Proceedings World Geothermal Congress 2005
Antalya, Turkey, 24-29 April 2005

Financial Modelling of Geothermal Projects

James B Randle

Sinclair Knight Merz Ltd, PO Box 9806, Newmarket, Auckland, New Zealand

jrandle@skm.co.nz

Keywords: Geothermal Power, Financial Modelling, Project Finance

ABSTRACT

Engineers and geoscientists preparing feasibility studies for geothermal projects need to include some form of financial model of the proposed project. Their model usually presents a fairly accurate projection of capital and operating costs, but is often insufficient for lender financial purposes. The lenders then prepare their own model, which often inadequately represents the construction and operational detail of the project. A composite model is described which builds on a true representation of the technical aspects of project development, construction and operation to provide inputs to a corporate finance module which provides the developer with target annual corporate financial data and meets the requirements of potential commercial investors of equity and debt.

1. INTRODUCTION

Project models, incorporating financial and/or economic data, are required for a number of reasons, including:

- Economic analysis of project viability – often from a national economic perspective
- Evaluation of technical alternatives
- Tender evaluation
- Business planning
- Project financing for both equity and debt participants

Engineers and geoscientists are very familiar with creating some of these, but not with all, especially the last two. Similarly, financiers and economists are familiar with many, but again not all.

As a consequence, the various models developed for a project will have different emphases and the modellers will concentrate on different aspects of the model, to the detriment of others. Engineers will tend to concentrate on issues related to either or both of the construction schedule or the operational performance of the plant. Financiers will tend to concentrate on aspects associated with debt drawdown, interest and repayment and will tend to give less focus to the accuracy of the engineering parameters.

A financial model of a pro-forma geothermal project has been prepared, using Microsoft Excel, to provide a template for a modeller to prepare a project specific model. As such, it incorporates most of the diverse requirements of the various potential users, whilst retaining both the technical and financial integrity of its various portions. A number of basic calculation engines are integrated within the model and fully documented to provide a structure which is open and can readily be modified by an experienced modeller with good spreadsheet skills.

2. THE PRO-FORMA PROJECT

The model has been based on a conceptual geothermal project, comprising three condensing steam turbine units each of 25 MW gross.

It was assumed that initial investigations and drilling had been carried out, sufficient to provide confidence for investors that the project can proceed for at least the first unit. Additional drilling will be carried out to permit the second and third units to be developed as subsequent and overlapping stages, each with its associated civil works, steamfield, and transmission facilities. Initial drilling, make-up and replacement drilling requirements were estimated as being typical for a project in a continental margin/cordillera tectonic situation.

Some additional geoscientific investigations will be required during the early stages of the project and was allowed for in the project establishment costs.

The transmission system was assumed to comprise a relatively short (12.5 km) overhead connection to an existing system. A single circuit will be initially installed with the first unit, on double circuit overhead towers, and a second circuit will be added onto the towers when the second unit is added. It was assumed that when the second unit and the second transmission circuit are added, the switchyard would then become a node in the transmission network, with appropriate expansion to a more sophisticated busbar and circuit breaker configuration.

It was assumed that the bulk civil works for the first stage would involve the formation of a power plant platform large enough for the entire three unit development. Subsequently civil works will be largely confined to the steamfield, with only minor additional facilities to be installed at the power station.

Capital costs for the project were estimated as being indicative for similar projects undertaken in recent years (recent to 2004). A figure of 1,000 US$/MW gross was assumed for the power plant only, from the steam supply at the power plant fence and up to and including the generator transformer high voltage bushings. Steamfield costs were estimated as 150 US$/kW for the first unit and subsequently as 140 US$/kW, these figures being for the supply and installation of all piping and separator station plant, plus the reinjection system; they exclude wells and bulk civil costs. The initial steamfield installation was assumed to provide a small steam surplus and additions are for the additional power plant gross capacity only.

Operating parameters, such as auxiliary power, were estimated based on the manufacturer's stated performance of recently installed condensing steam turbine plant. Maintenance and overhaul outages were estimated based on performance reported by operators of recently installed plant (in particular, an overhaul outage periodicity of 3 years was used, which assumes that the steamfield is capable of suppling high quality steam with minimal brine carry-over). Operating and maintenance costs are similarly a reflection of reported requirements, with these costs being entirely capacity related with no energy variable component. It was assumed that the plant would be dispatched as base load generation, with a dispatch factor of 98% of available generating capacity.

The Pro Forma model uses US$ as the units of currency. In practice, any units of currency can be used, but it is strongly recommended that modellers do not attempt to mix currencies within a single model. Reasonable accuracy can be obtained by converting everything to a single currency at the start of the analysis and then assuming that variations in exchange rate over time will be approximately cancelled out by variations in escalation.

Carbon credits are of increasing significance for projects being developed in Kyoto Protocol Annex A countries ("developing member countries"). An estimate was prepared for the credit likely to be available by displacing heavy oil used in slow speed diesel engines. A very conservative figure was used for the monetary value of the carbon credits.

The project timing was based on a 22 month delivery to commissioning for each unit of the generating plant. It was assumed that the three units would be commenced at 12 month intervals, as drilling proves the steam availability for each stage. The project was assumed to have a 20 year life from the delivery of first power (which is typical for geothermal Power Purchase Agreements).

The assumed financing plan called for equity injections as each of the three stages is commenced. Debt financing for each stage comprised a bank loan, plus export credits. The export credits for each stage were lumped together as a single loan line, with drawdown being phased in parallel with the power plant supply and construction contract. The bank loans were kept separate and were modelled as being drawn down according to a manually inserted schedule. The bank loan associated with Unit #3 was used as the balancing "top-up" source of funding for the construction phase.

The Pro-Forma Project assumed a 30% corporate income tax rate. Depreciation was allowed at an accelerated rate, whereby annual depreciation is allowed up to the total net income (gross revenue minus all operating and finance charges) in that year; this is fairly typical of the type of investment incentive offered by developing countries to attract overseas investment into the renewable power sector.

An assumed tariff was based on recently awarded tariffs (outside Indonesia) and modelled as a monomeric price per kWh, ie a 100% energy tariff rather than a capacity tariff, without any "take-or-pay" break points. It was assumed to be subject to an escalation formula which produces a slight difference from the projected overall escalation (inflation) to be seen by the project – in fact the tariff was assumed to increase at slightly above overall inflation, which may actually be less common for real projects. A royalty payment was assumed to be required, based on a proportion of the tariff revenue.

Dividend policy, holdings of consumable stocks and average debtor and creditor days and insurance dividends were assumed as being typical for such a project.

3. BASIC STRUCTURE OF THE MODEL

The model is based on a number of interconnected worksheets in a workbook. The overall structure and inter-relationships is shown in Figure 1.

A number of important early decisions were required which subsequently made modelling much easier:

- As much as possible, input parameters would be restricted to one sheet.
- Various sections of the model would be structured with different time scales – either monthly or financial year. Monthly time scales are measured from Project Start and/or Construction Start (usually some time after Project Start, which is the point in time when active modelling commences). Annual time scales are in Financial Years, measured from the start of the Financial Year immediately prior to the start of the project. The reason for using either monthly or financial year time scales relates to the time period over which various activities occur and also to the nature of the various outputs of the model – for example construction is an activity that takes place in a timeframe measured in months, whilst corporate fiscal reporting is based on financial years.
- Extensive use would be made of Excel range names. Preliminary versions of the model had not done this, using instead cell references, but it was found that this made subsequent development, reading of expressions, proofing and modification of the model extremely difficult. Consequently an exercise was undertaken to convert a preliminary (and relatively simple) version fully to range names. This exercise, incidentally, underlined the value for the future of making this decision as early as possible for complex spreadsheets. A sheet was then included in the workbook that contains a listing of the various variable and range names and their cell references. This has proved an invaluable reference during development of the model.
- Colour would be used quite extensively to improve the readability of the both the working spreadsheets and the printed output.
- The model would be fully documented so that other users would be able to understand the underlying principles and calculation methodologies – and again colour would be used to assist in understanding complex, nested Excel functions.

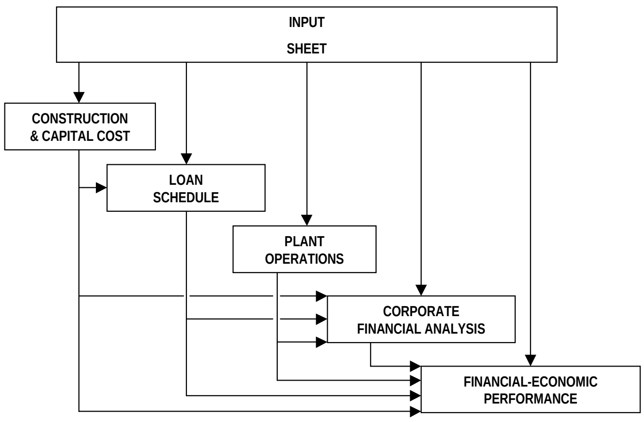

Figure 1: Structure of the Financial Model

3.1 Input Sheet

The first sheet in the model is the input Sheet, which is used as the single place to input virtually all of the variables that describe the project, both technically and financially. Preparation of these variables may require additional analysis to be undertaken outside of the workbook, although it is recommended that such analyses be entered into one or more additional worksheets within the same workbook, to ensure that the details are not lost. Some of the input variables are used to provide derived values in this worksheet. Where the known inputs are in a different form from that shown (eg plant costs in total dollars rather than dollars per megawatt), then the required input values can be calculated outside the worksheet, or the Excel GOAL SEEK routine can be used to generate the required input values from the known derived values.

Room has been provided at the right hand side of the Input Sheet to insert free form text (not referenced elsewhere) to amplify the information presented in the sheet. This space can be used to provide a very brief description of the project and its stages, the financing plan and any other features of the project which will help anyone reviewing the model to understand the basic features and especially any departures from the pro-forma model.

3.2 Construction & Capital Cost Sheet

The first major calculation engine of the model is to determine the construction cash flows and from this the drawdown of equity and loan funds required for construction. These calculations are contained in the Construction & Capital Cost Sheet. This sheet is time framed primarily in months, although it starts from the financial year start of the project and the months are allocated to financial years to permit subsequent carry forward to the Corporate Financial Statements.

Cash flows are determined for each of the capital estimate items. A reference expenditure profile is determined for most line items – semi-linear for engineering costs and normal distribution for construction costs. Provision is made to manually over-write the reference cash flows and to manually insert other items for which no reference is determined.

In meeting the capital cash flow requirements, equity inputs are first scheduled and deducted to determine the debt cash draw down required. This is allocated to each of the debt lines in turn, again with provision for predetermined profiles to be manually over-ridden.

3.3 Loan Schedule Sheet

The next set of calculations is contained in the Loan Schedule Sheet, again with a monthly time scale. A monthly treatment is required to enable individual loans and their respective terms to be correctly modelled. Most of the loans will have different starting points, depending on the construction cash drawdown requirements, and repayments (and interest recognition) are normally required every 3, 4 or 6 months, with anniversaries based usually on first drawdown. Although using the same time frame, this sheet has been kept separate from the Construction & Capital Cost Sheet because it will run for a much longer period – quite possibly up to 10 years from first drawdown and probably even longer from Project Start.

The Loan Schedule determines, month by month, the status of each loan in terms of outstanding balance and interest amounts. Provision is also made in this sheet for the manual input of loan fees etc, which are too variable in nature to be pro forma modelled. These fees are the only manual adjustments that would normally be required in this sheet, as all other parameters about the loan operation, including the capitalisation of interest, are determined from the Input Sheet. Note that interest capitalisation, if used, is always taken as being to the time of the first repayment, at which time the interest is capitalised into its own loan.

Following the specific information about each individual loan, the Loan Schedule totals are summed to provide information for carrying forward to the annual corporate accounts. The Loan Schedule Sheet also calculates basic revenue and expenses on a monthly basis, in a similar way to the Plant Operations Sheet, in order to determine monthly, and on a rolling selectable period basis, the Debt Service Coverage Ratio (DSCR). This parameter, which is the ratio of debt service payments (loan repayments plus interest charges) to free revenue (gross revenue minus operational expenses) is of prime interest to debt lenders, who will typically require DSCR to be calculated on each repayment anniversary of their loan and will require that it be covenanted to be more than unity, or a higher figure such as 1.4, at each such recalculation.

3.4 Plant Operations Sheet

The Plant Operations Sheet looks at the long term operation of the project and determines the gross revenue of the project on an annual basis through its life. The availability of each unit is determined, starting from a part-year availability when first commissioned. Provision is made for output reduction due to both recoverable and non-recoverable degradation of the plant, with recoverable degradation being reset to zero at each overhaul. The overhaul cycle is determined and the annual available hours used to determine the annual generation for each unit.

Inflation and marginal tariff escalation (tariff escalation relative to inflation) are calculated, with total tariff escalation being the product of inflation and marginal tariff escalation. Applying the average annual tariff to the total generation produces the annual gross revenue from generation.

Annual operating costs are calculated, as both operations and maintenance costs internal to the project and also corporate overheads that may be charged to the project as well as insurance costs. There is provision for the manual input of any additional costs. Note that, depending on the details of the project PPA, these may include such items as the cost of transmission losses and wheeling charges.

Make-up and replacement well drilling is treated as an occasional operating cost (often referred to as "Non-Recurring Maintenance Costs") allocated to the years in which it is anticipated that additional drilling will be required. Note that this is not allocated uniformly and in inputting the details in the Input Sheet consideration should be given to the reality of how this drilling will be undertaken – ie as a number of wells at one time, probably not as a series of single wells.

This sheet also calculates carbon credit inputs, royalty payments and, for use in the corporate financial statements, the value of consumable stocks required (taken as a percentage of O&M costs).

3.5 Corporate Financial Analysis Sheet

The Corporate Financial Analysis Sheet draws on the previous sheets to generate a number of standard financial reports, these being:

- Statement of Income (essentially Profit and Loss account)
- Balance Sheet
- Cash Flow Statement
- Sources and Uses of Funds

The first two of these will be familiar to many engineers and are the items commonly found in corporate financial reports. The Cash Flow Statement and the Sources and Uses of Funds are reports that are of greater interest to accountants, financial managers and bankers.

Provision is made for checking that the Balance Sheet and the Sources and Uses of Funds reports do, in fact balance, and this check should monitored at all times to ensure that modifications to the model do not introduce errors in these reports.

3.6 Financial-Economic Performance Sheet

Finally, based mainly on information contained in the Corporate Financial Analysis Sheet, the Financial-Economic Performance Sheet determines a number of standard through-life and annual parameters that are commonly used to determine the financial strength and ongoing wellbeing of the project. Aside from a summary of the sources and uses of construction funds, this sheet presents the levelised cost of electricity sold in both current (subject to inflation) and real (excluding inflation) terms and a number of other net present value (NPV) and internal rate of return (IRR) calculations. The sheet also includes a number of other financial parameters. Note, however, that there are very many other parameters (or the same parameters referred to by different names) that individual parties may request to see and which can be included into this sheet.

4. SOME MODELLING HINTS

The following contains some suggestions that the author has deduced during the development of the Pro-Forma model and from a number of real-life modelling exercises.

4.1 Construction Cash Flow Profiles

The model provides a template for establishing the construction cash flow profile. While overall most construction contract cash flows tend to follow a normal distribution (cumulatively an ‘S’ curve), a better approach to establishing the cash flow is to break down the costs into a number of elements (a number of small “guesstimates” are more accurate than one big one!). The model therefore uses the elements from the Input Sheet cost estimate and for reference purposes assigns a normal distribution to each item. The modeller needs to refine each element to reflect the actual expected cash flows. Points to watch out for that will distort the simple normal distribution include the likelihood of the contracts requiring advance payments (typically 10% to 20%) and the owner’s requirement for retentions (typically 10%, with 5% released at Taking Over and the final 5% when the Completion Certificate is issued, although many contractors will request the release of the final 5% in exchange for a bond. Additionally, many contracts are established with payment terms based on milestones, which may be “front-end loaded” to cover the cost of purchasing materials or vendor supplied equipment.

Note also that some items will not have a normal distribution. These include project management and engineering (both relatively linear, but with a front end loading to engineering). Also drilling costs will probably be fairly linear through the drilling campaign.

Figure 2 shows the cash flow profile from the model. It can be seen that, even with an extended construction period covering three units starting at different times, plus some linear inputs for engineering, drilling and project management, the overall affect is still a recognisable ‘S’ curve.

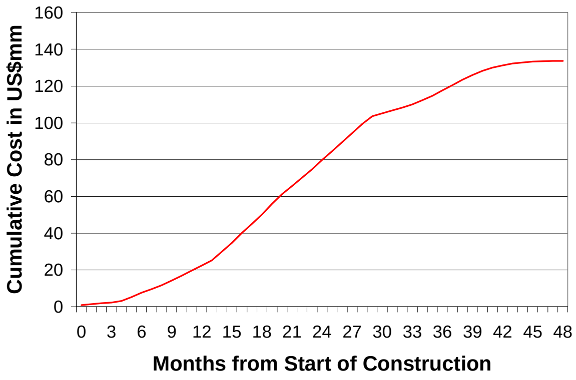

Figure 2: Construction Cash Flow

4.2 Funding Inputs

Care must be taken when modelling the inflow of construction funds to the project. Equity and bank loan funding is normally injected in tranches, or discrete amounts which are usually multiples of some pre-determined, relatively large amount. This is because the funds have to be arranged and reserved in advance and the administration of multiple small and variable amounts would be very difficult. There is some room here for optimisation. Enough funds must of course be drawn down to meet requirements until the next tranche can be drawn, but too much cash drawn too early will only incur excessive interest charges (although these can be at least partially offset by lodging the funds into appropriate instruments, if the lender will permit). Also, un-drawn funds may incur a commitment fee.

Supplier credit finance (including export credits) usually works differently in that the debt is incurred in parallel to the expenditure. It can be modelled as simple pro-rata of the relevant contract expenditure. To simplify modelling it may be acceptable to use one key contract (for example the power plant) to provide the drawdown profile for the export credit finance.

4.3 Debt Funding

Almost invariably the majority of the funding inputs into the project will be in the form of bank or similar loans. The modeller needs to be very aware of the impact of the terms of these loans. Obviously interest rate is going to be based on market conditions (usually expressed as a margin above LIBOR – fine, but make sure that you understand which LIBOR rate to use as they vary for currencies and period – often the 3 month US$ rate is used). However, a lot of attention needs to be given to estimating the likely term of the loan. Usually there will be a grace period equal to the relevant construction period plus a few months (so that the project is developing a revenue to meet the repayments), with repayments spread over the remaining duration of the loan (the term is normally quoted from first drawdown). Small loans as short as 4 years may be called for if risks (country, owner, resource etc) are seen as high, but the principal repayments of such a short loan can be very difficult to support. 7 to 10 years may be more normal and more supportable.

Different types of loans may have different interest rates and terms. Usually, bank loans will have a first call on the revenue and assets of the project. There may be a second tier of so-called mezzanine finance, which will have a second call on the project and is therefore at higher risk and will demand higher interest rates. Some supplier credits will require a lien on the assets being supplied under the supplier's contract – this must be carefully checked and confirmed with the lead lenders.

As the model develops, the modeller will be looking carefully at the debt ratios (especially Debt Service Coverage Ratio – DSCR – the ratio of net cash income in a period to the debt serving obligation of principal and interest repayments in the same period – typically required to be greater than 1.4). This ratio may go through a "pinch" early in the repayment cycle when the interest cost is high. The modeller should examine the balance sheet to see if there is surplus cash being held in the bank. Using this surplus cash can be usefully used to make early repayments of loans. If doing this, make the repayments first to the loan with the highest combination of interest rate and principal repayment – get the best value for the cash being used.

4.4 Plant Degradation

The model includes provision for recoverable and non-recoverable degradation. Recoverable degradation is largely due to such effects as turbine scaling and condenser or cooling tower fouling, which can be corrected during a maintenance period by cleaning the offending components. Non-recoverable degradation is normally associated with such things as erosion damage to turbine or pump internals or to leaking and plugged heat exchanger tubes.

In a conventional thermal project, such degradation will directly affect the financial performance by degrading the plant heat rate and hence requiring additional fuel input to maintain output, or by reducing output. In a geothermal plant, however, the effect may not be so obvious. For relatively small degradations, the plant output can be maintained simply by increasing the steam flow into the plant, which may in turn require an increase in inlet pressure. In an integrated project (ie combined steamfield and power plant operation), this is relatively easy to achieve such that the plant maintains a constant out put at rated capacity. The impact will be an increased drawdown on the reservoir and/or reduced well outputs against an increased separation pressure. In the short term, there may be no impact at all on the financial model. In the longer term, there may be a need to increase somewhat the frequency of drilling make-up and replacement (M&R) wells. The marginal increase in the cost of M&R wells is very unlikely to outweigh the benefit of keeping the plant operating at full output. The modeller must be aware of this issue and may well choose to set the degradation parameters to zero, whilst marginally increasing the frequency of drilling M&R wells.

4.5 Plant O&M Costs

The model has taken a very simplistic approach to representing power plant and steamfield Operations and Maintenance (O&M) costs. This may be challenged by financiers (and especially by accountants, as distinct to bankers) because they tend to think in terms of a chart of accounts for the operating company, with such headings as salary and other employment related costs, vehicle operations, spare parts costs and external contract costs. However, existing plant operators tend to be either very secretive about these costs (if they are private sector) or not really know accurately what they are (if public sector). The available data does not therefore justify a more refined approach to this item and the overall, composite format suggested is probably as accurate as it will be possible to be, unless the owner is itself an existing, well established and experienced operator or has single, composite contract with an operator. The North American Electricity Reliability Council is a useful source of reference data for overall O&M costs like this.

4.6 Carbon Credits

Even though the Kyoto Protocol has not yet been ratified, carbon credits are already proving to be an important feature of the financing of geothermal projects in developing countries (which is where many of them are!). Calculation of carbon credits is really quite simple. Given knowledge of the average NCG content and composition for the resource, the actual CO_2 discharge can easily be calculated. The modeller needs to check on the marginal generation being displaced and a reasonable starting point is heavy fuel diesel. It is then easy to calculate the actual and avoided CO_2 discharge per kWh and hence the total annual credits in tonnes of CO_2 per year. It is then necessary to ascribe a value to the credits and external advice will probably be required for this. A realistic figure being currently quoted, based on contracts that have been placed through the European Union, is 5.0 US$/tonne. Changes in this figure can make quite a noticeable impact on the project debt ratios, so it is probably in the project's interest to seek as high a figure as possible and in order to do this to start the process of carbon credit commercialisation as early as possible.

CONCLUSIONS

The Pro-Forma Geothermal Project Financial Model provides a useful starting point for someone experienced in using Excel spreadsheets to develop a project specific financial model, with confidence that the major technical and financial elements of the model are correctly represented and integrated. Caution needs to be observed in developing the project specific model in order to realistically represent the various processes that will affect the project and its financial performance, but a well presented handbook will help the modeller through this process. Once the basic model is erected, the extraction of various indicators is relatively simple as the users are presented with financial information in a conventional form of projected financial statements. The projected financial statements will also be of benefit to the project company in planning its future operations.