Policy Report on the Electricity Sector in Zambia

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<td>African Development Bank</td>
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<td>Copperbelt Energy Corporation</td>
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<td>CPI</td>
<td>Consumer Price Index</td>
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<td>DAM</td>
<td>Day Ahead Market</td>
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<td>DRC</td>
<td>Democratic Republic of Congo</td>
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<td>ERB</td>
<td>Energy Regulation Board</td>
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<td>FiT</td>
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<td>FPM</td>
<td>Forward Physical Market</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GETFiT</td>
<td>Global Energy Transfer Feed-in Tariff</td>
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<td>GNI</td>
<td>Gross National Income</td>
</tr>
<tr>
<td>GoZ</td>
<td>Government of Zambia</td>
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<td>GWh</td>
<td>Gigawatt hours</td>
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<td>IDM</td>
<td>Intra-Day Market</td>
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<td>IEA</td>
<td>International Energy Agency</td>
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<td>IMF</td>
<td>International Monetary Fund</td>
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<tr>
<td>IPP</td>
<td>Independent Power Producer</td>
</tr>
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<td>IRENA</td>
<td>International Renewable Energy Agency</td>
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<tr>
<td>kWh</td>
<td>Kilowatt hour</td>
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<td>LCU</td>
<td>Local Currency Units</td>
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<td>Lunsemfwa Hydro Power Company</td>
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<tr>
<td>MW</td>
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<tr>
<td>MEWD</td>
<td>Ministry of Energy and Water Development</td>
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<td>NWEC</td>
<td>North Western Energy Corporation</td>
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<tr>
<td>NECL</td>
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<td>PPA</td>
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<td>REA</td>
<td>Rural Electrification Authority</td>
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<td>REFiT</td>
<td>Renewable Energy Feed-in Tariff</td>
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<tr>
<td>REMP</td>
<td>Rural Electrification Master Plan</td>
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<td>SAPP</td>
<td>Southern African Power Pool</td>
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<tr>
<td>USS</td>
<td>United States dollar</td>
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<td>VAT</td>
<td>Value Added Tax</td>
</tr>
<tr>
<td>VRE</td>
<td>Variable Renewable Energy (mainly solar and wind)</td>
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<td>ZDA</td>
<td>Zambia Development Agency</td>
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<td>ZMW</td>
<td>Zambia kwacha</td>
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<tr>
<td>ZPL</td>
<td>Zengamina Power Limited</td>
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Executive Summary

Zambia has experienced daily 8-hour power-cuts since July 2015. Low water-levels at the main reservoirs for hydroelectric generation have led to a power deficit of about one-third of electricity demand. With the country’s historically sufficient power supply, the sudden crisis has exposed low diversification of the fuel mix and caught households and businesses unprepared and without alternative or back-up sources of electricity supply. Left without electricity many households have reverted to charcoal for cooking, causing a spike in prices and accelerating the rate of deforestation. While only 22% of the population has access to electricity, the entire population has been affected indirectly through negative impacts on the economy and public infrastructure services.

Zambia’s shortage of power generation capacity has been estimated at about 1000 MW (as at March 2016). The shortage is due to both economic and political constraints which are discussed in detail in this report. Without significant inflows into the dams in the short term the situation is likely to get worse, as demand is growing by around 200 MW annually without matching increases in supply.

Short term measures to alleviate Zambia’s electricity crisis are in limited supply and, where they do exist (such as diesel generators), are costly. The past heavy reliance on hydropower means that alternative technology back-up capacity is limited. In addition, imports are expensive and of limited availability given the overall electricity supply shortfall across Southern Africa.

Longer-term measures to avoid, or at least mitigate, the impact of future crises are readily available, but at a cost. In this context, of fundamental importance is “getting the prices right”! The current all-pervasive subsidies for electricity consumers encourage consumption, discourage investment, and divert government funds from more efficient avenues of allocation.

On the demand side, there appears to be few attempts to introduce energy efficiency measures, such as mandatory energy labelling or minimum energy performance standards for both consumer and industrial products, which are commonplace in more developed economies.

This report discusses the challenges that need to be addressed in order to provide a blueprint for possible options and avenues for addressing the long-term adequacy of Zambia’s electricity supply sector.
Introduction

Zambia has experienced impressive economic growth rates over the last decade, averaging a 6.7% per annum increase in real GDP. This growth has been largely spurred by high copper prices, and copper mining and refining remains the mainstay of the economy. However, growth has recently slowed, and in 2015 the Zambian economy faced economic headwinds initially due to fast rising government expenditures and a fiscal deficit that more than doubled from 2013, compounded by slowing demand from China that reduced global copper prices to their lowest level in more than seven years. The situation was exacerbated by low agriculture output and a growing electricity supply crisis. The most recent estimates show that real economic growth fell to 3.6% in 2015, its lowest level in 15 years and missing the IMF prediction of 5.5% by a significant amount. Copper prices declined by 28% in 2015, while mining output remained roughly the same as the previous year. Slow economic growth is projected for the medium term as poor copper market conditions and an electricity-supply deficit continue to have a detrimental impact on the domestic economy. The 2016 agricultural season was also expected to be poor following El Niño weather effects in 2015, however recent rains have provided some encouragement.

The electricity-supply shortfall, which began in June 2015, exacerbated by an El Niño-caused drought in the region has, directly or indirectly, affected all sectors of the economy. It is estimated to amount to 40 to 50% of base load requirements, necessitating considerable daily load shedding. Load shedding inevitably involves increased operating costs for businesses, as they would either have to curtail production or invest in diesel generators. Of particular concern is its impact on restricting water supplies, as these need power to shift water to the consumer. To the extent that firms can pass on these higher costs, then consumers would also experience an increase in the cost of goods and services. With waning confidence in the economy, the Zambian kwacha (ZMW) depreciated by 42% against the United States dollar (US$) during 2015, an event that, in turn, was a significant contributor to end-of-year inflation rising to 21% and a huge increase in overseas indebtedness. Further, the slowdown in the economy has also resulted in more than 9000 job losses in the formal private sector.
Overview of the Zambia Economy

The Republic of Zambia is a landlocked country located in the southern part of the African continent (15º00 S, 30º00 E). Zambia has a population of 16.2 million people, and this is expected to grow to over 25 million by 2030 (World Bank 2015 estimates). In 2015, Zambia was the 103rd largest export economy in the world according to the CIA World Factbook and had the 85th (out of 124) most complex economy according to the Economic Complexity Index published by Harvard University.

In 2014, Zambia exports amounted to US$12.6 billion, whilst imports were US$9.6 billion, resulting in a positive trade balance of US$2.99 billion. In 2015 the Gross Domestic Product (GDP) of Zambia was US$21.2 billion (World Bank), a sharp decline from US$27.1 billion the previous year. The economy of Zambia is heavily resource-based. The top exports of Zambia in 2014 were Refined Copper (US$8.04 billion), Raw Copper (US$1.68 billion), Raw Tobacco (US$282 million), Cobalt (US$232 million) and Sulfuric Acid (US$217 million). Its top imports were Copper Ore (US$1.19 billion) and Refined Petroleum (US$1.02 billion). Electricity exports are not included as a separate item in the trade accounts. However, using available data on electricity sales by ZESCO to the South African Power Pool (SAPP), we estimate that electricity constituted about 2% of Zambia’s electricity sales in 2014 (SAPP 2015).

In 2015, the Zambian economy faced the deepest crisis of the past decade due to fast rising expenditures, fiscal deficit, flat copper prices, and an ongoing electricity crisis. Zambia’s over-dependence on copper has affected its economy after slow demand from China had reduced copper prices to their lowest level in more than seven years. According to the African Development Bank (AfDB), copper prices declined by 28% while global mining output of copper remained roughly the same as in 2014 (Figure 1). Further strains on the economy came from low agriculture output and a growing electricity crisis. Real economic growth fell to its lowest level in 15 years, with GDP growth estimated to have slowed to 3.5% from 6.0% in 2014 (Table 1). Some 9,000 jobs were lost in the private sector in 2015, while the rate of inflation reached 21% in the same year.¹

¹ Note that the GDP data given in Table 1 differs from the World Bank data quoted earlier.
Zambia is classified as a lower middle income country by the World Bank, with a GNI per capita of US$1,760 (2014). Inflation in 2015 rose by double digits to 21.2% for the first time in over a decade.

Since 1991 the country has been undertaking major economic reforms that have spurred increased investment and trade. Today, Zambia has a liberal and open economy with no price or foreign exchange controls. Copper and cobalt remain by far the major exports accounting for about 70% of foreign exchange earnings. Other exports include sugar, precious stones, tobacco, and other base metals. The
Major imports are machinery, motor vehicles and petroleum products. The heavy dependence on copper has made the country vulnerable to significant drops in copper prices.

Foreign Direct Investment to Zambia has been increasing. In 2015 $3.3 billion worth of investment pledges were recorded. The major sectors attracting this increase were manufacturing, real estate, tourism, agriculture and construction.

Economic forecasts for the medium term anticipate continuing slow economic growth as copper prices remain low and Zambia continues to suffer from the electricity supply deficit. The growth rate has been further compromised by rising domestic interest rates designed to support the Zambian currency. In addition, the 2016 agricultural season is expected to slow following El Niño weather effects.

Moody’s credit rating for Zambia was downgraded to B3, with negative outlook, on 19 April 2016. This ranking considers investments in Zambia as “highly speculative” and is just one grade above “substantial risks”.

In 2010, 60% of Zambians were living in rural areas. Official projections show that urbanisation will have risen to 45% by 2025. This, combined with an increasing rural electrification rate, will be an important driver of electricity demand, aside from any increase in the contribution from the mining sector. The greatest contributors to the country’s domestic product are the capital city, Lusaka, and the major mining towns of Chingola, Kitwe, and Ndola. Urbanisation is both a result of natural population growth and rural-to-urban migration.
Electricity Demand by Sector

According to a USAID 2016 report, Zambia has a national electrification rate of 26%, with approximately 25% of the households in urban areas having access to electricity, while the rural community electrification rate is only 3%. About 16% of the population has access to modern cooking fuel, but almost 60% still rely on fuel wood for cooking.

Electricity demand grew by an average rate of 3.5% between 2002 and 2010. According to official estimates shown in Figure 2, the growth in peak demand was linear at an almost constant rate and is expected to stay the same in the near future (ZDA 2014). The main electricity consumer (54.8%) is the mining industry, followed by the residential sector (30.3%), and the commerce and industry sectors (15%), while the rest is consumed by exports, and social and agricultural services.

Figure 2: Electricity demand growth and projections

Source: ZDA (2014)
Demand for electricity is projected to grow significantly in the future, mainly due to rising demand from the mining sector whose share in total consumption has been steadily increasing. Despite the recent drop in copper prices, international agencies have given a generally favourable outlook for Zambia’s mining sector (World Bank 2016b, KPMG 2013). Copper production in Zambia in 2015 was 710,560 tonnes, which is expected to rise to 746,000 in 2016 with new mines coming on-line. The official forecast for 2017 is 1.5 million tonnes but this appears to be a rather ambitious target given the current state of the copper market. Nevertheless, the World Bank is forecasting a gradual rise in copper prices on the next five years.

Overall, Zambia has been facing a higher growth in power demand and electricity exports than the development of domestic generation capacity. This power deficit is attributed largely to the lack of investment in generation capacity over the last 20 to 30 years. The reasons for this underinvestment were of both an economic and a political nature. Low and non-cost-reflective electricity tariffs limited development of new generation capacity besides cheap hydropower. Other risks include political uncertainty about moving towards cost-reflective tariffs, difficulties with payments collection, and ZESCO’s monopolistic structure (World Bank 2013). These issues are at best indicated by a low overall number of independent power producers in the region. The electricity tariff structure in Zambia is discussed below in more detail.

To address the shortage of available power generation capacity, Zambia developed the Zambia Power Rehabilitation Project (PRP) which involved various capacity and transmissions upgrades as well as demand side management measures. With a budget of more than US$ 75 million, it was supported by the World Bank, European Investment Bank (EIB) and ZESCO. Despite its good intentions, this initiative has not been very successful in addressing the problem because of the sheer scale of the power supply gap. The power rehabilitation project report published by the World Bank indicates that the main efforts were concentrated around refurbishment of existing hydropower facilities and transmission lines which resulted in an effective increase of available generation by about 100 MW. Meanwhile, a parliamentary ministerial statement by the Minister for Energy and Water Development stated that Zambia’s power deficit was 1000 MW in capacity terms in March 2016.
Overview of the Electricity Sector

Main players in generation, transmission and distribution

Zambia’s electricity sector operates under the single buyer model, with several large independent power producers and transmission and distribution operators. The structure of the sector is shown in Figure 4. The single buyer functions are assumed by the vertically-integrated utility ZESCO which also controls the majority of generation and transmission and distribution capacity in the country. ZESCO Limited, previously known as Zambia Electricity Supply Corporation, is a parastatal company under the Companies Act. It was established in 1970 after an Act of Parliament was passed in 1969, and its governance has evolved over time to one that defines an arms-length relationship with Government.

Figure 4: The structure of Zambia’s electricity sector

As of 2013, there were three operational private Independent Power Producers (IPPs), namely Lunsemfwa Hydro Power Company (LHPC); Ndola Energy Company Limited (NECL); and Zengamina Power Limited (ZPL). The installed capacity for the power stations was as follows; LHPC (56MW); NECL (50MW); and ZPL (0.75MW).
The Copperbelt Energy Corporation (CEC) is a privately-owned corporation that is responsible for high-voltage transmission and distribution systems that supply electricity to Zambia’s mining companies in the Copperbelt province and the neighbouring population. ZESCO supplies high voltage electricity to CEC under an exclusive bulk supply agreement that covers all of the mining sector’s requirements until 2020. In turn, CEC also operates 80 MW of standby gas turbine generation at strategic locations in case of interruptions to ZESCO supplies. Besides supplying electricity to the mining sector, CEC has been exporting/wheeling electricity to a mine in the Democratic Republic of Congo (DRC) since 2007, and trades in its own right through the SAPP.

ZPL and the North West Energy Corporation (NWEC) distribute electricity to rural and mining communities from off-grid mini hydro plants and the national grid, respectively. ZESCO, CEC, and the LHPC are currently the major power generators with shares of 94%, 4% and 2%, respectively. In the transmission sector, the corresponding shares are 69%, 29%, and 2% (Figure 5).

**Figure 5: Shares of generation and transmission capacities by company**

![Pie chart showing generation and transmission shares by company](image)

Source: Zambia’s Energy Sector Report 2014

**Electricity generation mix**

Zambia’s electricity generation mix is dominated by hydro power which comprises over 95% of total generation capacity. About 90% of hydro generation comes from just two projects – Kariba North and Kafue Gorge, located in the country’s south. Most of Zambia’s hydroelectric capacity was rapidly developed soon after its 1964 independence with support of the World Bank and donor countries. The main goal of these projects was the removal of the country’s inherited vulnerability to dependence on power supplies from the Kariba South Power Station located in Southern Rhodesia (now Zimbabwe) (ECA 2010).

With 40% of the water resources in the Southern African Development Community (SADC), Zambia has about 6,000 MW of unexploited hydropower potential, while only about 2,255 MW has been developed. Thus its focus, almost exclusively, on hydroelectricity is understandable but clearly makes it particularly vulnerable to drought.
In 2014, Zambia’s total installed capacity was 2,396MW consisting of hydro 2,255MW (mainly large scale), thermal 80MW, diesel 11MW, heavy fuel oil 50MW, and solar 0.06MW. Between 2013 and 2014, the total capacity increased from 2,038MW to 2,255MW as a result of the commissioning of the 360MW Kariba North Bank Extension (KNBE) power station. Total electricity generated was 13,440 GWh in 2015, an 7% decline compared with 14,453 GWh the previous year.

The first (of two) 150 MW units of the country’s first coal-fired power plant, the Maamba power plant, with a total capacity of 300 MW, was connected to the grid and commenced operations in July 2016. It is scheduled to reach full operational capacity in late-2016/early-2017, and a doubling in size to 600 MW is included in plans for any second phase, if required. Water is sourced from Kariba Lake. It is a mine-mouth plant fuelled by low grade coal which is a waste product of the Maamba Colliery.

Transmission and distribution

The Zambia National Grid is composed of the 330 kilovolts (kV) main line that spans a total of 2241 km across the country. Most power flows within the country go from the hydropower stations in the south to the Copperbelt province in the north, where the mines and main load centres are located. The rest of the transmission network consists of 348 km of 220 kV lines serving as interconnectors with neighbouring DRC, Namibia, and Zimbabwe, 202 km of 132 kV lines and 754 km of 88 kV mainly in the Lusaka area, and 3033 km of load2 transmission lines, and 66 kV in the north-eastern and western parts of the country. The total system losses in the Zambia grid network were estimated at 13.1%, with transmission losses averaging 4.6% and distribution losses averaging 13.8%, in 2011 (ZESCO, 2011). These numbers are high compared with standards in developed countries, however they are comparable with other SADC member states (IRENA 2013), and are marginally below ZESCO’s key performance indicator ceilings of 5% and 15% respectively.

ZESCO plans on upgrading existing transmission infrastructures and developing new ones to new power plants that are currently being built. In addition to these projects, the country has planned further expansion of the national grid to the north-western province to new mining areas and developing new interconnectors with neighbouring countries to increase power trade. Zambia also identifies grid extension as being the main strategy to expand access to rural areas as highlighted in the 2009 Rural Electrification Master Plan (REMP).

Electricity tariffs and generation costs3

Historically, Zambia has had one of the lowest electricity tariffs in Southern Africa and the roots of the current electricity crisis are in non-cost-reflective tariffs which have deterred new investments in the power sector for decades. Direct and indirect subsidies have been provided to all sectors including mining, industries, and households for power purchases above the cost of the relevant tariff. Figure shows (rather dated) data series by the World Bank comparing operational expenses of power plants and recovered electricity tariffs. It can be seen that operations of power plants were unprofitable if compared to average tariffs.

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3 Electricity tariffs are expressed in terms of kwacha, whereas international comparisons are expressed in terms of US$. Thus, nominal increases in electricity tariffs expressed in kwacha will result in significantly smaller increases expressed in US$ when depreciation of the former, against the latter, occurs over time.
The current tariff structure for residential consumers is based on a three tier inclining block tariffs methodology. The pricing, or billing, is based on energy use and monthly fixed charges (Table 2).

### Table 2: Tariff structure: residential (2016)

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<tr>
<th>Band</th>
<th>Consumption level</th>
<th>Tariffs ZMW (US$)/kWh</th>
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<tr>
<td>R1</td>
<td>Up to 100 kWh</td>
<td>0.15 (0.015)</td>
</tr>
<tr>
<td>R2</td>
<td>101 – 300 kWh</td>
<td>0.31 (0.031)</td>
</tr>
<tr>
<td>R3</td>
<td>Above 301 kWh</td>
<td>0.51 (0.051)</td>
</tr>
<tr>
<td>Fixed charge</td>
<td>Fixed monthly charge</td>
<td>18.23 (1.823) /month</td>
</tr>
</tbody>
</table>

Source: ERB, Electricity Tariff Determination Guidelines for Retail Customers.

As a means of attracting investments in power generation capacity and grid expansion, the tariffs have been gradually increased since 2009. In 2010 ZESCO’s average electricity tariff was increased to US$0.065/kWh (up 25.6% from 2009). In 2011, a further step was made to increase the tariffs for the mining sector by 30%, with no incidence on other sectors. In 2014, a further tariff raise was approved with the following rates: 32% for residential, 24% for commercial, 18% for the services customers, 24% for small power, and 11% for large power customers. Faced with a lot of criticism for prolonged tariff rises, ZESCO’s board of directors was dissolved by the government in 2015 and in the following year ZESCO withdrew its application to increase charges for households, businesses, and factories, despite getting the regulator’s approval. As of early 2016, the average subsidized tariff rate is about US$0.07/kWh, while mining companies pay about US$0.1035/kWh.

Due to the severe power deficits that the country was facing, in July 2015 ZESCO declared a Force Majeure event on all its contracts with its mining customers and advised them that it would limit supply to 70 percent of contracted demand. Further, following approval from the Government, ZESCO contracted Aggreko, a company specializing in providing emergency power supplies, for the supply of 148 MW of emergency power for the period September to December 2015, which was reduced to 40
MW for the period January to December 2016 as the company had earlier committed 108 MW to other customers. These imports came at a very high cost, amounting to US$40.0 million (or US$0.1843/kWh) for the 148 MW of power. ZESCO was in turn selling the power at an average of US$0.05/kWh. This resulted in a huge deficit. Out of the US$40.0 million total cost of power supplied between September 2015 and December 2015, the GoZ transferred a total of US$32.5 million whilst ZESCO paid a total of US$7.5 million. Then for the 40 MW for the period January to December 2016, it would cost ZESCO about US$5.5 million per month.

Consequently, when Aggreko commenced the supply of emergency power to ZESCO in September 2015, all mining companies that required supplies above 70% of their respective declared demand were required to pay a premium of US$0.1016/kWh.

In addition, the tariffs for the mining companies were further adjusted to US$0.1035/kWh effective January 2016 through a separate negotiation process facilitated by the MEWD. This was done because it recognizes the validity of the respective Power Purchase Agreements, and the need to adjust the tariffs in order to enable ZESCO to continue operating viably. The new tariff is all inclusive in that it takes into account the cost of ordinary as well as emergency power to the mines.

Zambian mining companies have filed a lawsuit against the proposed increases and the case is currently before the Lusaka High Court. However, ZESCO has billed the mining companies at the new tariffs, but they have refused to recognize them and have continued to pay ZESCO at the old contract prices.

**Tariffs, subsidies, and industry profitability**

It should be noted that despite the increase in consumer tariffs, it is difficult to make a conclusion about the overall profitability of the power generation sector without information about tariff breakdown, trends in generation costs and revenue collection data by ZESCO, and other generators. On 24 June 2016 the Energy Regulation Board (ERB) announced that it would undertake a study to provide a structure for estimating “cost reflective tariffs” for Zambia. Electricity tariffs paid by end-users are generally calculated on a “cost stack” methodology. The “stack” includes costs associated with the four component parts of the final tariff: generation, transmission, distribution and retailing (including miscellaneous costs such as value added tax (VAT), renewables subsidies, and carbon taxes, where relevant). However, information about the breakdown of electricity tariffs in Zambia into their component parts is not publically available, if indeed it exists, making it difficult to estimate what percentage of the current tariff is actually paid to the generating company. Generation costs are also not a constant, as they can increase due to increases in wages and costs associated with maintaining and replacing power plant components arising from the deteriorating efficiency of ageing equipment and infrastructure.

Another important issue is the ability to collect payments for the services delivered which has been a problem for ZESCO, as indicated by the World Bank (World Bank 2013). In an industry with low profit margins uncollected revenue makes it difficult, even for a state monopoly, to break-even. Low revenue streams for power generators do not provide them with sufficient resources to maintain good quality of service and invest in new and upgraded facilities.

Electricity sector subsidies in Zambia take two forms: direct and indirect. The former relate to specific payments designed to cover the gap between the current tariff to the end-user and the delivered purchase price of the power to the grid. Indirect subsidies, however, refer to direct capital investment by the GoZ in the electricity sector for not only generation, but also for transmission and distribution.
In 2015, the GoZ budget allocation for ZESCO was 600 million ZMW for this purpose alone. Whilst the GoZ is attempting to encourage IPPs and Private Public Partnerships (PPPs) their international credit rating is hardly encouraging for international finance corporations.4

**Renewable energy**

Solar energy holds some potential for Zambia, and ZESCO could consider the amount of solar energy that can be added to the grid without compromising system integrity. As an interim measure, the MEWD has approved that a total of 300 MW be procured into the grid. It has allocated 250 MW for procurement through its investment vehicle, the Industrial Development Corporation (IDC), and 50 MW under the Get FiT Program, the latter being supported by the German Government.

Any projects undertaken outside of the two above programmes will be prohibited from using the ZESCO grid, and therefore would have to operate off-grid.

**Feed-in-tariffs for renewable energy**

In 2014, Zambia commenced the process of drafting a renewable energy policy framework which has largely been completed by mid-2016. The initiative provided conditions and regulations facilitating development and investments in renewable energy. Furthermore, the framework is designed to include a feed-in-tariff (FiT) pricing and methodology, grid access rules, and license rules for investment and the procurement of power from the renewable energy IPPs. Typically, in other jurisdictions, the cost of the total FiT subsidy would be spread over all electricity consumers on a cents/kWh basis. However, if the FiT subsidy is covered by the GoZ this could increase the strain on its budget as the number of FiT beneficiaries grows. Conducting proper due diligence is therefore extremely important for developing countries with small budgets before committing to a FiT scheme. According to Bloomberg, the maximum FiT rate that ZESCO is willing to accept is US$0.12/kWh (Bloomberg 2016).

**Governance and policy functions**

In 1994, Zambia formulated a National Energy Policy (NEP), revised in 2008, aimed at promoting optimal supply and utilisation of energy at “lowest economic, financial, social and environmental costs consistent with national development goals”. The revised NEP focuses on diversifying current generation mix with shares of coal, biomass, and solar, extension of the existing transmission lines, and an increase of the electrification rate in rural areas. So far it is difficult to evaluate the success of this plan, because it does not give any quantitative targets and timelines. As of 2016, Zambia’s electricity mix still consists of 95% hydropower.

The MEWD is responsible for policy implementation and guidance through the Department of Energy. Several offices within MEWD are responsible for body coordination, investment attraction and advisory on energy matters. The Energy Regulation Board (ERB) is responsible for regulating operations and pricing of the electricity sector. The ERB is also responsible for setting fuel prices (including electricity tariffs), establishing and monitoring the application of the Zambia Grid Code, and designing standards with regards to the quality, safety and reliability of supply of energy in conjunction with the Zambia Bureau of Standards. In rural areas, the Rural Electrification Authority (REA) is the

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4 Required investments in the electricity sector that need funding or strategic partners have been listed by the GoZ at: [https://www.giz.de/fachexpertise/downloads/pep2015-en-ssa-in-pr-mmembe.pdf](https://www.giz.de/fachexpertise/downloads/pep2015-en-ssa-in-pr-mmembe.pdf)
main institutional body responsible for electrification, grid operation and extension, as well as granting incentives to projects designed to supply energy in rural areas. The rural electrification programme also tests application of solar technology in areas remote from the main grid.

The legal and regulatory framework of Zambia’s electricity sector is outlined in the following documents:

- **Electricity Act of 1995 (amended in 2003):** this act formulates the principles of generation, transmission and distribution of electricity in Zambia. It liberalised the electricity sector by formally opening all three segments to private operators and outlines the administrative structure of the sector.

- **Energy Regulation Act of 1995 (amended in 2003):** the act formulates the role of the Energy Regulation Board and defined its functions and powers.

- **Rural Electrification Act of 2003:** this act mandates REA to oversee and implement the rural electrification programme. In order to improve a very low rural electrification rate in Zambia, REA with external consultants have prepared a detailed Rural Electrification Master Plan (REMP) that provides a trajectory for electrification for the period 2008 – 2030. REMP highlighted three main electrification methods: extension of the national grid, mini hydro, and distributed solar power. It is expected that REMP will increase the rural electrification rate of 3% in 2008 to 51% by 2030 at an estimated cost of about US$ 1.1 billion, equivalent to an annual expenditure of US$ 50 million.

- **Zambia Grid Code of 2006:** The Zambia Grid Code was drafted in 2006 to provide open and non-discriminatory access to the transmission system for IPPs and ITCs. The document is being developed by ERB and consultative stakeholders, and has not yet been formally implemented.

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5 REMP was developed with the support of the Japanese International Cooperation Agency (JICA) through a high-level consultative process (IRENA 2013).
Electricity Imports and Exports

Figure 7 shows ZESCO electricity import and export trends from 2010 to 2015. The sharp increase in imports in 2015 is attributed to the power deficit which necessitated emergency power imports. In general, exports occur when there is surplus capacity (i.e. in off-peak periods) for Zambia, while imports are required during supply shortfalls (i.e. peak periods).

Zambia plays an important role in the regional interconnection known as the Southern African Power Pool (SAPP), both as an electricity supplier and transmitter. SAPP was formally established in 1995 with the objective of providing reliable and economical electricity supply to each of the SAPP members, to be aligned with national development goals, and to provide reasonable utilization of natural resources in each country. SAPP evolved from the pre-existing bilateral interconnections between some Southern African countries and currently includes power utilities of 12 countries: Angola, Botswana, Congo, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe. The total installed capacity of SAPP was 61,589 MW in 2014, out of which 62% was coal, 21% hydro, 8% renewables, 6% oil and gas, and 3% nuclear. In geographical terms, the thermal-based power generation is mainly located in the south of the interconnected region, while hydro-based power generation is located in the north. The single nuclear power station, the Koeberg nuclear power plant, is located in South Africa. Current and planned SAPP interconnections are shown in Figure 8.

Figure 8. SAPP interconnection, existing (solid) and planned (dashed)
Southern African Power Pool: How it operates

The current mode of operation of the SAPP has three mechanisms which can broadly be divided into long-term, medium term, and short-term markets. Electricity is the only product traded on the markets. The charges for provision of balancing services are calculated within each control zone and are not linked to electricity prices.

The market is open to participants who have:

- Been licensed or given permission by the host country to undertake cross border trading;
- Have been accepted as a Market Participant by the SAPP Executive Committee;
- Are physically connected to one of the SAPP Control Areas and have arrangements for provision of balancing services;
- Signed the SAPP Market governance documents;
- Have opened the requisite accounts for trading purposes.

Source: SAPP (2016)
**Long-term market**

The majority of electricity is traded in the long-term market via bilateral contracts between the member utilities. Bilateral markets provide security of returns to utility companies and security of supply to the member states. The contracts are arranged for a period from 1 to 5 years, but could be longer. The pricing of electricity is usually cost-based, but also depends on the consumption period which can be peak, standard, or off-peak. Naturally, supply delivered at peak hours is priced higher. Trading arrangements are mutually agreed between bilateral parties and the transmissions paths are secured in advance. The contractual agreements can be firm or non-firm. Firm contracts cannot be interrupted and hence the buyer pays a reliability premium. Non-firm contracts can be interrupted with appropriate notice. Prices are not necessarily related to domestic prices, unless the parties agree. Most contracts are subject to review on an agreed periodic basis to take account of changed circumstances, usually inflation or traded quantities. (ECA 2010, SAPP 2016).

**Medium-term market (FPM)**

The Forward Physical Market (FPM) is a competitive market operating on the timescale of between a week and a month. This trading platform provides some shorter-term flexibility for parties involved in bilateral contracts. FPM is open for market participants to trade monthly (FPM-M) and weekly (FPM-W) products. The monthly product is primarily base load generation delivered at a uniform price and output level for all hours of the month. The weekly market has two products, on- and off-peak generation. Each of these products must have uniform price and output levels within their respective hours and cannot overlap with the monthly products. Trading in FPM-W is done on a Thursday every week. Forward markets have an auction-trading model similar to the Day-Ahead-Market discussed below.

**Short-term markets (DAM and IDM)**

Two other competitive markets facilitate trading on a short term scale: the day-ahead market (DAM) and the intra-day market (IDM). These markets help participants to align their supply and demand curves on daily and hourly basis, subject to the available transmission capacity at the time of delivery.

The DAM trading mechanism is based on the common principle of a uniform market clearing price at the price point of the last successful supply offer. Before the trading window opens, market players submit their generation offers and individual demands. The SAPP Coordination Centre, which is the market operator, aggregates this information in order to establish market supply and demand curves. The intersection point of these two curves determines the market clearing price, a uniform tariff paid to all cleared generators. The DAM trading mechanism is more advanced than its bilateral predecessor where individual sellers and buyers were matched at their respective generation and price levels.

The intra-day market is a continuous market, and trading takes place every day until one hour before delivery. The role of the IDM is to allow each individual market participant to adjust the power balance and be a tool for them to manage incidents and failures in the power system between the closing of the DAM and delivery the next day. The IDM is based on a price matching auction model. Bids (sales orders) or Asks (purchase orders) are submitted to the market where they are matched automatically by the system on price or a buyer / seller can accept and “hit” an order in the market. The market contracts are settled at the matched price. The IDM trades with hourly contracts. As of 2015, both the DAM and the IDM had more purchase than supply offers, reflecting the aggregate supply shortfall in the SAPP. As of year-end 2015, SAPP had available operating capacity of 43,964 MW against a demand
of 51,821 MW, representing a shortfall of 7,857 MW. Towards the end of 2015, the average the monthly clearing price reached almost US$0.10/kWh.

Three Zambian companies are members of the SAPP: ZESCO, which is registered as the operating member, Copperbelt Energy Company (CEC), which is an independent transmission company, and an independent power producer (IPP), Lunsemfwa Hydro Power Company (LHPC). Zambia’s physical grid interconnection are with the DRC in the north and Zimbabwe in the south. On-going projects seek to interconnect the country to Tanzania in the northeast, Malawi in the east, and Namibia in the west through the Zimbabwe-Zambia Botswana-Namibia interconnector. Besides providing power links, ZESCO is also responsible for balancing electricity supply and demand and power flows in the local control area between Zambia, DRC, and Zimbabwe.

During the SAPP 2014-2015 fiscal year, ZESCO sold 3441 GWh of electricity through the SAPP, which ranked it as the second largest electricity exporter in SAPP after South Africa’s ESKOM with 4909 GWh (SAPP 2015). Assuming that ZESCO sold electricity at the average SAPP monthly clearing price of US$0.067/kWh, this would yield a revenue estimate of US$230.5 million, or just under 2% of the value of Zambia’s total exports in that year. CEC sold a total of 85 GWh in 2013, mainly to mining companies in the DRC through an agreement with the DRC’s national electricity company (CEC annual report 2013). Over the same time period Zambia imported 165 GWh of electricity from its neighbouring countries and from an emergency power ship docked at the Mozambique coast. In the latter case, the cost of imports was US$0.1835/kWh, which is almost three times higher than the subsidized domestic power tariff and the average SAPP clearing price given above. It may appear incongruous that, given its domestic supply shortfall, Zambia exports electricity. However, exports come from the electricity that is surplus to requirements during periods of low demand, whilst imports are required at times of peak demand. Since many members of the SAPP have similar load profiles to Zambia, the latter’s exports tend to be during periods of relatively low prices whilst the reverse is true for imports.
Local Potential for Energy Resources

Zambia is well endowed with domestic energy resources which are currently only being exploited to a limited extent. The country has large deposits of coal, ample sunshine, biomass, hydropower, wind, and some geothermal resources. Coal deposits are estimated at between 30 million and 100 million tonnes with the mining sector recovering only about 2,000 tonnes annually. Maamba Collieries is the country’s largest coal producer, located in the country’s south. During the 1980s Maamba Collieries, the main coal supplier to the country’s copper mines, produced nearly 600,000 metric tons of coal per year, but its production declined due to years of undercapitalization and operational losses (KPMG 2013).

Hydropower reserves, consisting of small, medium and large-scale hydro, are estimated at 6,000 MW with only 2,225 MW so far exploited. The biomass potential is estimated at 2.15 million tonnes, or 498 MW. Zambia has an average solar insolation of 5.5 kWh/m²/day, with approximately 3,000 hours of sunshine annually, providing good potential for solar thermal and photovoltaic applications. Some wind and geothermal hotspots are available throughout the country. Overall, a detailed potential resources assessment is required to derive a reliable estimate of the achievable levels of electricity generation from renewable resources.

Several notable power projects that are currently being developed include: Kafue Gorge Lower Hydropower Project (hydro, 750 MW), Maamba Thermal Project (coal, 300 MW), Itezhi-Tezhi Project (hydro, 120 MW), and Kabompo Hydropower Project (hydro, 40 MW). It is unclear however, with the exception of the Maamba project, when these projects are expected to be commissioned due to numerous delays in the past. The most notable example here would be the Kafue Gorge Lower Hydropower Project, announced in early 1990s, which is still under construction.

Besides building new generation capacity, several transmission and distribution projects have been commissioned in order to improve the quality of electricity supply. Details of these projects can be found in the Energy Sector Report 2014.
Addressing Challenges in Electricity Sector

It can generally be concluded that the immediate challenges in Zambia’s power sector are caused by insufficient electricity generation capacity serving domestic requirements, primarily non-mining sector activities, exacerbated by weather impacts on the main source of electricity in the country – hydropower. Further strains are caused by undeveloped transmission capacity which can be concluded from the low electrification rate. Zambia is currently relying almost exclusively on hydropower while the local potential for other energy resources including coal and renewables remains largely unexploited. These resources could be tapped to provide adequate electricity supply to domestic consumers. However, the slow progress of capacity development indicates the need to revise the planning and governance approach for the electricity sector. In addition, there is a need to ensure that the new capacity is incentivized to prioritize the domestic market, before participating in cross-border electricity sales. We now discuss these issues in more detail.

Insufficient generation capacity

The progress of domestic electricity capacity development in Zambia has been very slow. The sector has stagnated for decades despite forecasts of strong electricity demand growth. New project development has been constantly lagging behind the planned time frames, especially for ZESCO-led projects (Electricity Sector Report 2014). One of the main reasons for this is low electricity tariffs across the whole Zambian economy which do not provide attractive returns for power producers. Some new capacity developments were announced only after the country had decided to gradually increase the tariffs in order to make them cost reflective. For example, in 2013 an independent coal mining company committed to building a 300 MW coal-fired power plant which has started serving the grid in the second half of 2016. However, at least 1000 MW is required to address the current demand shortfall (Minister for Energy and Water Development statement to Parliament in March 2016).

Measures to address the challenge

Short-term

Zambia has ample hydropower, coal, and renewable resources to be self-sufficient in electricity production. In the short term, the country could consider emergency measures such as demand-side management, better management of hydropower, and electricity imports. Demand-side management programmes are designed to encourage consumers to alter their level and pattern of electricity usage during on and off-peak hours. Demand side management could include financial measures such as time-of-use tariffs or incentives to prioritize power use when it is abundant and cheap. The use of hydropower facilities could be improved by optimizing the recharge times by taking into account weather patterns and demand needs. In addition, increasing the size of emergency storage tanks in hydropower facilities could be considered. Importing power is another emergency measure to address domestic power requirements, however this could be very costly considering the aggregate supply shortfall situation in the SAPP. In most cases, ZESCO would have to pay significantly more for these imports compared to its domestic cost of generation and then sell it at a subsidized rate to all end users. Such measures would place a high economic burden on the GoZ budget and could only be sustained in the short-term. In the long run, Zambia needs to expand its domestic capacity, utilising domestic energy
resources and supported by clear long-term electricity capacity development plans set by the government.

**Long-term**
Zambia’s strengths include abundant energy resources and a fairly supportive government for third-party power sector participants. The main impediment for independent power producers is low electricity tariffs which are amongst the lowest in Southern Africa. Shifting towards tariffs that would allow adequate returns to power producers after deduction for transmission, distribution, and miscellaneous fees would stimulate more investment in this sector.

In the long run, diversification of domestic supply sources would be beneficial for Zambia. The current strong reliance on hydro (representing around 95% of the electricity mix) exposes the power system to seasonal climate variation known to include droughts and floods, which can greatly hamper hydropower generation. Such risks could be minimized by expanding other sources of baseload power such as coal and utility-scale renewable energy. Furthermore, new interconnectors can be developed in order to provide emergency routes for power transfer through the SAPP.

**Conflicts of interest in electricity use**
Another important issue contributing to the power crisis in Zambia is the conflict of interest between multiple parties in receiving power supply. The mining industry is the largest consumer of electricity in the country and is crucial for the Zambian economy. Until recently, the mining industry had been prioritized in receiving electricity over other sectors due to the nature of ZESCO’s contractual obligations with the CEC. This has no doubt exacerbated the frequency of power outages for households and small industries whenever the residual power supply was insufficient to meet demand. It is worth noting that when the mines were restricted to 70% of their requirements under ZESCO’s force majeure, they were willing to pay for SAPP imports at a much higher price to cover the shortfall.

SAPP member countries, in aggregate, experience supply capacity shortfalls being exceeded by both current and anticipated growth in electricity demand. The availability of willing buyers in SAPP creates a risk that any new capacity brought about by IPPs in Zambia currently may give priority exports into the SAPP over the local market because of the more favourable tariff structure. As long as there is a willing party offering a bilateral contract priced higher than domestic electricity in Zambia, therefore, there is the potential threat that new generation capacity from IPPs will not cater for the shortfall in the domestic market. Contracting IPPs to sell all output to ZESCO would be possible, and the Maamba project has done exactly that, but the price may be high!

**Measures to address the challenge**

**Tariff revision and subsidy removal**
Removal of electricity subsidies and migrating towards cost-reflective tariffs should be a long-term goal of electricity sector reform. Fuel and electricity subsidies have been historically common in all sectors of the Zambian economy, albeit to different degrees. Such measures are frequently used as an extension of social welfare policies and result in a loss of efficiency, and hence consumer welfare, in both domains. Fuel and electricity subsidies are cited as the main causes of the current budget deficit in Zambia. Subsidised prices encourage consumption, particularly by rich consumers who are not the intended beneficiaries of the subsidies. Further, if the government budget is used to finance such subsidies, clearly there is an opportunity cost involved with regard to alternative expenditure options. However, once they are established, withdrawing such subsidies can cause hardship for some and, potentially,
significant levels of political/social discord for the government, in addition to contributing towards domestic inflationary pressures.

Whilst removing subsidies is a relatively straightforward exercise, offsetting the impact on poorer communities is fraught with difficulties, particularly for countries where a comprehensive welfare “safety net” infrastructure does not exist. Cost-reflective tariffs would put a high financial burden on such communities who would require other means of support from the government.

**Establish terms for capacity use**

Terms for capacity use such as power purchase agreements (PPA) can be used in order to ensure that domestic customers will benefit from new power generation projects. In particular, partnerships between mining companies and utilities could be a viable option. Such partnerships would facilitate generation and transmission investments in large-scale projects supplying electricity to the mining industry based on a long-term PPA. Alternatively, mining companies could be the IPP themselves. Given that electricity tariffs in the mining sector are increasing and the sector’s demand projected to grow by 50% between 2012 and 2023, while domestic electricity supply remains precarious, mining companies have a clear incentive to invest in their own power generation.

The World Bank notes that the potential for power-mining integration is substantial in Zambia. However, there is no guarantee that the benefits of large scale projects would be shared with the local population. Under the current tariff structure, there is no clear incentive for power companies, including ZESCO, to prefer residential consumers over the mining sector or SAPP. Vesting contracts between ZESCO and domestic consumers could be used to allocate generation capacity to the domestic economy. Vesting contract are long-term contracts signed between the generator and consumers (typically large scale) where both parties agree on amount, timeline and tariff of energy supplied. It should be noted that vesting contracts are possible if they bring benefits to both sides. In other words, there should be an economic case for power producers. There is also an option of unbundling the ZESCO’s selling unit into separate domestic market and cross-border sales units with separate operating units and contractual agreements. This option would prevent potential conflict of interests within ZESCO, as separated units would be committed to different markets based on the long-term supply contracts.

**Low rural electrification rate**

The electrification rate in Zambia is very low by world standards, especially in rural areas, leaving nearly 12 million people without access to electricity. The population density is low at only 20 people per square kilometre and the distance between rural communities can be many kilometres. Due to both of these factors the prospects for rural electrification remain challenging. In general, rural communities can be provided with electricity either through central grid extension or through off-grid solutions such as solar, small-scale hydro, and biomass. However, these solutions pose questions from the viewpoint of financial affordability because the majority of the rural population lives below the poverty line and is extremely price sensitive. The relatively small size of the off-grid market and poor affordability for end-users make the sector unattractive for private investors and thus requires provision by local private operators with the support of donors and development partners.

Renewable energy solutions such as solar and wind face high transportation costs for equipment, long supply lines, and fiscal barriers. There are also no clear standards for grid integration of variable renewable energy based on the grid’s physical ability to include variable power. On the positive side, however, once established off-grid solar power operates at an extremely low cost per unit of electricity generated (provided adequate maintenance support is undertaken).
Measures to address the challenge

The current mode of facilitating rural electrification in Zambia relies heavily on support of international partners and donor agencies. Optimal use of these funds can ensure the most effective outcome for the end users. The possible options for grid expansion should be carefully analysed from an economic point of view before actual implementation can take place. As indicated by IRENA, off-grid or mini-grid solutions are often more economically viable than grid expansion of standalone diesel generation (IRENA 2013). As affordability of electricity is a key issue in rural Zambia, options to facilitate end user access to electricity services can include targeted subsidies and deferred payments schemes. Business models such as providing energy for value-adding services can be considered both for stand-alone systems and mini-grids to make decentralised renewable energy projects more attractive for private investors.

A potential solution for consumer financing could be pay-as-you-go (PAYG) technologies. Under PAYG, customers pay an installation fee for a solar energy system that powers basic lights and devices such as radio and television. Following the installation, access to electricity is unlocked after buying a credit through a mobile platform paid for monthly. PAYG sales have not yet become common in Zambia, however they have gained some prominence in Tanzania where the electrification rate is even lower than in Zambia. PAYG could provide the means to increase the ability of low-income households to purchase solar-based power.
Case Studies

The Tasmanian Energy Crisis 2016

Tasmania is part of Australia’s liberalized National Electricity Market, being joined to the mainland via the Basslink underwater interconnector to Victoria. Its electricity generation is primarily hydro and, as a result, the state is highly dependent on rainfall for electricity generation. Peaking capacity is provided by four gas turbines, with base load capacity from a combined cycle plant, all of which comprise the Tamar Valley Power Station. Due to high water levels and the interconnector, the combined cycle plant was thought to be redundant and was decommissioned in 2014 to be subsequently sold.

However, on 20 December 2015 Basslink had to be shut down due to a cable fault offshore. This event coincided with a particularly dry period, leaving dams severely depleted, which meant that Tasmania’s security blanket for such times of drought had been lost.

Actions taken to minimise the consumption of water from Hydro Tasmania’s storages included:

- Recommissioning of the gas-fired Tamar Valley Power Station
- Striking agreements with the three major industrial customers – the two Tamar Valley smelters Bell Bay Aluminium and TEMCO, and Norske Skog’s paper mill at Boyer - to reduce their load by a combined 180 MW
- Deploying up to 200 MW of portable diesel generators
- Bringing Hydro Tasmania’s cloud seeding programme, usually scheduled to start in May each year, forward by a month

Despite these actions, wholesale power prices surged by more than 350% as a result of the crisis, and the economic “hit” to the state was estimated to be in excess of A$560 million. Fortunately, the gas pipeline from the mainland was still operational so that emergency supplies for the gas-fired power plants could still be delivered.

The moral of this event is very clear: energy security is an essential element of any power system. In addition, diversity of energy technologies is an important aspect of energy security, as is diversification of supply sources.

The Brazilian Drought Crisis 2014-16

The 2014–16 Brazilian drought was a severe drought affecting the southeast of Brazil including the metropolitan areas of São Paulo and Rio de Janeiro. As over seventy percent of Brazil’s electricity is generated by hydropower there was concern that a lack of water may also lead to energy rationing in addition to water rationing. Thermal plants were used to fill the energy gap, but the switch was very costly. In response to decreased hydroelectric power, rolling power cuts were also instituted.

A novel approach to the problem was to install floating PV arrays on the dams to generate power when water supplies were depleted. The logic behind placing solar panels on dams is that hydro acts as a back-up for the variable output of the PV, and utilizes the same transmission infrastructure. Thus water is “saved” during daylight hours. In addition, one of the most expensive aspects of grid scale PV is its associated transmission requirements which are avoided in this situation.
Floating solar panels are more efficient than land-based arrays, largely due to the fact that they have water on hand to cool them down. “Floatovoltaics” is also appealing because it is cheaper to float panels over water than to rent or buy land. They can be constructed more quickly than land-based installations, and more easily tucked out of sight. Finally, floating arrays also shade the water and consequently reduce algae blooms and water evaporation. Brazil’s first floating solar arrays came on-line in March 2016.

New Zealand

Hydroelectric generation contributes around 60% of New Zealand’s total electricity supply, with many generators of widely varying sizes distributed throughout the country.

Inflows (rainfall and snowmelt) can be stored in hydro lakes until needed. The lakes have quite limited operating ranges – for technical and resource consent reasons, each lake’s level cannot be lowered below a certain point. It is not possible to completely “empty” a hydro lake. In the absence of inflows, the lakes can only hold enough water for a few weeks of winter energy demand.

For security of supply purposes, hydro storage is divided into two categories: controlled and contingent storage. Generators can use controlled storage at any time, but contingent storage may only be used during defined periods of shortage or risk of shortage. During sustained dry periods, controlled and contingent storage are important indicators of overall supply risks. Storage is expressed in gigawatt-hours – GWh (a measure of the energy that can be produced using the water).

New Zealand has a liberalized power market, and therefore (the theory goes) as prices climb during periods of unusually dry conditions additional, fossil fuel, plants (currently moth-balled) would be encouraged to return to supplying the grid. However, at present, one of the generators is paid to keep a 500 MW gas and coal power station in reserve, which is really in conflict with the liberalized market model. The correct approach would be to offer a backup dry-year supply determine by auction, but the market is probably too small to deliver a competitive outcome.

The New Zealand model clearly relies upon a surplus of generating capacity, particularly for dry years. Nevertheless, Zambia could perhaps adopt the concept of controlled and contingent storage, adapted for domestic conditions.

Pump Storage

Pumped storage projects store and generate energy by moving water between two reservoirs at different elevations. At times of low electricity demand, like at night or on weekends, excess energy is used to pump water to an upper reservoir. During periods of high electricity demand, the stored water is released through turbines in the same manner as a conventional hydro station, flowing downhill from the upper reservoir into the lower reservoir and generating electricity. The turbine is then able to also act as a pump, moving water back uphill.

The power used to move water back uphill would generally come from surplus generation capacity from inflexible technologies such as nuclear, brown coal, solar, and wind. In other words, technologies which cannot be easily ramped down during times of low demand, or those that are variable in output and generate power when conditions are favourable irrespective of demand.

According to the IEA (2010), pumped-storage hydropower is the largest and most cost effective form of electric energy storage at present. It claims that the current global capacity of pumped-hydro storage
could increase tenfold as some existing hydropower plants could be transformed into pumped-hydro storage plants.

In South Africa the first of four units of the 1332 MW Ingula Pumped Storage Scheme came into operation in June 2016. The plant uses water from the upper reservoir to generate electricity during the peak demand periods of the day. At night, excess power on the grid generated by conventional coal and nuclear plants is used to pump water back to the upper reservoir. However, there are currently no plans to build pump storage hydropower in Zambia, probably because the inflexible technologies mentioned above do not currently exist in the country (with the possible exception of the Maamba coal-fired plant).
Policy Options

On the basis of the information contained in this report, a number of promising areas for follow up study and action to address the challenges facing Zambia’s electricity sector are listed below. The order is of little relevance, although the “option” that electricity tariffs migrate to cost reflective levels clearly has ramifications for virtually all of the others. In addition, all of the options given below are, in general, not independent of each other.

- The removal of all direct and indirect electricity sector subsidies, and migration to cost reflective tariffs, subject to the establishment of an appropriate mechanism for supporting low income consumers. However, calculation of “cost reflective tariffs” is not a trivial exercise and, in a non-liberalized market, the question of how such tariffs should be calculated is not unambiguous. Thus external expertise may need to be employed, to complement local expertise, in order to ensure both the technical credibility and financial viability of the framework of the resulting tariff structure.

- Encourage private investment in order to exploit the full potential of Zambia’s hydropower resource. Zambia has the potential to become a significant electricity exporter into the SAPP, when the current drought ends. Such exports could be particularly valuable if they are excess to domestic power requirements and could be sold during peak periods in order to benefit from the corresponding high prices. Currently, ZESCO and the CEC are importing during peak periods and exporting during off-peak!

- The establishment of a dry years reserve policy, designed to provide energy security of supply during drought years. Given the interconnected nature of the SAPP, this may best be accomplished on a multi-lateral basis. In addition, since drought conditions may well affect all of the SAPP countries, reserves would likely have to be either VREs or coastal fossil fuel and nuclear plants.

- Invest in more fossil-fired capacity to meet baseload demand, particularly where plant can be brought on-line in a relatively short time frame and at a low per MW cost compared with hydro. The introduction of cost reflective domestic tariffs would make building thermal capacity a more favourable business proposition for IPPs than it is at present.

- Diversity the VRE generation technology mix by investing in on-grid solar to the extent that it can be integrated into the current grid structure. Future investment in the transmission infrastructure would need to ensure that it is VRE “friendly”.

- Opportunities for off-grid solar installations to be identified, and evaluated financially, with the ultimate intention of reducing the energy poverty level of the rural population by giving them access to electricity. Off-grid solar tends to be significantly more expensive than on-grid, but it can deliver considerable welfare benefits for rural communities. However, even if finance can be raised for the initial investments, on-going financial resources have to be devoted to ensuring that proper maintenance regimes are put in place in order to ensure the long-term integrity of such investments.

- Facilitate the role of the private sector in investment in power generation plant and, in particular, power purchase agreements with ZESCO. Again, cost reflective electricity tariffs should unlock such options, as is illustrated by the recently commissioned Maamba coal-fired power plant.

- Develop medium and long-term energy policy objectives, including energy efficiency and demand-side management, supported by the appropriate legal and regulatory frameworks. It is important that project and policy developments follow the agreed timelines;
• Break up ZESCO’s vertically integrated structure into its natural component parts: generation, transmission, and distribution. Further, encourage private companies to enter at the generation stage through appropriate incentives, again provided cost reflective tariffs are in place. Transmission and distribution are natural monopolies and, privatized or not, they would still need to be the subject of strict financial, regulatory, and operational scrutiny to ensure that they operate not only according to market-based principles but also in the interests of the broader Zambian community.

• Separate out the retailing functions of ZESCO so that residential consumers are not competing with mining sector requirements or exports to the SAPP. Vesting contracts could be used to ensure sufficient supplies are dedicated for the residential sector at a contractual (i.e. pre-determined) cost. The mining sector has the capacity to purchase from the SAPP, via the CEC, during periods of supply shortfall and, based upon recent experience, has the ability to pay the resulting higher prices.

• Establish a long-term roadmap for the power sector, with appropriate milestones. This exercise would be required to formulate both power supply and demand scenarios for Zambia, together with developments in power generation technologies, energy efficiency improvements, and the move towards the smart grid. Inevitably, external developments will largely determine the latter and thus external expertise would be required to develop the roadmap scenarios in conjunction with Zambian counterparts.

• A detailed renewable potential resources assessment is required in order to derive a reliable estimate of appropriate renewable technologies for Zambia and corresponding achievable levels of generation from those sources.

• Development of long-term power strategies and actions for supply security, energy efficiency, and demand-side management, and the provision of technical assistance for policy review and the establishment of an appropriate legal and institutional framework. If tariffs are raised to cost reflective levels, then aggressive action is vital in giving electricity consumers detailed information on how they can reduce their consumption to offset the resulting increase in their electricity costs. Empowering the consumer via information is essential for minimizing the adverse cost impact of electricity sector reform.
On 7 September 2016, the Zambian Watchdog reported that President Lungu had agreed to a number of conditions specified by the IMF in order for Zambia to receive a US$1.3 million (that should read “billion”) bail-out package (i.e. budgetary support). It claimed that conditions relating to the electricity sector were as follows:

“Massive” reduction of the ZESCO workforce;

ZESCO to be disbanded into three entities: generation, distribution, and marketing (no mention of transmission!) and sold to the private sector; and

All subsidies and support schemes to be removed in the power sector.

The statement is rather vague, and lacks an indication of timelines. However, one would expect the IMF not to give, or even offer, budgetary support if a substantial part of it were to pay for further subsidies.
References


World Bank. 2016b. *How can Zambia Benefit More from Mining*?


Glossary

Cost reflective tariffs

Cost reflective tariffs are tariffs that are just sufficient to cover efficient input costs, and at the same time provide for a reasonable return to the generator, the network operator(s), and the retailer. Their calculation entails the evaluation of the following components that contribute to the “cost stack” of the electricity tariff to the end-user:

- the cost of generating electricity;
- the cost of transmitting electricity across the transmission and distribution networks;
- the cost to retailers of meeting their renewable energy obligations (e.g. feed-in tariffs);
- the billing, call centre and other costs associated with running a retail electricity business; and
- the return that each of these stages must earn to have an incentive to provide a service.

“Efficient input costs” are those that would prevail if there were a perfectly competitive market (which, in general, there is not).

Feed-in Tariffs

A feed-in tariff (FiT) is a subsidy scheme designed for electric utilities to purchase electricity generated by renewable energy plants at a tariff that is determined by the utilities and guaranteed for a specified period of time. The tariff can vary for different renewable energy technologies, locations, and sizes. FiTs are typically offered when domestic electricity tariffs are below the cost of production of renewable energy sources. For long term policy stability, any FiT scheme should involve:

- Payments based on the cost of producing renewable energy;
- Guaranteed grid access;
- Guaranteed off-take of all electricity generated; and
- A review date or sunset clause.

Ideally, the total cost of the subsidy should be spread across all electricity consumers on a cents/kWh basis to avoid undue financial pressure on the Government budget.

Vesting contracts

Vesting contracts are signed between generation companies and retailers. With a vesting contract, a generation company is committed to sell a specified amount of electricity (viz. the vesting contract level) at a specified price (viz. the vesting contract price). This removes the incentives for generation companies to exercise their market power by withholding capacity to push up market prices. They are often used to cover supply to non-contestable end-users under a regulated tariff, which are generally composed of households and small businesses.

The vesting price is generally set by taking the long run marginal cost of the most efficient generation technology. The policy objective is to promote efficiency and competition in the electricity market for the benefit of consumers. To ensure that vesting contracts reflect the prevailing market conditions, they must be reviewed on a regular basis or at other times when it is considered necessary.