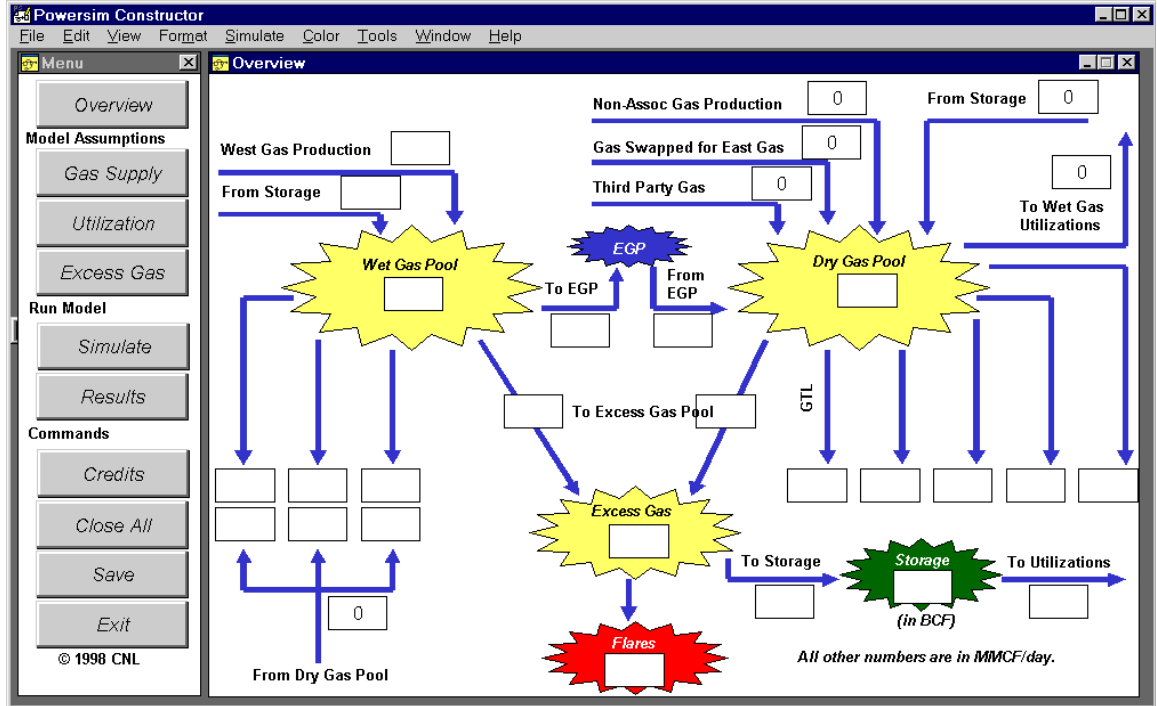


Figure 6: Simulation Overview Screen

Note: Some information has been changed to protect confidentiality

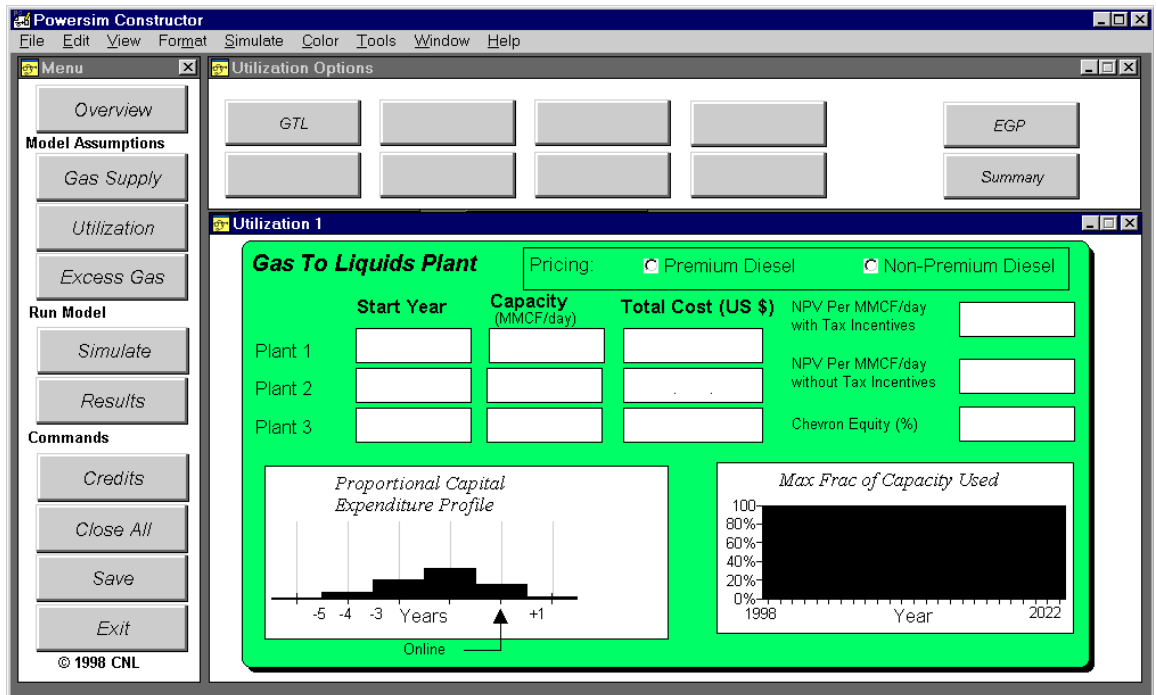


Figure 7: Enter Investment Decision

Note: Some information has been changed to protect confidentiality

Next Steps

Now that we have completed this simulation prototype, we see a number of areas in which this tool can be expanded to provide additional assistance in strategic planning for Chevron's Nigerian operations.

- (1) Create a two-way link to a detailed spreadsheet-based financial model, allowing planners to use existing tool with data from system dynamics model.
- (2) Create a stand-alone version of this simulation that can be given to gas managers allowing them to create their own forecasts of alternative strategies and decisions.
- (3) Explicitly model Chevron and competitor's activities in market development, assisting Chevron management in considering long-term competitive strategy.
- (4) Include oil development and transportation, providing the ability to examine the impacts of oil-related decisions on the gas market and vice-versa.
- (5) Expand simulation concepts to build a management model for business planning coordination of oil & gas operations and future expansions in Nigeria

Being Successful With System Dynamics

On a final note, we believe that there is more to making an effective planning tool than simply building a good model. This is as true for a system dynamics simulation as any other decision support model. A few of our key learnings in this area include:

- Show clear value of the simulation to the organization
- Get buy-in and continued sponsorship from high-level managers
- Communicate results and insights from simulation to broad set of managers within the organization
- Train/educate planning staff to use the simulation
- Explore opportunities to combine system dynamics with other techniques (such as Decision Analysis) when appropriate.
- Make a continuous and relentless effort in developing, sharing, and using the simulation to make good decisions.

References

Hodgson, A.M. (1994). Hexagons for Systems Thinking. In Morecroft, J. and Sterman, J. (eds), *Modeling for Learning*, Productivity Press, pp. 359-374.

Mathesen, D., et al (1998). *The Smart Organization: Creating Value Through Strategic R&D*, Harvard Business School Press, Cambridge.

Keeney, R.L. (1996). *Value Focused Thinking: A Path to Creative Decision Making*. Harvard University Press, Cambridge.