

Power generation expansion planning for the large-scale integration of renewable energy sources in developing countries: the case of Angola



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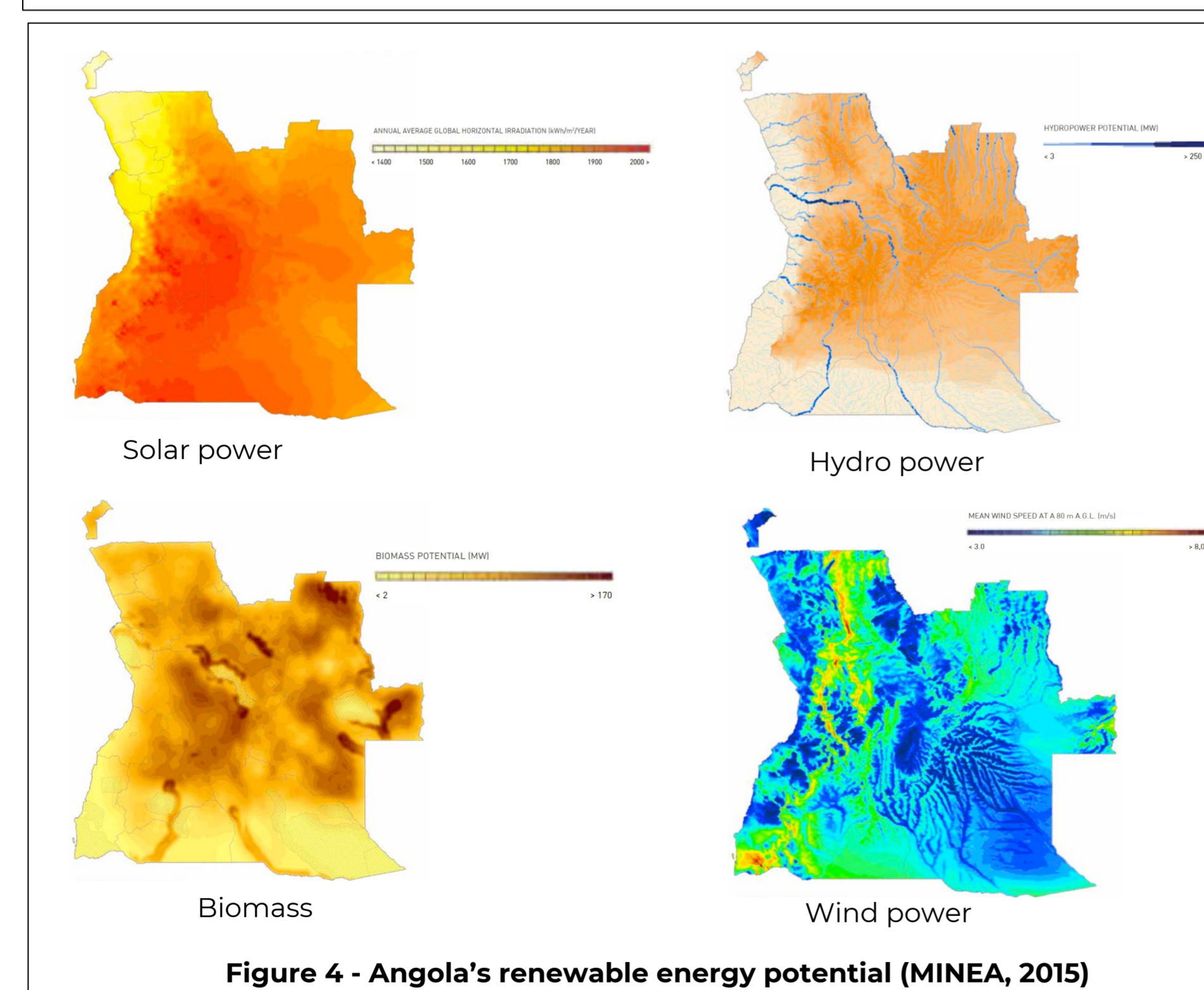
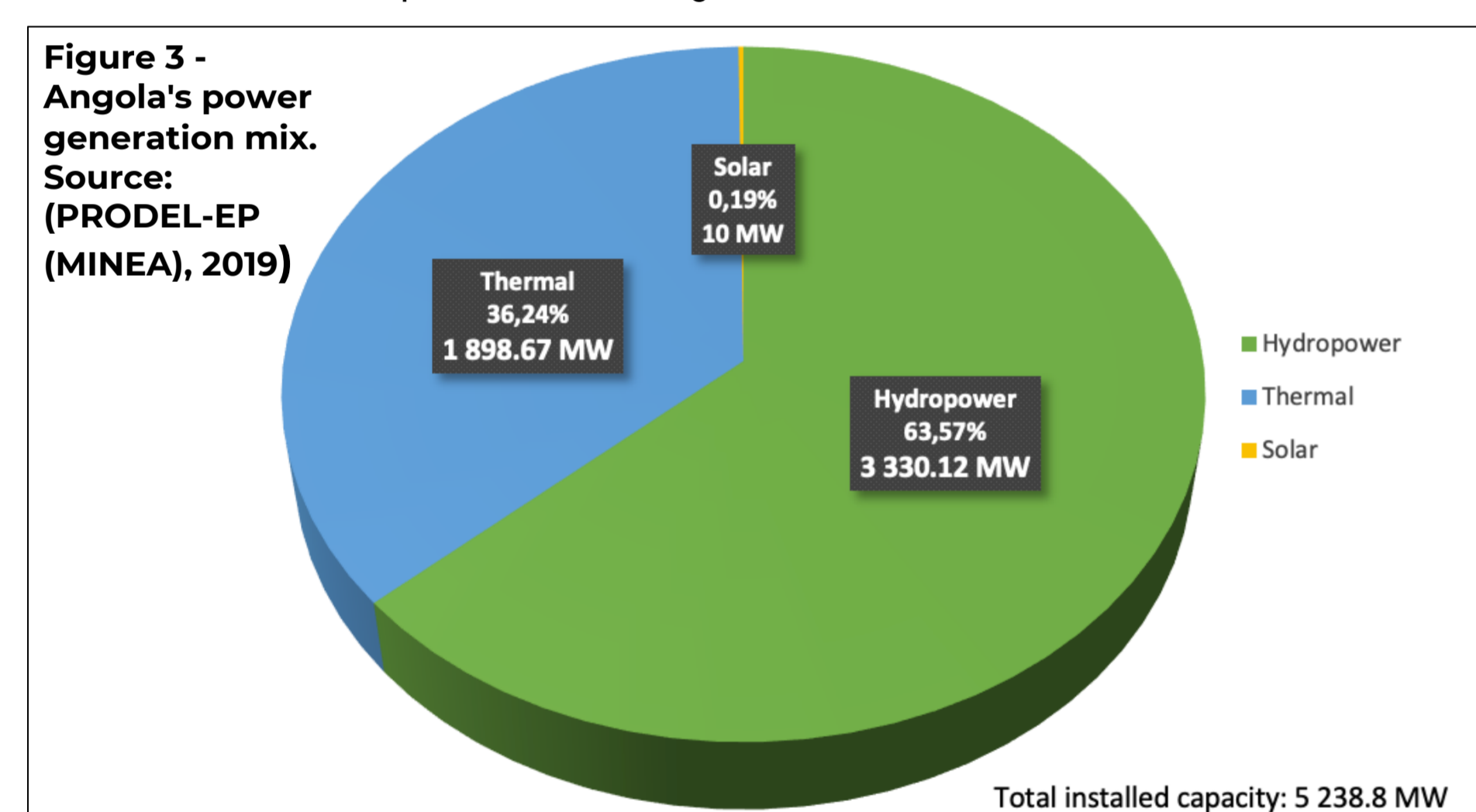
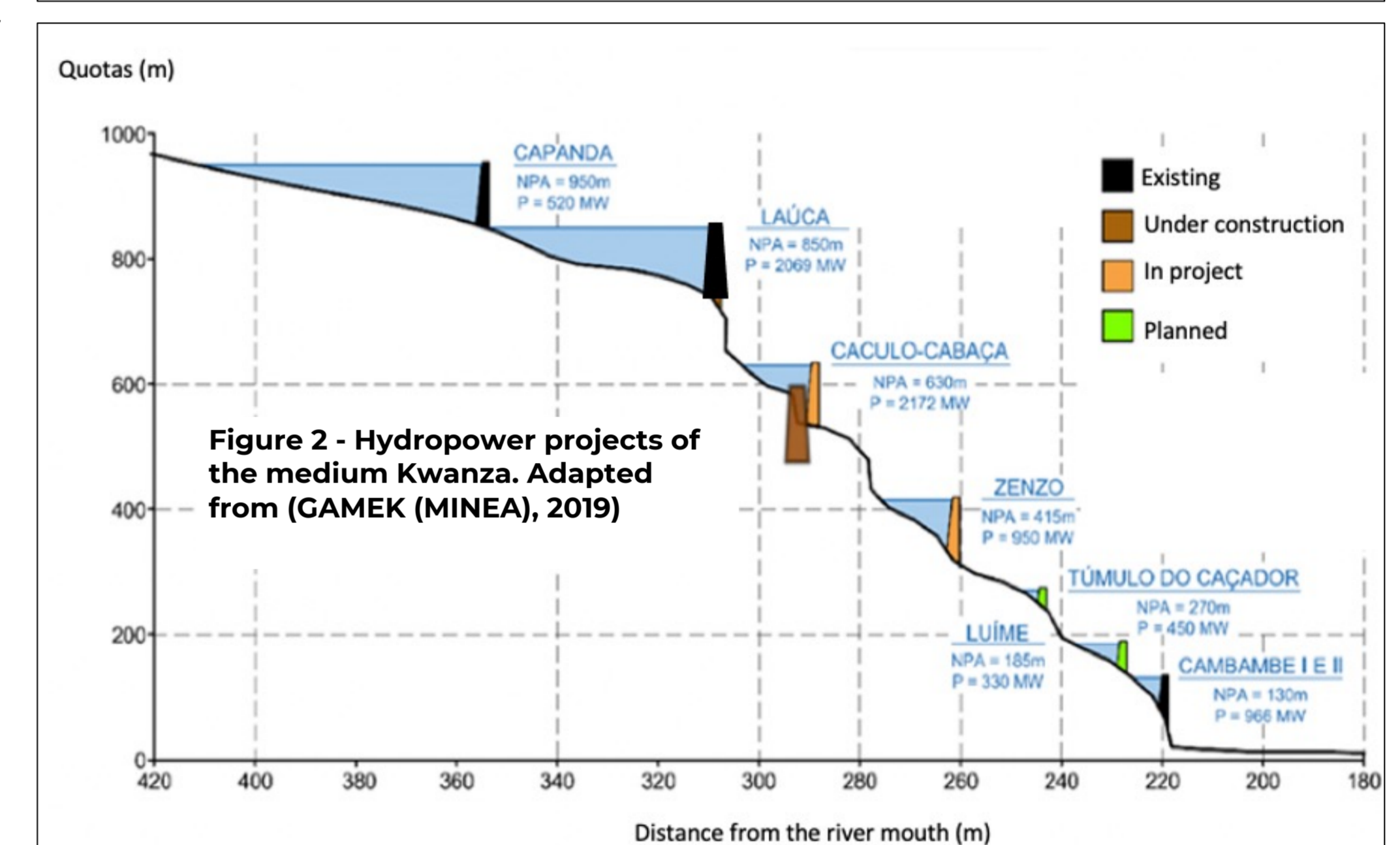
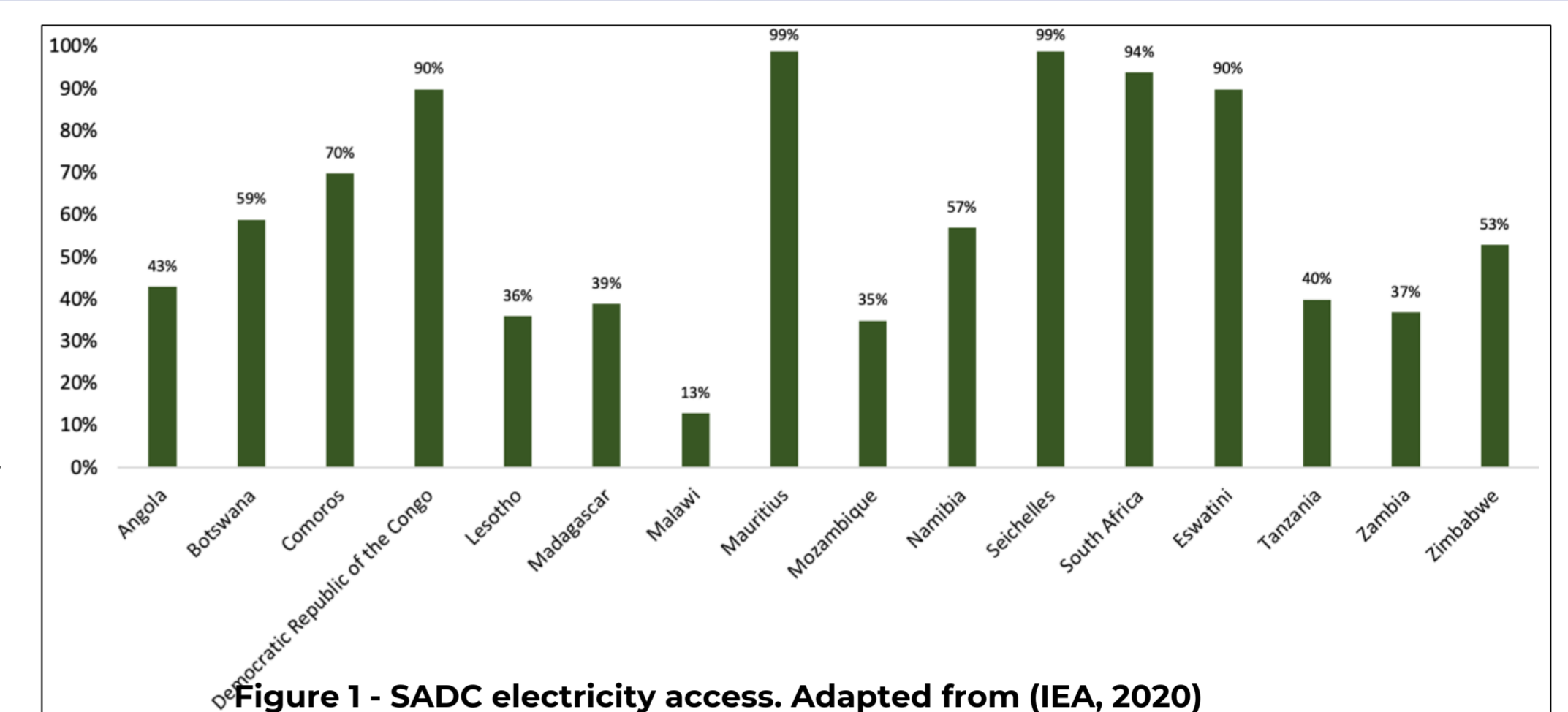
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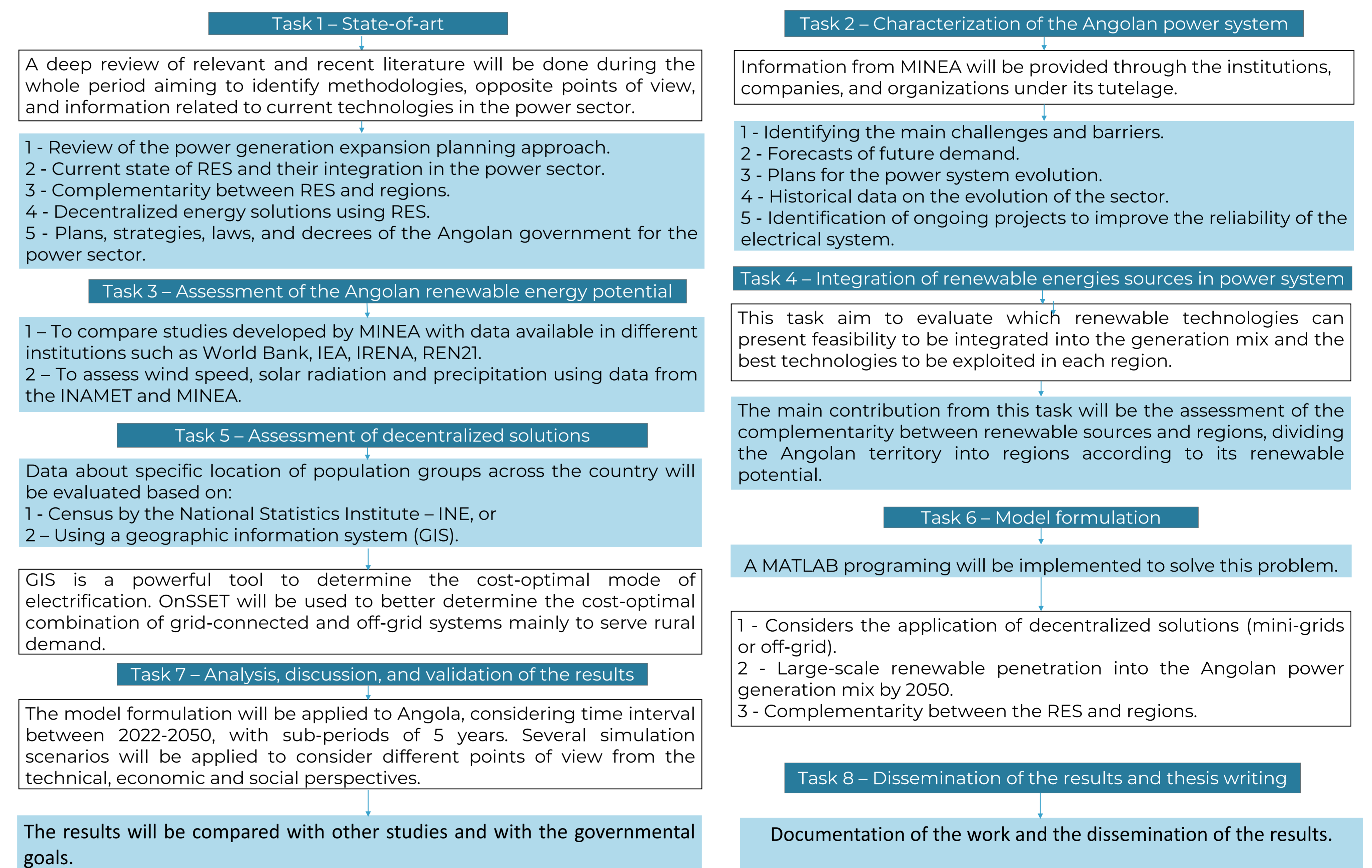
1. Background

According to IEA, 578 million people in sub-Saharan Africa did not have access to electricity in 2019, with the electrification rate remaining at 48%. In Angola, this number is even lower, with an electrification rate of 43% (Figure 1), corresponding to 18 million without electricity access, being one of the 20 countries with the lowest electrification rates in the world. To improve electricity access, the Minister of Energy and Water of Angola (MINEA) under the “Angola Energy 2025” program, defined the expansion of the power system mainly with hydropower plants, most of them located in Kwanza River (Figure 2). This initiative is justified by the large hydropower potential of the country, estimated at more than 18 GW. Angola occupied in 2017 fourth place in the list of countries with the highest percentage of hydropower in its generation mix, currently representing more than 63% of the total capacity (Figure 3). However, the current dependence of the electricity sector on hydropower does not ensure the reliability of the power system, especially in drought periods. It is crucial the introduction of the new Renewable Energy Sources (RES) that also present high potential in the country, namely: solar photovoltaics, wind, and biomass (Figure 4). Additionally, the complementarity between RES in the different regions of the country should be considered to smooth the impact of renewable generation intermittency. Yet, there is also an urgent need to think of decentralized solutions for remote locations, instead of a complete expansion of the electrical grid that is a slow and expensive process. Therefore, this investigation proposes to answer the following questions: (1) What areas should be served by the electrical grid or by decentralized solutions? (2) What are the best decentralized solutions to guarantee electricity to remote populations? (3) How can the reliability of the power system be ensured in drought periods with a system based on RES? The literature presents multi-objective models that analyse the expansion of power systems with RES integration. However, these are seen from the perspective of countries with a high electrification rate. The present research proposal aims to develop a power generation expansion planning model with new RES integration suitable for Angola and that can be replicated to countries with low electrification rates, with a focus on countries in the SADC region whose average electrification was 47% in 2019. The model will consider aspects such as: the costs of expanding the electrical grid, the integration of intermittent RES into the electrical grid, the complementarity between RES and regions, distributed generation (microgrids), flexibility requirements ensured by hydropower and other storage options, environmental impacts, economic restrictions, and population density. To this end, government studies, plans, and targets for the electricity sector, population data and other sources characterizing energy resources in Angola will be used. The main goal is to present a methodology that can provide solutions and help policymakers in the development of strategies for the expansion of the power sector by 2050.

Keywords: power generation expansion planning, multi-objective, renewable energy sources integration, developing countries, complementarity.



2. Research Methodology



3. Expected results

The expected result is to present a methodology that can provide solutions and help policymakers in the development of strategies for the expansion of the power sector by 2050. For the case of SSA, mainly SADC countries that present similar characteristics in terms of resources, such methodology should also serve as a technical and scientific reference, to improve the power sector and consequently increase the access to electricity for most populations.

4. Conclusion

The main objective of the proposed thesis is to develop a Multi Objective Linear Programming for power generation expansion planning to the large-scale integration of renewable energy sources in developing countries with limited initial electricity infrastructure, which means, low electrification rate. The model will consider decentralized solutions (mini-grids or off-grid), most for rural communities as well as the complementarity between the sources and regions. The case of study will be the Angolan power sector. A geographic information tool will be used to acquire information about the distribution of populations groups.

5. References

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