Anchor Energy

Nseleni Power Corporation

Fact Sheet: Synergy with Renewables

The Anchor Energy LNG terminal (AELNG) and the Nseleni Independent Floating Powered Plant (NIFPP), a large combined cycle power plant, is a project to be established near the sensitive natural environments in the port of Richards Bay.

Far from being in competition with renewable energy sources such as solar and wind, the Nseleni Independent Floating Power Plant (NIFPP) has the ability to maximise the use of renewable energy projects by Eskom. While the Government's Integrated Resource Plan calls for greater use of "clean" energy sources, renewables and other clean energy technologies cannot in isolation sustain security of supply.

A combination of dispatchable technologies that support carbon reduction commitments, is required. The NIFPP is such a solution.

Gas turbines

Gas turbines, especially at the scale being proposed for the NIFPP, are versatile in that they can be used as baseload, mid-merit, peaking or emergency power stations; or a combination thereof. Where renewable power is available, it can be utilised by Eskom to the maximum extent, knowing that any reduction in supply, even if unexpectedly and momentarily, can be compensated for from a ramp-rate (also referred to as load-following) power station such as the NIFPP.

Grid management

South Africa has a large and complex electrical grid which is based on the principle that if electricity is required, it can be provided instantaneously. The grid is made up of power generation facilities (mainly large coal-fired power stations); high voltage electrical transmission lines which transfer power (transmission) from where it is generated to where it can be distributed; and distribution networks which provide the correct voltage (best thought of as the 'push' that moves electrical charge) and current (the electrical charge itself) to end users.

The grid also has multiple substations with transformers that step up the voltage for transmission and step it down for end users. The substations contain switchgear (essentially electrical disconnect switches, fuses or circuit breakers) to control, protect and isolate electrical equipment. Switchgear is used both to de-energise equipment to allow work to be done, and to clear faults downstream. If there is a fault on the circuit, the system will trip (the electrical circuit will be opened automatically to discontinue the flow of electricity).

If the grid has the capacity to precisely supply the power demanded and there are no faults, the grid will be stable. Demand changes continuously, sometimes following well-established patterns such as the morning increase in demand as people wake up and start using electrical appliances; and in industrial applications that only use power during the day. Demand also generally increases from summer to winter when power is used for heating and lighting purposes.

Other circumstances, where the demand changes unpredictably, include when a large power-use operation trips out or multiple users start up industrial processes. Even where the power demand patterns are well understood, there is still uncertainty in exactly how power will be demanded at any given point. This means that the grid must always have reserve capacity so that there is enough supply to meet the demand at any given time. This excess capacity (spinning reserve) is generally about 15% higher than the anticipated demand.

Load shedding occurs when the grid does not have enough reserve capacity to guarantee that all demand can be met. Load shedding is implemented countrywide to protect the electricity power system from a total blackout, i.e. the complete shutdown of the grid. If demand exceeds supply, the power system could trip in its entirety.

If the South African grid trips, the system has to be started slowly and systematically, energising one power plant and one section of the country at a time. It could take up to two weeks to restore full power after a total grid trip in South Africa, with disastrous economic and social consequences.

Dispatchability

Dispatchability refers to the ability of a power generator to be engaged at a moment's notice and to "dispatch" power in direct response to changing (especially increasing), power demand. The benefit of a national grid is that the grid can accommodate multiple sources of power generation which can be brought online as and when needed and to dispatch the power to meet the demand.

A key challenge for Eskom with the introduction of large quantities of renewable energy, is the complete lack of dispatchability of this power. Renewables generate power in response to the availability of their primary energy sources, such as sunlight and wind. While solar thermal technology has the potential for improved dispatchability, wind and solar only work when the wind blows and the sun shines.

The dispatchability issue could be dealt with by developing improved storage of electric power such as batteries. To this end, there are already initiatives to facilitate increased storage through battery arrays. These, however, are limited in terms of capacity as well as duration. Consider the world's biggest battery factory, the one Tesla built in Nevada: it would take 500 years for that factory to make enough batteries to store just one day's worth of America's electricity needs.

To make renewables commercially viable in the face of dispatchability constraints, Eskom currently has a "take it or pay" tariff obligation with the renewable Independent Power Producers (IPPs). Whenever the solar and wind farms produce power, it is dispatched and Eskom has to accept the power regardless of whether it is needed.

The effect of this tariff is that the power is significantly more "expensive" than the direct production cost as the cost cannot be recovered if the electricity is not sold to an end user. The variability of the power inputs and matching those with power demand, introduces significant complexity in electrical grid management, especially one as complex as the South African grid.

With power being generated by renewables in a grid, the uncertainty of demand is extended to an uncertainty of supply, and the grid operator now has to match variable demand with supply that is also variable.

INTEGRATING RENEWABLES INTO THE GRID

A number of ancillary services are required to safely run a large, interconnected power system such as the national grid. Such ancillary services cannot be delivered by renewable energy sources, unless the entire market structure changes. These required ancillary services include frequency regulation, instantaneous reserve and black start.

FREQUENCY REGULATION

Frequency control or regulation means that active power generated should at each moment equal the active power consumed (active power is that which does the useful work such as driving motors and lighting and is dissipated through that use). A deviation from this equilibrium results in a deviation from the 50hz frequency of the national grid.

Eskom uses frequency control as the mechanism for a stable grid. This control can be achieved by either adding additional generating capacity to the grid or removing load (demand) from the grid in order to maintain the equilibrium.

Eskom has achieved this reduction in demand by “load shedding” its clients. With the take-or-pay contracts applicable to renewable energy power projects, there is no incentive to either provide frequency control capability or to react to changes in load.

Gas turbines, especially at the scale being proposed for the NIFPP, introduce a significant ramp rate (the rate at which power can be brought online in response to demand). The total ramp rate is simply a function of the number of turbines online for NIFPP as well as the individual units’ unique ramp rate.

Eskom can therefore use renewable power to the maximum extent, knowing that any reduction in supply, even if unexpectedly and momentarily, can be compensated for from combined-cycle gas turbine (CCGT) power utilities.

Even where frequency control is available from renewable sources, it is extremely difficult to effect frequency regulation only with renewables. Wind turbines are easier than photovoltaic, but requirements for frequency control will have to be addressed from other sources.

The synchronous gas turbines are an attractive way of doing so. In an alternating current (AC) electric power system as used in South Africa, synchronisation means matching the speed and frequency of a generator or other source to a running network. An AC generator cannot deliver power to an electrical grid unless it is running at the same frequency as the network.

Gas turbines, on the other hand, are ideally suited to this, as they are able to rapidly respond to frequency deviations in order to regulate the frequency within the limits imposed by the Grid Code.

FAULT CURRENT

Synchronous generation sources such as gas turbines, are also an essential source of fault current. Inverter-based technologies, such as solar panels, do not provide sufficient current under fault conditions. This means that where there is a trip from an inverter source of power, there is no way for the grid operator to pinpoint the exact source of the fault.

By way of example: If a fault were to occur on a 300 km transmission line being supplied by an inverter-sourced power supply, the entire line would need to be inspected to locate the fault. The fault current generated by synchronous generation can be maintained for a specific period, thereby allowing the fault to be immediately pin-pointed for repair.

In addition, effective voltage control is heavily influenced by network fault level, as small changes in load can have a significant impact on voltage in weak networks (those with little fault current typically associated with renewables). The fault current contribution from the gas turbines therefore increases the system fault level, which also improves the voltage control performance of the network.

Instantaneous reserve

Total renewable energy production normally falls away at the same time as power demand increases. This energy generation reduction is due to the load profile of especially solar PV installations that reduce towards the end of the day, although wind turbines often experience greatest wind speeds in the late afternoon/early evening.

This drop-off imposes increased ramping requirements on the remaining generation resources as they have to cater for both the normal load increase and the "lost" solar contribution. Units and/or facilities such as CCGTs that are able to rapidly change power output, are ideally suited to this environment. This drop-off effect can be largely compensated by the addition of energy storage (batteries or other), but this comes at a significant financial cost, especially at the scale required for the renewable projects.

Black Start

A black start is the process of restoring an electric grid without relying on an external electric power transmission network to recover from a total or partial blackout. In the absence of grid power, a black start is needed to provide the initial power needed for the progressive start-up of the different generation sources.

South Africa has particular challenges in dealing with such a network trip. To this end, a gas-turbine facility is an ideal candidate to provide a black-start service as the facility has the ability to self-start without any power requirements from the grid and then to supply local customer load.

The fact that there is a significant store of fuel on site, independently available and outside the influence of the grid, means that the NIFPP qualifies as a true black-start facility as opposed to only having a self-start capability.

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