Subsidy Swap:

Reducing fossil fuel subsidies through energy efficiency and renewable energy in Zambia

GSI REPORT

IISD International Institute for Sustainable Development

Global Subsidies Initiative

CUTS International

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About GSI

The IISD Global Subsidies Initiative (GSI) supports international processes, national governments and civil society organizations to align subsidies with sustainable development. GSI does this by promoting transparency on the nature and size of subsidies; evaluating the economic, social and environmental impacts of subsidies; and, where necessary, advising on how inefficient and wasteful subsidies can best be reformed. GSI is headquartered in Geneva, Switzerland, and works with partners located around the world. Its principal funders have included the governments of Denmark, Finland, New Zealand, Norway, Sweden, Switzerland and the United Kingdom, as well as the KR Foundation.

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Written by Richard Bridle, Mikko Halonen, Markus Klimscheffskij, Chenai Mukumba and Charity Siwabamundi

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Executive Summary

Fossil fuel subsidies promote wasteful consumption, can be extremely costly to public budgets and the bulk of the value of subsidies tend to be captured by the richest groups in society (Kojima et al., 2016). The reform of fossil fuel subsidies creates opportunities to reinvest savings into other priority areas such as infrastructure, health or education. In the past, reforms have largely focused on the removal of subsidies to fossil fuels without developing a sustainable, affordable energy system that can cover its costs and meet the needs of the people. This is a missed opportunity; a reallocation of fossil fuel subsidies to clean energy could accelerate the deployment of clean energy technologies, ultimately delivering a clean energy system without the need for ongoing subsidies. This concept is called a subsidy "swap" (Merrill, 2017). This report presents an analysis of the impact of fossil fuel subsidies on the Zambian energy sector and an assessment of the potential for removing the remaining fossil fuel subsidies and reallocating some of the savings to fund an expansion of the clean energy supply.

In Zambia's electricity sector, demand has risen faster than supply. The 7th National Development Plan states that Zambia's peak demand for electricity stood at 1,949 megawatts (MW) in 2015, considerably more than current peak generation of 1,281 MW, creating a deficit of 668 MW (Republic of Zambia, 2017). Government projections indicate that growth in demand will continue to increase at a rate of 150 to 200 MW per annum. Around 28 per cent of the population currently has access to electricity (62 per cent in urban and 5 per cent in rural areas) (RECP, n.d.).

In response to rising demand, several new power plants have been commissioned. In 2016 the 300 MW Maamba coal power plant and the 120 MW Itezhi Tezhi hydropower plant came online, increasing total capacity by 17 per cent. The investment in coal marks a significant departure from the hydro-dominated electricity system (Energy Regulation Board of Zambia, 2016). As of June 2017, coal accounts for just over 10 per cent of generation capacity. To meet the projected demand increases, a pipeline of electricity generation projects will be needed or demand will need to be reduced.

Subsidies, particularly in the form of under-recovery of electricity sector revenues caused by below-cost pricing, have led to electricity sector deficits and threatened the financial sustainability of the sector. In 2016, the World Bank reported that, between September 2015 and May 2016, fuel subsidies in Zambia averaged close to USD 36 million per month and electricity subsidies around USD 26 million per month, costing a combined total of USD 576 million over the period (World Bank, 2016). Price increases for petroleum products in October 2016 and the adoption of a cost-plus pricing methodology have effectively eliminated these direct transfers for liquid petroleum fuels. Price increases in the electricity sector in 2017 of 75 per cent have reduced electricity sector subsidies, but costs remain higher than revenues. Electricity consumption in the mining sector accounts for 55 per cent of all electricity consumed in the country (Energy Regulation Board, 2017). Electricity pricing in the mining sector is therefore essential to bridging the gap between costs and revenues in the electricity sector.

In light of the challenges facing the country, two subsidy swap concepts were reviewed that could help to reduce the cost of subsidies and promote investment in sustainable energy.

1. **Reduce electricity subsidies to the mining sector and fund energy efficiency**

   In the mining sector, electricity is below cost-recovery levels. Low electricity prices provide a disincentive to save energy. Price increases could threaten the competitiveness of mining companies. However, if subsidies can be partially redirected to promote energy efficiency, it may be possible to design policies that promote less consumption of electricity, saving the government on subsidies, with higher unit prices for electricity but lower overall energy costs.

2. **Reduce subsidies through replacement of expensive fossil-fuelled electricity generators with renewable energy**

   The gap between the high prices paid to some generators, particularly diesel generators, and the revenues received from retail tariffs could be reduced by supporting a gradual replacement of expensive diesel generators with increasingly lower-cost renewable generators.

This report finds that both concepts are feasible and relevant. The first concept, promoting energy efficiency in the mining sector, has been selected for further study. Despite recent price increases, the tariffs paid by mines remain below cost-recovery levels. The deployment of an initiative to use subsidy reform savings to promote energy efficiency could provide a "win–win" scenario, reducing energy costs of mining companies and displacing subsidized generation.

For the second concept, replacing subsidized diesel generation with solar photovoltaic (PV), there are already several initiatives that aim to increase the deployment of solar PV and reduce the consumption of electricity from diesel as cheaper sources become available. These plans could be accelerated through further coordinated actions, but this area is already relatively well served.

Subsequent research will include a consultation with mining sector companies and government aiming to assess the options for swapping subsidies from low electricity prices to support energy efficiency. This research will focus on the following areas:

- **Current energy management practice** – What is the energy consumption of mines in Zambia, and how large is the savings potential? How can good examples from current practice be expanded and further improvements developed drawing on best international practices?
- **Stakeholder engagement and political will** – Who are the key stakeholders in government, the private sector and the donor community that would be interested in taking a support scheme forward?
- **Set-up of a potential fund** – How could a fund be administered? How would the internal organization work? Which best practices could be used?

The research will also seek to promote awareness within the mining sector of the pressures to increase electricity prices, the potential impact on the mining sector and the potential of energy-efficiency investments to "future-proof" mining in Zambia.

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Abbreviations

BPCL	Bangweulu Power Company Limited
CEC	Copperbelt Energy Corporation
ERB	Energy Regulation Board of Zambia
GET FiT	Global Energy Transfer Feed-In Tariff
GWh	gigawatt-hour
IMF	International Monetary Fund
IPP	independent power producers
kWh	kilowatt hour
MW	megawatts
NPCl	Ngonye Power Company Limited
PPA	power purchase agreements
PV	photovoltaic
REA	Rural Electrification Authority
SDG	Sustainable Development Goal
TWh	terawatt-hour
ZDA	Zambia Development Agency
ZESCO	Zambia Electricity Supply Corporation Limited

1.0 Introduction

Fossil fuel subsidies have been introduced in many countries for several reasons, including to increase access to energy, to protect consumers from fluctuating international prices or to increase competitiveness in nationally important industries. Subsidies are often introduced as temporary measures but, once in place, are very difficult to remove. Fossil fuel subsidies include subsidies to oil, gas and coal, as well as electricity generated from fossil fuels.

Fossil fuel subsidies promote wasteful consumption, they can be extremely costly to public budgets, and the bulk of the value of subsidies tend to be captured by the richest groups in society (Kojima et al., 2016). Due to these negative impacts, many countries and groups of countries including the G20, the G7 and the Asia-Pacific Economic Cooperation have pledged to reform fossil fuel subsides, and fossil fuel subsidy reform has been included as part of Sustainable Development Goal 12 (SDG 12). Between 2015 and 2017, more than 40 countries reformed their fossil fuel subsidies (Merrill, Gerasimchuk, & Sanchez, 2017).

The reform of fossil fuel subsidies creates opportunities to reinvest savings into other priority areas such as infrastructure, health or education. At the same time, there is a need to protect and enhance affordable energy access for households and industry. In the past, reforms have largely focused on the removal of subsidies to fossil fuels without developing a sustainable, affordable energy system that can cover its costs and meet the needs of the people. This is a missed opportunity; a reallocation of fossil fuel subsidies to clean energy could accelerate the deployment of clean energy technologies, ultimately delivering a clean energy system without the need for ongoing subsidies. This concept is called a subsidy "swap" (Merrill, 2017).

The swap concept is simple: reduce fossil fuel subsidies and reallocate a portion of the savings to promoting the deployment of clean energy.

This report outlines two options for a subsidy swap in Zambia and provides an assessment of their feasibility. The concepts are: 1) swapping electricity subsidies for support to mining sector energy efficiency and 2) replacing subsidized diesel generation with solar PV.

2.0 Country Context

Zambia's population has risen from approximately 10 million in 2000 to 16 million in 2016 (World Bank, 2018). This has been accompanied by a large increase in energy demand. The 7th National Development Plan states that Zambia's peak demand for electricity stood at 1,949 megawatts (MW) in 2015, considerably more than current peak generation of 1,281 MW, creating a deficit of 668 MW (Republic of Zambia, 2017). Government projections indicate that growth in demand will continue to increase at a rate of 150–200 MW per annum. Around 28 per cent of the population currently has access to electricity (62 per cent in urban and 5 per cent in rural areas) (RECP, n.d.).

Electricity generation is traditionally dominated by hydropower, which was available in abundance and ensured extremely low electricity prices. In recent years, droughts have restricted the availability of electricity generated from hydropower, which led to the expansion of fossil-fuel-based generation. In 2016, hydropower accounted for 84.5 per cent (2,388.3 MW) of the total national installed capacity, followed by power generation from coal (10.6 per cent, 300 MW), diesel (3.1 per cent, 88.6 MW), and heavy fuel oil (1.8 per cent, 50 MW) (Energy Regulation Board of Zambia [ERB], 2017a). Solar photovoltaic (PV) made up less than 0.1 per cent (0.06 MW) of power generation. Zambia's state-owned electricity utility, Zambia Electricity Supply Corporation Limited (ZESCO), a vertically integrated company, owns the bulk of generation stations. ZESCO's largest customer is the Copperbelt Energy Corporation (CEC), a private company that sells electricity to the copper mines. CEC purchases more than 50 per cent of all generated electricity (RECP, n.d.). The mining sector is by far the largest electricity consumer in Zambia (see Figure 1).

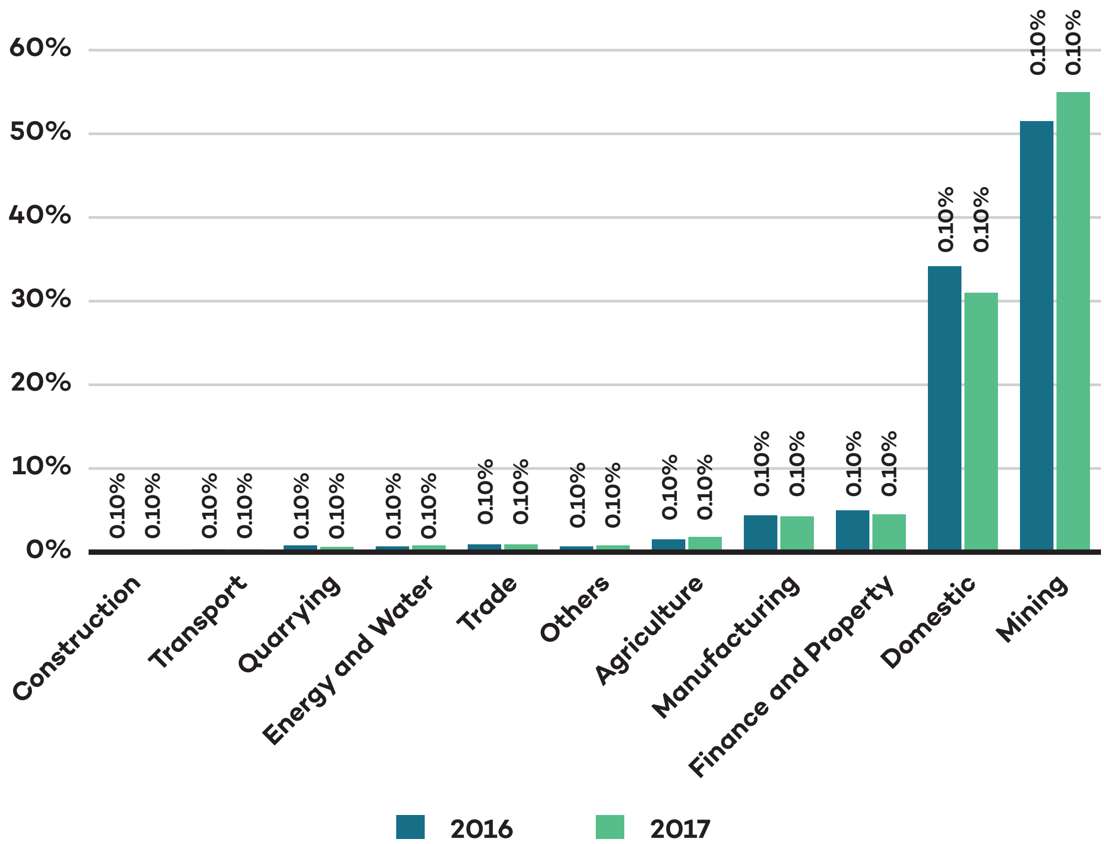

Figure 1. Electricity consumption by economic subsector, January to June 2017 and 2016 (Source: ERB, 2017b)

In response to rising demand, several new power plants have been commissioned. In 2016 the 300 MW Maamba coal power plant and the 120 MW Itezhi Tezhi hydropower plant came online, increasing total capacity by 17 per cent. The investment in coal marks a significant departure from the hydro-dominated electricity system (ERB, 2016). As of June 2017, coal accounts for just over 10 per cent of generation capacity (Figure 2). To meet the projected demand increases, a pipeline of electricity generation projects will be needed. Independent power producers (IPPs) have started to play an increasing role in Zambia's energy sector and have delivered much of the recent capacity increases.

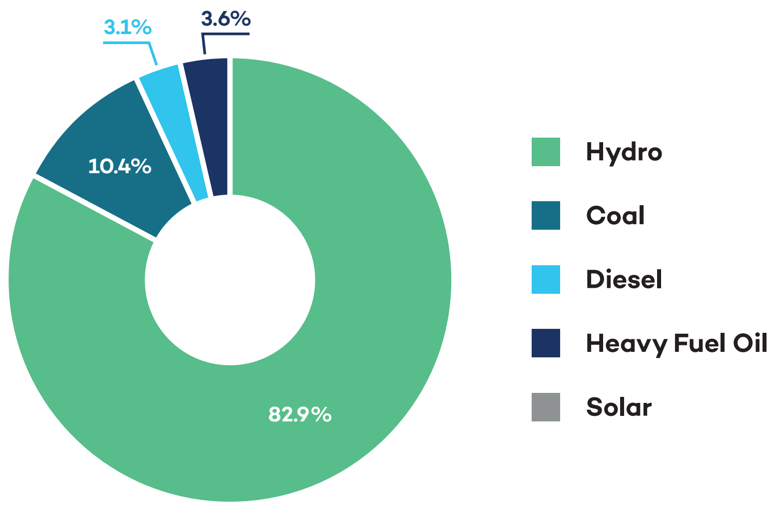

Figure 2. Electricity generation capacity by source, June 30, 2017 (Source: ERB, 2017b)

3.0 Fossil Fuel and Electricity Subsidies in Zambia

Zambia successfully eliminated its consumption subsidies on petroleum products in 2016.[1] The International Monetary Fund (IMF) estimates that in 2015 there were approximately USD 2 billion "pre-tax" subsidies to fossil fuel consumption, including in the electricity sector. Under the IMF definition, pre-tax subsidies exist where consumers pay prices below the cost of supply. In addition, foregone tax revenue in 2015 totalled a further USD 270 million (IMF, 2015). In 2016 the World Bank reported that, between September 2015 and May 2016, fuel subsidies in Zambia averaged close to USD 36 million per month and electricity subsidies around USD 26 million per month, costing a combined total of USD 576 million over the period (World Bank, 2016). Price increases for petroleum products in October 2016 and the adoption of a cost-plus pricing methodology have effectively eliminated these direct transfers for liquid petroleum fuels.

The main subsidies left in Zambia are therefore in the electricity sector. Electricity tariffs have historically been set at rates lower than the cost of supply, creating a shortfall between the revenues from customers and operating costs. Zambia has indicated intentions to move to cost-reflective tariffs in 2017, in line with the regional targets of the Southern African Development Community (RECP, n.d.). To address this, two price increases for electricity consumers were implemented in 2017—a 50 per cent increase in May followed by a 25 per cent increase in September. However, these price increases did not apply to the mining sector, by far the largest single consumer of electricity in Zambia. These price increases are expected to have significantly reduced the cost of electricity subsidies; the exact extent of the remaining subsidies will be evaluated as the cost of service study is published.

To address mining sector underpricing of electricity, following a process of negotiation since December 2016, it was agreed that, effective January 1, 2017, mining tariffs would increase to 9.30 U.S. cents per kWh up from of individually negotiated rates that averaged 6 U.S. cents/kWh (Reuters, 2017). Thereafter, mining tariffs will be determined based on the results of the cost of service study, which is being undertaken countrywide. Further to this, the Electricity Act and the Energy Regulation Act are being revised to address issues such as power purchase agreements with the mines.

The transition to higher prices for the mines is controversial. In January 2017, seven mining companies in the North-Western and Copperbelt provinces started paying the revised electricity tariffs; however, in late 2017, there was a standoff between Mopani Copper Mines Plc and the CEC, the grid operator for the mining region. CEC cut supply to Mopani to 94 MW from 130 MW. Following the threat of job losses, the CEC and Glencore's Mopani Copper Mines eventually reached an agreement to restore full power supply to the mine. This indicates that further price increases may face opposition from the mining sector.

In addition, there may be subsidies to power generation, given the high tariffs paid to diesel generators, particularly temporary diesel generators installed during 2015 and 2016, which are reported to have received 14–18 U.S. cents per kWh, reflecting the high operating costs of these technologies (Federal Ministry for Economic Affairs and Energy, 2016). One approach to measuring the effective subsidy paid to these IPPs is to compare the prices paid to IPPs to a benchmark tariff.

Choosing an appropriate benchmark is a challenge, especially where a large amount of the generation capacity has long ago depreciated. This renders the "average" cost of existing generation far lower than the cost of adding any new capacity to the system. A subsidy analysis that selects an average cost of current generation as a benchmark will conclude that all new IPPs are subsidized. In Zambia, the cost of operating existing hydropower

[1] The nationally applied definition of the term "subsidies" in Zambia is limited to direct transfers. Costs of purchasing fossil fuels and the revenues generated from consumer sales and shortfalls are recorded as subsidies by the finance ministry. However, internationally applied definitions of subsidies typically include foregone tax revenues, provision of goods or services below market rates and market price support through tariff regulation in addition to direct transfers (Global Subsidies Initiative, 2014). The difference in the definition applied explains the variation in estimates from various international observers.

plants, which tend to be low cost, is of little use in determining the price that should be paid to new generators. However, comparing the cost of operating existing generators to new generators can provide information on the current cost of generation. The cost of power purchase from IPPs ranged from 7 U.S. cents per kWh to 15 U.S. cents per kWh (ERB, 2015), which provides an indication of the levelized costs from recently constructed hydro, coal or diesel generators. Similarly, a number of recent renewable energy auctions have resulted in bids significantly below the price of some of the more expensive IPPs. For example, in 2016 the World Bank Group launched the Scaling Solar program. The power price for generators was determined by reverse auctions. The first round of auctions yielded bids of 6–7 U.S. cents per KWh (Industrial Development Corporation, 2016). As of June 2018, a further auction for 100 MW of solar PV is underway as part of the Global Energy Transfer Feed-In Tariff program Get FiT (Get FiT Zambia, 2018). The prices achieved in Get FiT auctions will give a further indication of current renewable energy prices. It seems that wind and solar energy are increasingly competitive with other available new generators, as costs paid to IPPs and the renewables auction results attest. The higher tariffs granted to fossil fuel projects could therefore be considered as fossil fuel subsidies.

3.1 Potential Fiscal Savings from Reform

Between September 2015 and May 2016, electricity subsidies averaged around USD 26 million per month according to an estimate by the World Bank (2016). Since then, the 75 per cent price increase for retail electricity has reduced the cost of the subsidies to the public budget. The forthcoming cost of service study by the ERB will be key to determining the remaining gap between operating costs and customer revenues in the electricity sector and the resulting subsidies. The most striking example of this is currently the mining sector, which consumes more than half of all electricity yet pays some of the lowest tariffs. If full cost recovery is achieved without parity of tariffs between mining and other sectors, cross-subsidies would arise and other consumers could still be effectively paying a subsidy to the mining sector.

To get a sense of where cost-recovery tariffs might lie, we can consider the power prices of other sub-Saharan African countries. Due to the large amount of existing hydro generation in Zambia, national prices are likely to be considerably lower than regional averages. The forthcoming cost of service study will shed more light on the true cost of electricity generation. In the meantime, a comparison with average tariffs in the region can provide an indication. Figure 3 shows a summary of industrial and commercial tariffs in the region. In 2014, Zambia's power prices were among the lowest in the region. Notwithstanding, the recent increases in electricity tariffs are generally 2–4 times higher in nearby countries. Electricity costs are nationally specific based on the available resources, the generation assets available and the history of the sector. However, this finding provides an indication that, since few countries in the region are able to sell power as cheaply as Zambia, there may still be significant historical underpricing of electricity.

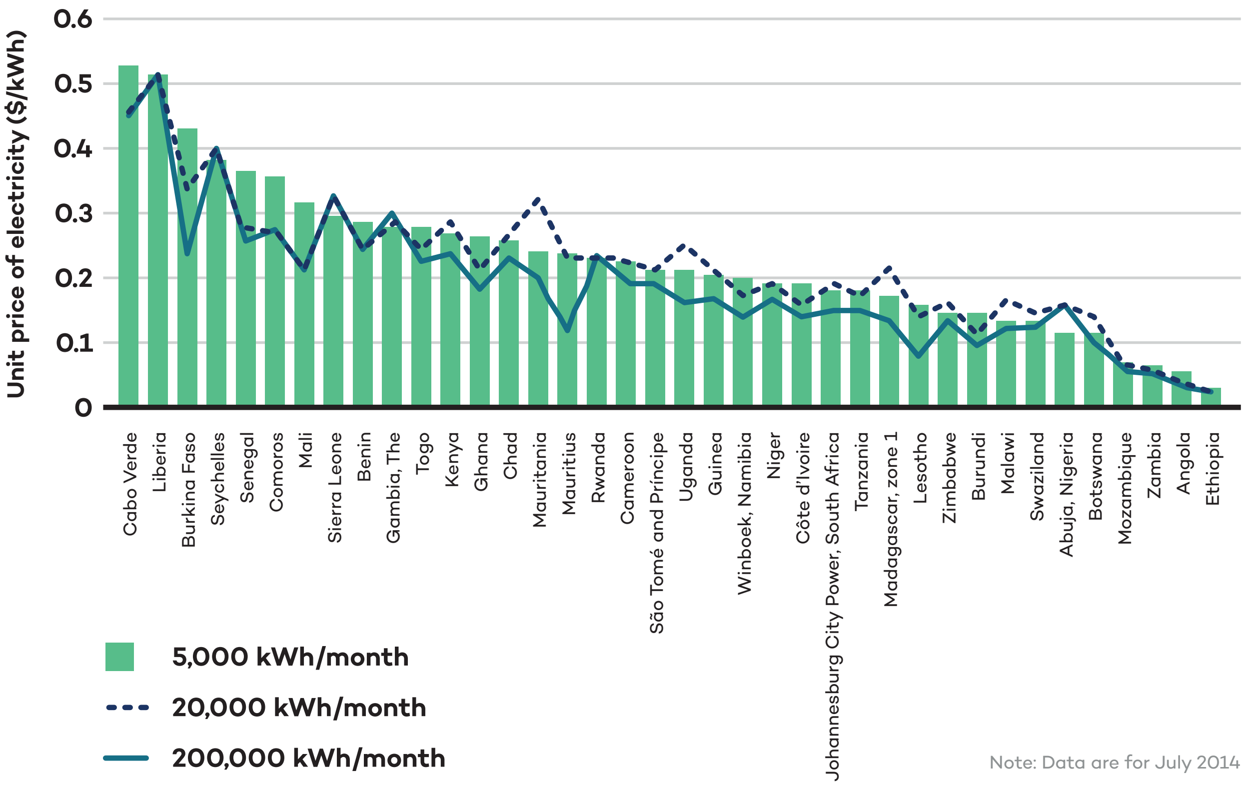

Figure 3. Unit price of electricity paid by commercial and industrial customers in selected countries in sub-Saharan Africa, 2014 (Source: Kojima & Han, 2017)

To provide some indication of the level of funding that could be available from cost-reflective tariffs, it is possible to compare the current tariffs with regional averages. Mining sector tariffs rose to 9.30 U.S. cents per kWh in 2017 (Reuters, 2017). As of June 2017, the standard rate for residential consumption was ZMW 0.77 per kWh (approximately 7.4 U.S. cents per kWh). Consumers of up to 200 kWh pay a lifeline tariff of just ZMW 0.15 per kWh (approximately 1.5 U.S. cents per kWh) (ERB, 2017b). These rates are well below comparable rates in the region. The mining tariff is just 55 per cent of the 2014 sub-Saharan African median commercial tariff of 17 U.S. cents per kWh (Kojima & Han, 2017). This indicates that, if the true cost of power generation is similar in Zambia to other regional countries, electricity sector revenues may need to almost double to reach cost-recovery levels. An increase in revenues in line with typical regional prices would very substantially free up scarce government resources for other priorities.

The replacement of diesel generation with solar could also yield substantial financial savings. ZESCO has observed that connecting all districts that are currently running on diesel-generated power to the national electricity grid will save about USD 8 million, which it spends on fuel per annum (Lusaka Times, 2016b).

A further source of cross-subsidies comes in the form of the lifeline tariff. Many countries in Africa use lifeline tariffs to promote access to electricity. A source of debate is how much consumption should be provided at the lifeline rate. A study by the World Bank found that 50 kWh is the most common lifeline tariff block, adopted by eight countries, followed by 25, 75 and 100 kWh (three countries each) (Kojima et al., 2016). This indicates that Zambia, which sets the lifeline tariff at 200 kWh and applies it to all customers, allows a greater proportion of households to have access to subsidized electricity tariffs. If lifeline tariffs apply to too many consumers, the benefit is likely to be increasingly captured by the rich, who tend to use more electricity, especially since grid electricity is only available to around 31 per cent of the population, predominately in urban areas (Energy Access Africa, 2017).

4.0 Managing the Impacts of Reform

Two groups would be particularly affected by an increase in electricity tariffs: the mining sector and those benefiting from the lifeline tariff. In addition, high-voltage users as well as schools, hospitals and other social services also pay below-cost-recovery tariffs. All of these groups are likely to face price increases from electricity subsidy reform in the future, as prices rise to cost-recovery levels. Understanding these impacts and determining whether to put in place mitigation policies to limit these impacts should be key considerations for policy-makers contemplating reforms.

To understand what kind of impacts could be expected, previous subsidy reforms can be evaluated. CUTS Lusaka reviewed the impact of the reforms to diesel and gasoline prices in 2013. The reforms took place at a time when the government was spending 3.6 per cent of revenues on fuel subsidies, and reform was considered the only option to reduce fiscal deficits (CUTS, 2013).

The research analyzed the welfare impacts of the price increases on different consumer groups with a particular focus on the impacts on poverty. The findings of the study were that the rich, who tend to consume more energy, were hardest hit in absolute terms, seeing their spending on energy increase suddenly. However, in relative terms, the poor saw the energy costs increase as a proportion of their income. The price increase led to a reduction in diesel consumption in the manufacturing and agricultural sectors of approximately 40 per cent (CUTS, 2013). This reduction represents a decline in some aspects of economic activity, particularly in the transport of goods. The tariff increases were quite controversial at the time and were put in place without a comprehensive package of measures to limit negative impacts on vulnerable groups. The key finding that can be taken from the experience in 2013 is that more could have been done to predict the impacts on the various beneficiary groups and to mitigate the worst of these.

In the electricity sector in 2017, residential users consumed 31 per cent of electricity and the mining sector consumed 55 per cent (Figure 2) (ERB, 2017b). These sectors account for the vast majority of consumption and should receive particular attention. Efforts to assess and manage the impacts of reform should therefore focus on these sectors.

For residential consumers, there is already a mechanism for ensuring access to electricity at affordable prices—the lifeline tariff. As discussed, the lifeline tariff must strike a balance between protecting the vulnerable from price increases, which is generally agreed to be a legitimate development goal, and charging cost-reflective prices to customers who can afford them.

The impact of power prices on the mining sector is significant. In 2016, with the assumed electricity price of 9 U.S. cents per kWh, the total electricity bill of the mining industry equals some USD 620 million per year. Indeed, a typical Zambian mine spends several million USD on electricity per month (Mining for Zambia, n.d.). An increase in prices could threaten the viability of some mines. An understanding of the potential impact of energy price increases on viability should inform subsidy reform plans. Conversely, measures that can promote mining sector efficiency can serve to reduce exposure to energy prices.

5.0 Building Support for Reform

A stakeholder mapping exercise was undertaken to explore the perceived attitudes toward fossil fuel subsidy reform and renewable energy deployment among key stakeholder groups. The review assessed the interests of each group and produced an estimate of the support for renewable energy deployment, support for fossil fuel subsidy reform and an indication of their perceived influence on both issues. The stakeholder analysis is based on interviews with key institutions as well as desk-based research. While such stakeholder mapping exercises always contain a degree of subjectivity, they can help to highlight the potential allies and opponents of the subsidy swap concept and inform strategies. The following sections provide a summary of the main stakeholders.

5.1 Stakeholder Analysis

Ministry of Energy

This ministry is the principal institution responsible for energy planning and development of the energy sector. It coordinates and implements sector programs in support of economic growth and poverty reduction. The ministry has been undertaking efforts to meet the country's energy deficit. These efforts have resulted in importing electricity and purchasing power from IPPs at a high cost.

The objectives of a subsidy swap to increase affordable electricity supply and remove inefficient subsidies are in line with the policy direction of the Ministry of Energy. The Ministry of Energy has therefore a high level of interest in the implementation of the subsidy swap programs.

The Energy Regulation Board

The ERB is responsible for ensuring that utilities earn a reasonable rate of return on their investments necessary for providing quality service at affordable prices to the consumer. In addition, the ERB also ensures that all energy utilities in the sector are licensed, monitors levels and structures of competition, and investigates and remedies consumer complaints.

The ERB supports cost-reflective tariffs and the promotion of renewable energy and so would appear to have interests aligned with the subsidy swap.

Zambia Electricity Supply Corporation Limited

ZESCO is the vertically integrated electricity utility responsible for the generation, transmission and distribution of electricity in Zambia. In addition, ZESCO's role is to attract new investments into the sector, increase access to electricity in Zambia and promote new technologies, such as renewable energy initiatives in Zambia, that will ensure sustainability of power supply and the environment.

ZESCO has conflicting incentives with respect to renewable energy. On the one hand, they have a role to enable the growth of IPPs, including renewable energy generators; on the other, they are concerned with the potential for additional operating costs and the management challenges of adding significant quantities of variable generators.

International Finance Institutions

In 2016 the World Bank advised the Zambian government to cut down on its expenditures in order to stay within its annual budget and avoid external borrowing targets. It suggested that, by dropping fuel and power subsidies whose expenditure was estimated to be about USD 600 million annually, the government was going to stay within the limits of the budget and in turn reduce borrowing (African News Agency, 2016).

The IMF and the World Bank generally recommend the removal of fossil fuel subsidies in particular and subsidies in general (Coady, Parry, Sears, & Shang, 2015; World Bank, 2017). While they may be generally supportive of renewable energy, they may be reluctant to support policies that they view as being detrimental to other economic priorities.

The Patriotic Front Party

The Patriotic Front provides the current government in Zambia. Its manifesto has a section on energy development that states: "The country is aiming to reach 90 per cent and 51 per cent access by 2030 in urban and rural areas, respectively. In order to exploit the potential and attract IPPs to invest in power generation, the Patriotic Front government has commenced the revision of the electricity tariff with a view of arriving at a cost reflective tariff" (Patriotic Front, 2016).

Within the next five years, some of its objectives include:

- Attain cost-reflective tariffs by 2019, thereby promoting IPPs to invest in power generation. Additionally, to allow ZESCO to make a profit and recapitalize.
- Promote investment in alternative energy sources such as thermal electricity generation from coal and nuclear reactors.
- Promote investment in the development of renewable energy sources such as solar, biofuels and wind (Patriotic Front, 2016).

The Patriotic Front can therefore be expected to be in favour of renewable energy, though they are also supportive of other forms of generation, including fossil fuels. The Patriotic Front has a large influence on the course of reforms.

Energy Consumers (Electricity)

Following ZESCO's 2016 electricity tariff increases, there was a significant outcry from consumers who felt that the increase in the cost of electricity would adversely affect their cost of living directly through the increase in their electricity bills as well as indirectly through an increase in the cost of goods and services. The government had to reverse tariff hikes following numerous complaints from many domestic users (Lusaka Times, 2016a).

Consumers would likely be keen supporters of measures that expand grid access and reliability, but price increases would likely be met with opposition. An intensive sensitization campaign would be required in order to convince the general public of the benefits of subsidy reform on the economy as a whole, and information would need to be provided on mitigation measures such as targeted cash transfers or targeted subsidies. Ensuring that citizens are informed is a key step to achieving collaboration from consumers.

Mining Companies

Zambia is Africa's largest producer of copper, and cobalt and mining companies are the largest consumers of electricity, accounting for 55 per cent. The primary concern of mining companies is to have access to low-cost, reliable energy sources. If renewable energy or energy-efficiency measures lower costs or increase reliability, they would be supported. It is expected that, if renewable self-generation becomes cost effective, they may even make investments in this area. Mining companies are considered to generally support measures that would upgrade the electricity system and increase reliability. However, based on previous experience with the last increase in mining tariffs, they would likely be strongly opposed to price increases in the tariffs they pay.

Zambia Development Agency

The focus of the Zambia Development Agency (ZDA) is investment promotion, privatization, export promotion and market development as well as support to micro and small enterprises. The ZDA provides investment incentives for businesses investing in priority sectors and provides information on the available investment opportunities. The ZDA accompanies investors in the solar energy subsector, which benefits from investment incentives, including tax exemption for solar equipment. These incentives are meant to attract investments in renewable/clean energy (ERB, n.d.).

The ZDA is expected to be an ally in the discussion on the reform of subsidies and the promotion of renewable energy, to the extent that these reforms will promote opportunities for new businesses. On the one hand, the ZDA has an interest in the development of a reliable electricity system that that could be enabled by cost-reflective tariffs. On the other hand, price increases for electricity could undermine some potential businesses.

Rural Electrification Authority

The Rural Electrification Authority's (REA's) mission is to provide electricity infrastructure in rural areas using appropriate technologies in order to contribute to the improvement of the quality of life.

The REA would likely be keen to collaborate on the development of subsidy swaps to the extent that they would increase electrification in the rural areas, for example through a reallocation of subsidy savings toward grid extension or renewable energy off-grid technologies. This may also include targeted social spending or cash transfers to poor households, which are often located in rural areas that are not connected to the grid.

5.2 Summary of Stakeholder Positions

The review assessed the interests of each group and produced an estimate of the support for renewable energy deployment, support for fossil fuel subsidy reform and an indication of their perceived influence on both issues. Figure 4 shows a visualization of the positions of the various stakeholder groups. The position of each organization shows an indication of the perceived support for fossil fuel subsidy reform (x axis), their support for renewable energy deployment (y axis) and their perceived influence (size of bubbles).

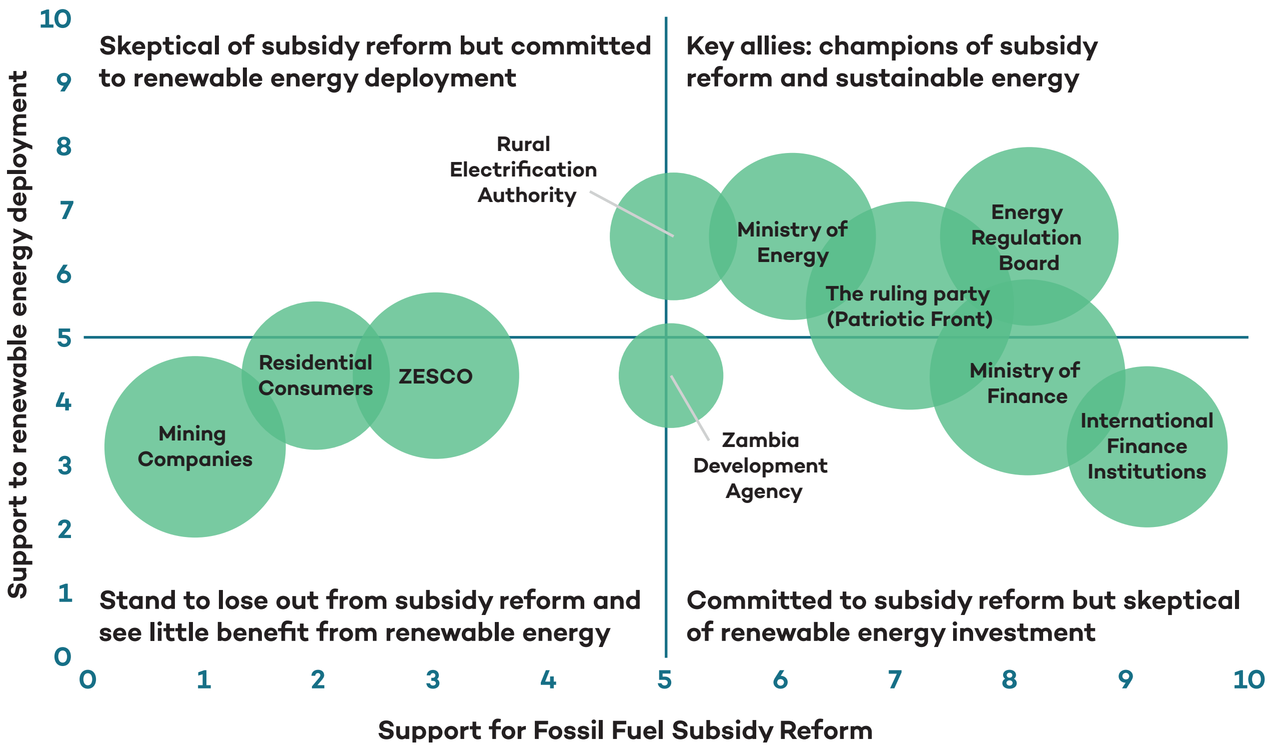

Figure 4. Visualization of support for fossil fuel subsidy reform and renewable energy deployment

This exercise highlights a number of findings. First, government agencies tend to be broadly supportive of both fossil fuel subsidy reform and increased use of renewable energy. After all, it is current government policy. This indicates that the idea of using revenues from fossil fuel subsidy reform to fund a subsidy swap could be well received in government at least. However, some parts of government are being asked to make trade-offs that may be difficult to reconcile with a subsidy swap. For example, the finance ministry may be broadly in favour of renewable energy, but its main priority is to ensure economic development. Faced with the choice of using savings to reduce government deficits and promoting renewable energy, the finance ministry would need to be convinced that renewable energy expansion would offer concrete economic benefits.

Second, there are several stakeholders who may lose out from subsidy reform and may therefore be opposed to a subsidy swap inasmuch as it increases their overall costs. The main groups in this category are the mining companies and residential consumers, who could all see their tariffs increase if subsidies were removed without any form of mitigation measures in place. These groups might not necessarily be opposed to renewable energy deployment as long as it supports lower tariffs.

6.0 Swaps for Sustainable Energy

Subsidy swap policies can be designed to meet the concerns of affected groups to maximize support and limit opposition. In the mining sector, price increases could threaten the competitiveness of companies. However, if subsidies can be partially redirected to promote energy efficiency, it may be possible to design policies that promote less consumption of electricity, saving the government on subsidies, with higher unit prices for electricity but lower overall energy costs. A similar logic holds for residential customers that might not be affected by cost-reflective tariffs if the cost of generation can be lowered by replacing expensive generation capacity. If it is possible to achieve much of the social benefit at a lower cost, it should be possible to convince people of the case for reform.

The feasibility of two swap concepts have therefore been analyzed: 1) swapping electricity subsidies for support to mining sector energy efficiency and 2) replacing subsidized diesel generation with solar PV.

6.1 Swapping Electricity Subsidies to Support Mining Sector Energy Efficiency

Electricity consumption in the mining sector accounts for 55 per cent of all electricity consumed in the country (ERB, 2017b). Electricity pricing in the mining sector is therefore essential to bridging the gap between costs and revenues in the electricity sector. The government has been actively engaging with the mining sector for some time to increase tariffs, as was described in Section 3. Along with increasing tariffs ("the stick"), promoting energy efficiency in the mining sector can be seen as "the carrot" for reducing electricity subsidies.

Promoting energy efficiency in the mines serves two purposes: reducing electricity subsidies and mitigating the impact of price increases on the mines. While increases in tariffs are politically and economically sensitive, with potential repercussions for competitiveness, decreasing consumption may be used to reduce electricity subsidies, since every unit of electricity that is saved through energy efficiency will reduce the effective subsidy to the mining sector. Furthermore, since expensive sources of generation are generally the last to be dispatched, energy-efficiency savings at peak times may reduce the cost of operating the electricity systems proportionally more than by average cost of generation. These savings are therefore very valuable for the government and ZESCO.

Energy efficiency is also desirable for mining companies where the costs of investments are lower than the value of the energy savings over a reasonable time horizon, contributing to a lucrative payback period. Before the recent price increases, mining companies had little incentive to make investments in energy efficiency; however, current tariffs shorten the payback of these investments and push mining companies to take energy efficiency more seriously.

One solution therefore is simply to raise mining sector electricity tariffs and allow market forces to drive investments in energy efficiency. However, this approach has a few negative consequences. First, a sudden price shock could drive mining operations to close down due to a sudden change in operating costs. Second, mines may face other barriers to investment such as a lack of affordable credit for energy investments. Finally, this approach creates a political dynamic whereby the mines may use their influence to oppose price increases. Working with the mines to enable energy-efficiency investments offers a more productive way to find a solution that will not be opposed and will therefore be easier to implement.

6.1.1 Options for Energy Efficiency and Renewable Energy in Mining

According to the U.S. Department of Energy (2007), electricity accounted globally for approximately one third of the total energy consumption in the mining industry, with diesel and other fuels also representing one third each. There is limited data available breaking down the mining sector's energy consumption specifically focusing on Zambia. In the international literature, major energy-consuming processes in metal mining are reported to include production machines, including grinding[2] (Holmberg et al., 2017); onsite transportation; and pumping, ventilation and other ancillary processes. Grinding and ventilation have a large potential for improving energy efficiency. Efficient consumption management and monitoring of energy performance through smart metering and other technologies could provide information to highlight opportunities for energy efficiency (Energy Manager Today, 2015).

On the production side, prices of renewable energy (solar, wind) options have fallen drastically over the past years and have, in many regions, become less expensive than conventional power sources, raising the possibility that mines could become self-generators (Deloitte, 2017). Faced with load shedding and power outages, mines employ diesel generators to ensure a stable power supply to the mines. Solar-diesel hybrid power plants or micro-grids can provide reliable power and save costs, as well as hedge against tariff increases (Federal Ministry for Economic Affairs and Energy, 2016). This potential could be realized either through installing mini-grids on site or through power purchase agreements (PPAs) with IPPs that produce solar energy close to the mines.

Box 1. International experience of mining sector energy efficiency

A savings potential of up to 20 per cent of the total energy consumption was identified for the U.S. mining industry (U.S. Department of Energy, 2007). Holmberg et al. (2017) calculated more recently that approximately 2 exajoules (EJ) of energy goes annually to remanufacturing parts worn out in mining. New technologies to overcome these effects include the potential savings of EUR 31 billion per annum globally.

The *Energy Management in Mining Handbook* by the Australian Government (2016) identifies the following options for improving energy efficiency in mines:

1. **Operating buildings**, where typical energy savings measures such as solar heaters and efficient lighting solutions may be implemented.
2. **Blasting**, where improved 3D modelling may be used for improving resource characterization as well as for targeted smart blasting and selective blast design. Smart blasting case studies have reported a 30 per cent energy savings (Energy Exchange, 2018).
3. **Onsite materials movement**, where factors such as speed, payload, cycle time, vehicle condition, vehicle size, layout of the mine and dump site, idle time, engine parameters as well as drive patterns may be managed to improve fuel efficiency. For example, performance indicators implemented by Downer EDI Mining enabled tracking energy intensity of haul trucks over time. In a pilot study, energy intensity improved by 18.2 per cent in an open-cut coal mine. Also, modernization of the fleet plays a key role. For example, Rio Tinto achieved 30 per cent energy savings when upgrading its haul truck fleets to be powered by overhead wires (Energy Exchange, 2018).
4. **Comminution** (grinding, crushing), where factors such as grinding technologies, selection of the grind and particle size, comminution circuits, efficiency of the separation process and waste removal may be managed to optimize energy consumption. Energy mass-balance models and geometallurgy data on the nature of ore bodies (that depict technical options for comminution) also play a crucial role in optimizing the comminution process as they enable targeting the blasting to highest ore concentrations and can decrease energy use by 10–50 per cent (Energy Exchange, 2013). Furthermore, the energy efficiency of the milling process is typically 30–40 per cent when using semi-autonomous grinding, but the efficiency could be doubled using a high-pressure grinding roll, thus halving the required input energy.

[2] According to the Australian Government (2016) mining handbook, comminution (including grinding and crushing) accounts for at least 40 per cent of a mine's energy consumption. According to Holmberg et al. (2017), approximately 40 per cent of a mine's total energy consumption goes to overcoming friction.

5. **Water, ventilation and ancillary equipment**, where relatively low-cost energy savings may be achieved through keeping the systems in good condition (regular maintenance), adjusting ventilation according to demand (initially optimized level may change over time), using local water and ventilation systems (to avoid unnecessary pumping) as well as reducing unnecessary ventilation/ water flow restrictions to avoid pumping energy losses. For example, several case studies referred to by the Australian Government (2016) have reported payback periods of two years or less, with investments in reducing energy losses in ventilation and water circulation as well as upgrading pump control systems and lighting equipment.

Sources: Australian Government, 2016; U.S. Department of Energy, 2007; Energy Exchange, 2013, 2018.

Reliable mapping of total energy savings potential of Zambian mines through energy-efficiency measures would require a more in-depth analysis of the current situation and energy balance of the mines. However, as exemplified in Box 1, energy savings from 10 to 50 per cent are possible within all energy-intensive phases of mining. Hence, a conservative estimation of at least a 10–20 per cent efficiency increase may be given, which is supported by the Swedish example given in Box 2 (Australian Government, 2016; Department of Energy, 2007). In addition, the replacement of equipment with new technology holds large potential for productivity gains that might benefit the competitiveness of the Zambian mining sector.

The key for an energy-efficiency scheme is to create a win–win for the mining industry and the government. Government support to energy-efficiency or renewable-energy investments can accelerate the transition, while leading to electricity savings that can reduce the effective electricity subsidy to the mining companies. Box 2 describes two successful approaches from other countries that could be considered as part of the design process.

Box 2. Energy-efficiency scheme models

Energy-efficiency schemes can be mandatory or voluntary. Mandatory schemes are more powerful in terms of ensuring results if compliance can be enforced. Voluntary schemes entail less risk to those subject to the scheme, so they may provoke less opposition, but they also provide less control of impacts. Sweden and Finland have adopted mandatory and voluntary schemes, respectively. In addition, revolving funds have been used in many countries to support projects with low-cost finance. These examples are presented below.

Voluntary Energy Efficiency Agreements (Finland):

- Companies and the government agree on voluntary energy-efficiency targets through a process of consultation and engagement.
- Companies receive financial support for conducting energy audits and installing energy management systems (e.g., smart meters) in the form of grants, tax credits or other payments.

The Energy Efficiency Agreement is a voluntary multidisciplinary contractual proceeding with the aim of rationalizing energy usage in Finland. A company joining the agreement must commit to energy-efficiency targets. The program also provides government support for energy-efficiency investments. By the end of 2016, total energy consumption of parties in the program yielded 371 terawatt-hours (TWh), or 65 per cent of the total energy consumption of Finland. Annual energy savings were approximately 16 TWh (4 per cent of total applicable consumption), which translated into 4.7 million tonnes of carbon dioxide annually.

Mandatory Energy-Efficiency Scheme (the Swedish Model):

- Companies are entitled to lower electricity rates if they conduct and report energy audits and implement energy-efficiency measures proposed in the audits and which entail less than a three-year payback period.
- Companies are compelled to engage with the scheme otherwise they fail to qualify for the lower electricity rates.

Following a taxation renewal in 2003, the mining (and manufacturing) industry in Sweden became subject to an electricity tax of SEK 0.005 per kWh (USD 0.0006 per kWh). However, a full exemption was offered for companies able to improve energy efficiency. A condition for the exemption is to introduce an energy management system and perform recurrent energy audits. Companies must also implement all energy-efficiency measures identified in the audits with less than a three-year payback period. The program resulted in 3 TWh in annual energy savings in the applicable 34 TWh consumption (10 per cent), but it is worthwhile to note that the program was not limited to the mining sector (Energimyndigheten, 2016).

Revolving energy-efficiency fund

- A surcharge on electricity pricing is allocated to an energy-efficiency fund, possibly to be match-funded with additional donor, climate finance or government funds.
- The fund hosts regular calls for proposals, where mining companies can apply for low-cost loans to fund energy-efficiency projects.
- Loan repayments return to the fund to be reallocated to future projects

Sources: Energimyndigheten, 2016; Energy Efficiency Agreements, 2016; International Energy Agency, 2017; Motiva, 2017.

6.1.2 Feasibility of the Subsidy Swap

This swap concept offers the possibility to balance the public sentiment that mines should not be subsidized with concern about the competitiveness of the mining sector. For this reason, many of the stakeholders interviewed have expressed a willingness to develop this idea further.

In terms of the legislative instruments needed to implement such a proposal, the government is currently in the process of reviewing the Electricity Bill, 2017, and the Energy Regulation Bill, 2017. This review is an effort to avoid prolonged tenures of PPAs and also to devise tariffs that will ensure that consumers are paying cost-reflective tariffs. The review of the bills will give the ERB greater oversight of the energy sector as well as create a consistent framework for tariff determination, which has been problematic. These bills will also provide regulatory oversight of power and bulk supply agreements and empower the ERB to review and determine tariffs for all electricity consumers, including the mining companies. These new powers could be a key enabling factor for tariff reform and could be linked to an energy-efficiency fund.

The feasibility assessment conducted for this research has demonstrated that the concept of an energy-efficiency fund is feasible. It seems likely that engaging further with the mining sector and providing support to either energy-efficiency measures or renewable energy generation could improve the dialogue and accelerate the transition. However, further work is required to assess the energy savings potential in mining in Zambia, as well as the potential for a support mechanism. If a support fund were to be established, its organizational structure, the acceptability of the business model to stakeholders and potential sources of funding to help in its establishment would need to be explored. Securing the political mandate for such support and buy-in from the mining sector would be key preconditions for such an endeavour.

6.2 Replacement of Diesel Generation with Solar PV

Replacing the highest cost generation, usually from diesel or heavy fuel oil, with lower cost generation like solar PV can yield considerable savings, as described in the *Swap and Roadmap for Sustainable Fossil Fuel Subsidy Reform* (Bridle & Klimscheffskij, 2017). These generators have previously received PPAs of 14–18 U.S. cents per kWh (Federal Ministry For Economic Affairs and Energy, 2016).

In 2016 total electricity generation from ZESCO's diesel power plants decreased by 14 per cent, to 20.2 GWh in 2016 from 23.5 GWh recorded a year earlier. The decrease in generation was mainly attributed to the decommissioning of the Mwinilunga diesel power plant in September 2016 following the connection of Mwinilunga District to the national electricity grid (ERB, 2016; Zambia Daily Mail, 2016).[3]

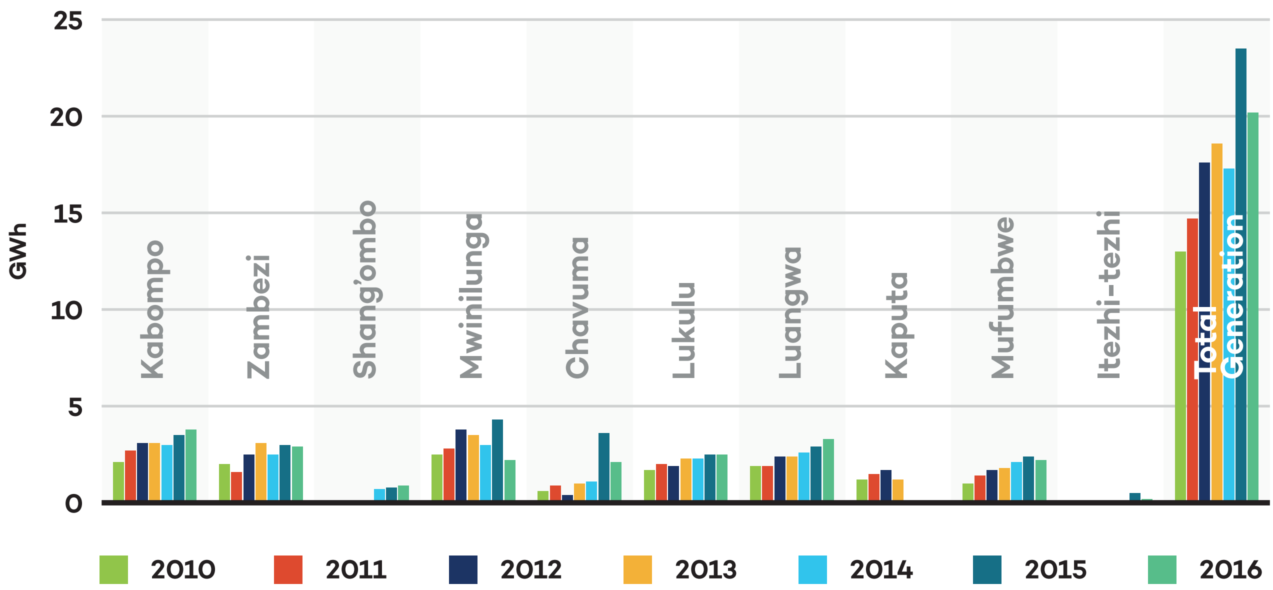

Figure 5. Electricity generation from ZESCO owned diesel generators (Source: ERB, 2016)

With regards to the other diesel power plants, Itezhi Tezhi, Mwinilunga, Chavuma, Mufumbwe and Zambezi recorded a reduction in electricity generation of 60 per cent, 48.8 per cent, 41.7 per cent, 8.3 per cent and 3.3 per cent, respectively. However, Luangwa, Shang'ombo and Kabompo recorded increases in electricity generation of 13.8 per cent, 12.5 per cent and 8.6 per cent, respectively (ERB, 2016).

6.2.1 Options for Replacing Diesel Generation with Solar PV in Zambia

Solar energy in Zambia is approximately 0.1 per cent of the country's power generation capacity, despite a solar resource described as having "very high potential" (World Bank ESMAP, 2014). The PV market in Zambia is dominated by donor-funded projects, government, non-governmental organizations and mission institutions for schools, clinics, related staff housing and water supply.

[3] The decommissioning of the Mwinilunga diesel power plant was due to a project that ZESCO is currently undertaking entitled Connection of North-Western Province to National Grid, funded by a loan facility from the Swedish Export Credit Corporation and Standard Bank of South Africa. ZESCO operates five diesel-fired power stations in North-Western Province, located in Mwinilunga, Mufumbwe, Kabompo, Zambezi and Chavuma. The older districts of Mwinilunga, Kabompo, and Zambezi have been using diesel power stations for approximately 40 years. Solwezi and Kasempa are the only two districts in the province supplied from the grid through a 66 kV line from Luano near Chingola (ERB, 2016). Mwinilunga was connected to the national grid under the USD 165 million North-Western grid extension electrification project aimed at connecting the district to the national grid. Mufumbwe became the second rural district in North-Western Province to be connected to the national electricity grid. The development is expected to save ZESCO USD 8 million in operational costs and supply of diesel annually, once the province is connected to the national grid (Zambia Daily Mail, 2016). The project is also expected to connect Kabompo, Mumbeji, Zambezi, Chavuma and Lukulu to the national grid so that they can be powered by hydroelectricity. The electrification of the seven districts will go a long way to providing reliable power supply to a province that is characterized by mining activities.

The World Bank is currently the largest single financing agency of PV sales in Zambia. Annual sales are in the range of USD 2 million–3 million, with as much as 70 per cent being through large donor-financed procurements. In 2016, the Zambian government, working with ZESCO, implemented a number of measures in order to mitigate the inadequate power supply. One of the long-term measures included fast-tracking the development of grid-connected solar PV generation (ERB, 2016).

Scaling Solar Initiative

The Scaling Solar project is a World Bank Group program designed to support government procurement of solar power projects. In 2016 the Industrial Development Corporation conducted a competitive tender for the procurement of solar generation power projects of 47.5 MW and 28.2 MW. The winning bidders were Bangweulu Power Company Limited (BPCL) and Ngonye Power Company Limited (NPCL). Both companies entered into a 25-year PPA with ZESCO with tariffs of 6 U.S. cents per kWh for BPCL and 7.8 U.S. cents per kWh for NPC. It is expected that the solar power plants at the Lusaka South Multi-Facility Economic Zone will cost USD 57.329 million and USD 43.194 million respectively (ERB, 2016).

Global Energy Transfer Feed-In Tariff

The Global Energy Transfer Feed-In Tariff (GET FiT) program is designed to leverage private sector investment into renewable energy generation projects. In 2016, the ERB worked closely with the Government of Zambia and the German Development Bank (KfW) to jointly develop the GET FiT Zambia program. The program intends to fast-track a portfolio of up to a maximum of 20 MW (each) small-scale renewable energy generation projects promoted by private developers. Preparations advanced well in 2016 and the German government committed full funding for Phase I of the program in December 2016. The program was launched in early 2018 with a solar PV auction for a total capacity of 50 MW (ERB, 2016).

6.2.2 Feasibility of a Subsidy Swap

The recent solar auctions have shown that there is considerable potential for solar prices to undercut prices by the highest cost generators. At present however, the development of solar PV is in its early stages, with only 0.1 per cent (0.06 MW) of power generation. There is, however, a keenness by the government to move toward solar PV. When the president launched the first round of the Scaling Solar Project targeting 100 MW in 2016 at the project site in the Lusaka South Multi Economic Zone, the Minister of Finance said that the milestone was “a practical fulfilment of President Edgar Lungu’s directive to diversify sources of power supply and to provide solutions in the short to medium term that will overcome load shedding” (Lusaka Times, 2017)

The move toward divesting from diesel generators is one that is supported by ZESCO, since it spends significant amounts of money on operation and maintenance of the diesel stations. Indeed, areas that are dependent on diesel generators often suffer due to low reliability and limited capacity.

To some extent, the swap here is already happening. The GET FiT program is designed to promote the installation of solar PV, and ZESCO is phasing out diesel generation as part of its broader aims to increase the coverage of the national grid. There is currently not an explicit link between the phase-out of diesel and the purchase of solar generation at lower prices. Support to programs like GET FiT and the Scaling Solar project will continue to reduce costs and prove the potential for solar energy to replace diesel generation.

7.0 Conclusions, Issues and Next Steps

Both swap concepts reviewed in this report are feasible. More progress has already been made with the deployment of solar PV and the reduction in expensive diesel generation. A number of significant donors and international finance institutions are actively supporting solar PV projects that are on the verge of competitiveness with other forms of generation.

Meanwhile, the mining sector consumes the majority of Zambia's electricity and receives effectively subsidized electricity at a significant cost to the public budget. With growing pressure to establish cost-reflective tariffs, there is significant pressure to look at measures to encourage mining companies to reduce their energy consumption and their reliance on cheap energy to remain viable. For these reasons, it is proposed that the focus of further work be on the potential for measures that promote energy efficiency in the mining sector as part of the ongoing subsidy reform plans in this area.

The next stages of research will focus on the conditions for and potential of promoting energy efficiency in the mining sector to reform electricity subsidies. As identified in this report, several models can be used to create incentives for mining companies to assess their energy use and make investments to reduce energy consumption and costs. Subsequent research will include a consultation with mining sector companies and government aiming to create an assessment of the options to support energy efficiency:

- **Current energy management practice** – What is the energy consumption of mines in Zambia, and how large is the savings potential? How can good examples from current practice be expanded and further improvements developed drawing on best international practices?
- **Stakeholder engagement and political will** – Who are the key stakeholders in government, the private sector and the donor community that would be interested in taking a support scheme forward?
- **Set-up of a potential fund** – How could a fund be administered? How would the internal organization work? Which best practices could be used?

The research will also seek to promote awareness within the mining sector of the pressures to increase electricity prices, the potential impact on the mining sector and the potential of energy-efficiency investments to "future-proof" mining in Zambia.

Finally, a further benefit to the government will be that the consultancy process will gather data to inform the government's thinking on electricity tariff reform by collecting information on mining sector exposure to energy prices and attitudes to subsidy reform.

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