Hydropower Solutions

HYPOSO

Hydropower solutions for developing and emerging countries

D6.3
Political recommendation papers
UGANDA

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1 Introduction

HYPOSO is a multi-approach project to tackle several objectives; identification and mapping of the European hydropower industry, hydropower stakeholders in the HYPOSO target countries, education of new hydropower experts through capacity building activities and bringing together relevant actors from the EU hydropower sector with stakeholders in the target countries. Interaction with stakeholders is therefore an integral part of the activities, as workshops, capacity building activities and interviews with national/local stakeholders are envisaged in all target countries which are outside the European Union, namely workshops in Bolivia, Colombia and Ecuador in Latin America, and in Cameroon and Uganda in Africa. Additionally, capacity building courses will be carried out in Bolivia and Ecuador, and in Cameroon and Uganda.

2 Information about Deliverable

The policy recommendation papers developed within HYPOSO shall be seen as a perspective from the European side on the small hydropower sector in the HYPOSO target countries Bolivia, Colombia and Ecuador in Latin America, and in Cameroon and Uganda in Africa. The following recommendations are composed of findings during the HYPOSO project (reports on the framework conditions, discussions during HYPOSO events), as well as of trends that have developed in the recent years and should be considered when a sustainable development of the sector is planned. The following recommendations do not claim to be comprehensive or to propose any concrete legislative changes. This must always be done at national level.

The recommendations made here may however be taken into account in discussions on this matter.

3 General information about the electricity sector in Uganda

The electricity supply system in Uganda was developed during the 1950s and 1960s with the construction of the Owen Falls Hydropower Station (later renamed Nalubale Power Station) with a total installed capacity of 150 MW. Later the power station was refurbished and upgraded to 180 MW and a new power station, Kiira, was constructed with a capacity of 200 MW.

When speaking about the electricity sector in Uganda, it needs to be stated that electricity represents only around 2 % of Uganda's total energy consumption. Around 80 % of the generating capacity is based on hydropower. Most of the remaining 20 % is also renewable, including several solar photovoltaic (PV) installations and thermal power plants that burn sugar cane bagasse (IEA, 2023).

Uganda has shown an impressive development of the national electricity sector in the last two decades. While in 2002 the national electricity generating capacity has been about 320 megawatts (MW), at the beginning of 2023 it has been increased to 1,402 MW (ERA, 2023).

The 600 MW Karuma hydroelectric power plant, which, after some delays, is expected to be ready for commissioning by September 2024, will increase the installed capacity to a little more than 2,000 MW (THE INDEPENDENT, 2023).

While these dates are really impressive, the IEA stated in its report "Uganda 2023 Energy Policy Review" that the transmission and distribution network are not yet ready to make use of the increased capacity, which led in combination with past power purchase agreements (PPAs) signed with the state-owned system operator (often having included take-or-pay clauses), to payments for energy that could not be used, and which consequently has added to the costs of power.

With the "Power Sector Restructuring and Privatisation Strategy" in the late 1990s and early 2000s, Uganda unbundled the vertically integrated Uganda Electricity Board (UEB) in 2001 into three state-owned companies that respectively covered generation (Uganda Electricity Generation Company Limited – UEGCL), transmission (Uganda Electricity Transmission Company Limited – UETCL), and distribution (Uganda Electricity Distribution Company Limited – UEDCL). In 2021, the government announced the planning of a "second generation" of power sector reforms, under which the previously unbundled UEGCL, UETCL and UEDCL would be re-consolidated into a new, vertically integrated Uganda National Electricity Company. The government is still defining the details and timing of such reforms, although it has already paved the way for them with several amendments in 2022 to the Electricity Act, following a Power Sector Reforms Study in 2017.

The National Energy Policy for Uganda 2023 focuses on expanding the electricity transmission and distribution grid networks; increasing energy efficiency; promoting the use of alternative sources of energy; and strengthening the policy, legal and institutional framework. Until today, Uganda has developed a number of subsectoral policies, including the 2008 National Oil and Gas Policy (currently under review), the Renewable Energy Policy (2007), and the Electricity Connections Policy (2018) (IEA, 2023).

According to the used source and definition of energy access, between 31 % (IEA, 2023) and 45 % of the population has access to electricity, and in rural areas access is considerably less (according to the CIA factbook for 2021, total population electrification rate: 45.2 %, urban 72.2 %, and rural 35.9 %,and according to IEA: national 31 %, urban 77 %, rural 17 %). Uganda has one of the lowest levels of per capita electricity consumption in the world with 215 kWh (CIA, 2023) or even 82 kWh (IEA, 2023) per capita per year.

What can be generally recommended is that the relevant deciding authorities of Uganda will develop, implement and track an Energy Transition Plan for achieving Uganda's energy-related goals while aiming for a transition to a low-carbon, climate-resilient economy, including by

considering new technologies and innovation, in line with the Paris Agreement and Uganda's Nationally Determined Contribution.

It will be further shown in these recommendations, that small hydropower (SHP) could support Uganda in addressing the experienced transmission bottlenecks.

4 Small hydropower in Uganda

Regarding small hydropower projects (up to 20 MW), the current policy is that their development is undertaken by the private sector. Renewable Energy Feed-in Tariffs (REFiT) are in place to promote investment in small hydropower and other renewable power projects. To avoid the difficulties experienced by small hydropower developers with stepped tariffs, a linear tariff structure was developed for hydropower projects between 5 MW and 10 MW (IEA, 2023).

Technology	Tariff USDc/kWh	O&M %	Cumulative capacity limits (MW)			Payment period (years)
			2019	2020	2021	
Hydro (10 < X ≤ 20 MW)	7.51	12.9%	30	60	80	20
Hydro (5 < X ≤ 10 MW)	Linear tariff decreasing with capacity 7.51-7.92	13.4%	20	40	50	20
Hydro (500 kW < X ≤ 5 MW)	7.92	13.8%	10	20	30	20
Bagasse	7.93	45.8%	30	50	60	20

Notes: O&M % = operations and maintenance; USDc = United States cent; kWh = kilowatt hour; MW = megawatt.
Source: ERA (2019).

Figure 1: REFiT Phase 4 tariffs, O&M %, capacity limits and payment period (IEA, 2023)

As of 2022, 25 SHP plants up to 20 MW were operating in Uganda with a total installed capacity of 186 MW. According to the latest available data, the World Small Hydropower Development Report (WSHDR) 2022, which has been published in August 2023 (UNIDO, ICSHP, 2022), the most recent estimate of potential capacity for SHP of up to 20 MW was approximately 400 MW, while the potential capacity for plants up to 10 MW is estimated at 214.1 MW.

However, within the HYPOSO project, the so-called HYPOSO Map was developed, and with this online tool, more than 475 potential sites for new hydropower plants have been identified. This gives reason to believe that the potential for more hydropower in Uganda is considerably larger than the 214 MW mentioned in WSHDR 2022.

4.1 Why (small) hydropower at all?

To deliver on the UN Sustainable Development Goals (United Nations, 2023), hydropower is crucial. For example, hydropower ensures availability and sustainable management of water

and sanitation for all (SDG6), and it ensures access to affordable, reliable, sustainable and modern energy for all (SDG7).The implementation of hydropower plants contributes to SDG8, sustainable economic growth and jobs, and hydropower represents like few other technologies SDG9, to build resilient infrastructure, to promote inclusive and sustainable industrialisation, and to foster innovation. In addition, hydropower is a key solution for taking the urgent action to combat climate change and its impacts (SDG13).

4.2 Facts about small hydropower that are not known everywhere

The French study “Hydropower and the challenge of flexibility” (“L’hydroélectricité au défi de la flexibilité” by France Hydro Electricité, 2020) has addressed the issue of flexibility services and has shown that hydroelectricity is essential for balancing the electricity system, especially in the low voltage system. According to the French study, a small hydropower plant is equivalent to ten domestic batteries (of each 10 kW), and can increase the capacity of a high-voltage line by 20 % to accommodate photovoltaics.

According to the German study ”Contribution of small hydropower plants hydropower plants to secure and cost-effective electricity supply in Germany” (“Netztechnischer Beitrag von kleinen Wasserkraftwerken zu einer sicheren und kostengünstigen Stromversorgung in Deutschland”), small hydropower plants have the capacity to considerably decrease the costs of electricity grid adaption if considerably more PV and wind energy are fed in. Small hydropower plants achieve high values of up to 5,500 full-load hours, and are also highly available and thus operate for an average of more than 8,000 hours per year and feed continuously into the grids. Hydropower plants are therefore reliable electricity producers and guarantee a steady supply of electricity.

If required, hydropower plants can also be operated as reliable control power plants: On the one hand, negative control power can be provided by reducing the very constant feed-in power on demand; on the other hand, additional feed-in power can also be provided by slightly throttling hydropower plants during normal operation. Especially with the use of dynamic reservoir management and associated storage capacities in the potential energy of the water, the control potential can be fully exploited.

These services bring a financial benefit with them. For example in Germany, the country where the study was carried out, a total of about 7,300 to 7,600 hydropower plants produce electricity. A distinction is made between large hydropower plants with an installed (electrical nominal) capacity of > 1 MW and small ones with an installed capacity of ≤ 1 MW. The large capacity class includes about 400 hydropower plants, whereas about 7,000 small hydropower plants are in operation. The share of large hydropower plants in the total amount of electricity is about 85 %, while small hydropower plants generate about 15 %. Although in Germany only about 4.1 GW of the 103 GW of installed renewable capacity is accounted for by hydropower (approx. 4%), they account for about 12% of electricity generation from renewable energy sources. This means that small hydropower plants are of great importance for the German electricity supply due to their grid-serving behaviour, as they feed in their output steadily and

with high full-load utilisation hours without causing grid overloads, which significantly reduces the need for grid expansion in the distribution grids. This is another reason why it is important to maintain the existing capacities of small hydropower as well as to ensure their economic operation. If this were not successful, in Germany, the amount of energy provided by small hydropower plants (< 1 MW) would have to be substituted by wind power and photovoltaic plants, which would increase the additional grid expansion costs in the medium and low voltage grid alone in Germany to an amount of about 750 million € (Zdrallek, 2018).For Uganda, given the considerably lower number of plants, the financial savings might be less but the information about the benefits of decentralised SHP should be considered, taking whatever financial savings as a welcome benefit.

5 Recommendations for the small hydropower sector in Uganda

As general recommendation it must be advised to use available tools and technologies that can bring the national hydropower sector forward. In the **HYPOSO** project for example, different tools that might be helpful for the Ugandan small hydropower sector have been developed; namely the HYPOSO Map (a useful online GIS tool to start the search for new hydropower sites from the desktop, providing more than 20 different layers with useful information for hydropower), the HYPOSO Business Cases (a replicable pre-feasibility study model and a financing model are publicly available via https://www.hyposo.eu/en/sector-information/), the HYPOSO **Meeting Platform** (an online meeting forum, free of cost, see more at https://www.hyposo.eu/en/hyposo-platform/), and the HYPOSO OCW Platform (the online platform of the HYPOSO **capacity building courses**, see more at HYPOSO (un-ihe.org)).

Furthermore, the **International Hydropower Association** (IHA) has developed some very useful material which should also be considered (see more under 5.3).

Considering the electrification rates in Uganda (between 31 % and 45 % of the population), the political deciders have already taken decisions to address the topic, and have surely made considerable developments. Still, there is a long way to achieve the goal. In our opinion, this should be done best with renewable energy sources (RES), and SHP should play the role it is able to perform (i.e., electrifying off-grid areas, supporting and stabilising the grid, and enabling more integration of volatile RES like wind and solar energy).

5.1 Accelerate the development of renewables through streamlined permitting and licensing

Uganda has started its journey to more renewable energies already and has an impressive share of RES in its electricity mix. With the Uganda Investment Authority (UIA), there is a one-stop shop where investors may obtain applications for company registration and various licences, including for investment projects in the energy sector. This is very good.

To our knowledge, support or a broker service for project developers to find finance is however not part of UIA. We would recommend that such service is provided for national stakeholders, knowing that this would make UIA to an admired pioneer of sector service.

5.2 Install strict measures to ensure that only "good" hydropower projects are implemented

Regarding hydropower projects, we recommend that only "good" hydropower projects are provided with licenses and permissions.

Hydropower projects that are sited, planned and executed in accordance with international good practice in sustainability can have positive wider non-power impacts on local communities, including but not limited to water supply, social investment, economic growth, livelihoods, irrigation, and flood and drought protection.

5.3 Embed hydropower sustainability practices in government regulation.

As mentioned, hydropower, be it large or small, will only be largely accepted if the realised plants will be really sustainable plants, taking care of people already living in and/or using the area, and of course taking care of the environment. The International Hydropower Association (IHA) has developed **sustainability guidelines** that should be embedded in national regulation. All different guidelines can be accessed via:

https://www.hydrosustainability.org/hydropower-sustainability-guidelines .

It is also worthy, checking the European approach on water related issues that shall lead to a more healthy status of the water environment, with the main element being the **Water Framework Directive** (WFD), which has the overall objective to achieve good environmental status for all waters, and which led to the request to EU Member States to draw up so-called river basin management plans based on natural geographical river basins, as well as specific programmes of measures to achieve the objectives. The WFD is supported by more targeted directives, i.e. the Groundwater Directive, the Drinking Water Directive, the Bathing Water Directive, the Nitrates Directive, the Urban Waste Water Treatment Directive, the Environmental Quality Standards Directive and the Floods Directive. These typical EU Directives might be interesting for political deciders in Uganda, who could check, whether the topics that are dealt within the EU are already an actual national topic to be addressed. If so, of course the contact to European representatives is recommended to start discussions with experts from the EU (European Parliament, 2023).

5.4 Incentivise sustainable hydropower development through financial and market mechanisms

We would recommend also to think about a **fair remuneration** of the services that hydropower (small and large) is providing for the electricity grids. As shown under 4.2, this service can save a lot of money when it comes to preparing the electricity grids for more volatile energy production from PV and wind energy.

5.5 Enable the national hydropower sector to grow for the better of the country

It is essential that the Ugandan hydropower sector will be able to grow and thrive. It is recommended therefore that hydropower stakeholders, especially political deciders, get familiar with the latest updates about hydropower. As mentioned before, interested stakeholders from Uganda are invited to enroll themselves in the **HYPOSO capacity building courses** (HYPOSO (un-ihe.org)). In addition, hydropower stakeholders from Bolivia are invited to **make contacts with European stakeholders**, on the one hand via the HYPOSO Platform, on the other hand via ETIP Hydropower (ETIP HYDROPOWER (etip-hydropower.eu)), currently a project funded by the European Commission, but already now and in future aiming to be a recognised interlocutor for the European Commission, Member States and Associated Countries about the hydropower's sector specific R&I needs, also open for making contacts to hydropower stakeholders from Africa.

The set-up of a **national open table** for all actors involved in the Ugandan hydropower sector is recommended further, as such exchange of positions and ideas can benefit the sector and lead to an improved situation for more dedicated and sustainable hydropower in Uganda.

It needs to be mentioned finally, that a **lack of gauging stations** is not only impeding good decision making for future hydropower opportunities, but also causing an unneeded risk for downstream communities (flood forecasts) and should therefore be **addressed wherever needed**.

5.6 Enable public involvement in SHP projects, making them Social hydropower projects

We recommend, if possible, that **public involvement** is facilitated, encouraged, and supported by regulative means to be taken by political deciders. Research by Noda et al. (2020) has shown that, based on the degree of citizens' involvement in small hydropower projects, inclusive relationships between their involvement and awareness were revealed. The acceptance of future plants could be improved if such involvement would see support.

5.7 Use available finance sources

Regarding finance for hydropower projects, national stakeholders like project developers are often lacking enough money and are not well informed where to get access to finance possibilities. We recommend that a dedicated office (in best case part of the one-stop-shop, see under 5.1) will be established and promoted in the national hydropower sector, to act as information hub for local developers who are seeking financial support and have no information where that could be done best. As first source of information a look into report D5.4 of the HYPOSO project is advised, in which it was revealed that if the needed finance for a project would be in the context of medium-term debt (i.e., 10 years including grace period), funding from commercial banks or crowdfunding sources (HYPOSO project partner and finance expert 1to3 Capital is linked to crowdfunding site 'CrowdPartners') is possible. In case a project would

not be pre-feasible within that context the assessment was performed (i.e., to yield a minimum DSCR (debt service coverage ratio) of 1.3x), it is recommended to take long-term finance (20 years including grace period) into account to come from covered debt - for political and commercial risks - from commercial banks plus an export credit agency coverage or from development banks who often also need governmental guarantees (in future for example through coverage from the EFSD+ (European Commission, 2023)).

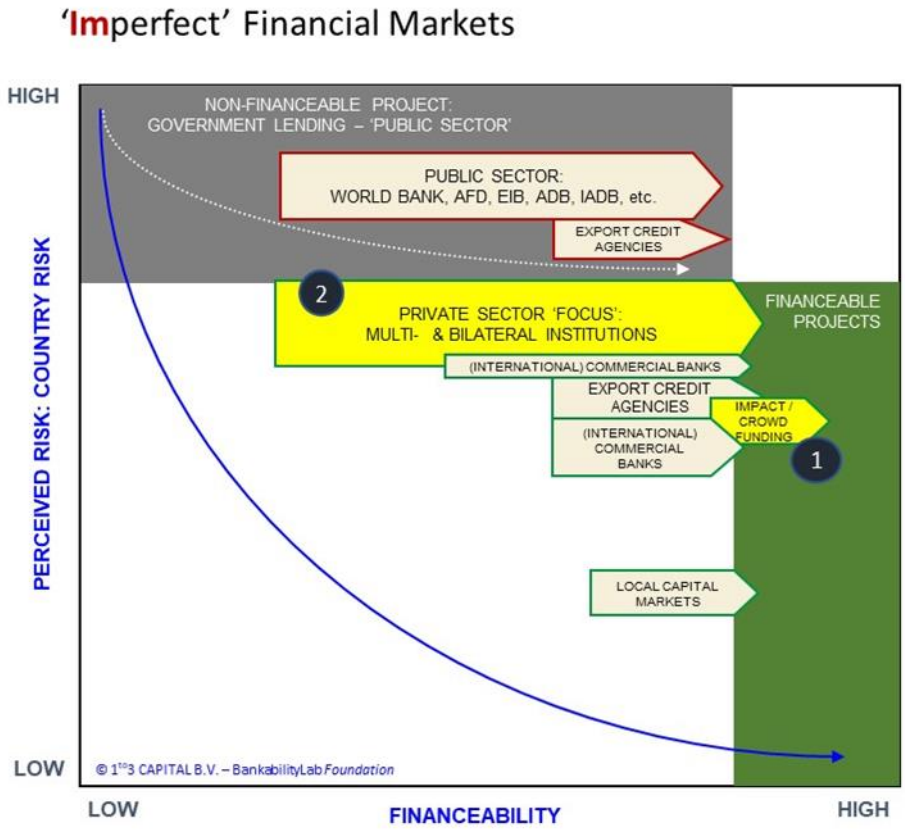

Figure 2: Financeability Matrix and Imperfect Financial Markets (Source: Marc J.M. Buiting)

In addition, it is recommended that available offers for financial capacity development are used. Prospective developers could apply for these courses. Most development banks have capacity development facilities.

5.8 Start today with planning future scenarios

As predictions of precipitation patterns for Uganda give reason to expect an increase in heavy precipitation (see IEA, 2020, as well as below the result from the HYPOSO Map, available via https://www.hyposo.eu/en/hyposo-platform/), it is recommended to **think already now how to best address these forecasts** (i.e., to prevent floodings). Multipurpose hydropower plants with reservoirs might be an answer for such precipitation scenarios in the future.

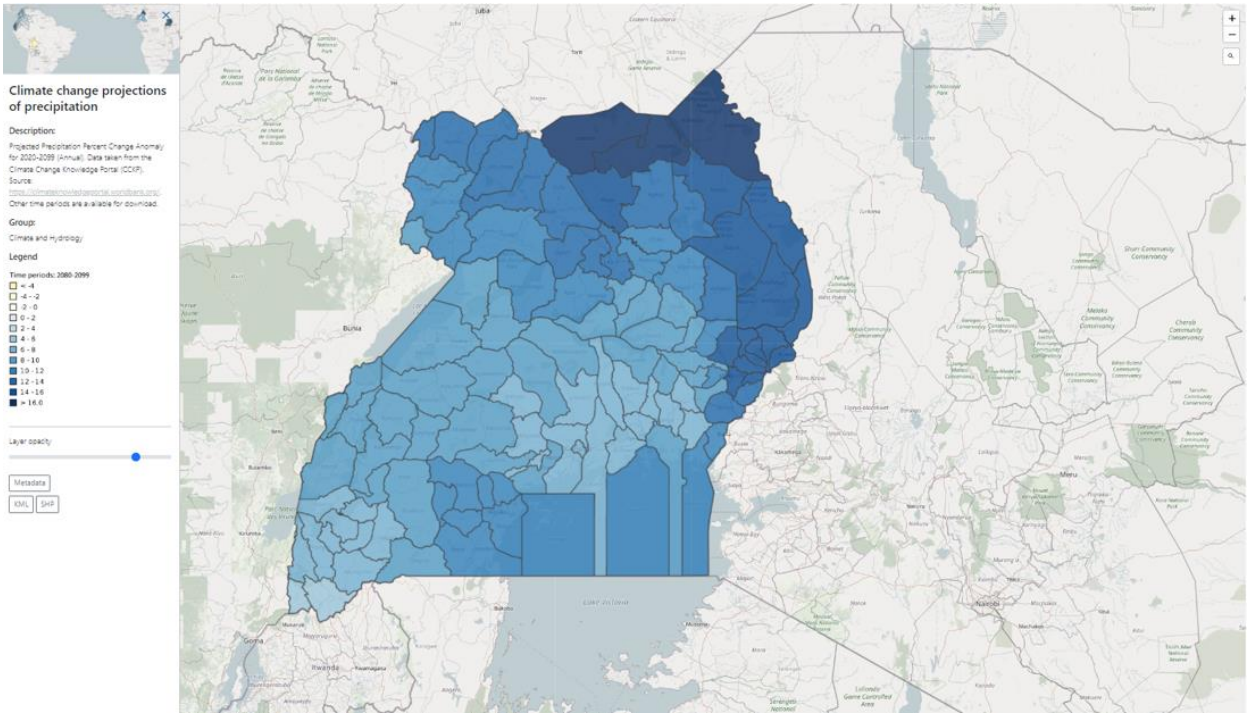

Figure 3: Screenshot of the HYPOSO Map, showing an increase of precipitation in some regions in Uganda

An interesting work carried out by the Australian National University (ANU) and published in 2022 has shown that in Uganda, there is also a considerable potential to implement **Pumped Storage Hydropower** (PSH or PSP). We recommend that the PSH/PSP is considered for accelerating even more the expansion of renewable energies in Uganda. There is no other proven renewable technology that matches its long lifetime and its ability to support reliable grids.

For Uganda, the Global Greenfield Pumped Hydro Energy Storage Atlas, developed by the Australian National University (ANU), might be a perfect tool to start the journey for PSH/PSP development in Uganda. The atlas can be accessed via: https://re100.anu.edu.au/ .

The screenshot below of this tool is giving an impression of the potential that Uganda is having.

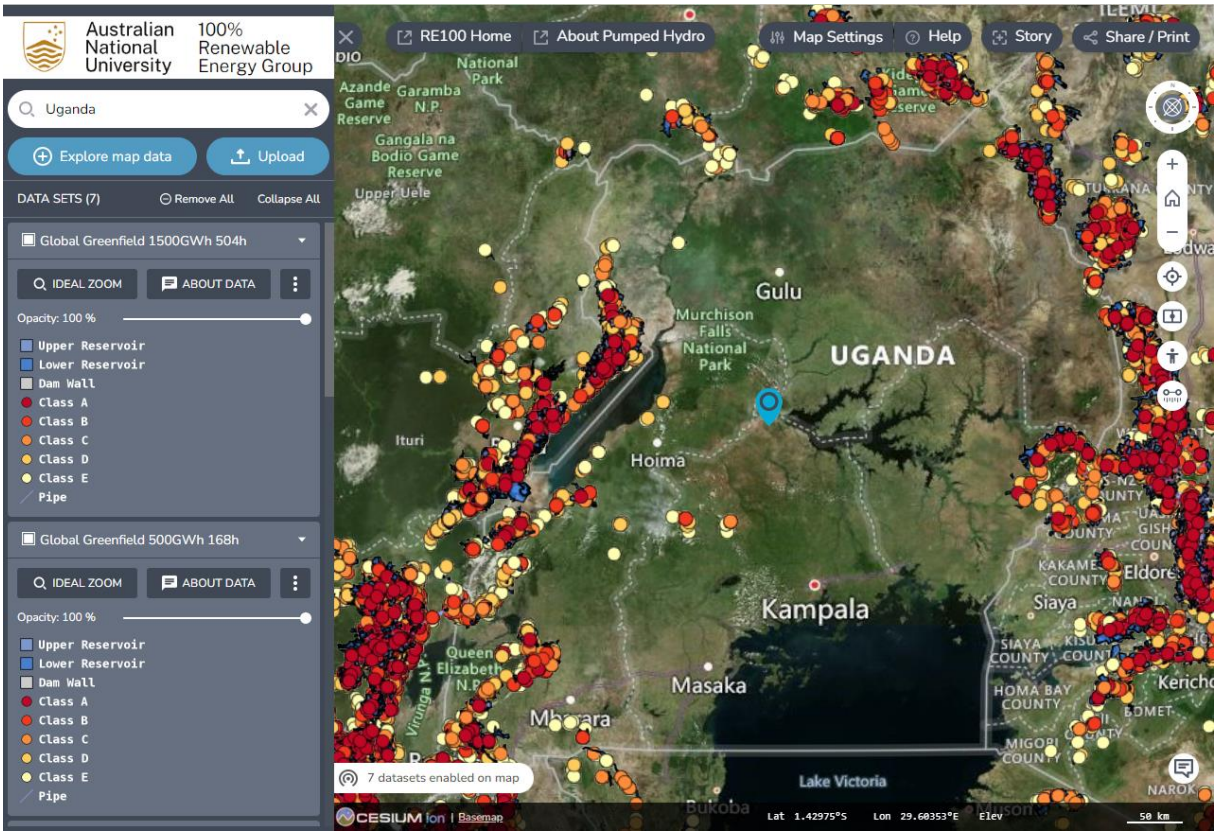

Figure 4: Screenshot of the Global Greenfield Pumped Hydro Energy Storage Atlas, showing parts of the PSP potential in Uganda

6 Conclusion

The HYPOSO consortium is convinced that **small hydropower plants (SHP) are a viable solution** as a contribution to achieving the **decarbonisation of the energy sector**, which, if implemented well, will enable the further expansion of other renewable energies. At the same time, the value of **small hydropower plants for a stable electricity grid** cannot be underestimated, especially in the mid– and low-voltage grid. In our view, measures should therefore be taken that will lead to **more SHP projects being implemented in the near future** in Uganda.

Uganda should not only look into more sustainable and sensibly located SHP, but should also make use of the **favourable geographical characteristics** which it has, and explore the potential of PSH/PSP in the country.

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