Managing Risks and Optimising an Energy Portfolio with PLEXOS®

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Leading the field in Energy Market Modelling

1 Introduction

Energy markets inherently exhibit far greater risk compared to traditional financial markets such as equities and bonds. Energy commodities in general display differentiating characteristics when compared to other asset classes which make conventional approaches to valuation, hedging and risk management a challenge for even the talented of risk managers. Market fundamentals play a larger impact with both supply and demand factors causing price behaviour to be very uncertain and at times volatile when compared to the price behaviour of other asset classes. Weather, infrastructure failure and fuel shortages coupled with rapidly changing demand for electricity on a daily or even hourly time scales make accurate price forecasting a constant concern. This white paper aims at analysing some of the quantifiable risks facing integrated energy companies and how fundamental optimisation software coupled with systematic and robust analysis can help decision makers manage risk and optimise their energy portfolio to retain their competitive advantage.

2 What components make up an Energy Portfolio?

Before we can investigate what risks are inherent to an integrated energy company and how we can optimise around these risks, we first need to define what exactly an energy portfolio could comprise of. Typically an energy portfolio will comprise two distinct parts, a physical portfolio of assets and a financial portfolio sitting alongside.

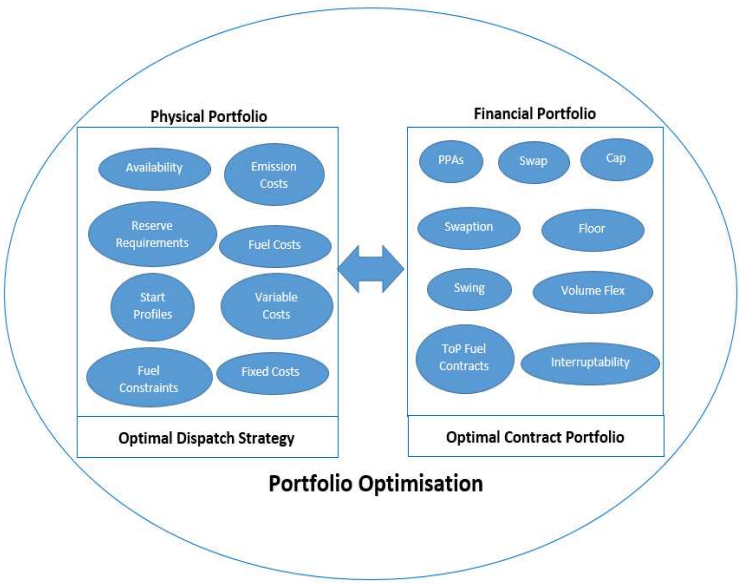


Figure 1 - Elements of an energy portfolio to an integrated energy company

In figure 1 on the preceding page, we can see that the physical portfolio comprises constraints and costs around a company's physical assets which might be generators, hydro storages and gas storages. Generators have a variety of costs that need to be considered in the optimal dispatch such as fuel, start-up, maintenance and emission costs; all which make up the short run marginal cost (SRMC) of the generator. On top of these costs there may also be fixed costs and even debt or equity costs representing the cost servicing the debt or paying dividends to shareholders that also need to be respected. There are also technical constraints on generators such as ramp rates, minimum stable generation limits, minimum on & off times as well as fuel and emission constraints that must be considered and optimised accordingly. Another major risk to the physical portfolio is the availability risk or outage risk that is present, what would the risks be to a company if a generator suddenly unexpected shutdown for an hour or even an entire day?

Alongside a physical portfolio of an energy company will sit a financial portfolio comprised of financial contracts with the primary aim of such a portfolio to minimise the risk of volatility in revenues from the sale of electricity, other bi-products (ancillary service or reserves, renewable energy certificates etc.) and in addition to reduce the price risk of purchasing the commodities used in the generation process (such as coal or gas). The financial portfolio therefore includes a variety of financial contracts such as futures, swap and forward contracts, options, financial transmission rights (FTRs), power purchase agreements (PPAs), take-or-pay (ToP) fuel contracts and even interruptability rights to physical load within the system also called demand side response (DSR). With such a large variety of financial contracts available to an energy company, any risk manager or portfolio manager has a challenging task of constructing the optimal contract portfolio to complement their physical asset portfolio.

3 What risks are there in an Energy Portfolio?

Given that there are both physical and financial elements to consider in an energy portfolio we need to carefully investigate the overall risks to the portfolio and how these can be best managed. The primary risks to an energy portfolio can be broken down into four primary buckets, as seen below in Figure 2.

Both counterparty and liquidity risks are generally mitigated by having individual counterparty limits as well as buying and selling financial contracts through a variety of different mediums (over-the counter and via regulated exchanges). However these type of risks can be difficult to accurately quantify as they generally occur when there is a low probability, but high volatility event in which would affect multiple counterparties at the same time. Asset and Market risks however can be analysed and quantified and this is where ***PLEXOS® Integrated Energy Model*** can be used to carry

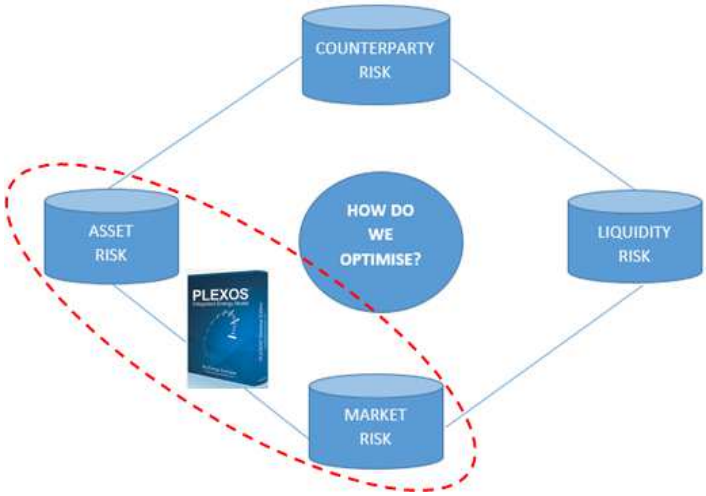


Figure 2 - Typical Risks in an Energy Portfolio

out a detailed analysis of the risks in an energy portfolio and assist in determining an appropriate optimisation strategy going forward.

Asset risk or operational risk is the risk of a physical asset non-performing which spreads across the whole asset life cycle. Long term risks to consider could include project risk, build risk, regulation risk, tax risk or even governmental risk. While short to medium term asset risks are focused on the capacity risk of generators not performing (outage risk), volume uncertainty (demand risk), weather risk (if the company owns renewable assets and relies on wind or water inflows) and even transmission risk that would affect route-to-market. Market risk is the risk that the value of an investment will decrease due to moves in the underlying market. Integrated energy companies have natural market risk both in the procurement of fuel through commodity markets (e.g. coal, oil, natural gas) as well as in the market where they will sell their generation and bi-products (RECs & reserve products) into. The accurate modelling of spot and forward prices and how they evolve over time is one of the most important part to any risk management and optimisation strategy. An accurate spot price forecast also forms the basis to many typical risk models to determine Value-at-Risk, Profit-at-Risk and Earnings-at-Risk.

4 Using PLEXOS® to manage risk and optimise an energy portfolio

PLEXOS is an advanced market simulation tool designed to build a fundamental model of an energy system or market by taking a 'bottom up' view. PLEXOS can be best utilised by taking two distinct approaches either to minimise system cost, whereby replicating the operation of an energy market dispatch system or to maximise profit for a company or companies in an energy market. When PLEXOS is configured in a 'profit maximisation' function, then some or all of commodity prices e.g. electric spot prices and/or fuel prices are 'known', being defined either as deterministic or stochastic series the objective function changes to include revenues as well as costs in optimisation process so the overall objective is to maximise profit.

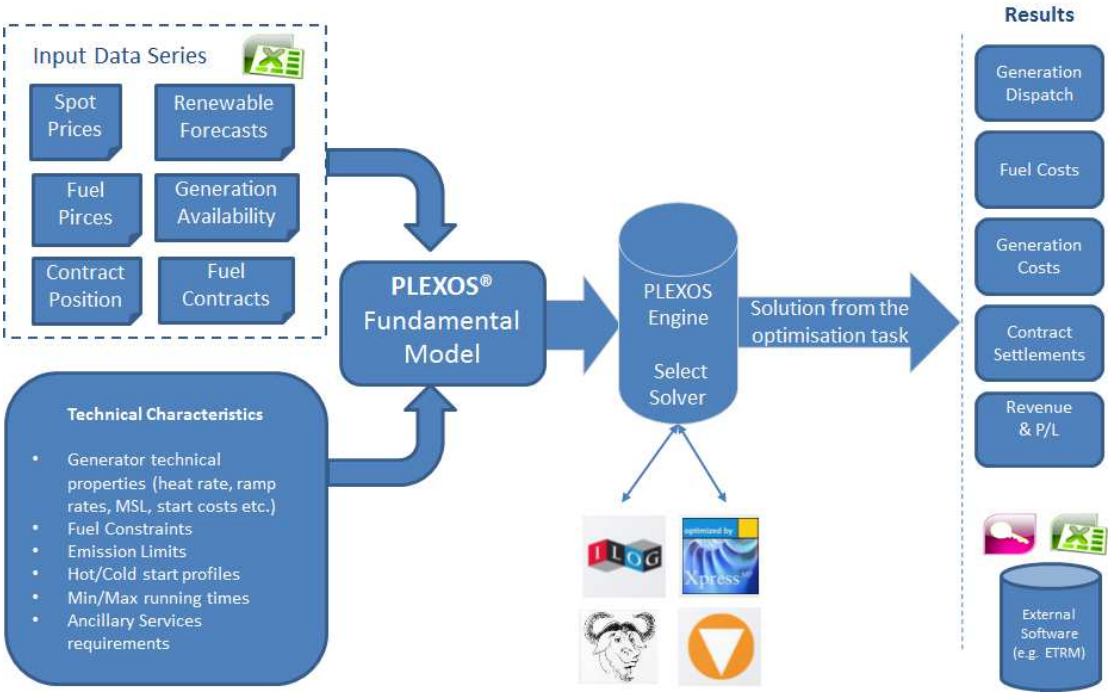


Figure 3 – The structure and flow of a Profit Maximisation model in PLEXOS

As discussed earlier one of the most important aspects of any risk management and portfolio optimisation strategies is to capture an accurate spot price forecast and how this may evolve over time. Setting up a profit maximisation model with PLEXOS enables the modeller to input multiple samples of price forecasts to represent spot electricity, fuel and even reserve prices if desired. This approach allows a company to better understand the sensitivity of their price forecasts and resulting effects not only on the potential dispatch decisions of each unit but the whole cash flow situation of the company and resulting variability in profit.

Apart from reducing the volatility of cash flows there is also another important aspect to hedging and this is minimising the probability of a very large loss which is generally what most risk managers are concerned about. Most energy companies welcome positive volatility because it an allow them to earn extra profits, however negative volatility are situations that want to be avoided as much as possible. In helping to better quantify and understand the probabilities and impact of such an adverse move PLEXOS features tools to better understand both Profit-at-Risk and Value-at-Risk.

5 Example: Risk management in an integrated energy company

Consider a hypothetical example of a small integrated energy company (see figure 4 below) holding a portfolio of three thermal and one wind generators and a mix of standard financial contracts. To enable the profit maximisation objective function, there is also a 100 sample price forecast given over a single month which has been created from a single price forecast using a endogenous auto-correlation model within the PLEXOS software, alternatively samples could have been created from external software and inputted. The detailed properties PLEXOS offers users allows a model to be constructed to very accurately depict technical characteristics and limitations on generators such as polynomial heat rates, varying start costs and states, fuel, emission constraints and ramp rates.

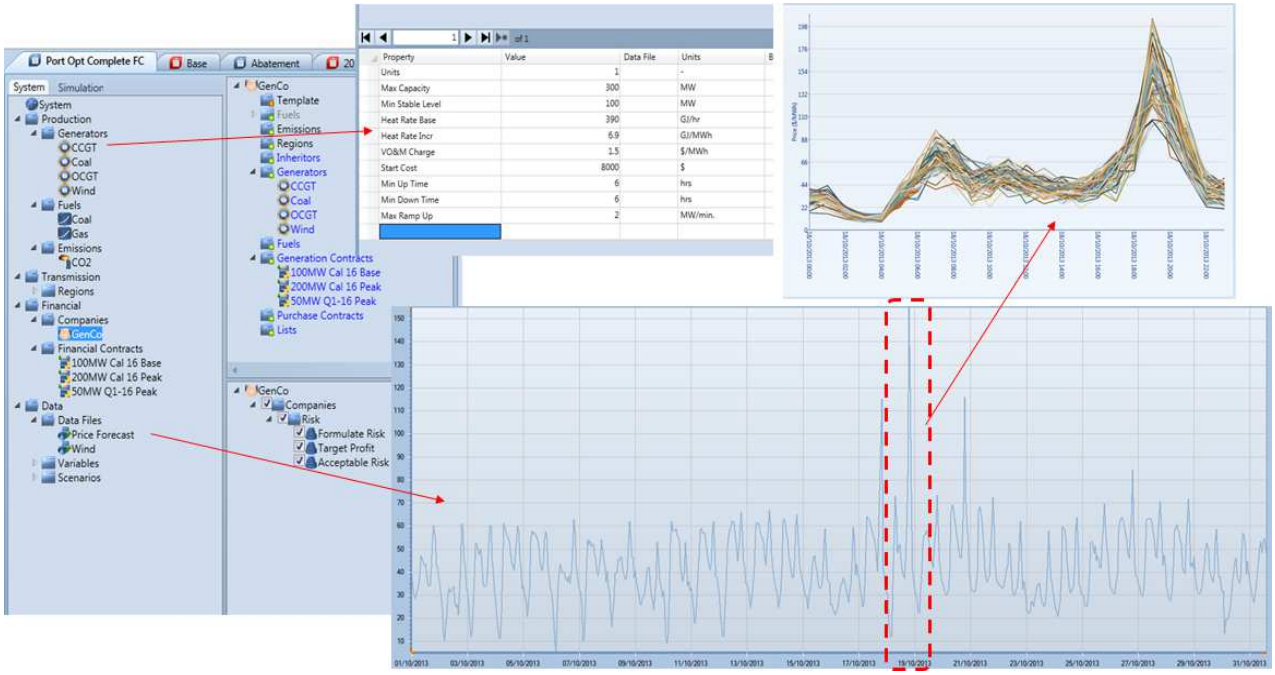


Figure 4 - Example setup of a profit maximisation model for an integrated energy company

From this simple example it is apparent that to meet just a single constraint then multiple options must be considered and each of the options must be evaluated against multiple factors that affect the company profits and eventual risk levels. There will be thousands of different ways to meet all the constraints in a model with each option producing a different profit level, PLEXOS will evaluate all the possible options and identify the one that will result in maximum value across the 100 different price samples. If we firstly analyse the results on a single day using the mean of the 100 price samples we can start to see what information can be utilised to aid a company's decisions making for day to day operations and risk management (see below figure 5). PLEXOS allows us to report the generation schedule of all our generators in our portfolio as well as detailing both the costs and revenue breakdown over the day, this is just a small snapshot of the results that can be reported and further analysed.

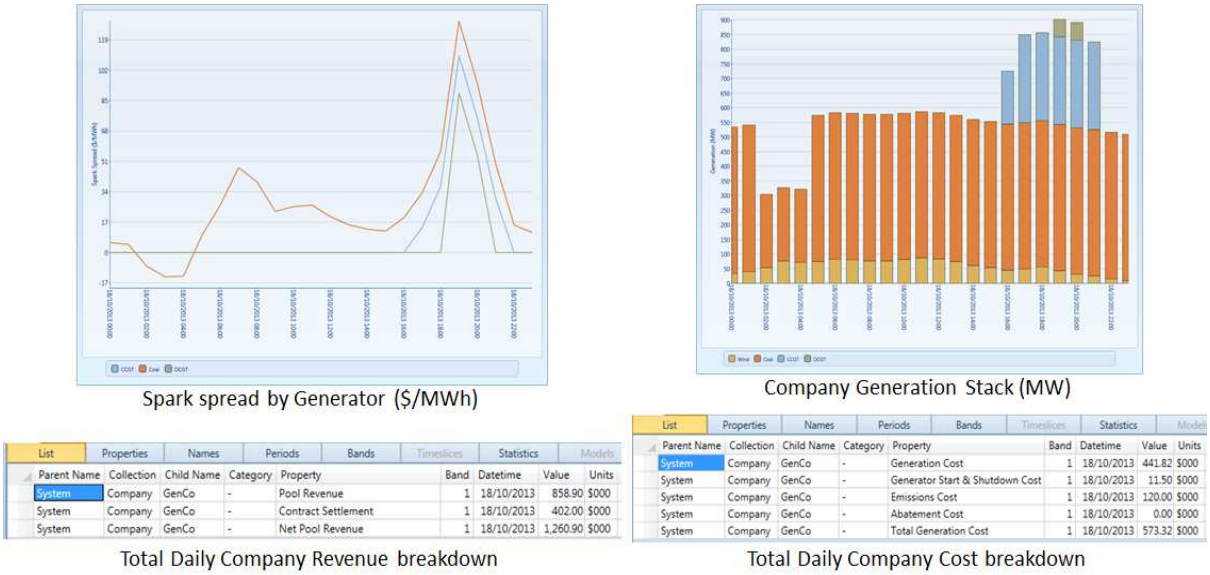
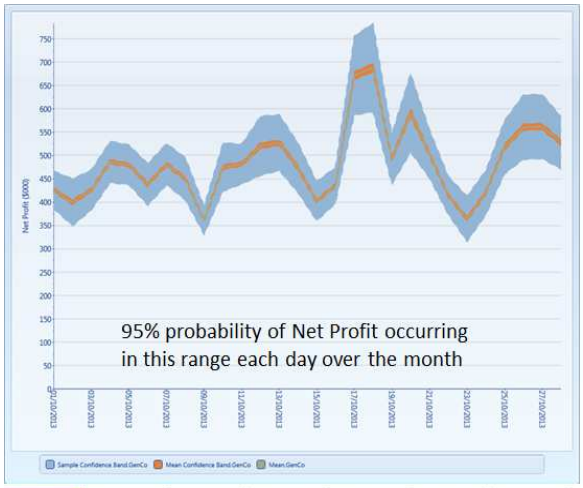


Figure 5 - 1 Day results example from PLEXOS

If we use the same model to analyse at a larger timeframe, for example the whole month of October we can run a similar profit maximisation however this will be optimised across the entire month instead of a single day to better understand how a company's profitability may be effected. In addition any fuel or emission constraint that is present in the model can also be properly optimised and allocated across the month with the use of the multi-phase optimisation approach that has been implemented in PLEXOS. This approach allows constraints that are longer than 1 week (for example yearly emission limits on generators or long term take-or-pay fuel supply contracts) to be properly optimised across a single optimisation step (in this case 1 month) and then targets passed down to short term phases where unit commitment and other short term technical constraints can be correctly modelled by PLEXOS.

Looking at the monthly results presented in figure 6 on the next page, we can now see in greater detail the effects on the company's profitability of running the same optimisation across a monthly period. We can see the range of daily profitability outcomes for the company as represented by the probability distribution of net profit chart on the right as well as a left chart which details confidence bands

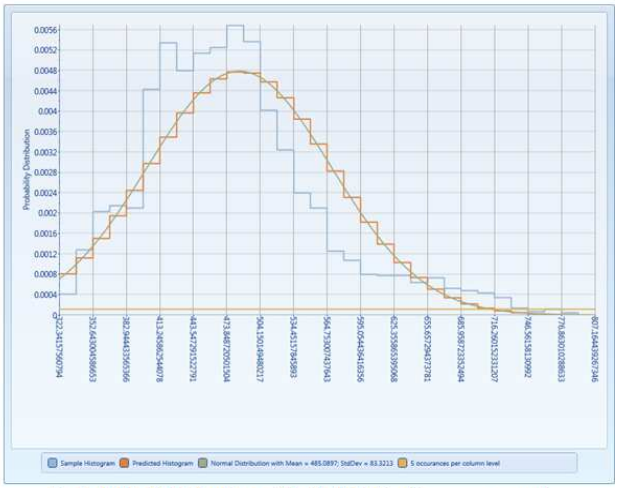
indicating the reliability of the estimate of net profit for the company. We are also able to report the Value-at-Risk (VaR) figure at a daily, or in this case monthly level to use in external risk management software if required.



List | Properties | Names | Periods | Bands | Timeslices | Statistics

Parent Name	Collection	Child Name	Category	Property	Band	Sample	Datetime	Value	Units
System	Company	GenCo	-	Net Profit	1	Maximum	October 2013	13,959.29	$000
System	Company	GenCo	-	Net Profit	1	Minimum	October 2013	13,140.67	$000
System	Company	GenCo	-	Net Profit	1	Std Dev	October 2013	150.94	$000
System	Company	GenCo	-	Net Profit	1	Mean	October 2013	13,582.51	$000
System	Company	GenCo	-	Net Profit	1	VAR 5%	October 2013	13,335.20	$000

Monthly Totals across all samples



Probability Distribution of Daily Net Profit across samples

Figure 6 - Monthly results example from PLEXOS

5 Final comments & implications for risk managers

The complexities faced by integrated energy companies in risk management and optimisation across both the physical and financial side is clearly a challenge that rivals one of the greatest within the financial world. Given the large number of physical and financial properties and constraints that need to be accurately captured as well as optimised to ensure that a company can maximise the value of its assets, there will always be a need for a complex analysis and optimisation tool such as PLEXOS. For energy companies that wish to maintain and grow their competitive advantage and utilise their physical assets and contracts to their best of their ability and in doing so, outperform their competition they must ensure they understand the risks to their portfolio under a range of different outcomes by using advanced portfolio optimisation software coupled with systematic analysis of the results provided by such a tool.

For further questions regarding this white paper or information about PLEXOS and it's capabilities in risk management and portfolio optimisation, please contact:

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