GAS AND RENEWABLES: PARTNERS IN POWERING INDUSTRY.

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Woodside believes gas-fired power and renewables are ideal partners to power industry. There are environmental and commercial reasons to integrate solar with gas-fired power generation to support industry, especially in the Pilbara where sunlight is plentiful. This would increase energy efficiency, and reduce fuel costs, enabling a transformative shift towards a lower carbon future without compromising reliability or affordability.

Woodside is maturing a concept to integrate an industrial scale solar farm, a battery energy storage system, and reciprocating gas engines, to provide hybrid renewable, dispatchable, power generation for industry on the Burrup Peninsula.

Feasibility studies have identified that a combination of Solar Photovoltaics (PV), with high efficiency, fast starting, medium speed gas engines, can supply reliable power at world class energy efficiencies.
Introduction
The partnership of natural gas with renewable energy technology is pivotal in changing today and tomorrow’s energy mix. As an efficient, flexible, energy source, gas fuelled power generation is an ideal partner alongside intermittent renewable generation. Together they provide the dispatchability, and grid stability, necessary to allow high renewable penetration whilst meeting the capacity, availability, and reliability needs of an industrial power microgrid.

Background
Woodside is an Australian oil and gas company and a leading global operator of offshore gas platforms, Floating Production, Storage, and Offtake vessels (FPSOs), and onshore Liquefied Natural Gas (LNG) facilities. At present Woodside operates dedicated microgrids, powered by gas turbine generators (GTGs), at each of its onshore LNG facilities. As individual gas turbine generation units reach the end of their design life Woodside is undertaking feasibility studies to understand the opportunity to develop suitable hybrid renewable power generation concepts as a replacement. These concepts consist of Solar Photovoltaic (PV) panels, Li-ion Battery Energy Storage Systems (BESS), and medium speed gas engines units.

Figure 1. Woodside Operated Onshore LNG facilities
Hybrid Renewable Power Generation concept

The Woodside operated LNG plants are in the Pilbara region of Western Australia at a latitude of 20.7° S. The regional climate is arid and tropical, with high temperatures, and low irregular rainfall associated with cyclones during the summer season (Dec. – April). The region has a very high quality solar resource with an annual average of 23MJ/m² Global Horizontal Irradiance (GHI). However, any solar PV installation needs to be suitable for a cyclonic wind region necessitating a fixed panel design.

Fixed panels installed at a northward tilt between 17-18° will be exposed to approximately 73% of the energy available, and convert approximately 15-20% of that to electricity (depending on panel efficiency and derating factors). For a fixed panel installation, the peak solar resource varies seasonally 30%+ (Jan GHI - July GHI). Consideration was given to the array size so as not to overcapitalise on solar PV capacity and generate electricity which then cannot be dispatched during the summer months due to grid constraints.

In non-cyclonic regions there is the potential to further reduce the array size, and optimise solar resource capture, through tracking technology that maintains the panels perpendicular to the sun throughout its daily journey. This increased capture is visible as the Direct Normal Irradiance (DNI) in figure 2. This optimization is not suitable for the Pilbara region as it is likely to be damaged in cyclonic winds compared to fixed panel design. As previously stated a fixed panel design will capture the 'thinner' GHI solar resource profile shown in figure 2 and would need to be sized based on the maximum summer GHI profile.
Providing dispatchable generation to support intermittent renewable generation without eroding the overall efficiency of the system, and maintaining the lowest possible levelized cost of electricity, requires the gas generation to provide:

- High thermal efficiency at low capital costs (recognising decreased utilisation when gas fired generators are paired with renewables)
- Minimal start/stop operating cost impacts
- Flexibility:
  - High thermal efficiency at full and part loads, enabling online turndown to accommodate renewable generation, without adverse efficiency impacts or start/stop operating cost impacts
  - Fast start-up and ramp-up to full load. Ideally on the order of 5-10mins in order to minimise BESS costs

Several models of medium speed reciprocating gas engines could meet the above criteria. Consideration should also be given to:
- NOx emissions and the feasibility/cost of Selective Catalytic Reduction systems fitted to the engine exhausts
- Fuel slip within the engine piston/combustion chamber. Unburned natural gas (Methane) is a greenhouse gas and so ensuring minimal fuel slip is necessary to minimise the overall CO2 equivalent emissions
- Maintenance intervals and costs.
- Optimisation of installed gas engine capacity against required electricity nominations

Ensuring that the overall system functions to the required level of availability, reliability, efficiency, and power quality requires the control system and BESS to provide:

- Power equivalent to the single largest gas generation unit, and energy capacity sufficient to enable time to make operational load or generation responses in the event of a generator trip
- Power, energy capacity, and response time to maintain grid stability across credible Solar PV cloud events
- Rate of change of frequency support to maintain the target electrical inertia (kW-s/kVA) of the system
- Other grid ancillary and electrical protection services

A hybrid power plant consisting of gas engines, solar PV at a peak penetration of 40-60% of the gas engine capacity, and BESS with sufficient capacity to remove the need for fired spinning reserve was modelled. The performance of this system in fuel gas usage studies showed a significant benefit. The average virtual ‘heat rate’ of <7GJ/MWh over 3 days shown in Figure 3 represents a virtual ‘thermal efficiency’ of over 50% and a peak solar PV penetration of 55%.

With further detailed network studies it may be possible to increase Solar PV penetration to a peak of 65% and therefore increase virtual ‘thermal efficiency’ to almost 60%.

Higher efficiency power generation from a hybrid renewable power plant is likely to save fuel gas compared to the existing installed infrastructure. Saved fuel gas can be converted into incremental LNG & Domgas production, and will therefore increase revenue over the life of the plant, Increased efficiency also leads to significantly reduced CO2 equivalent emissions per tonne of product produced. An overall focus on optimising the components of the hybrid renewable power plant, and basing the power plant design on Greenfields Utility specifications will also lead to increased capital efficiency.
Figure 3 Hybrid renewable generation profile and heat rate for a flat 90MW industrial load

Conclusion

A concept consisting of high efficiency, flexible, gas fired power generation, paired with solar PV generation, and a BESS, could provide industrial baseload power to facilities in the Pilbara. This concept can gradually replace aging power generation infrastructure - resulting in a mixed grid with a hybrid renewable component, and decreased emissions in the region.

Natural gas fired power generation offers a complementary value proposition to intermittent renewable generation technology such as solar PV. Hybrid renewable power stations will catalyse the transition to a lower carbon future, with natural gas providing the reliable, flexible, and dispatchable base load generation component, to homes and businesses.

Natural gas is the most flexible fuel source currently available for thermal generation. It is this flexibility combined with efficiency, and low emissions which will drive gas market share in the world energy mix. As an industry we are best placed to understand, and advocate, how to integrate these technologies for the benefit of all.