CLIMATE INVESTMENT FUNDS

February 14, 2019

Meeting of the SREP Sub-Committee
Ouarzazate, Morocco
Friday, February 1, 2019

SREP INVESTMENT PLAN FOR ZAMBIA
COMMENTS FROM NORWAY

Introduction

Zambia joined the SREP among the third set of countries in 2014.

The Investment Plan (IP) request for a total of USD 19.1 in grant funding for the following three components:

1. Energy Access in rural and peri-urban areas (USD 10 million plus USD 1.4 million for project preparation): Support through grants and subsidies to private sector-led electrification of through renewable energy mini-grids and standalone solar systems.
2. Wind power promotion (USD 2.1 million)
3. Geothermal promotion (USD 5.6 million)

With reference to deliberation in the Sub-Committee, these are more detailed comments as input for finalization of Zambia's investment plan.
Norway welcome investment plan for Zambia. We perceive ownership to be clear, and that the plan is well anchored in national priorities and plans.
We regard as positive that the plan maps other ongoing efforts and base its priorities on comparison of supply alternatives and considerations on where to add value.

- Component 1 (access through off-grid and distributed system) contributes to the realization of key ambitions for the energy sector in Zambia. SREP support may be supplementary to many other ongoing efforts that collectively may have transformative potential.
- Component 2. (wind) and Component 3. (geothermal) are both with first mover transformative potential and not covered by others.

The Zambian Government prioritize support to the Wind and Geothermal projects for the IP. WB will implement Component 1, whilst implementing MDBs for Components 2 and 3 have not yet been identified or determined.

General comments

Comparison of supply alternatives
The comparison of supply alternatives (Ch 4) is based on "levelized cost of energy", which can be a very crude and unreliable indicator for comparison of technologies with different delivery capabilities, such as for firm, non-firm, intermittent and regulating (auxiliary) power. The global data on renewable technologies presented does not appear convincing to get an idea of the cost competitiveness of the technologies in Zambia under consideration in the IP. A more comprehensive update, including all relevant renewable technologies also geothermal, with updated capex data on candidate projects and an independent review of the assumptions of the calculations is recommended. This is likely to bring out a a range of costs, dependent on-site specifics, size of plant, transactions costs of technology etc.

Additionality (technology focus of the IP)
Based on review of on-going and planned initiatives from GRZ and Cooperating Partners, the IP address the question of additionality considering the use of renewable energy sources (small hydro, biomass, solar PV, geothermal, wind) for on-grid, off-grid and mini-grid deployment. From this exercise additionality was found for the on-grid market segment, limited to wind and geothermal power technologies (Component 2 and 3).

The IP overview of other ongoing efforts in the off-grid subsector of Component 1 is not complete. AfDB will provide GCF funded TA work with the Government (MoE and REA) and the banking sector to improve the ecosystem and value chain for RE including mini-and off-grid projects. An updated

mapping of other ongoing initiatives is recommended for the IP.
It is encouraging to see the off-grid/distributed market in Zambia already is picking up, through wholistic planning, GIS-mapping and combined efforts led by the MoE task force. The additionality of Component 1 will not be automatically accomplished in a sub-sector with many already active development partners and needs to be better explained.
The leverage potential of Component 1 also needs to be clarified, as the IP estimate seems to be founded on already active interventions in the sub-sector.

Risk assessments

The IP risk assessment should completed and updated on the following issues in particular:

- Grid absorptive capacity and connection risk.
- Financial risks and ongoing efforts to improve the creditworthiness of ZESCO.

A few observations regarding financial risks that we consider is important to address in the further development of IP are just mentioned below.

- The government debt of Zambia appears to be beyond the level of sustainability, a situation that has been much in focus during recent years. Accordingly, the capacity to guarantee for additional sovereign finance can be expected to be limited, and any concessionary finance requiring state guarantee could take time to conclude.
- The financial situation of Zesco presents another challenge for on-grid projects in particular, given the utility's huge outstanding debts and insufficient revenues, notably in hard currency, to service the debt. Initiatives to alleviate the situation are underway, including increases in tariffs of supply to the mining industries and establishment of a bond to be floated in the local market. The bond would represent a refinancing of debt. To the extent Zesco would be involved in the IP the financing situation of the company might have an impact on program design.
- Other mechanisms to support off-grid project viability in rural areas would be to extend the successful Pay-As-You-Go (PAYG) systems in use by home system suppliers. Electricity consumers use mobile payments to settle bills thereby avoiding expensive debt collection and manual service disconnection.

Specific comments:
Ad Component 1 (energy access)

- SREP interventions in this sub-sector thus needs to be coordinated very carefully/actively.
- The barriers for scaling up renewable energy in Zambia, as identified in the IP, reflect the high transaction cost of bringing small renewable projects to financial close in Zambia.
- It may be helpful for the IP to focus on the capacity by the concessionaire to reduce the barriers for investors (such as regulatory framework, licensing, permits incl. right of way for transmission/distribution etc.), identify specific projects and provide financing for the early stage of project development (reconnaissance, pre-feasibility and feasibility studies) by investors).
- More specifically the IP could include an exercise to identify, define and rank the most promising sites/projects coupled with a revolving fund for development (reconnaissance, pre-feasibility and feasibility study, the cost of organizing financing and permits …) of the most promising ones. The starting point could be a review of the JICA funded Rural Electrification Master Plan of 2010 which identified Regional Growth Centres large enough to support off-grid electricity supply. Those candidate projects coming to implementation will under such an arrangement have to pay back the grant (subsidy) of the study(ies) for the next ones to draw on.

- Alternatives to competitive bidding processes to qualify/select project sponsors and a "one-stop facility" should be considered to facilitate for potential investors.

Ad Component 2 (wind)

Positive that the planned intervention continues efforts from the wind resource mapping recently carried out with the combined aim of improving the regulatory framework and getting the first utility scale project off the ground.

A more robust comparison of supply alternatives (ref general comments above), and confirmed competence and capacity of an implementing MDB will be critical for getting ahead with this component.

Ad Component 3 (geothermal)

Although the geothermal resources identified in the SREP plan are not high temperature fields, the furthering of geothermal energy harnessing should be considered in Zambia. Official support for added research is recommended to ensure that viable energy sources available to the country do not go unutilized.

The geothermal resource potential needs further analysis. A quick review of Component 3 carried out by Verkir (enclosed), found the IP to have some shortcomings that may impact on the expected outcomes and that should be taken into consideration in the scoping of the project.

A quick desktop study on the areas of Kapisya, Chinyunyu and Bweengwa should be carried out to further explore the potential in terms of utilization and to provide recommendations for the next steps.

Appendix: Memo on Geothermal Issus prepared by Verkis, Iceland

VERKÍS

SREP INVESTMENT PLAN FOR ZAMBIA

MEMO

PROJECT NO.:	19012001	DATE.:	2019-01-24
PROJECT PHASE:	01	NO.:	73117
AUTHOR:	Þorleikur Jóhannesson/Vilborg Yrsa Sigurðardóttir	Rev. 0	2019-01-24
DISTRIBUTION:	Odd K. Ystgaard, Simposya Boyd, Jóhannes Þorleiksson, Norconsult		

Subject:

Review of SREP investment plan report for Zambia with a special focus on geothermal issues

1 Introduction

Norad has requested Norconsult to conduct a high-level assessment of relevance/strategic fit and program design of "The Scaling up Renewable Energy Programme" (SREP) Investment Plan for Zambia.

For the geothermal section of the SREP Investment Plan for Zambia, Norconsult has engaged Icelandic Engineering firm Verkis, a consulting company with vast experience of geothermal power generation and direct use.

2 Procedure

There are mainly 3 sections in the SREP report dealing in particular with geothermal issues. These are:

- Chapter 3.1.5. Geothermal energy, pages 26 – 29
- Chapter 4 Economics of renewable energy technologies and the priorities for SREP in Zambia pages 37-40
- Chapter 6.3 Program Description, Component 3: Investment in Geothermal Development pages 52-55

Material contained in other chapters is mentioned or dealt with when assumed relevant.

3 Geothermal energy

Chapter 3.15 deals with the geothermal energy potential in Zambia and reservoir estimate.

It is correctly stated that geothermal fields in Zambia are sedimentary basins but comparing them with USA and Turkey and temperatures found in those countries is a bit misleading. Early research work indicates that temperature range in Zambia's geothermal field is in the 80 – 120°C range rather than 130 – 200°C range as in the USA and Turkey, unless more recent research indicates otherwise.

Five geothermal fields and three individual projects in Zambia are identified in the report. These are the following:

a) The area between Mweru and Tanganyika Lakes in Northern Zambia. **Project: Kapisya**
b) Mansa and the western Copperbelt
c) Kafue River basin including the Kafue Trough. **Project: Bweengwa River**
d) Luangwa and Luano Valleys
e) Zambezi Valley. **Project Chinyunyu**

A reservoir estimate is introduced for all three projects, i.e. Bweengwa River, Kapisy and Chinyunyu.

3.1 Bweengwa River

Results from reservoir volumetric estimates are set forth in the report as follows:

- P90 2 MW
- P50 15 MW
- P10 90 MW

This indicates that there is a 90% probability that the generation capacity will be greater than 2 MW, 50% probability that the generation capacity will be greater than 15 MW and 10% probability that the generation capacity will be greater than 90 MW. To state, as is done in the report, that power capacity is determined to be **as low as 15 MW and as high as 90 MW** is therefore a bit misleading. The capacity could be lower than 15 MW and higher than 90 MW.

The consultant has reason to believe that this interpretation of the reservoir estimate is based on a Kalahari paper, introduced at ARGO in Rwanda 2018.

It is worth mentioning that when the range between the P90 and P10 value is large, the data that is being used for the volumetric assessment is rather scattered and thus containing considerable uncertainty.

The reservoir temperature is assumed to be 150°C – 160°C, based on geo-thermometers indicating 130-180°C. These values are not real temperature measurements and should be treated as such. The suggested temperatures are considered high compared to Zambian geothermal fields in general.

To assume a 15 MW plant is thus considered optimistic, but drilling is planned and recommended as it will at minimum reduce uncertainty and improve the reservoir estimate. Any support to such drilling is highly recommended.

3.2 Kapisya.

The P50 estimate of 2 MW derived from a KenGen report is considered odd, as is the temperature range of 120-130°C. A recent Icelandic study indicates that the temperature is considerably lower and almost certainly lower than 100°C. This report is available and should be compared to the KenGen results.

The result from the Icelandic study was that the well temperature profile is possibly reverse, as the bottom temperature was lower (85°C) than halfway down the well (95°C). This might be one of the reasons why the 200 kW units were not commissioned some 20 years ago as was then planned. This also indicates that the resource may be difficult to harness.

Kengen has done a remarkable job in Kenya but it can be a pitfall when assessment methods from the African Rift valley are transferred to sedimentary basins as in Zambia. The KengGen report should be reviewed and interpreted by experts in sedimentary basing geothermal.

When temperature of geothermal resource is lower than 120°C, which is likely the case in Kapisya, large scale electrical production will always be very expensive and unfeasible. Other forms of utilization should be considered, for example direct use.

3.3 Chinyunyu

This field is not known to Verkis and no reports or data other than the KenGen report seems to be available. The KengGen report should be reviewed thoroughly for the same reasons mentioned in the previous chapter.

4 Costs of geothermal power plants

The cost of geothermal plants is discussed on pages 38-39 of the investment plan.

Table 10 shows cost figures for a hypothetical geothermal plant of 15 MW, utilizing brine at 145°C. It is assumed that this is a traditional ORC pumped brine-binary plant and the capacity introduced is 15 MW_{GROSS}, measured at generator terminals.

To make this gross power, the binary plant internal power cycle use is close to 12,5%. It should be noted that considerable pumping power, from the well and/or for reinjection into the reservoir again, may be of similar order of magnitude. This means the rated net power would be in the range of 11,25 MW_{NET}.

The assumed plant capacity factor of 0,96 is rather high but reasonable, especially if the plant is somewhat oversized. This indicates that net energy sales might be close to 95 000 MWh pr. year.

The cost information set forth in table 10 of the investment plan is rather incomplete. The cost per well assumed to be 2,5 MUSD is reasonable for about 1500 m low temperature standard (9 $^{5}/_{8}$) well. Well productivity and the number of production and re-injection wells should however be mentioned but this information was lacking.

The total project cost of 4 MUSD/MW_{GROSS} for a pumped brine-binary plant is considered unrealistic. A more realistic value would be in the order of 6 MUSD/MW_{GROSS}. A cost of 4 MUSD per MW is a common figure for high temperature steam plants which does not apply in this context. The total project cost for a 15 MW_{GROSS} plant is thus considered to be more akin to 90 MUSD.

The annual operational cost of 3,8 MUSD for a 15 MW_{GROSS} plant is considered high. A more realistic value would be close to 2 MUSD per year.

Energy sold from such a plant could provide an annual revenue of 9,5 MUSD. Subtracting 2,0 MUSD for operational costs leads to a project IRR of 6% for 25 years.

Using the figures set forth in the table, namely a 60 MUSD construction cost and a 3,8 MUSD annual operational cost, and assuming a net annual energy sale of 95 000 MWh, results a project IRR of 8% for 25 years.

The cost and economic analysis for Geothermal Energy in the report requires a more in-depth analysis of the assumptions made.

5 Investment in Geothermal Development

There is no doubt that developers might be interested in utilizing geothermal energy in Zambia. The geothermal resources are present, and it is more a question of fluid temperature, water level, chemistry and permeability whether they can be harnessed for electrical power or direct use.

At this stage official support is needed for further mapping and research of the geothermal potential. Private capital for such activities is limited, especially in a country with an unestablished geothermal sector and a potential that is somewhat less promising than in countries with known high temperature resources. Drilling the first production well in a new field always presents a challenge and requires official support. The SREP plan is a very positive first step towards the implementation of such a support mechanism.

All issues discussed in sections 6.3.1 to 6.3.5 are considered reasonable.

The issues reviewed and discussed in sections 6.4, 6.4.1 and onwards, are general in content but were found to be a bit negative when referring to geothermal utilisation. The below addresses some of these main negative issues.

Noise: Naturally there will be noise during construction of geothermal plants, as in any other power project irrespective of the power source. Noise from well drilling is comparable with other ground-breaking activity. There will be very limited noise from well field pumping as soundless submersible pumps are generally installed with the motor in the well. There is no, or at least very limited, flushing and no silencers or large mufflers are required as there is no steam vent involved. The water is kept at pressure in the pipes, preventing it from boiling. The only noise source of mention is the turbine and the cycle pump, which can be placed indoors if noise is considered problematic. The only noise that is difficult to deal with is that stemming from the cooling fans. This noise is comparable to that of large air conditioning systems.

Air Pollution: In most cases there is limited or no air pollution from a brine-binary plant. If gases are dissolved in the brine, they are not released. They are dissolved in the brine under pressure and will eventually be re-injected with the brine. In such low temperature resources as found in Zambia, gases are generally not a problem. However, the actual chemistry of the brine is required to establish this, so the actual encountered situation will only become clear once the first well has been drilled.

The report mentions gases from flash or dry steam technology. This is not relevant as this utilisation method is not applicable in Zambia. The temperature is too low for enough steam to operate such plants.

Since gas exposure is limited, it should not be an issue for health and safety. Pipeline failures are also very rare in geothermal and not worth consideration at the level of the SREP plan at hand.

6 General conclusion

Although the geothermal resources identified in the SREP plan are not high temperature fields, the furthering of geothermal energy harnessing should be considered in Zambia. Official support for added research is recommended to ensure that viable energy sources available to the country do not go unutilized.

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