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# A PRACTICAL GUIDE TO CAPEX MODELLING IN OIL & GAS

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# IS THIS BOOK RIGHT FOR ME?

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SEE IF WHAT YOU ARE ABOUT TO READ MATCHES YOUR REQUIREMENTS

BM

## BASIC GUIDES FOR MODELLERS

These guides contain broad recommendations for financial modellers that apply across sectors. They typically contain step by step instructions on topics that are common to all financial models. These guides tend to focus more on "construction techniques" which can be used in all modelling situations.

THIS GUIDE →

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## ADVANCED GUIDES FOR MODELLERS

These typically go beyond the Basic Guides by giving more advanced sector specific guidance. These are often related to specific code modules that are useful for sector specific models.

MM

## GUIDES FOR MANAGING MODELLING ASSIGNMENTS

Managing modelling assignments requires a separate skill set from building a model, especially where a team of modellers is involved. These books provide guidance on the process and risk of model build assignments, as well as recommendations on managing modelling teams.

CG

## COMMERCIAL GUIDES

These contain sector specific commercial guidance that is useful for modelling and modelling managers. As we know, spreadsheet modelling begins with a conceptual understanding of the business situation. (If you didn't know that – check out our ebook "An introduction to the business analysis lifecycle") These guides aim to increase your conceptual understanding of a specific topic.

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**AS A FINANCIAL MODELLER IN THE OIL AND GAS SECTOR, YOU WILL BE FACED WITH NUMEROUS "WHAT-IF" QUESTIONS. TO ANSWER THESE QUESTIONS YOU WILL BE REQUIRED TO REGULARLY RE-ESTIMATE THE CAPEX PROFILE.**

**THIS EBOOK TELLS YOU WHAT YOU NEED TO KNOW ABOUT S-CURVE MODELLING, AND GIVES YOU A FLEXIBLE SOLUTION IN EXCEL THAT YOU CAN APPLY IN YOUR MODELLING.**

# A PRACTICAL GUIDE TO CAPEX MODELLING IN OIL & GAS

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AM ADVANCED MODELLING

## ABOUT F1F9

F1F9 provides financial modelling and business forecasting support to blue chip clients and medium-sized corporates. We also teach financial modelling skills to companies around the world. Our clients have access to high quality, low-cost modelling support delivered by 40 professional modellers.

F1F9 co-developed the FAST Standard that allows modellers and non-modellers to work together and understand financial models. Transparency is the core value that drives our modelling and our business activities.

## F1F9 OIL & GAS TEAM

F1F9's dedicated Oil and Gas modelling team is led by Danie Prinsloo. Danie has more than 18 years of oil and gas experience. With a strong technical background in chemical and process engineering and a further qualification in computer science, Danie has worked in a number of major commercial functions and gained extensive experience in strategy development, project evaluation, business development and commercial agreements.

Danie's commercial negotiation and valuation experience covers Algeria, Australia, China, Iran, Latvia, Lithuania, Malaysia, Netherlands, Nigeria, Qatar, Russia, South Africa, Tanzania and the United Kingdom. He has a proven ability in the development of multibillion dollar energy investment opportunities and providing the financial models used to support these investments while ensuring high standards of quality control are maintained.

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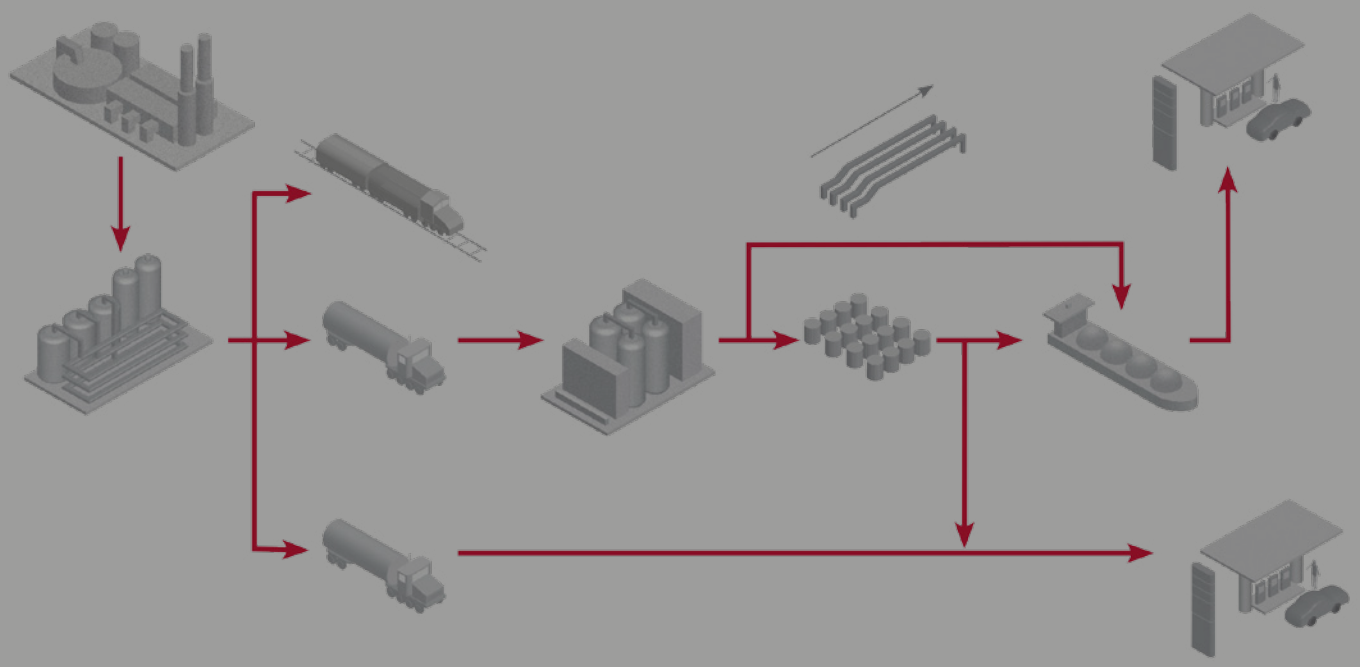
# INTRODUCTION

To realise a project in the Oil and Gas (O&G) industry requires the outlay of large amounts of capital over an extended period of time to buy and maintain assets.

The capital cost of a project is the total expenditure, or 'capex', incurred by a company to achieve the forecasted benefits of undertaking that project. In addition to fixed capital, capex includes working capital costs plus the cost of land and other non-depreciable costs, and all development costs from the generation of the initial idea through to commercial closure.

The time variation of cumulative expenditure from initial inception to commercial completion of the operational assets is 'S' shaped. The purpose of this e-book is to explain the origin and application of this so-called 'S-curve' and to provide you with a useful worked example module, built to the FAST Standard, which you can apply in your own modelling.



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# PROJECT DECISION MAKING

The high capital requirements for O&G projects mean that companies need to be sure that they are 'doing the right projects' as well as 'doing projects right'. This requires formal decision making procedures.

While the details of these procedures vary by company, they tend to follow a similar sequence of "decision-gates":

Economic and financial modelling is key to decision making at each stage-gate. The amount and timing of the capex spend are critical model inputs and are therefore crucial to the decision making process. Capex modelling has a huge impact on value creation and the future profitability of the project.

# ESTIMATING CAPEX

As a project is developed and engineered, the accuracy and level of detail of the capex estimates and the schedule of spend evolve.
Figure 1 illustrates the typical phases involved in an O&G project.

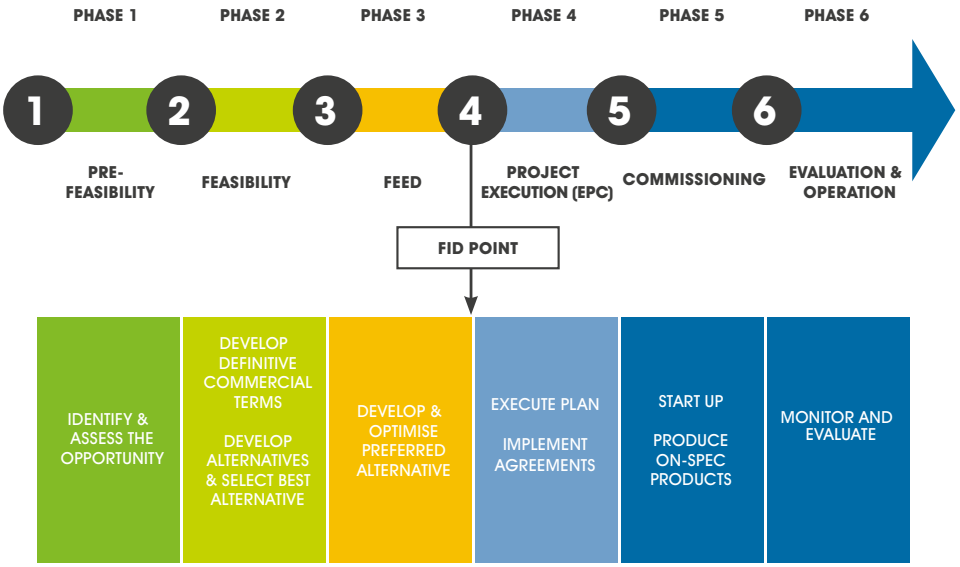


Figure 1: Phased Development of an Oil and Gas Industry Project

(FEED = Front End Engineering Design, FID = Final Investment Decision, EPC = Engineering, Procurement & Construction)

During the pre-feasibility phase, the Financial Modeller may be provided with a single value estimate of capex together with an overall schedule. This is often known as an 'order of magnitude' estimate. It may have been based on a ratio to a similar project, in-house experience, a rule-of-thumb, a best 'guestimate' or a combination of these. The Modeller will be expected to use this data for the financial modelling and profitability analysis.

As the project progresses, the Process Engineers will develop energy and mass balances, and begin to size equipment. This allows more accurate estimates to be generated. Prior to the FEED study being undertaken, the Modeller may still have to deal with an aggregate capex and duration, or may be provided with a limited breakdown by major area of spend and a schedule of capex. The FEED study is usually outsourced to a specialist contractor.

In the EPC phase, vendor quotations will be received for plant and equipment, the contracting strategy will be finalised and a comprehensive project execution plan developed. By this stage the capex breakdown will be highly detailed and the schedule, for a major project, may have 300 – 1000 activities.

In summary:

- As the project progresses through each stage-gate it becomes more clearly scoped and engineered.
- The basis, methodology, detail, accuracy and effort required to prepare the capex estimates differ for each phase of the project. As the project advances, the expected accuracy of cost estimates increases.
- In the early stages of a project, real cost estimates tend to be generated using non-deterministic methods such as ratios to similar projects.
- From FEED onwards, nominal cost estimates are produced by deterministic methods where individual items of equipment are sized and costs estimated, or vendor quotations obtained, with higher levels of confidence and accuracy.
- If it is not clear or explicitly stated, the Modeller should always check and seek confirmation on what basis the capex estimate was produced.



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# EXAMPLE PROJECT:
# PEARL GAS TO LIQUIDS PLANT IN QATAR

It can take investments of $ billions to bring a mega-project into operation with development times of a decade or more: capital costs can change dramatically from conception as the project progresses. One example of this is the Pearl Gas-to-Liquids (GTL) plant of Shell in Qatar.

In the early stages of Pearl GTL in 2003, the project capex had been estimated at $5 billion.

Following FEED, the project was approved in 2006, and achieved full production by the end of 2012. As of early 2013, capex had escalated to $19 billion with the final figure expected to reach $24 billion.

**The oil & gas modeller faces some interesting challenges!**



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# CAPEX PROFILE

The capex profile of complex O&G projects is not uniform. At the pre-feasibility phase, a relatively small team will be working on the project. Additional resources and disciplines will be added during the feasibility stage.

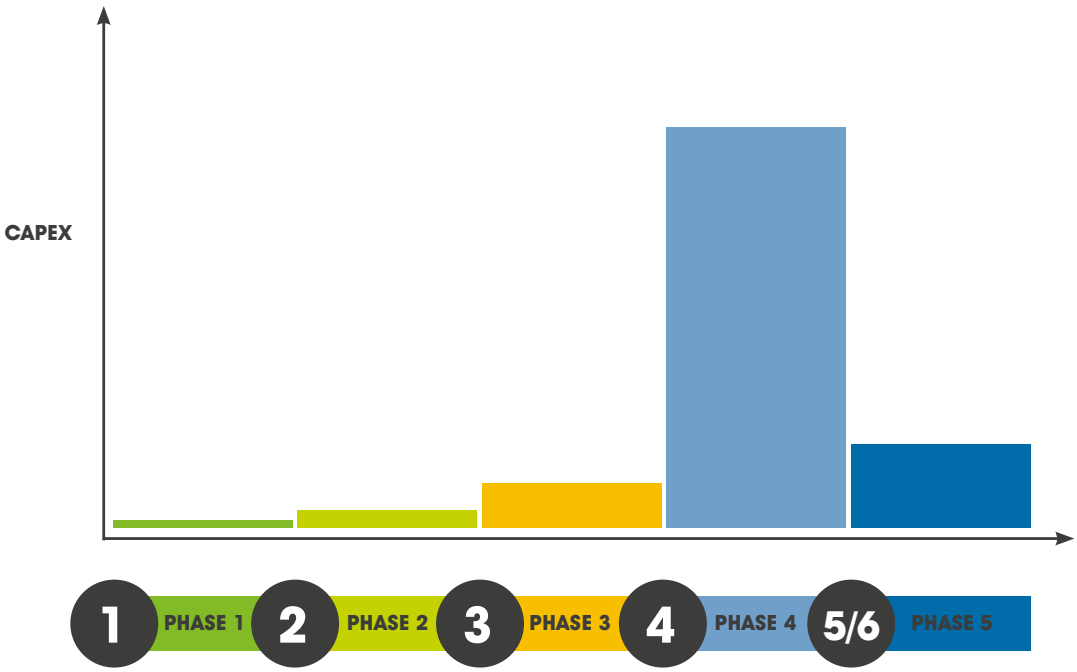


Figure 2: Indicative Relative Capex by Project Phase (not to scale)

The FEED stage involves a much larger, multi-disciplinary team resulting in increased costs. FEED is typically divided into separate packages covering different portions of the project. FEED for a large O&G project may take around 12 months to complete and involve tens of thousands of man-hours of effort. The FEED package is usually used as the basis for bidding the project execution phase contract.

The majority of the capex spend is incurred during the execution phase. This happens after a positive Final Investment Decision (FID) has been taken. As an extreme example, construction of Pearl GTL, shown earlier, involved over 50,000 workers from more than 50 countries.

The commissioning phase normally starts when the execution phase is between 80-90% complete.

Figure 2 shows a typical capex profile by project phase.

# MODELLING THE S-CURVE

A typical S-curve capex profile is shown in Figure 3 and features a continuously bending line, without angles, that is curved in two directions where the gradient is lowest at the start and at the end.

Observation and experience gained since the inception of the O&G industry has established the relationship between capex and the S-curve, and S-curves are widely used for planning, forecasting and control of cost, time and resources of a project.

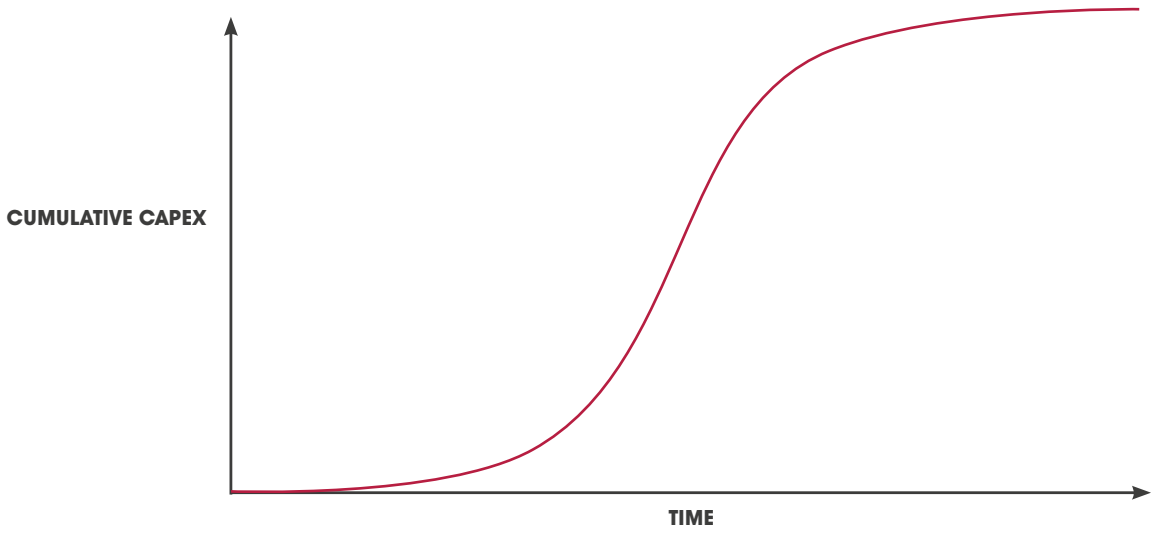


Figure 3: S-curve (asymmetric)

S-curves find extensive application across a number of fields from science (including biology, chemistry and physics), economics and financial analyses, through to project management. A time ('t') dependent S-curve can be defined by a number of mathematical functions including the logistic function.

**EQUATION 1**

$$f(t) = \frac{1}{1 + e^{-t}} \equiv (1 + \exp(-t))^{\wedge -1}$$

The S-curve of Equation (1) is a powerful tool that the Financial Modeller can use to model and manipulate the time variation of capex, represented by f (t), prior to a full capex schedule being available. Although t can range from – ∞ to ∞, the t-range of an S-curve that is superimposed onto the model timeline is much smaller to obtain a usable S-curve (this being due to the nature of the exponential function $e^{-t}$), and is typically up to 14 (this is the input 't-range' of the FAST model). The S-curve of capex can be manipulated to include compressed (steepened), stretched (flattened) and / or offset:

- A smaller t-range of the FAST model produces a flatter or more even capex profile versus time and vice versa for a larger t-range.
- The input *'t-offset'* of the FAST model allows the symmetry of the S-curve to change: a t-offset of 0 produces a symmetrical S-curve, while a positive value produces a left / right offset depending on whether the input *'t-offset switch'* is set to '1' (left) or '0' (right).

# WHAT-IFS & CHANGES IN CAPEX / SCHEDULE

As the project develops, the amount and schedule of the capex will change, and the Financial Modeller will be faced with numerous "what-if" questions.

These questions will come from decision makers and stakeholders such as management, the Executive Committee and the Board.

When information on the breakdown of capex and schedule remains limited and incomplete, which may be the case until the FEED has been completed, the Modeller may be required to address impacts of changes to the capex and / or schedule - but without being provided with an update of the S-curve - and asked to run sensitivities and what-ifs.

For those scenarios where the schedule estimate is altered, an existing S-curve, expressed in the format of percentage capex versus percentage of time, can be used as the basis to produce a revised capex profile for the new schedule. This is illustrated in Figure 4.

The red circles of Figure 4, joined by the red line, represent the cumulative capital spend (%) versus cumulative time (%) of the base S-curve. The project schedule has been extended and the modeller has had to assess the impact of the extended schedule on the economics – the blue triangles (representing the updated cumulative times between model periods for the extended schedule as a total percentage of the updated schedule) and blue line represent the updated capex profile. Ideally, the blue line is overlaid on the red line.

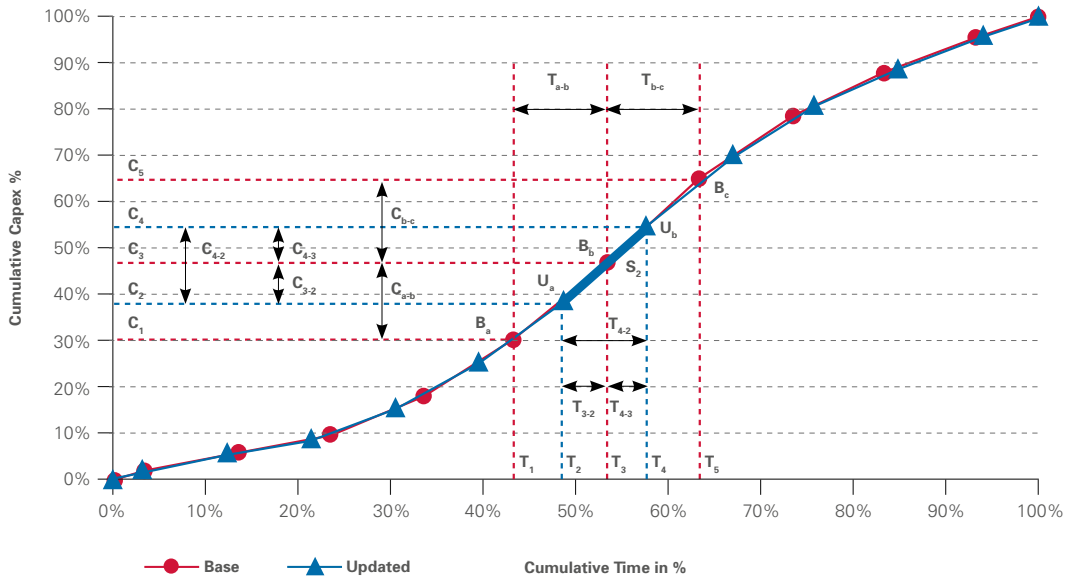


Figure 4: Using an existing base S-curve to update a capex spend profile

## The existing base S-curve can be used to model an updated capex profile as follows:

1. Calculate the percentage time elapsed at the end of each model period corresponding to the updated extended profile – i.e. the cumulative time as at the end of each period.

2. Estimate the percentage capex between consecutive abscissa points of the updated schedule – e.g. $U_a$ and $U_b$ – based on the gradients of the base S-curve between those abscissa points on the base S-curve which cover $U_a$ and $U_b$ including (i) the nearest cumulative time point < $U_a$ and (ii) the nearest cumulative time point > $U_b$ – i.e. $B_a$, $B_b$ and $B_c$ on Figure 4. {It is assumed that the S-curve is made up of a series of straight lines, the gradient of which varies between each two consecutive points on the S-curve.}

In Figure 4, the cumulative capex between $U_a$ and $U_b$ for the updated capex profile is the summation of the capex between (i) $U_a$ and $B_b$, based on the gradient being assumed to be the same as between $B_a$ and $B_b$, and (ii) $B_b$ and $U_b$, based on the gradient being assumed to be the same as between $B_b$ and $B_c$.

In this way a revised and updated profile of capex is generated.



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# S-CURVE PRACTICAL EXAMPLES:

The following section contains two practical examples of S-curve modelling in the Oil & Gas sector. These are available as worked example Excel files.

**Download the Excel files here**

# EXAMPLE 1: LNG IMPORT & REGASIFICATION PROJECT

(STAGE OF DEVELOPMENT – PHASE 1, SCOPING STUDY)

Your company is looking at the feasibility of establishing a new liquefied natural gas (LNG) import and regasification project. This project will involve the construction of:

1. Jetty and harbour facilities to receive ships carrying LNG.

2. Land based facilities to receive, store and regasify LNG for sendout to a local gas transmission system.

The project is in the scoping phase and you have built a model to assess the economic and financial potential of this project over a 25 years operating period.

Based on its experience of similar studies that your company has been involved in and projects that have been reported in the literature, the Process Engineering Department has provided you with an estimated project capex of $700 million with a schedule of 54 months to completion. No further breakdown of capex or schedule is yet available.

To estimate capex per period for your model, you have applied the standard S-curve profile of Equation (1). You have decided that it is adequate at this stage of development to model capex in quarterly periods and that it is suitable to use a t-range of 12 for the S-curve with no offset applied.

The day before the presentation to the Executive Committee ('ExCom'), your manager informs you that the project is now being developed to receive bigger ships. The consequences of this are:

(i) a longer jetty is required to deeper water and
(ii) an additional land-based LNG storage tank is required.

The costing engineer has revised the capex estimate to $850 million and the schedule has been increased to 60 months. This is due in part to:

(i) the need for additional up-front environmental and safety studies,
(ii) a potentially longer permitting process, linked to using larger ships, and
(iii) a longer construction and subsequent commissioning period.

You have been told that although LNG storage tanks are on the critical path for construction of an LNG import terminal, an additional storage tank would be built almost in parallel to the other LNG storage tank but will extend commissioning.

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## How can S-curve modelling help given that you still have to present the financial results to ExCom tomorrow, but based on the latest estimates?

In the absence of further breakdown, you take the following decisions to revise the capex S-curve:

- Increase total capex to $850m (from $700m).
- Increase total periods to 20 (covering 60 mths) from 18 (covering 54 mths).
- Increase the t-range of the S-curve to 14 (from 12) to steepen the S-curve to reflect:
  - the need for additional environmental and safety studies early in the project lifecycle.
  - a steeper spend profile during construction (primarily due to the additional storage tank).
  - a longer commissioning period.
- To not apply a t-offset to the base case due to the absence of further information on timing of the EPC phase of the project.

Figure 5 shows in blue the updated S-curve capex profile, compared to the base profile in red, which you use to recast your financial analysis prior to the presentation to the ExCom.

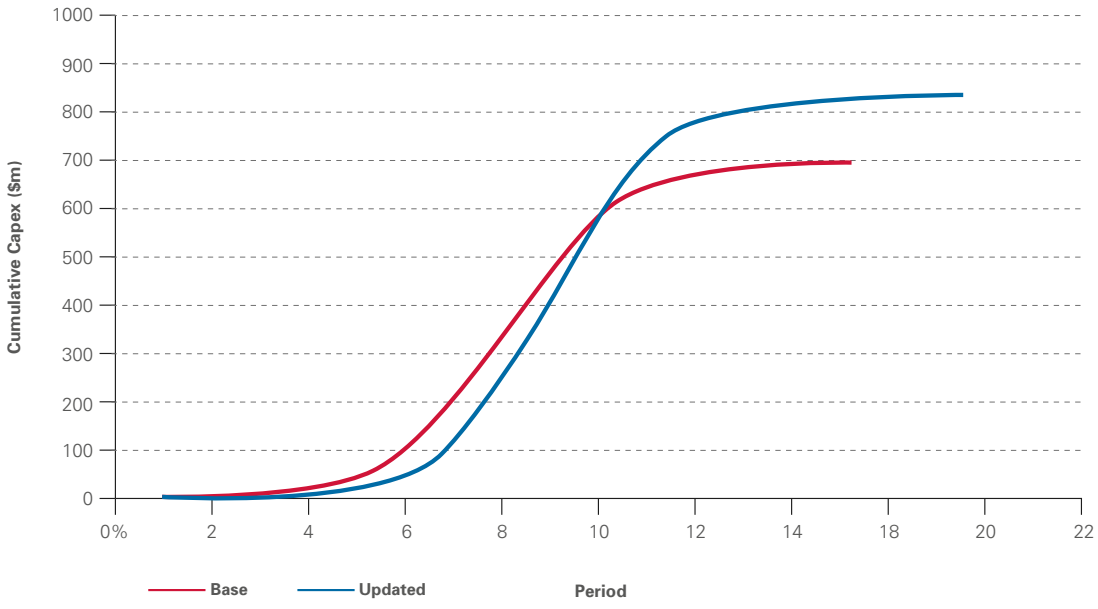


Figure 5: Original and modified S-curve following increase in capex and schedule

# EXAMPLE 2: GAS-TO-METHANOL PROJECT

(STAGE OF DEVELOPMENT – PHASE 2 FEASIBILITY)

Your company has an onshore stranded gas resource. Building a pipeline to market has been rejected in the scoping studies and the most promising option is to construct a gas-to-methanol plant. The results of the Phase 1 scoping and pre-feasibility studies were positive and the project passed a stage-gate with management committing further internal resources to undertake a more thorough feasibility assessment of the opportunity.

At the end of the Phase 1 studies, you had been supplied with a capex figure of $1.8 billion and a project schedule of 60 months. In addition, an S-curve had been provided. The capex had been sub-divided by major area and phased in 6-monthly periods of spend.

During the Phase 2 feasibility study, engineers started to revise capex based on factored equipment sizes, labour rates and productivity figures. It became apparent that equipment costs are greater than originally envisaged but that lower installation / construction costs, using local labour, cancel out this increase. The initial schedule of 60 months is too optimistic and the design team have added 6 months to the overall project schedule.

You are charged with re-running the model to find out how the increase in project schedule changes the breakeven price of methanol. Your enquiry into how the capex profile changes for the increased schedule was met with blank looks. What do you do?

The approach you adopt is to recast the base case S-curve supplied at the end of Phase 1 into the format of cumulative percentage capex versus cumulative percentage time. You can then apply this same S-curve profile over the revised schedule.

This could be done manually by reading values directly from the S-curve. In this case, each 6-month period originally represented 10% of the time of the original 60 month schedule, whereas when revised to a 66 month schedule, each 6-month period now corresponds to 9.1% of the total schedule.

As your analysis will also involve running a number of sensitivities and Monte Carlo simulations, you adopt the approach that is outlined in Figure 4 whereby an updated capex profile, for the 66 month schedule, is derived from the existing base S-curve based on the gradients of assumed straight lines joining consecutive points on the base S-curve.

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# NEXT STEPS?

**Download and review the worked example Excel files**

The worked examples have been built to the FAST Modelling Standard.

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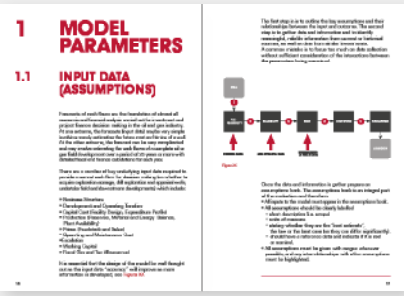


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To discuss how our team can help you improve your corporate modelling and forecasting call **Lynn Martin on +44 203 239 8575** or email **lynn.martin@f1f9.com**

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