EXECUTIVE SUMMARY

New baseload energy is critical to the delivery of the Government's economic plan. The first electricity could be generated from Ngonye Falls in 2026. However, this requires immediate commitment from ZESCO and GRZ to enable financial close by the end of 2023 and construction to start on the first day of 2024.

HIGHLIGHTS

180MW of new electricity generation and 110km of new 330 kV transmission line developed by Western Power Company (**WPC**). $680+ million private sector investment, the largest ever in the Western Province.

The plant will generate 836GWh per year of green, reliable, baseload electricity at a competitive price of US10.4 cents/kWh in 2026. This electricity could supply nearly 1 million people or 100,000 tpa of new copper production.

Contractual construction time is 36 months with the first unit online at 30 months. 3,000 direct jobs will be created during construction as well as significant indirect and multiplier jobs with many highly skilled operations and maintenance jobs over decades of operations.

This will accelerate much needed social and industrial development in the Western Province, currently severely limited by the sole, low-capacity, unreliable transmission line, constructed in 1973.

A trust has been formed, the *Barotse Royal Establishment Development Trust,* to hold a 6% golden share of the Ngonye Falls project in trust for all the people of the Western Province. This golden share will result in a regular stream of dividends for development projects and, in addition, the community will receive a fixed annual sum each year with the first payment being made at start of construction.

Developed to the highest standards by the Zambian private sector, the project is now ready to finance and has significant interest from potential funders including IFC, DBSA and other DFIs.

cont .....

Western Power is a private Zambian company based in Lusaka that has invested $12.5m in the development of the Ngonye Falls hydroelectric project over the past 10 years.

…. cont

VISION 2030 - THE NATIONAL ENERGY OBJECTIVES

The Vision 2030 8th National Development Plan calls for an additional 1,100MW of generation capacity by 2026. The recent Government Green Paper on electricity forecasts demand of 8GW by 2030 to support social and industrial development.

Zambia is now projected to experience an increasing deficit of electricity generation, particularly for the reliable baseload power like Ngonye required to support new intermittent renewables including solar PV and wind. Western Province has good solar radiation but no PV can be installed without Ngonye's baseload.

Achieving the Vision 2030 targets will require new generation capacity of 370MW to be commissioned every year, equivalent to a new project the size of Ngonye Falls constructed every 6 months. Ngonye Falls is one of the only baseload projects which can be completed in time to meet the 2026 deadline.

LOW RISK, COMPETITIVE AND AFFORDABLE ELECTRICITY

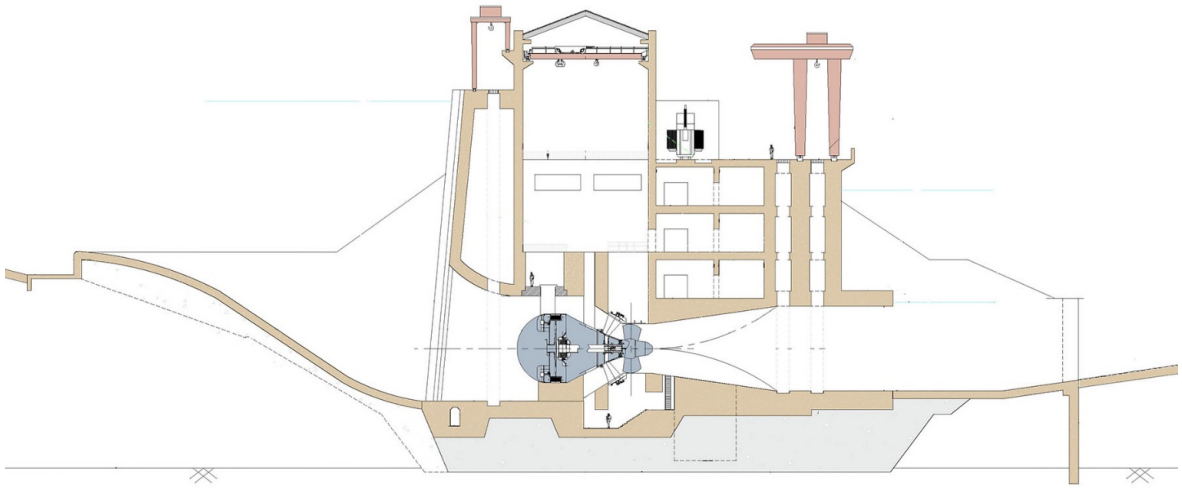
WPC shares with ZESCO the primary objective of minimising the cost of electricity of the Ngonye Falls project.

With our development partners, InfraCo Africa, and world-class technical advisors, WPC has sought to optimise every aspect of the technical design and financial structuring of the project to deliver the lowest possible electricity tariff.

Full transparency, including of financial returns for all investors, is assured with an open-book, cost build-up financial model that has been presented to all key stakeholders. An energy-only Power Purchase Agreement places all of the hydrology risk with the project equity investors rather than ZESCO as is usually the case.

The Ngonye Falls project requires an electricity tariff of c. US10.4 cents at commissioning in order to be financeable. This price is competitive with comparable sources of reliable baseload electricity with similar risk profiles and fits comfortably within ZESCO's tariff glide-path.

COMMERCIALLY CONFIDENTIAL



NGONYE FALLS HYDRO-ELECTRIC POWER STATION
PROJECT HIGHLIGHTS

NGONYE FALLS PROJECT – NEW DAWN

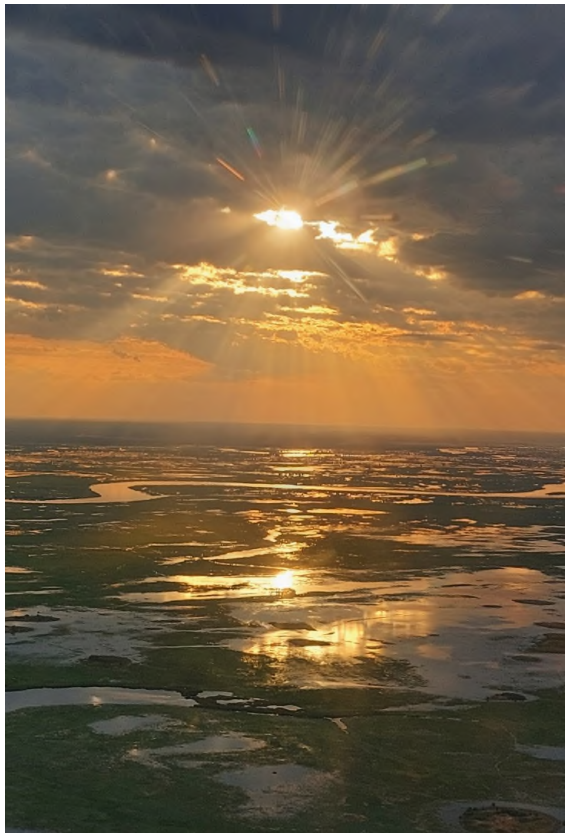
The Ngonye Falls Project helps to delivers the **New Dawn Government's *Vision 2030*** set down in the 8th National Development Plan for *An Industrialised and Diversified Economy* through *Enhanced Generation, Transmission and Distribution of Electricity.*

"..why are we taking so long to generate clean, green energy from the Ngonye Falls? Personally, I'm tired of talking about potential. We want to convert the story telling about opportunities and potential into reality. **That is what the New Dawn Government is here to do, to unlock potential like the Ngonye Falls Project and get it done**.

Under this New Dawn Government … you will see an acceleration of actualisation of projects … I have no doubt about it. But we will only do it if we work together as a team … and you must tell us in Government how we can quickly accelerate the realisation of the potential."

The President of Zambia, Hakainde Hichilema speaking to the *Western Province Trade and Investment Expo* in Mongu on 10th October 2022.

New power generation is critical for delivery of every aspect of the 8th National Development Plan.



A **New Dawn** over the Barotse Floodplain – Western Province, Zambia

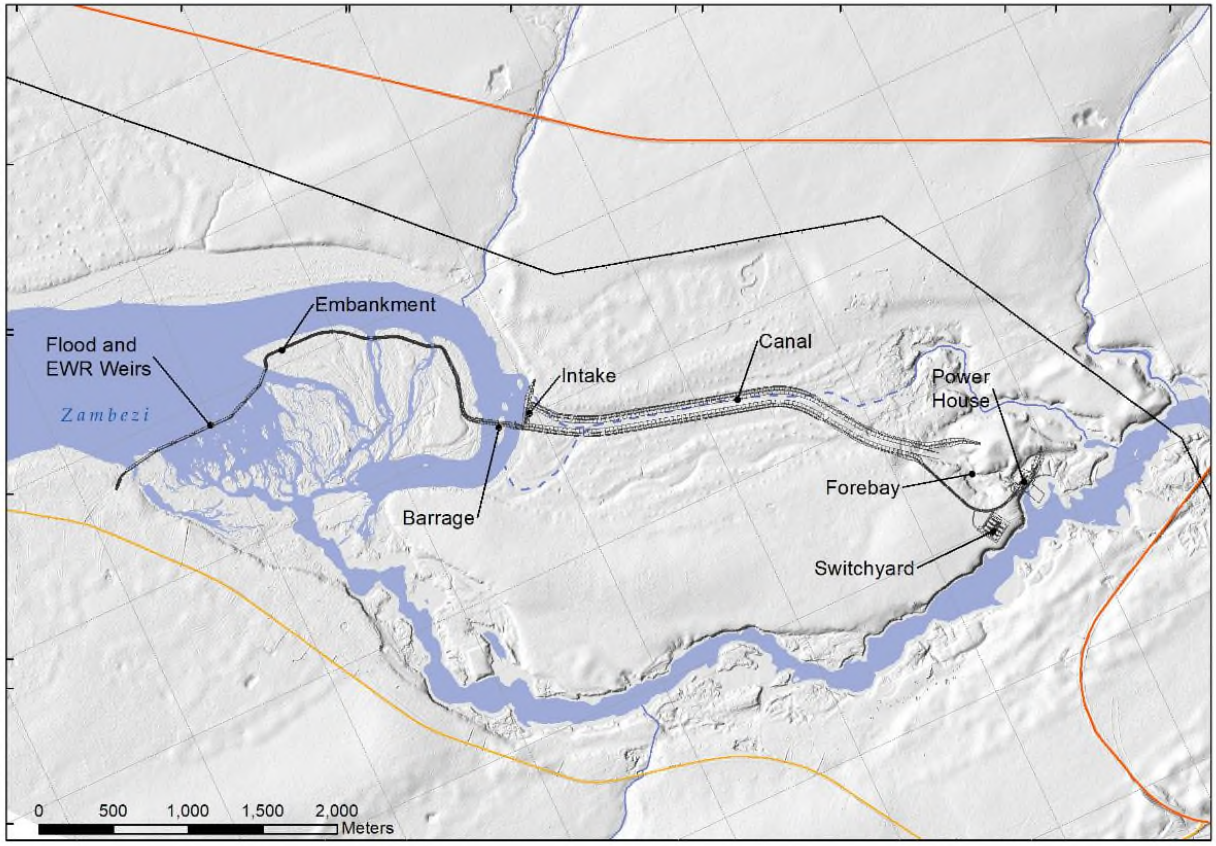
NGONYE FALLS PROJECT – NATIONAL PARTNERSHIP

- **The Ngonye Falls Project** is a 180MW, $680m+ run-of-river hydroelectric project on the Zambezi River in Western Province.
- 836 GWh per year of green, reliable baseload electricity at a sustainable, competitive and affordable price.
- 110km of new transmission line to the Zambian network substantially increasing the supply of electricity to the Western Province.
- Simple design and low construction risk with no large dams or tunnelling.
- Short construction time of 36 months with first electricity produced after 30 months.
- A partnership with the community of the Western Province represented by the *Barotse Royal Establishment*.
- Significant community development benefits through equity participation and fixed annual payments.
- Developed under an Implementation Agreement with GRZ, to the very highest standards, over 9 years at a cost of over $12.5m.

THE NGONYE FALLS PROJECT

- Construction Investment: **$680m+**
- Location: **Western Province**
- Capacity: **180MW**
- Electricity For: **1,000,000 Zambians**
- Electricity For: **100,000 tpa of copper**
- Construction Workforce: **3,000 people**
- Construction Time: **36 months**
- Operating Life: > **100 years**

TECHNICAL DESIGN & PROJECT LAYOUT



- A series of low weirs and embankments stretch across the **Zambezi River** upstream of the Ngonye Falls to regulate environmental flows, provide fish passages and direct power generation flows into a power canal.
- The 3km long power canal has a maximum capacity of 1,100m^3/s and transfers water to a forebay behind the power house which provides flow regulation.
- The powerhouse, which is excavated into the river bank, contains 4 bulb turbine units of 45MW capacity each.
- Having flowed through the turbines to generate the electricity, water flows back into the Zambezi River.
- Electricity is evacuated at 330kV 110km south to Sesheke and from there **serves customers across Zambia**.

The Ngonye Falls Project has a simple, low-risk design with no tunnelling and no large dams. Construction can be completed along the length of the project simultaneously reducing the risk of delay and cost overrun.

DIRECT PROJECT BENEFITS

- **The Ngonye Falls Project** helps meet the goal of **Vision 2030** for an additional 1,100MW of generation by 2026.
- Green, reliable and cost effective **baseload** electricity for nearly 1 million people or 100,000 tpa of copper production.
- **110km of new National Grid transmission line** in Western Province.
- **$680+ million private sector investment** in Western Province of Zambia – the largest ever in the province.
- **3,000 direct jobs** during construction plus significant indirect and multiplier jobs. Many highly skilled operations and maintenance jobs over decades of operations.
- Unlocks the economic and industrial potential of Western Province which is currently constrained by lack of electricity.
- 180MW of new generation capacity in western Zambia, because of its location, will provide **significant support to the national transmission grid** by providing voltage support and frequency control as well as reducing power losses.

COMMUNITY BENEFITS

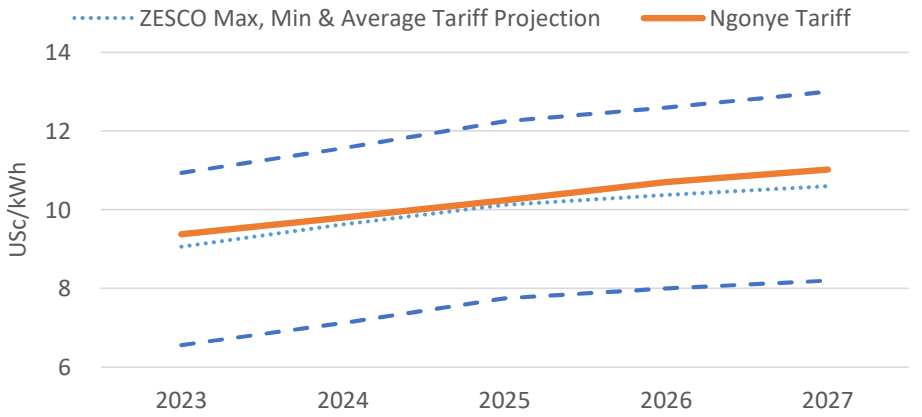
- The *Barotse Royal Establishment (BRE)* is the administration of the Kingdom of Barotseland headed by His Majesty the Litunga who is the traditional leader of the communities of western Zambia.
- The BRE represents all the **communities that host The Ngonye Falls Project** and **own 6% of the project** in trust for the community in recognition of the natural resources being supplied to the development.
- As well as earning 6% of all project profits through their equity share, the community will also be paid $500,000 per year for community development projects. **In total, including dividends, the project will fund community development projects with between $500,000 and $2,500,000 per year**.
- Western Power and the BRE are actively exploring mechanisms and seeking funding partners to help increase the community equity share above the minimum 6% level.
- The BRE have been instrumental in working with Western Power, the Government of Zambia and our other partners to bring the project to a successful conclusion having recognised the **development benefits that the project will provide to the people of western Zambia**.

TRANSMISSION BENEFITS

- The **Western Province** economy is currently acutely constrained by lack of power. The whole of the province is currently supplied by a single, unreliable, low capacity 66kV transmission line.
- The **maximum amount of electricity** that can be supplied to the province over this line is around 7MW which is equivalent to the needs **of one or two large shopping malls** or hotels.
- Without new transmission capacity for the Western Province, there can be no new industrial, commercial or social developments of any significant size anywhere in the province.
- **The Ngonye Falls Project** includes the **finance and construction of 110km of 330kV transmission line**, that will be handed to ZESCO on completion. This new transmission line will form part of the long planned ZESCO construction of the Grid section from Sesheke to Lukulu and thereby complete the national ring circuit.
- No more power can be exported through Sesheke to the Southern SAPP region without an upgrade of the Livingstone-Sesheke line. However, because of its location to the west of this bottleneck, power from Ngonye Falls will be available as an additional export to the south.
- Along with other local distribution upgrades planned by ZESCO, this will provide a modern transmission network for Western Province **that will meet the Vision 2030 economic and social development needs** of the region for decades to come.

COMPETITIVE ELECTRICITY

- The base case financial model for **The Ngonye Falls Project** produces a tariff of approximately USc10.5/kWh in 2026.
- Renewables such as wind and solar power may produce lower headline tariffs but their unreliability and intermittency compared with the stable, reliable, predictable power produced by Ngonye does not allow direct tariff comparisons with these technologies.
- Reliable baseload power with synchronous generators such as that produced by Ngonye is required by the grid to enable additional intermittent renewables to be developed.



The cost of Ngonye Falls power sits comfortably within the ZESCO tariff glide path.

Project	Cost USc/kWh
Economic cost of unsupplied electricity	>60
Diesel generators	>40
Kabompo Gorge	15
Kafue Gorge Lower	13.5
Batoka Gorge	13 – 14
Ngonye Falls	10.7

Planned & existing comparable Zambian hydro projects

SOURCE	TYPE	CAPACITY MW	Contract Period	TARIFF (USc/kWh)
EDM	Hybrid	80-150	Jan 2016- Dec 2017	14.00
Aggreko	LNG	148	Sept - Dec 2015	18.86
Aggreko	LNG	40	Jan 2016 - Dec 2016	18.86
Karpowership	HFO	100	Jan 2016- Dec 2017	16.73
ESKOM	Hybrid	50-300	Jan 2016 - Dec 2016	6 to 19

The cost of emergency power is significantly higher than new generation like Ngonye Falls.

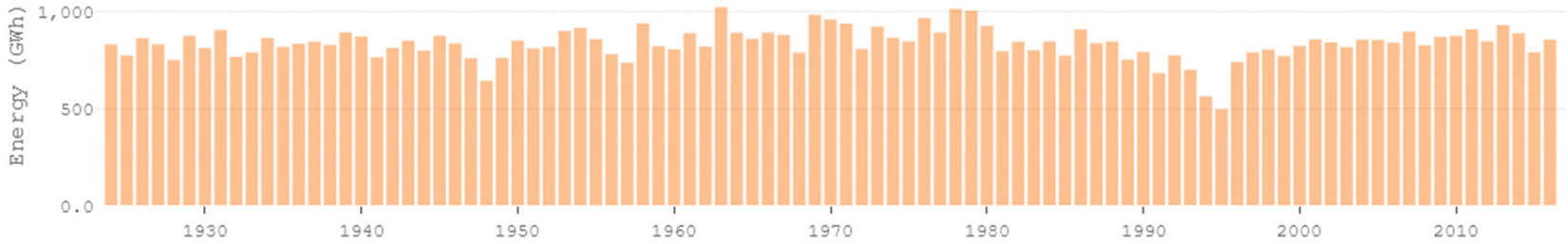
PROJECT STATUS – READY TO FINANCE

Over the past 10 years Western Power has spent $12.5m to develop the **Ngonye Falls Project**. All of the required technical and environmental surveys and studies have been completed. The technical and financial feasibility of the project has been proven. Following the improvement in investor sentiment and the macro economic situation following the election of the New Dawn Government potential financiers are ready to engage with the project.

The first electricity can be generated from Ngonye Falls by autumn 2026. However, this requires immediate commitment from ZESCO and GRZ to enable construction to start on the first day of 2024.

HYDROLOGY RISK AND THE NGONYE FALLS PPA

- All hydroelectric power stations must handle **hydrology risk** which arises due to variations in the flow of water in the river leading to variation in the power output of the power station.
- Hydrology risk is greater for run-of-river hydroelectric plants (without a dam and storage reservoir), for power stations on smaller rivers - with more variable flows - and on rivers without long-term flow measurements - where flow variations can't be properly predicted.
- **The Ngonye Falls Project has a low hydrology risk** for a run-of-river power station because of unique hydraulic conditions, the size of the Zambezi River and because detailed daily river measurements have been collected at Victoria Falls for nearly 100 years.
- Because of the low hydrology risk, **The Ngonye Falls Project has an energy-only Power Purchase Agreement (PPA)** which means that all of the hydrology risk is carried by Western Power and ZESCO only pays for the electricity actually produced by the power station and always at the tariff fixed in advance in the PPA.



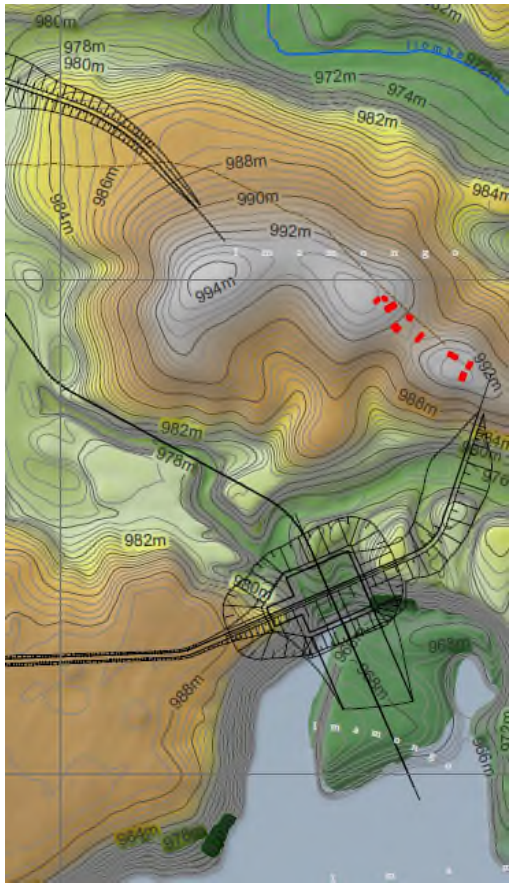
A simulation of the energy (GWh) that would have been produced each year by the Ngonye Falls plant if it had been built in 1924. Shows the relatively low annual variation in output which demonstrates the low hydrology risk of the project.

The Ngonye Falls Project has an energy-only PPA and all the hydrology risk is carried by the project.

CLEAN, RELIABLE BASELOAD ELECTRICITY

- Different types of power station including **The Ngonye Falls Project** run-of-river hydroelectric, coal-fired, solar PV, diesel and wind powered all produce electricity which flows into transmission lines and on to supply homes and businesses.
- However, **different types and sizes of power station have very different characteristics** that support the electricity network, its operator (ZESCO) and consumers in different, complementary ways. Different types of power station also have very different environmental impacts and development and employment benefits which need to be considered when assessing their national and strategic value.
- The different characteristics and qualities of power stations make direct comparisons of cost and value between different types of project problematic.

Whilst affordability is critical, the investment case for any particular power project must look beyond simply the marginal cost of electricity produced to consider lifetime value-for-money including value to the grid, strategic value, social development value and environmental impact.

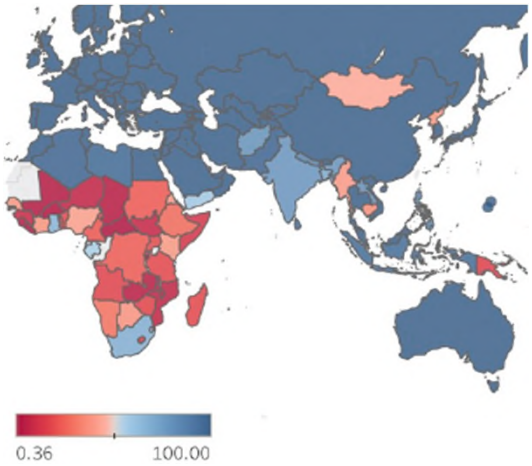


ELECTRICITY IS NOT ALL THE SAME

	Run-of-river hydroelectric	Storage hydroelectric	Coal Fired	Solar PV
Example	**THE NGONYE FALLS PROJECT**	Kariba	Maamba	Lusaka MFEZ Solar
Acts as a battery	No	Yes	No	No
Predictability	Weeks to months ahead	Up to one year ahead	Years ahead	Minutes ahead
Requires 'balancing' power from other power stations	No	No	No	Yes
Project life	Indefinite	Indefinite	~20 years	10-20 years
Greenhouse Gas emissions	Almost zero (1.25gCO2e/kWh)	Can be significant methane from reservoirs	Very high (1,000gCO2e/kWh)	Low (40gCO2e/kWh)
Construction cost	High	High	Medium	Low
Greenfield electricity cost	High	Higher	Lower	Lowest
National Grid Services	Frequency support, voltage support, black start	Load following, frequency support, voltage support, black start	Frequency support, voltage support	None
Environmental impact	Low – No storage reservoir, no disruption to river flow	High – Storage reservoir, disruption to river flow	High – emissions and infrastructure	Low
Export quality electricity	Yes	Yes	Yes	No
Ease to secure finance	Easier	Hard due to environmental issues	Hard due to environmental issues	Easier
Development time (from inception)	10 years +	20 years +	5 years +	2-3 years +
Climate Change Resilience	Medium	Low	High	High

ECONOMIC DEVELOPMENT & THE IMPACT OF ELECTRICITY

- **Access to and consumption of electricity is highly correlated with a number of economic and social development metrics.**
- No economy has successfully developed without also delivering 100% access to electricity.
- Studies have consistently shown that the cost to business of unsupplied electricity is many times the cost of additional electricity supply e.g. *Oseni and Pollitt (2013)* calculated that the **cost of unsupplied electricity to the Zambian economy** in 2007 dollars is **USc62 per kWh** which is 6 times the cost of new electricity from the Ngonye Falls project.



Proportion of population with access to electricity, rural areas. Source: UN SDG database, 2017

Per Capita Electricity Use and GDP (2014). Source: The Impact of Electricity on Economic Development: A Macroeconomic Perspective, Oxford Policy Management Centre for Effective Global Action

THE NATIONAL ENERGY OBJECTIVES

- The **Vision 2030 8th National Development Plan** calls for an additional 1,100MW of generation capacity to be commissioned by 2026. The recent *Government Green Paper* on electricity forecasts demand of **8GW by 2030.**
- The Green Paper projected demand of 8GW by 2030 would require new generation of 370MW per year to be commissioned, **equivalent to a new project the size of Ngonye Falls commissioned every 6 months.**
- The time required to develop new power stations is not less than 3 years for solar, 5 years for wind and often 10 years or more for clean, reliable baseload like **The Ngonye Falls Project**.
- Intermittent renewable power such as solar PV and wind can only be installed if there is sufficient baseload to support it.
- The **economic growth** and social development required for Vision 2030 means that everything must be done to facilitate and **fast-track new generation projects**.

The first electricity can be generated from Ngonye Falls by autumn 2026. However, this requires immediate commitment from ZESCO and GRZ to enable construction to start on the first day of 2024.

Key Numbers Driving Zambia's Electricity Demand
Current installed capacity: 3,300MW
GRZ target capacity: **4,400MW by 2026**
Population growth rate: 3%
GRZ target GDP growth rate: **4.5%**
Current electricity access: <30%
GRZ target electricity access: **100% by 2030**
Current Cu production: <1m tpa
GRZ target Cu production: **3m tpa by 2034**

DELIVERING THE NATIONAL ENERGY OBJECTIVES

- The **Vision 2030 8th National Development Plan** calls for an additional 1,100MW of generation capacity to be commissioned by 2026. The recent *Government Green Paper* on electricity forecasts demand of **8GW by 2040.**

  Eighth National Development Plan 2022-2026

- The Green Paper forecast demand of 8GW by 2040 would require new generation of 370MW per year to be commissioned, **equivalent to a new project the size of Ngonye Falls commissioned every 6 months.**

  Government Green Paper Aug 2022

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- **"Energy is a critical catalyst in restoring growth and achieving economic diversification.**
- "Cabinet to endorse and publish a multi-year tariff framework and a related action plan to ensure cost-reflective and sustainable electricity tariffs
- "ZESCO's guaranteed external debt will be restructured as part of the overall debt restructuring exercise for central Government while the non-guaranteed external debt including emergency power imports will be restructured bilaterally between ZESCO and the respective creditors
- "major projects that require to be financed from ZESCO's balance sheet will not be embarked on during the … turnaround period.

  IMF Country Report Sep 2022

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If Government's **Vision 2030** and IMF policy targets are to be met:

- Additional generation capacity needs to be contracted now
- Major projects need to be delivered in a partnership between the private sector, ZESCO and Government
- Cost reflective tariffs are required to enable ZESCO to purchase power at its true cost
- Finance and construction costs need to be locked in now before they rise any further.

The first electricity can be generated from Ngonye Falls by August 2026. BUT THIS REQUIRES immediate commitment from ZESCO and GRZ to enable construction to start on the first day of 2024.

NEXT STEPS

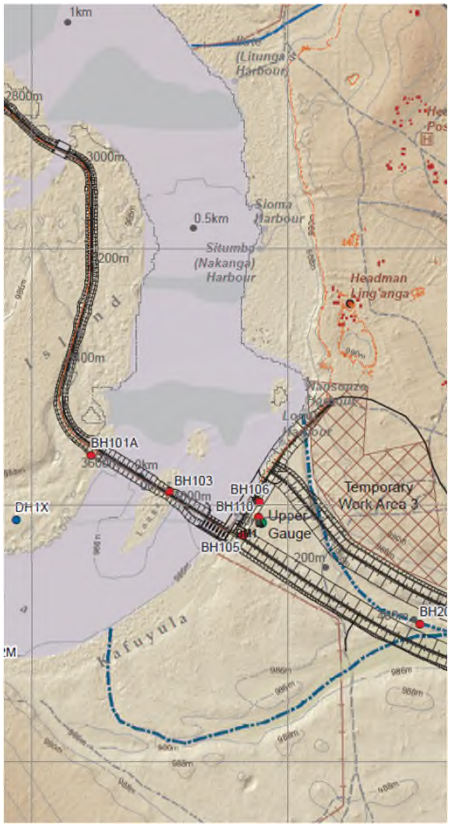
The first electricity can be generated from Ngonye Falls by autumn 2026. However, this requires immediate commitment from ZESCO and GRZ to enable construction to start on the first day of 2024.

COLLABORATION NEEDED WITH ZESCO

1) Conclusion of the Power Purchase Agreement (PPA) at a sustainable tariff and with bankable payment support mechanisms.
2) Settlement of other critical project agreements including the Transmission Line Agreement and Connection Agreement for the construction of the new transmission line into Western Province.

COLLABORATION NEEDED WITH GOVERNMENT

1) Resolve, alongside ZESCO, financiers' requirements for limited, targeted government support.
2) Support Western Power to conclude enabling issues including tax, investment incentives and streamlining of permitting approvals.
3) Align the existing signed Implementation Agreement (IA) with the PPA and other project documents.
4) Determine the extent to which GRZ wishes to replace foreign finance with Zambian institutional equity investors (e.g. NAPSA, ZESCO, IDC) – to keep profits within Zambia and to lower the cost of electricity.



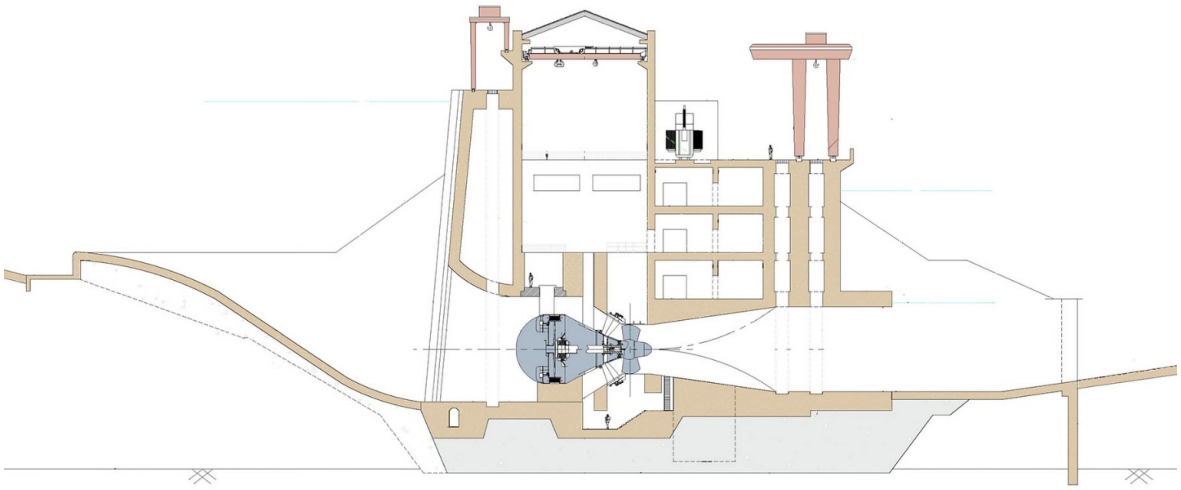
DEVELOPMENT AND FUNDING PARTNERS

African Power Projects (APP) is a Mauritian project development company established to develop renewable power projects across Southern Africa. APP was set up by a group of private international investors and Zambians. APP has raised significant private sector development funding for the Ngonye Falls project and is an active part of The Ngonye Falls Project management team in cooperation with InfraCo Africa.

InfraCo Africa is an infrastructure development facility of the Private Infrastructure Development Group (PIDG). InfraCo Africa seeks to alleviate poverty by mobilising private sector expertise and finance to develop infrastructure projects in sub-Saharan Africa's poorer countries. InfraCo Africa receives funding through PIDG's publicly funded trust, from the governments of the UK (DFID), the Netherlands (DGIS) and Switzerland (SECO). InfraCo Africa is a major shareholder in Western Power and is supporting the company with significant development funding as well as expertise.

The Development Bank of Southern Africa (DBSA) is a development finance institution seeking to improve quality of life, support economic growth, support regional integration and promote sustainable use of scarce resource. It has supported Western Power from the earliest stages of the project.

The International Finance Corporation (IFC) is the largest global development institution focused on the private sector in developing countries. IFC, a member of the World Bank Group, advances economic development and improves the lives of people by encouraging the growth of the private sector in developing countries. It is currently in late stage discussions with Western Power to provide support to the project.



TECHNICAL APPENDICES

GREEN POWER FOR A CLEAN ENERGY TRANSITION

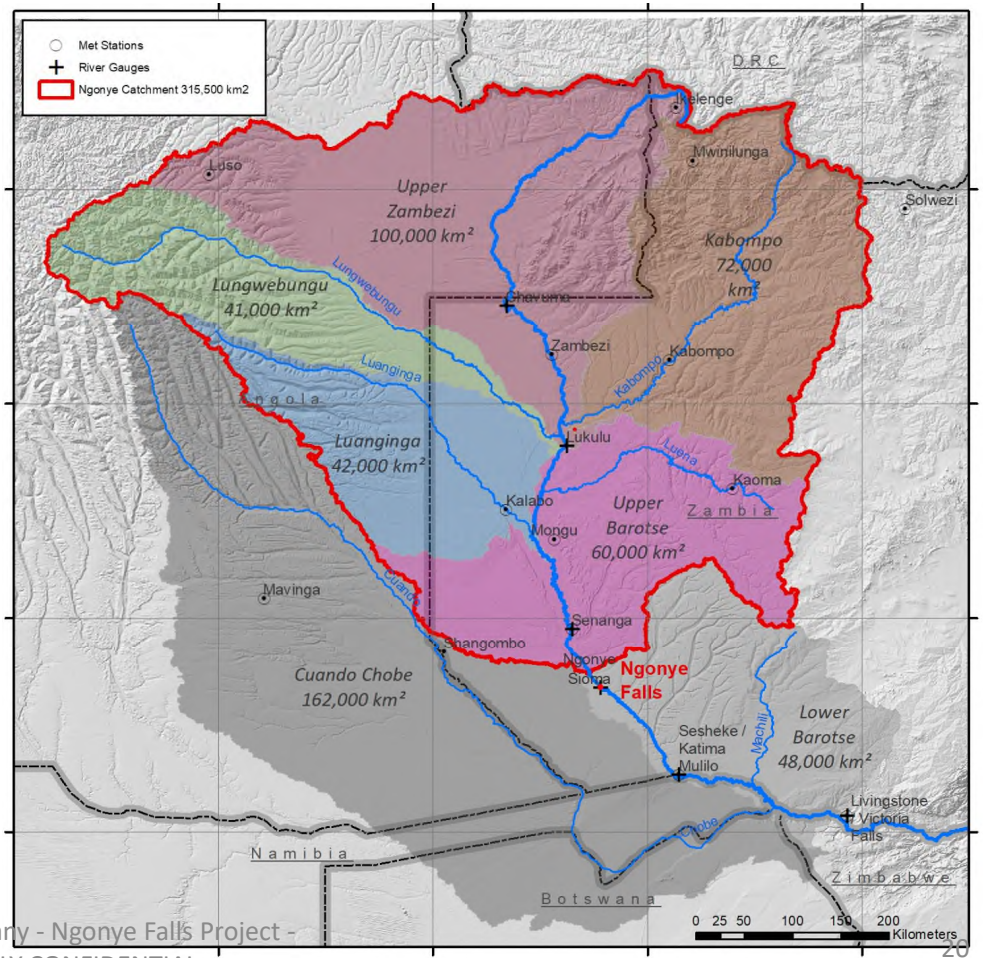
- Run-of-river hydropower can have one of the lowest environmental footprints of any power generation technology available today.
- **The Ngonye Falls Project has a very low environmental impact compared to any power generation project or technology.**
- Over the last 10 years a comprehensive set of surveys and studies has been completed to understand the impacts that the project will have on the environment (particularly the Zambezi River) and its host community and to design-in impact minimisation, mitigation and, where necessary, compensation of the small number of effected people.

No high dam and no reservoir (lake). No impact on the flow of water downstream of the power station.	One of the lowest greenhouse gas emissions of any type of power generation.
Comprehensive set of 'environmental flows' – water bypassing the power station under all conditions to support fish, plants and other river life and ensure the aesthetic of the water falls.	Outside any protected area - National Park – and new transmission line follows existing line and road so does not open a new linear environmental impact.
Structures and systems to ensure that fish can migrate past the power station.	No impact on any critical habitat or any wetlands.
Low resettlement impact.	Power station infrastructure designed to minimise aesthetic impact.

Lifetime Greenhouse Gas Emissions per Unit of Electricity for Various Generation Technologies	
Ngonye Falls	1.25 gCO_2e/kWh
Onshore Wind	23 gCO_2e/kWh
Solar PV	40 gCO_2e/kWh
Coal Fired	1,000 gCO_2e/kWh
Storage Hydro	Can be significant methane from reservoirs

HYDROLOGY RISK & ENERGY SECURITY

- The **Ngonye Falls Project** has a very large catchment area upstream of all other dams and hydropower stations.
- The catchment covers nearly 6 degrees of latitude north to south and 7 degrees of longitude east to west encompassing a range of climate and rainfall zones.
- There are no other dams upstream of the project and no significant agricultural or industrial extraction of water.
- The Barotse Floodplains upstream of the project act as a buffer, smoothing the flow downstream.
- **The Ngonye Falls Project has a low hydrology risk**:
  - Large catchment size and the effect of the Barotse Floodplains leads to stable and predictable output.
  - 100 years of daily flow records for the Zambezi river allow for detailed modelling and a high degree of confidence in forecast energy production.
  - Unique hydraulic conditions mean that power output is maintained at relatively high levels even in drought periods.



CAPACITY OPTIMISATION

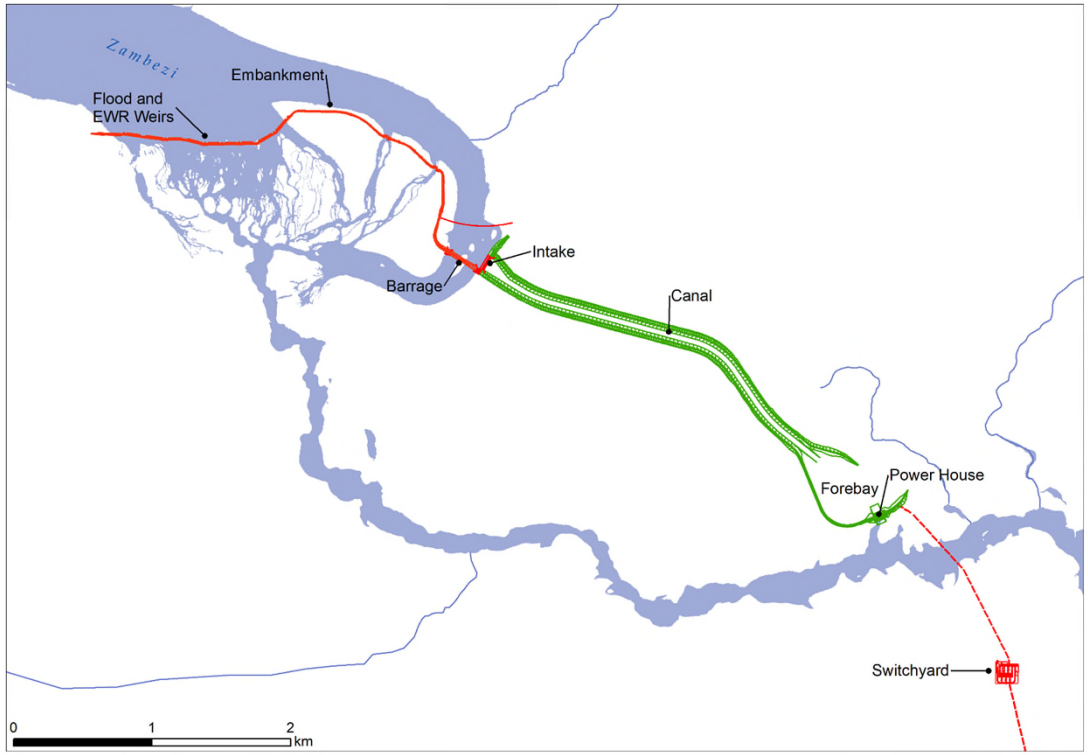
The size in MW of run-of-river hydroelectric power stations, such as Ngonye Falls, need to be optimised to balance the financial economies-of-scale afforded by building larger sized plants with the diminishing return in additional energy production of larger plants.

This process, a techno-economic optimisation, has been completed for the Ngonye Falls power station by the project's engineering consultants, *Mott MacDonald*, to establish an optimum plant size of 180MW, balancing electricity production with project capital cost.

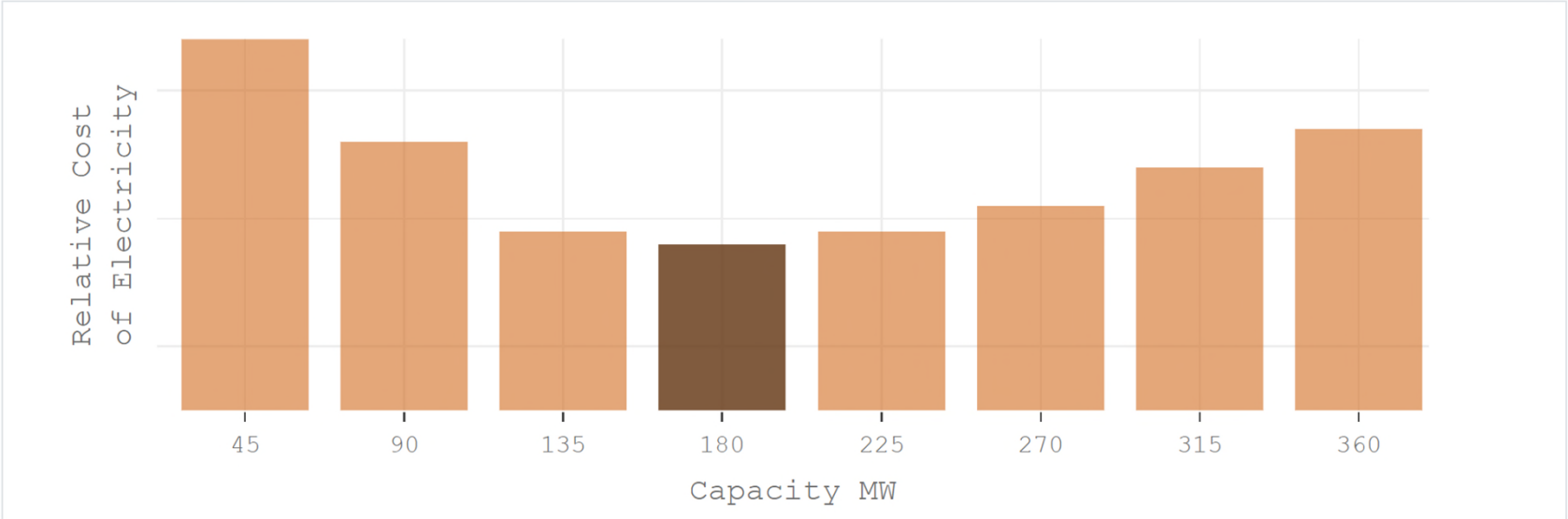
The drawing shows the layout and primary infrastructure elements of the Ngonye Falls power station. Infrastructure elements marked in **red** have a fixed cost irrespective of the installed capacity. Those marked in **green** have a fixed cost component and component that increases with increasing installed capacity.

Because of the seasonal variation in flow in this run of river scheme, each additional generating unit added will have greater idle time over the year.

Given the very high cost of the fixed cost infrastructure (red), additional generating capacity should be added until the additional energy generated is insufficient to pay for the added generating capacity.



CAPACITY OPTIMISATION (2)



The chart shows the relative cost of electricity produced as the installed capacity of the Ngonye Falls power station increases.

This is calculated by dividing the project cost for the capacity by the median average annual energy generated by that capacity (P50 energy). This amount is proportional to the required electricity tariff and at 180MW the tariff is approximately 10.5 cents per kWh.

The capacity factor is highest, nearly 100%, with only 30MW of capacity as there is always enough water in the river for this plant to operate at full output. However considering all the costs of building the power station, the cheapest electricity comes from a plant with 180MW of capacity.

The most economic power station size is 180MW.

COST EFFECTIVE POWER GENERATION

The **cost of power** stations is sometimes compared on the basis of the cost to construct each unit of capacity – **cost per MW of installed capacity**:

- In 2012, the International Renewable Energy Agency (IREA) produced their *Renewable Energy Technologies: Cost Analysis Series* which included a detailed analysis of the cost per MW of new hydropower developments across the world. This report showed that, at that time (2010 $s), project costs of $1m to $4m per MW were usual in Africa. This equates to $1.4m to $5.5m in 2022 dollars.
- THE NGONYE FALLS PROJECT : $680m for 180MW = **$3.8m/MW**
- **Kafue Gorge Lower**: $2,300m for 750MW = $3.1m/MW – this does not include the historic cost of the Itezhi-tezhi dam which is required for KGL but had already been constructed.

However, this simple measure does not capture the plant's Capacity Factor. To capture the value of plant's Capacity Factor, compare plants on the basis of cost to construct each unit of annual plant production - **cost per MWh of annual production:**

- THE NGONYE FALLS PROJECT : $680m for 830GWh production per year = **$0.74m** per GWh per year
- **Kafue Gorge Lower**: $2,300m for 2,585GWh per year = **$0.89m** per GWh per year – this does not capture the significant environmental cost to the Kafue Flats wetlands caused by the Itezhi-Tezhi dam required for this power station to achieve its capacity factor.

Neither of these measures of plant costs captures the value of wider benefits which hydropower plants deliver and that cannot be achieved by other types of power station including stability benefits for the electricity grid and social and developmental benefits.

Capacity Factor (also called Plant Factor or Availability Factor) is a measure of the proportion of time that a power station is operating at full output and is given by:

$$\textbf{\textit{Capacity Factor}} = \frac{\textbf{\textit{Actual Production}}}{\textbf{\textit{Theoretical Maximum Production}}}\%$$

The Capacity Factor for a hydroelectric plant is generally less than 100% because there is not enough water to run the plant at full output all the time. Thermal power plants such as coal, gas and nuclear can have very high Capacity Factors as their output is not restricted by fuel availability.

In general plants with higher Capacity Factors are more cost effective than plants with lower Capacity Factors.

The Capacity Factor of THE NGONYE FALLS PROJECT plant is 53% and for Kafue Gorge Lower it is 45%.

The Ngonye Falls plant has a high Capacity Factor for a run-of-river hydro plant because of unique hydrology.

PPA STRUCTURE, HYDROLOGY RISK AND ELECTRICITY COST

- Historically, hydroelectric power projects have used **capacity-based Power Purchase Agreements (PPAs)** (also called availability payments) either entirely or in part.
- With capacity-based PPAs, the power station is paid a fee for being ready and available to produce electricity irrespective of how much electricity is actually produced. The capacity charge is the same is the same even in drought years where much less electricity is produced. Capacity-based PPAs pass hydrology risk to the offtaker (eg ZESCO) and may also pass risk to the government if they are guaranteeing the offtaker's payments.
- **In drought years,** capacity-based PPAs can lead to electricity costing more and less in years with higher rainfall.
- **Any errors in forecasting the hydrology** for the Zambezi River can lead to the electricity costing the offtaker more than forecast.
- However, because the hydrology risk at Ngonye Falls is relatively low and well understood by Western Power, the PPA for **THE NGONYE FALLS PROJECT** has no capacity charge. It is an **energy-only PPA.**

Example capacity-based PPA

Power Station Capacity: 180MW
Capacity Charge: $40,000/MW/month

$$Payment = Capacity * Capacity\ Charge$$

$$Payment = 180 * 40{,}000 = \$7.2m$$

Expected Cost of Electricity:
Expected Production (P50): 80,000MWh

$$Cost\ of\ Electricity = \frac{Payment}{Actual\ Output}$$

$$\boldsymbol{Expected\ Cost\ of\ Electricity} = \frac{7.2}{80{,}000} = \boldsymbol{\$90/MWh}$$

Actual Cost of Electricity Drought Year:
Actual Production: 40,000MWh

$$Cost\ of\ Electricity = \frac{Payment}{Actual\ Output}$$

$$\boldsymbol{Actual\ Cost\ of\ Electricity} = \frac{7.2}{40{,}000} = \boldsymbol{\$180/MWh}$$

With a capacity-based PPA, the offtaker (ZESCO) has hydrology risk and the cost of electricity per unit can be higher than expected.

PPA STRUCTURE, HYDROLOGY RISK AND ELECTRICITY COST(2)

- The PPA for **THE NGONYE FALLS PROJECT** is an **energy-only PPA.**
- With an energy-only PPA, the offtaker only pays for the electricity actually produced by the power station in any given year. With an energy-only PPA **all of the hydrology risk will be carried by Western Power** and ZESCO will have absolute certainty of the actual price they will pay for each unit of electricity.
- **In drought years,** where the power station generates less electricity, Western Power will be paid less than in years with high rainfall and higher power generation. The drought risk lies with Western Power**.**
- **Any errors in forecasting the hydrology** for the Zambezi River that lead to less electricity being produced will lead to lower payments to Western Power. In all cases ZESCO will only pay for the electricity they actually receive and always for a fixed price per MWh agreed up-front in the PPA**.**

Example energy-based PPA

Power Station Capacity: 180MW
Energy Charge: $90/MWh

$$Payment = Energy * Energy\ Charge$$

Expected Cost of Electricity:
Expected Production (P50): 80,000MWh

$$Payment = 80{,}000 * 90 = \$7.2m$$

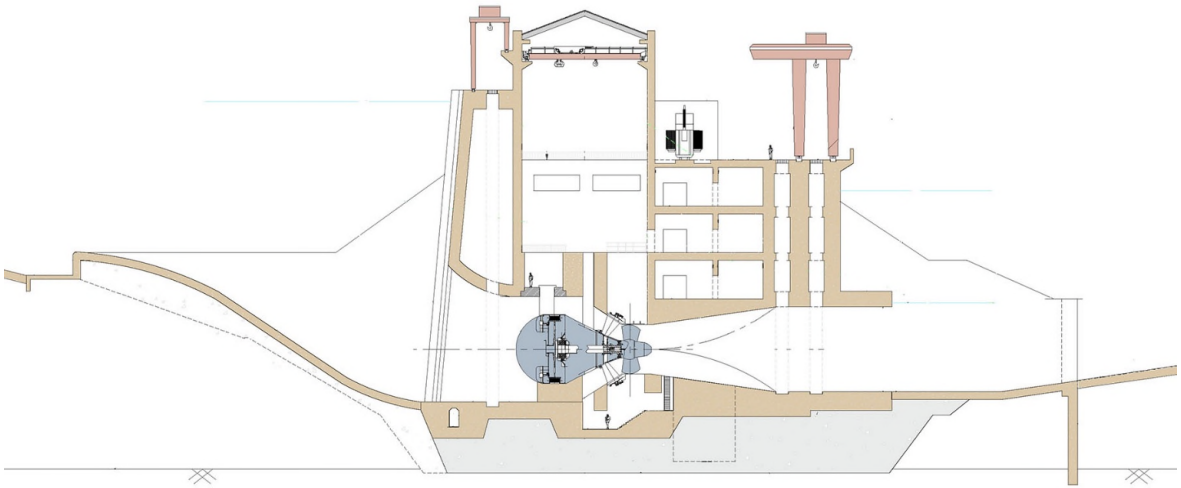
$$\boldsymbol{Expected\ Cost\ of\ Electricity} = \frac{7.2}{80{,}000} = \boldsymbol{\$90/MWh}$$

Actual Cost of Electricity Drought Year:
Actual Production: 40,000MWh

$$Payment = 40{,}000 * 90 = \$3.6m$$

$$\boldsymbol{Actual\ Cost\ of\ Electricity} = \frac{3.6}{40{,}000} = \boldsymbol{\$90/MWh}$$

With an energy-based PPA, the offtaker (ZESCO) has no hydrology risk and always pays the same amount for each unit of electricity purchased.



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