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### **Mozambique Domgas** Gas to power opportunities

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According to the World Bank, Sub-Saharan Africa had an electrification rate of 48% in 2018<sup>1</sup>. Of the households, businesses and communities that have access to power, most suffer from poor and expensive service from their local utilities along with regular blackouts that can last for days. The Mozambique Domgas allocation (refer to intro) suggests that gas could play an increasingly important role in meeting Sub-Saharan Africa's increasing demand for power – fuelling economic growth for the Southern Africa region.

Many of the challenges to the regional energy supply include population growth and urbanisation resulting in increased electrification needs. This is driving rapid build-out of new generating capacity, coupled with the retirement of a large portion of legacy coal-powered units. This is then combined with the need to stabilise energy prices for consumers after many years of large rate increases as well as the need to transition the grid to allow for higher levels of cheaper cleaner renewable energy. All of this needs to be handled in an environment where capital is also very constrained and returns must be attractive. Natural gas has a strong role to play in addressing some of these challenges.

In addition to providing strategic security of supply for electricity generation, the development of natural gas reserves will provide significant investment opportunities to the region in infrastructure, jobs and new energy opportunities for industrial, commercial and residential applications. Gas-to-power is one area where the combination of cost competitiveness, security of supply, sustainability (emission reductions) and regional abundance as a primary energy source will result in increased investment momentum.





#### Why not use coal-powered energy generation?

Many believe that the decline in coal-powered energy generation is purely due to environmental concerns. While this is partly true, there is also a technical reason. On a \$/MWh basis, wind and solar energy are consistently setting new record low prices with further reductions expected for years to come. Apart from concerns around greenhouse gas (GHG) and other emissions, coal-powered generation is most suitable for baseload (i.e. consistent demand), and it is most economical when running close to nameplate capacity. However, demand from users varies, and now with increased renewable energy supplied to the grid, the supply will also vary, requiring a greater need for generation flexibility in order to stabilize the grid. Energy networks need a supply that matches these requirements - dispatchable, responsive and economical, even at partial loads. The U.S. Environmental Protection Agency (EPA)<sup>2</sup> conducted a global study of 9,719 coal power unit start-up events and found the following:

- 20% of boiler restarts fail and require the unit to be shut down again
- The average failed start combusted fossil fuel for less than 8 hours with a median of 4 hours – It can take hours of burning fuel before any electricity is generated, and 20% of the time the unit fails to start and needs to shut down again.
- Units typically (50th percentile of the 9,719 start event) produce only 30% of nameplate capacity after 3 hours and 38% after 4 hours, with still less than 80% of nameplate capacity being supplied 24 hours after start up.

Demand often peaks in the evening at the same time that solar generation is diminishing. Wind can be fickle as well. For coal, the alternative is to run the units continuously but only supply when electricity is needed, which results in additional cost and emissions while not producing any revenue.

Natural gas generation, on the other hand, presents itself as the perfect complement for increasing intermittent generation, as it has a very different response profile:

- A single stage gas turbine (Peaker plant) can produce 80% nameplate capacity after 11 minutes.
- A combined cycle gas turbine (CCGT plant) can typically produce 80% nameplate capacity 25 to 30 minutes after start-up.
- Ramp rates (the rate at which supply can be turned up or down) are typically 10% of nameplate capacity per minute.
- Gas-powered generation produces roughly half the greenhouse gas (GHG) emissions compared to an equivalent coal-powered unit.

Although energy storage may provide a solution to stabilise the grid and balance demand, the amount of energy storage required makes it unfeasible as a current solution. Whereas, natural gas-powered electricity generation can supply the needed energy while balancing supply, all while still being economical.

<sup>2</sup>U.S. Environmental Protection Agency, Office of Air and Radiation. Assessment of startup period at coal fired electric generating units. Peter Kokopeli, Jeremy Schreifels, Reynaldo Forte. 17 June 2013.

Currently, Africa is largely powered by hydroelectric and coal. Both can be problematic. Hydroelectric power can be unreliable due to climate-related events and is only possible in limited locations, where the appropriate geography permits. The social and environmental impact of flooding large areas also must be considered. Coal is largely being phased out because of increasing pressure over emissions, difficulties in securing capital funding and competitive alternatives in renewables. While coal will have a future in the regional energy mix for years to come, new build coal struggles to compete on a levelized cost of energy (LCOE). Historically, coal power has been the cheapest form of electricity and ideal for baseload power (reliable and dispatchable – all critical for industry). We believe that coal will still have a role in the power mix, but increased new solar and wind power output necessitates that more responsive technologies are also in the mix - especially for new builds. The need for a reliable baseload is underpinned by the fact that solar and wind produce power that is intermittent, requiring other forms of back-up or power generation to ensure stable supply.

Gas offers a unique opportunity to power producers and consumers to combat the above issues through offering dispatchable energy which is much faster to respond, complementing renewables and allowing for cleaner energy while maintaining reliability of supply. South Africa's Integrated Resource Plan (IRP) 2018<sup>3</sup> acknowledges the link between gas-fired power and renewables. The energy system simulation used in the IRP 2018 found "that in the long term, the system uses the combination of renewable energy, gas and storage to meet demand". Gas-fired power generation is a better proposition because it is very responsive, being able to increase or decrease supply faster than coal. It is also possible to build a variety of plant sizes, and the infrastructure is much quicker to build. Both state power utilities and independent power producers (IPPs) see the benefits of gas-to-power projects as they have proven to be among the most cost-effective forms of power generation with high energy efficiency, lower emissions and higher flexibility.



#### Levelised cost of Energy - LCOE (\$ / MWh)

Coal Power - International Benchmark CCGT - International Benchmark CCGT - Southern Africa Wind Onshore - International Benchmark Wind Onshore - Southern Africa Gas Peaker - International Benchmark Gas Peaker - Southern Africa Solar: Community Scale - International Benchmark Solar: Utility Scale - International Benchmark

Source – Lazard⁴. LCOE measures the lifetime cost relative to the energy generated. The higher LCOE for Southern Africa is primarily due to higher capital costs.

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#### Relative Capital intensivity for new build power generation capacity (\$ / kW)



Source – Lazard<sup>4</sup>. For new-built power generation capacity, estimates show that gas power, both single-stage and CCGT, are more capital efficient relative to coal and competitive to renewables while also being dispatchable. This is important for developing economies as balance sheets are often constrained and the higher cost of capital in developing markets can deter investors where there is any perceived risk. Capital efficiency allows for faster capacity build out.

Natural gas is the most efficient burning fossil fuel, and converting an existing peaker plant engine to operate on gas can offer significant benefits, both economically and environmentally. A diesel-powered peaker plant can be converted to run entirely on gas.

CCGT power plants have an overall efficiency of more than 62%; whereas, coal-fired power plants are less than 50%. Gas power plants also take up considerably less terrain (as little as half that of a coal power plant), operate with considerably lower emissions and are not nearly as demanding on water as coal or nuclear.

With average development time of 18 -24 months for a 600 MW plant, gas-fired power plants could fill the critical electricity gaps faster than large-scale hydro, coal or nuclear plants. To construct a similarly-sized power plant running on nuclear or coal would take an average of 7.5 years and 5 years respectively.

It is critical for the region to have a clear understanding of what the power generation strategy will be for the next 10 years in Southern Africa, as this will help to inform the potential off-takers necessary to drive investment in gas-to-power. South Africa's state utility provider has spent R47.4 billion (approximately \$3 billion) on diesel between 2009 and 2019 for power generation in open cycle gas turbines (OCGT). Some of their OCGTs have also been designed to run on LNG (natural gas).

They operate 4 gas turbine facilities in the Western Cape and Eastern Cape with a combined capacity of 2,418 MW. Enabling nearby ports (Mossel Bay / Cape Town / Saldanha Bay) to handle LNG imports will reduce operating cost and provide a route for other industries to access this needed energy source by sharing the infrastructure.



Building on the success of the South African Renewable Energy Independent Power Producer Procurement (REIPPP) programme, a gas-to-power IPP program was promulgated by the Department of Energy (DoE) in South Africa in 2012. It is clear from the most recently released IRP that gas-based power generation will play an important role in South Africa's energy mix with 3,126 MW of additional capacity to be procured by 2027. Putting generation capacity in quantities of natural gas (or LNG) required, 1 GW of CCGT power would require 780 000 tonnes of LNG annually (operating at 60% thermal efficiency and 75% capacity factor). 1 GW of single stage gas turbines would consume roughly 200 000 tonnes of LNG annually (37% thermal efficiency and 12% capacity factor).

Although South Africa has shale gas reserves identified in the Central Karoo and natural gas offshore, environmental concerns and regulatory delays mean that of South Africa's gas demand will most likely be largely satisfied by imports of LNG for the foreseeable future. The government has signalled the intent to establish the required port infrastructure in Richards Bay and Coega, but no investment has followed this up. In the meantime, private companies have signed a joint development agreement to place a FSRU (floating storage regasification unit) in the Maputo harbour. In addition to supplying Maputo, this gas can also be fed into the Maputo-Secunda Gas Pipeline (MSP) enabling the import and distribution of LNG into South Africa via existing pipeline networks. This gas could be available as early as 2023. Similar plans are being explored for East Africa.

Mozambique's Integrated Master Plan (2018)<sup>5</sup> calls for local electricity generation increasing from 3.9 TWh in 2015 to 35.4 TWh by 2042 which will require a significant increase in installed capacity. The plan is now to connect an addition 3 million Mozambican households by 2042 – bringing the total up to 4.3 million households from a mere 1.9 million connected as of 2017. This plan includes 752 MW of gas-powered generation by 2023 and a further 1,880 MW by 2042.

Both the South African IRP and the Mozambique Integrated Master Plan (IMP) long term plan lay out an energy procurement plan that is largely renewables focused; although, there is an opportunity for gas to supplement this by offering exceptional responsiveness, easily dispatchable power and reduced emissions and without the large capital investment required for nuclear. Gas is a great complement to renewables and aids in decarbonisation.



For utility scale gas-to power, size matters. Larger turbines allow for higher thermal efficiencies. For CCGT, where efficiencies can be over 60%, configurations generally require plant sizes of 100 MW or more. On single stage configurations, efficiency is around 40% for larger units and drops as turbine size decreases to around 30% for turbine ratings below 10 MW. Below the 5 MW size, natural gas-powered diesel engines start be used with around 40% efficiency.

A small embedded unit can still be valuable where some of the following conditions exist:

- Waste heat generated can be reused
- Operations which currently rely on diesel power generation
- Operations can reduce stoppages caused by an unstable local grid or load curtailment/load shedding.

Where these can be addressed, this significantly changes the economics of the business case. As an example, a 1 MW embedded gas-to-power solution can also generate an additional MW of heat that can be used in industrial applications or to run heating, ventilation and air conditioning (HVAC) systems via an absorption chiller. These co-gen configurations have the benefit of reducing power/energy demand from heating or cooling while potentially reducing their current cost of electricity. In addition, embedded power allows users to continue operating during power failures, curtailment and helps to avoid load shedding. The cost of poor power availability should also be considered in the business case.

It is not just state-owned enterprises and large IPPs that need to pay attention. Embedded power generation for self-consumption and co-generation for industrial heating are applications that can bring benefit to the consumer irrespective of the size. End users should not only be limited to solar when considering a "behind-the-meter" solution. This "behind-the-meter" generation can add to the capacity and stability of grid infrastructure if regulators think outside the box and act quickly. If they want distributed generation to add value to energy security, then these privately-owned systems need better integration back into the network. The technical challenges for doing this have been resolved; it is regulation that is now the roadblock. Alternatively, this distributed generation capacity will remain as-is, providing value in isolated pockets and to limited users.

Industrial users, whether medium or large, in mining, manufacturing or even the service sector, need to change their approach to energy. Legacy energy systems allowed users to pay for what they use but otherwise not be concerned with the energy system. Going forward, users that proactively manage their energy supply will benefit from reduced costs, higher operational effectiveness, energy availability and lower GHG emissions. Gas-to-power solutions are accessible to industrial users, and these can form part of the portfolio of solutions industrial users can utilise to meet their energy needs. Governments can support this development by looking to regulation that allows distributed generation access to a wider market. Regulatory developments in South Africa allow municipalities and users to buy/generate their own electricity, and gas-to-power could play a unique role given the superior economics, its green credentials and the associated job creation potential at a local level. Local municipalities and large users being allowed to procure power directly from private IPPs will also open opportunities in an uncompetitive and closed power market. While regional governments often look to large IPP-style projects as the cornerstones to national energy plans, emphasis should also be placed on policies that enable the full range of technologies available. Specifically, they should consider policies that integrate smaller generation into the grid and how these would enable faster change and unlock greater economic value. Regulation such as power wheeling, licensing requirements for smaller power generation and distributed power generation networks are not part of current government policies. With the correct regulatory framework, governments can benefit from embedded power generation capacity while end users benefit from an improved business case for embedded power.

There is a convergence of multiple market forces in favour of natural gas playing an important role in energy generation in the Southern Africa region. Its relative abundance, state-owned power utilities with weak balance sheets, the rise in renewable energy generation and the decarbonisation of power markets provide an opening for natural gas-to-power.

Looking at the cost competitiveness of gas-to-power as well as its complement to renewables, any new build programmes will benefit from consideration of natural gas.

For gas to play a growing role in energy generation, a concerted effort is needed by both government and private business to develop the requisite infrastructure in order to provide a compelling business case for new build gas-to-power or fuel switching on older assets.



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