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AWESOME

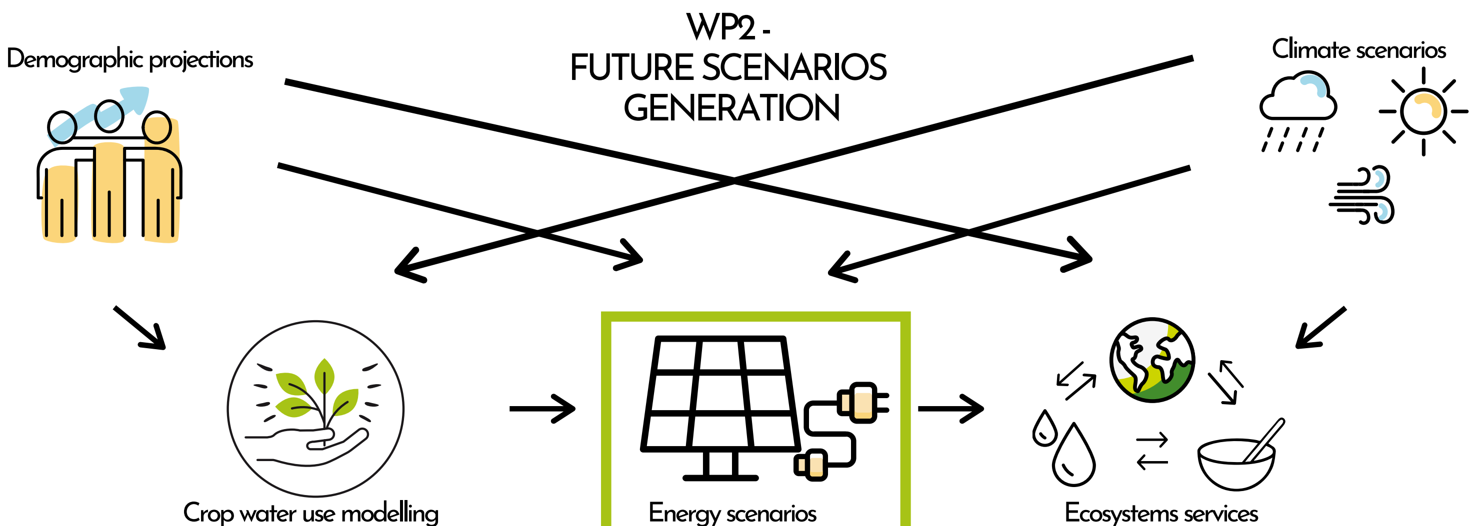
WATER-ECOSYSTEM-FOOD

Energy modelling approach

Demand projections

Energy scenarios

In this factsheet we present the **energy model** developed through the open-source OSeMOSYS model, which represents the energy demand and supply systems of **Egypt, Ethiopia, and Sudan**, under different economic projections. Specifically, the strong energy dependency of the economic activities of these countries and the **underdeveloped energy infrastructure** within the area make the planning of future capacity expansion a crucial task for ensuring a better understanding of the **impact of the investment decisions and energy policies**.



Electricity generation in Africa

Energy represents a key factor for poverty eradication and sustainable development in Africa. According to the International Energy Agency (IEA) World Energy Outlook 2024, more than 579 million people in Africa do not have **access to electricity**. Moreover, Africa's total energy supply highly depends on wastes and biomass (Figure 1) which leads to daily exposure to noxious fumes, with **adverse health and social impacts**, such as the burden of collecting fuelwood, falling heavily on women and children.

Improvements in the energy system infrastructure represent the key factor to give access to clean energy to African population along with boosting economic growth in the area. Nonetheless, the energy mix appears rather different across countries.

In **Egypt**, where there is a relatively advanced energy infrastructure, the electricity production is highly dependent on **fossil fuels** (Figure 2), with an increasing share of renewable power improving the country's energy security.

In **Ethiopia**, electricity generation relies heavily on **hydropower** (Figure 3), which provides both opportunities and threats. On the one hand, the high dependency on hydro resources decreases the energy security due to a low level of diversification. On the other hand, the chance to have low-cost electricity production gives the potential for exporting electricity to other countries in the region.

In **Sudan**, the electricity mix strongly relies on **hydro and oil power** (Figure 4), which implies a low level of diversification in the electricity generation mix.

Figure 1

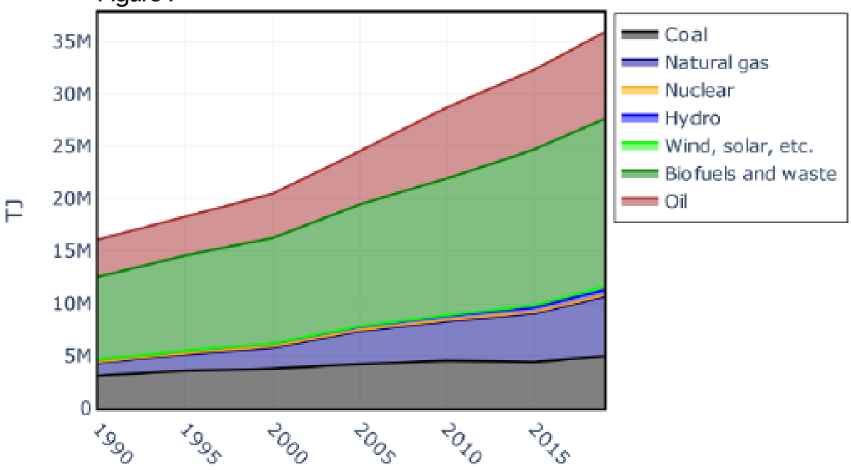


Figure 2

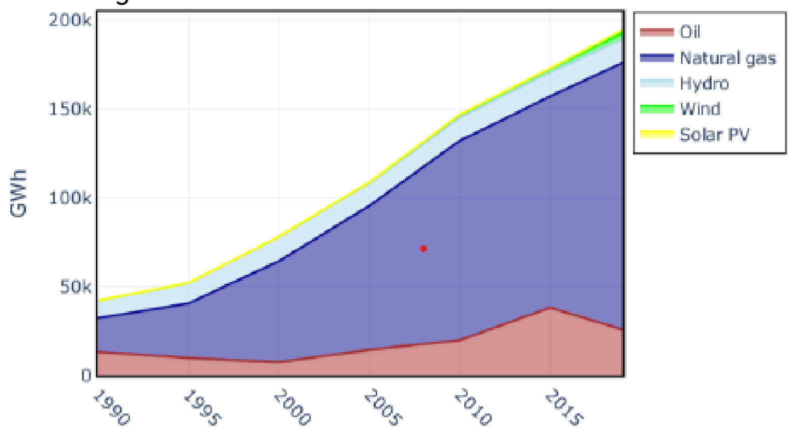


Figure 3

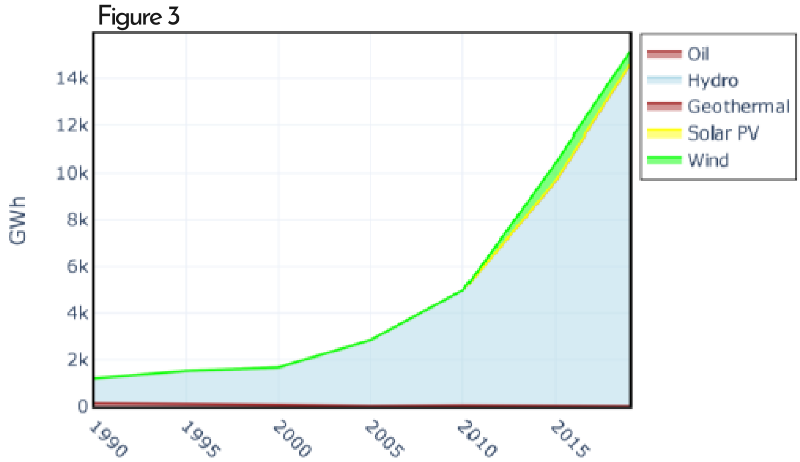
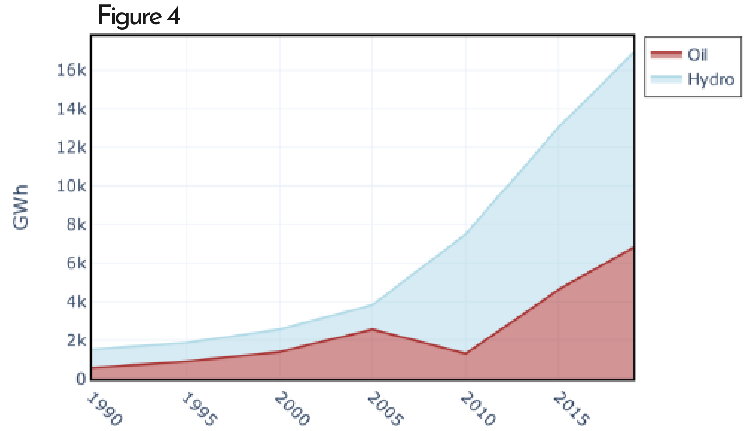


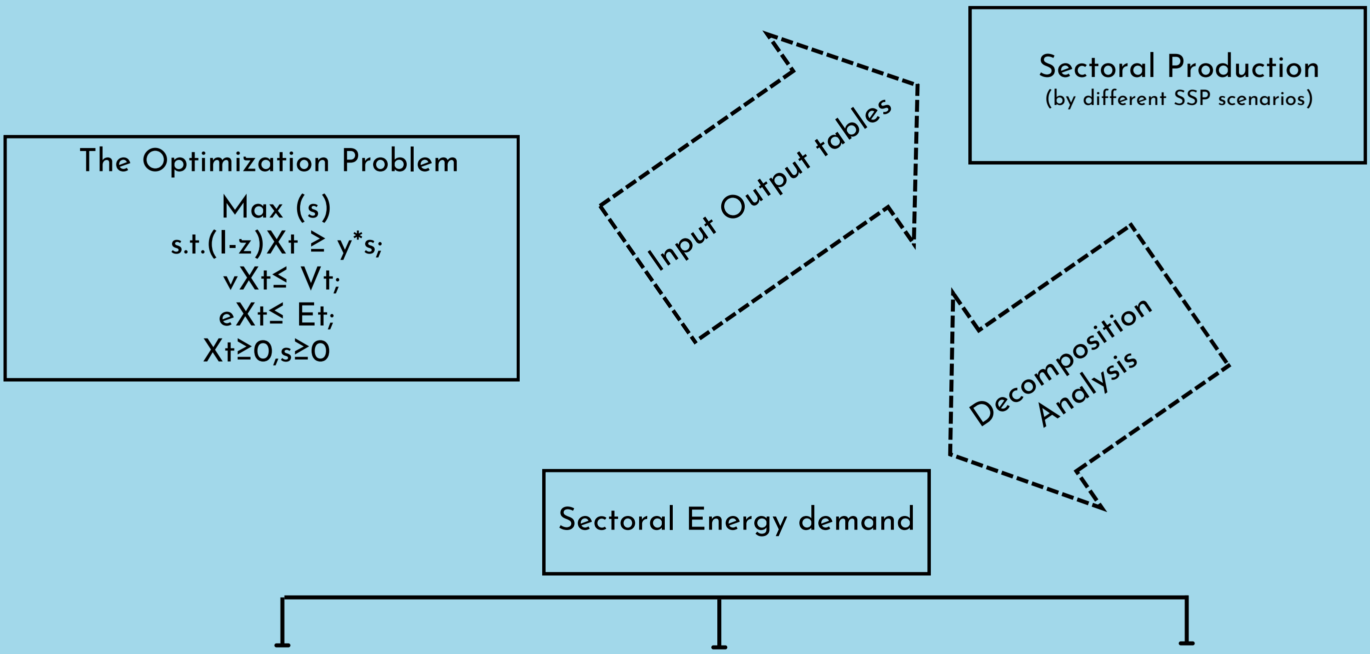
Figure 4

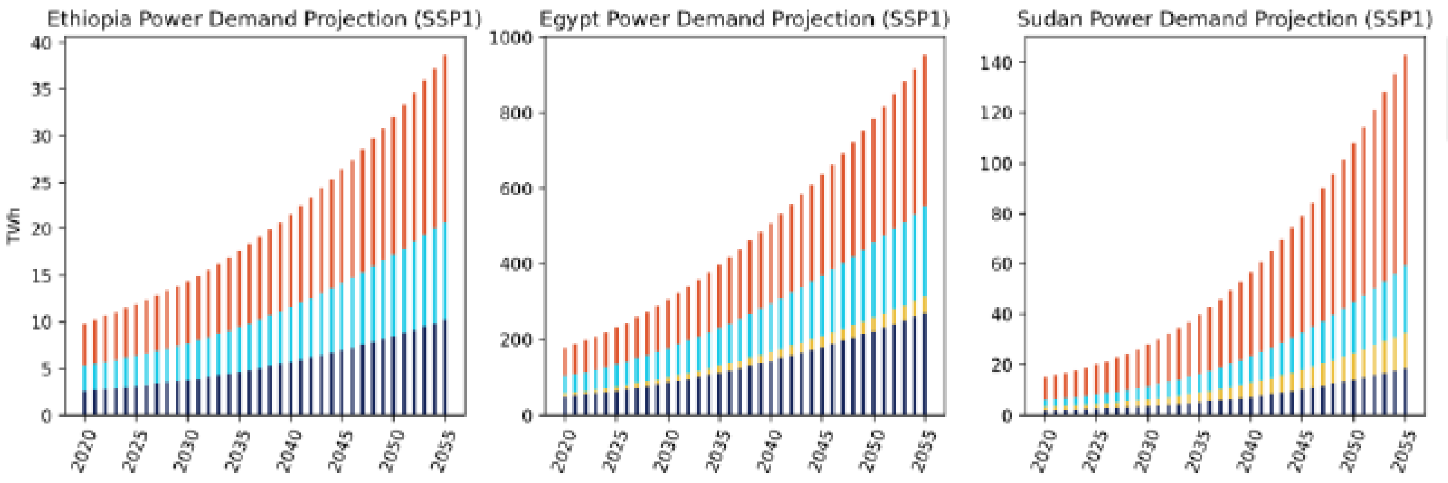


Energy Model

The need to come along with future integrations of other AWESOME partners (especially those involved in Work Package 3 and 4) and improve the quality of the interactions across the models motivated the team to choose **OSeMOSYS**, i.e. an **open-source linear cost-minimization energy-system framework for long-run energy planning**, that calculates the least-cost and technically feasible solution, given certain energy demand projections. This is done by respecting a series of **exogenous constraints on available technologies** (e.g., costs and performance parameters of different types of power plants), on **energy resources** (e.g., availability of solar radiation, and cost of different fuels), as well as on **policy constraints** on future decisions reguarding the development of the renewable energy sector. One of the main advantages of this framework is the need of less detailed data requirements required to build the energy model, which makes it our best choice for addressing the energy modelling for the African context. To be in line with other projects' modelling frameworks, the time horizon of the energy model is 2020 – 2050, and every year considers both daily and seasonally intra-day variability of energy demand and resource availability, thus providing detailed estimates.

Demand Projection





Energy Scenarios

Once we have defined the **energy demand**, which is the main driver of the model, different **scenarios** concerning both **demand projections** (according to IIASA SSPs) as well as **policy and costs alternatives** (Table 1) on the future energy situation of the three countries are analyzed. Within these scenarios, it is possible to evaluate the impact of changes in diffent parameters (e.g. the cost of renewables, the discount rate, the role of carbon tax policies) on both energy and environmental variables.

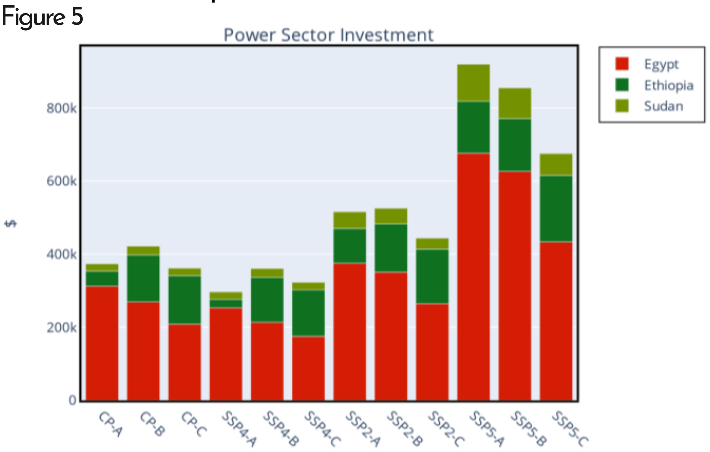
Table 1

SCENARIO	RENEWABLE COST	DISCOUNT RATE	EMISSION PENALTY	FOSSIL FUELS INVESTMENT PHASE OUT
A	25% yearly reduction until 2030	15%	30$/ton and 2.5% yearly increase till 2050	After 2040
B	50% yearly reduction until 2030	5%	40$/ton and 2.5% yearly increase till 2050	After 2035
C	70% yearly reduction until 2030	2.5%	50$/ton and 2.5% yearly increase till 2050	After 2025

Emissions and costs

Based on the availability of natural resources in the area, **Egypt** is expected to be the most **emission**-generating country, whereas the availability of hydro resources in Ethiopia and Sudan leads to a cleaner power production mix. In parallel, Egypt dominates the total **investments** required in the power sector, as it has the highest demand among the three countries (Figure5). Furthermore, as the renewables penetration increases under the assumption made in scenario C, the power generation mix is dominated by renewables to avoid emission penalties.

Figure 5



Electricity trades

The **energy trade** between the three countries will be highly impacted by the penetration of renewable energy. Indeed, pushing towards green sources will make countries with renewable power **net exporters**, while countries like Egypt, with limited access to the hydro resources, may rely highly on the **import** of electricity, as it will be the cheapest solution to meet its prospective electricity demand. In particular, the incresing import from Ethiopia will impact relevantly the energy security in Egypt, especially in scenario C, where its dependency ratio will exceed the 20% (Figure 6).

Figure 6