



## The changing energy landscape

Recent developments in energy markets have highlighted the need to adapt to new pricing and risk management approaches. While in the past it has been relatively straightforward to calculate a 'merit order' table for various generation technologies, it is becoming increasingly necessary to combine various forms of generation (and storage) to ensure reliability at the lowest cost.

As such combinations will inevitably take the form of partnerships (for example a new gas generator partnering with a number of intermittent renewable generators) or service offerings (for example an energy storage facility offering services to renewable generators), it becomes extremely important to precisely calculate the value of such arrangements.

The nature of intermittent generation means that such calculations must consider the timing aspects of any potential variation and price them accordingly. As such, average figures such as levelised cost of electricity and short-run marginal costs are unsuitable for this kind of analysis.

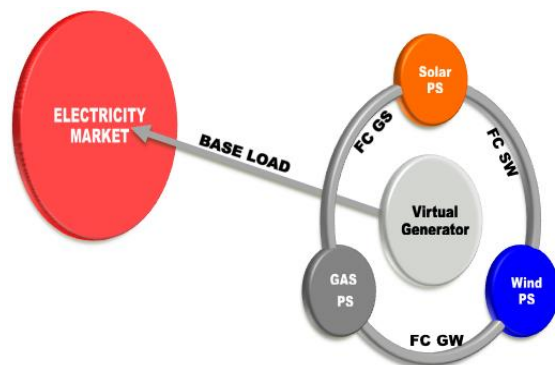


Figure 1 - The Virtual Generator

<sup>1</sup> A proposal for the aggregation of geographically separated generators was submitted by AEMO to AEMC, National Electricity Rule Change Request – Small Generation AGGREGATOR FRAMEWORK, 22 December 2011, currently under consideration.

## New approaches to meet new challenges

GTS has developed a two-faceted solution enabling financing and integration of intermittent generation like solar and wind into the NEM. This is comprised of:

1. A methodology for constructing partnership contracts between an intermittent generator and storage / gas or between complimentary renewable generators in the same region; and
2. A set of financial derivatives addressing the needs of generators and encouraging / guiding storage and reliable generators to compliment renewables.

## Volumetric contracts: Virtual Generator

The Virtual Generator (Figure 1) financially links physically separated variable generator and energy storage or a rapid ramping generator (e.g. gas-fired), in a single NEM entity (i.e. a NEM-registered generating and bidding system<sup>1</sup>). The Virtual Generator acts as an intermediary between partnering generators and NEM by bidding in the spot market on behalf of the partners.

The VG is an entity, which is able to guarantee reliable generation 24x7. As such, it bids into the electricity market as a single bidder and is dispatched as a market-scheduled participant. Both solar and wind outputs<sup>2</sup> can be forecasted so that the gas generation required can be scheduled in advance with some margin for error. We have demonstrated the financial viability of the Virtual Generator using actual data<sup>3</sup>.

<sup>2</sup> In certain circumstances Wind Power station as complimentary source provides additional advantages

<sup>3</sup>Radchik et. al. *Ensuring long term investment for large scale solar power stations: Hedging instruments for green power*. Solar Energy (March 2013).

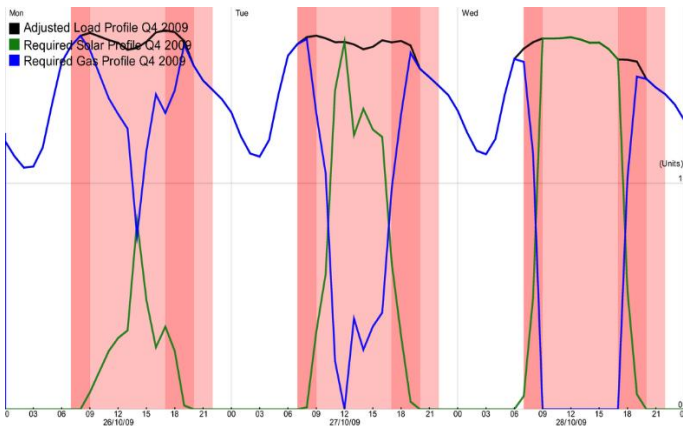


Figure 2 - Example of Profiles

Figure 2 shows an example of solar and gas contract profiles combined to match a typical NSW Q4 state load profile. It demonstrates that the GTS Virtual Generator is capable of supplying green baseload – an attractive feature for obtaining a PPA.

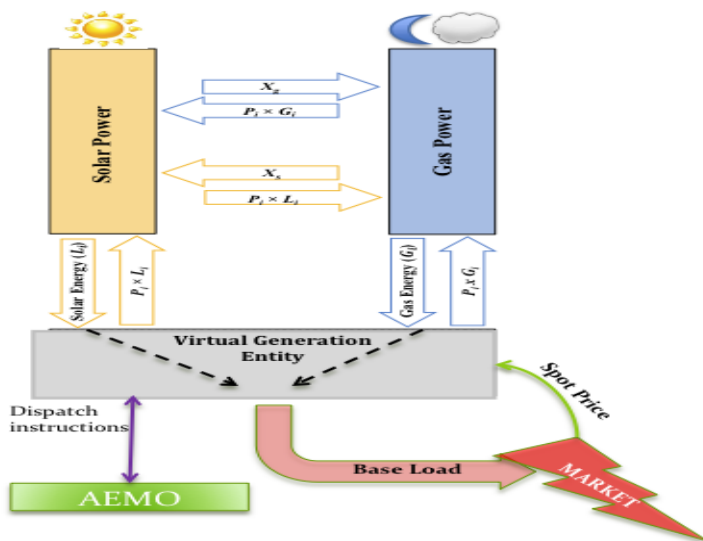


Figure 3 - Cash flows

Swap cash flows between Solar and Gas power stations operating under a Virtual Generation Entity are shown in Figure 3. The contracts will compensate each party for the intermittence in supply due to exogenous events

## Volumetric Derivatives

Existing standard OTC or exchange-traded energy derivatives are designed to hedge risks associated with variation in electricity market clearing price. These hedging instruments are inadequate for intermittent power as they don't protect against sudden drops in output. GTS *volumetric derivatives* are tailored to provide each party with revenue compensation due to a variation in market clearing price as well as in solar insolation or drop in wind speed and thus renewable energy generated for any given half-hour interval. The *strike* of the *volumetric derivative* is set by a historical or forecasted level of renewable power generation over a financial quarter which serves as a contract parameter. Examples include *Volumetric Future* (or Swap) and *Volumetric Floor*.

While the *Volumetric Future* (or *Volumetric Swap*) is a 'linear' hedging instrument, the *Volumetric Floor* is a quarterly sequence of half-hourly put options similar to standard electricity Floor options. It pays the buyer (quarterly settled cashflows) on every instance the output drops below the Floor level.

## About Green Trading Systems

Green Trading Systems (GTS) provides value-added data for renewable-centric energy approaches including trading, generation, storage and retail. GTS also develops financial products addressing the intermittency of renewable generation in the most cost-effective manner.

The directors of GTS have over 60 years of combined experience in energy markets, solar generation, financial modelling and risk management. We have spent more than a decade developing our current suite of models and tools and from this base are building a data analytics platform for forecasting, derivative pricing and storage optimisation applications.