European University Institute

ROBERT SCHUMAN CENTRE FOR ADVANCED STUDIES

FLORENCE SCHOOL OF REGULATION CLIMATE

Synergies and Trade-offs between Energy Access, Climate Change and Water Use in Sub-Saharan Africa

Isabella Alloisio, Research Associate, FSR Energy and Climate

European University Institute

5th AIEE Energy Symposium - Current and Future Challenges to Energy Security. 16 dicembre 2020

Research Objectives

- The **Water-Energy-Food and Climate nexus** is at the centre of Agenda 2030 for Sustainable Development. (It touches directly upon SDGs 2, 6, 7, 13 … but it also interacts with SDG 9, 12, 14, 15...).
- It tackles simultaneously food and water security, the connection between global warming and water scarcity, between climate change and food production as well as energy security, and the connection between energy production and water and land use.
- The paper aims to analyse the **synergies** and **trade-offs** between **energy access, climate change and water use** in **Sub-Saharan Africa** (SSA).

Methodology

The nexus can be divided into sub-themes:

- **Water - Energy nexus**
- Food - Energy nexus
- Food - Water nexus

- **Climate Change – Energy nexus**
  - **Climate change and renewable energy**
  - **Climate change and energy access**
    - **Energy access and growth**
    - **Energy access and GHG emissions**
- **Climate Change – Water nexus**
- Climate Change – Food nexus

The research will tackle the highlighted interactions only

Methodology

The paper novel approach is represented by the analysis of the **Water-Energy-Climate Nexus under the energy access perspective,**

including not only the **impact of growing energy demand on CO2 emissions,**

but also the **impact of climate change on energy supply and water availability**

as well as the **linkage between climate policies, energy prices and affordability of energy access** in Sub-Saharan Africa.

The Water Energy and Climate Nexus

- Current climate change projections show that crucial changes in the temporal and spatial distribution of water resources and the frequency and intensity of water-related disasters rise significantly with increasing GHG emissions.

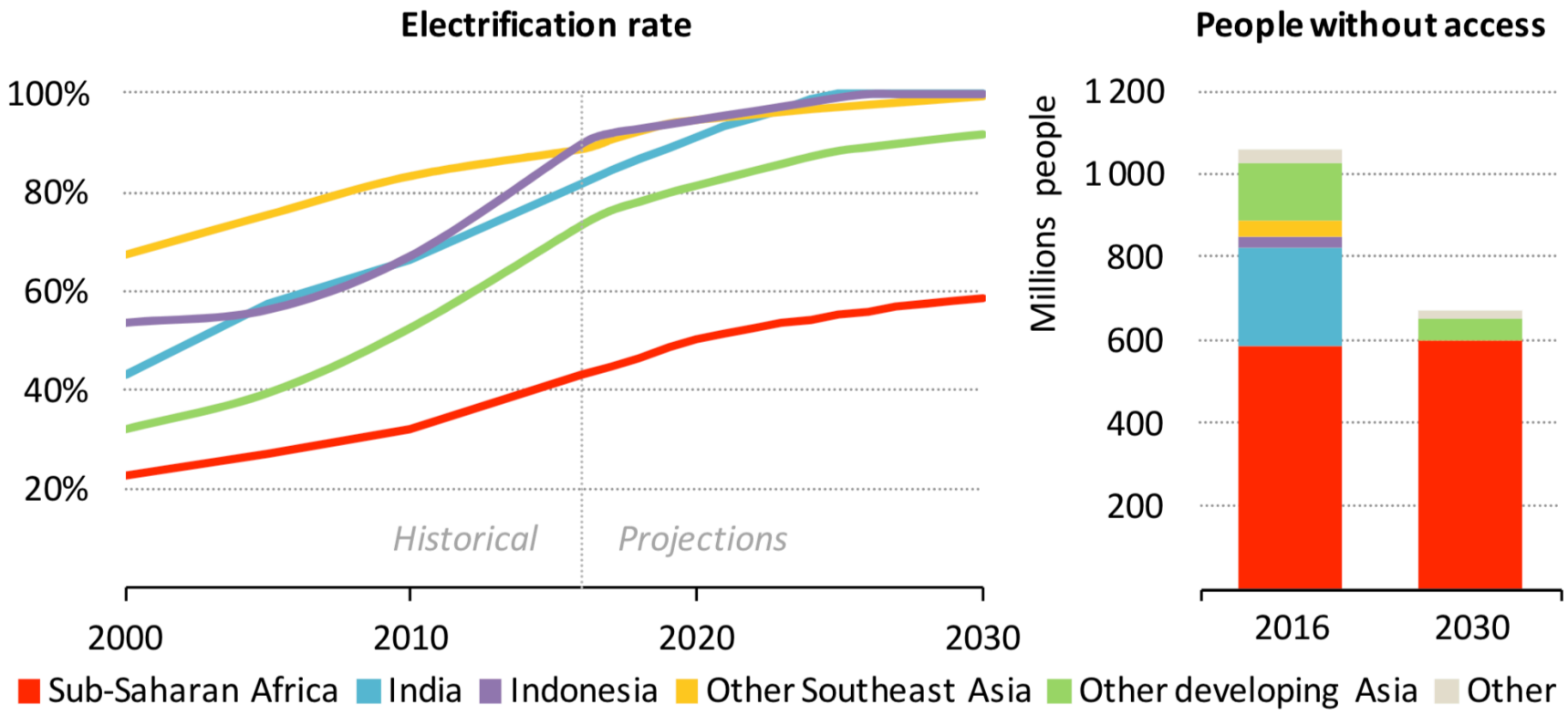
- **Climate change will have an impact on water availability,**
and on energy supply and demand.

Global Projections

Under the pressure of climate change, but also of population growth, economic development, urbanization and technological change, the demand for freshwater and energy will increase significantly over the next decades:

- Global water demand is projected to increase by 55% by 2050 (FAO 2011);
- 2 billion people will be affected by water scarcity by 2025;
- Global energy consumption is projected to grow by one third by 2050 (IEA 2013);
- Of the 674 million people still **without access to electricity** in 2030, **90% live in sub-Saharan Africa** (WEO 2017).

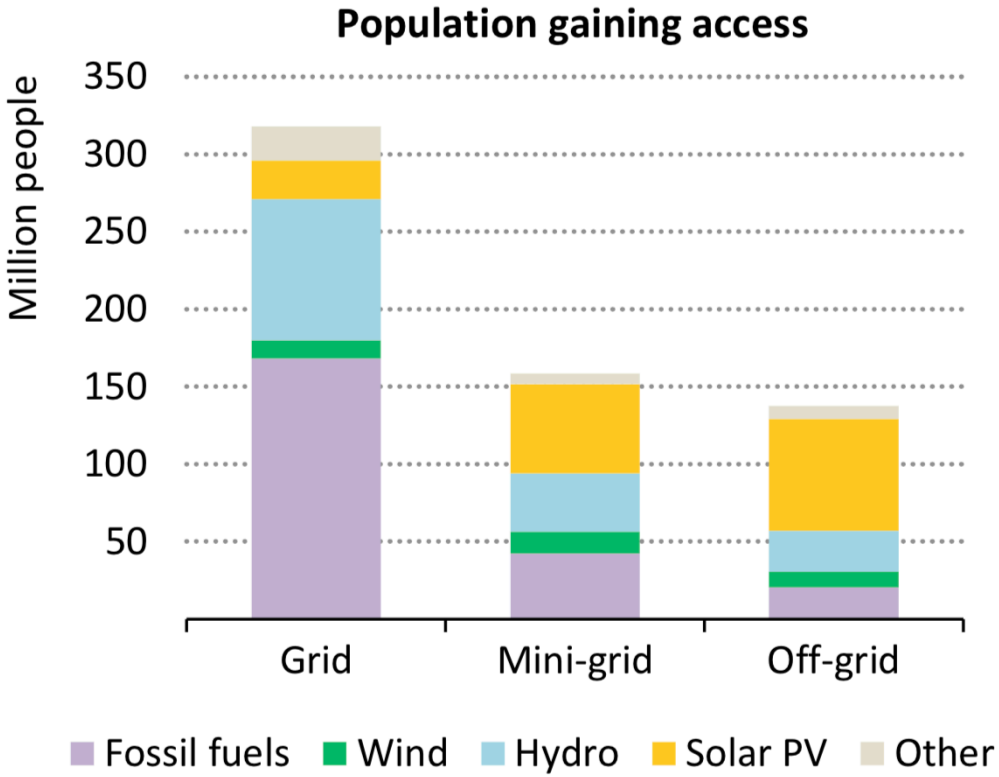
Electricity Access by region

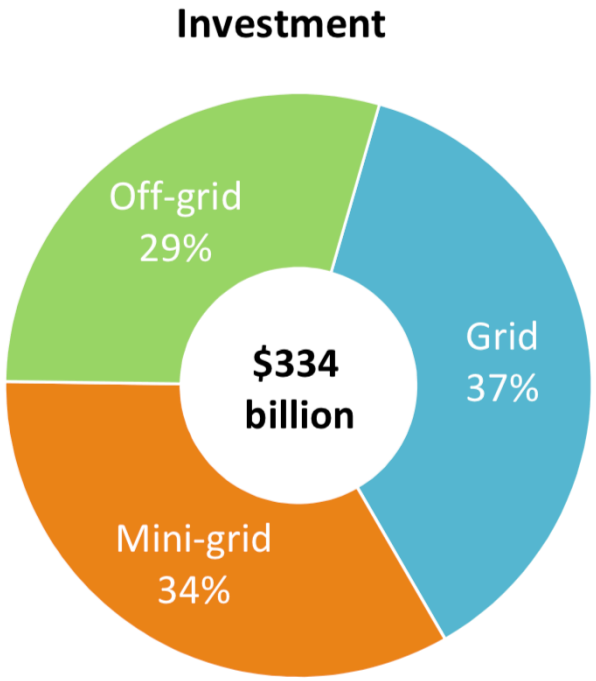


- ✓ China achieved universal electricity access in 2015.
- ✓ In India, half a billion people gained access to electricity since 2000.
- ✓ In sub-Saharan Africa, **43% of the population has access to electricity today**.
- ✓ By 2030, **nine-out-of-ten people without access will be in sub-Saharan Africa.**

Source: WEO 2017, Special Report on Energy Access, IEA

IEA New Policies Scenario, 2017-2030





- ✓ **Half of those who gain access by 2030 do so via a centralized grid.**
- ✓ More than 60% of those who gain access by 2030 do so **through RES**, mostly **solar** and **hydro**.
- ✓ **In rural areas of sub-Saharan Africa,** by 2030, **off-grid and mini-grid systems** generate the majority of the electricity used.

(Other includes nuclear, bioenergy, geothermal, concentrating solar power and marine)

Source: IEA-WEO 2017; KTH Royal Institute of Technology (KTH-dESA).

The Water-Energy Nexus (1/2)

Water and energy are closely interlinked and are interdependent.

- **Energy** is required for the extraction, treatment and distribution of water.
- **Water** is needed to produce, transport and use **nearly** all forms of energy.

✓ But, **unlike water, the energy sector can switch to other resources**, e.g., solar and wind energy

The Water-Energy Nexus (2/2)

- Intermittent RES, such as **wind and solar (PV)**, have a negligeable use of water.
- **Hydropower, Concentrated Solar Power, and biofuels** have a very high water footprint.
- **Geothermal energy** power plants have lower water footprint.
- **Thermal power plants** use large quantities of water for cooling. **Carbon Capture and Sequestration** (CCS) systems will have negative effects on water consumption, requiring additional water for cooling.
- **Shale oil and gas** extraction and production are more water intensive than conventional oil and gas.
- When **CCS is associated to bioenergy** (BECCS) it has important drawbacks in terms of higher water (and land) use.

Climate Change and Energy Nexus (1/3)

- Climate change has an impact on both **energy demand and supply**, as well as on the **reliability of the energy system** as a whole.
- On the **demand side**, rising temperatures change the balance of heating and cooling demand patterns.
- On the **supply side**, impacts include changes to the averages and variability of solar, wind and hydropower resources.
- The paper focuses on the climate impacts on the **supply side** and attempts to suggest the most resilient energy production systems for Sub-Saharan Africa.

Climate Change and Energy Nexus (2/3)

- **Hydropower** is vulnerable to climate change and impacts are globally unevenly distributed: mainly local impacts.
- In the Southern hemisphere decrease in rainfall is expected to cause a reduced hydropower production, as it is the case in **Southern and West Africa** (IPCC, 2018).
- **Eastern Africa** will experience risks of flooding leading to likely damages to hydropower dams (such as in Kenya).
- Climate change has a relevant impact on intermittent **wind and solar energy**.
- **Geothermal** energy is less dependent on climate conditions, and climate change is not expected to have a significant impact on its resource potential.

Climate Change and Energy Nexus (3/3)

- Projections of climate change impacts on water resources in SSA are associated with large uncertainties.
- The most affected SSA countries will be those where hydropower accounts for **90% or more of electricity generation**, such as Burundi, Central African Republic, DR Congo, Lesotho, Malawi, Namibia, Swaziland, and Zambia (Mekonnen et al., 2015).

1st Tradeoff: Climate Change and Energy Access

➢ **Decoupling GHG emissions and growth**

Reducing overall emissions while keeping a high pace of economic development is at the heart of sustainable development.

➢ **Energy access and GHG mitigation: a contradictory picture**

- **IEA** (2013) estimates that achieving access by 2030 would increase electricity consumption by 2.5%, and fossil fuels use by 0.8% (based on basic level of electricity use).
- **Chakravarty and Tavoni** (2013) assess a global final energy consumption increase of about 7% by 2030 (encompassing both basic & productive use), and bulk in Africa where final energy consumption need to double wrt a scenario without energy poverty policy.
- **Pachauri *et al*.** (2013) estimate that to achieve total rural electrification by 2030 will increase emissions by about 2 - 4%.

1st Tradeoff: Sub-Saharan Africa

- The share of SSA in global electricity-related emissions is projected to be very small (**0.7% in 2030**) compared to global emissions.
- This is due to a **decrease in carbon intensity** in **western and central Africa** thanks to:
  - ✓ Fuel switch
  - ✓ Use of more efficient coal and gas-power plants
- However, this is offset by a **growing use of coal** in **southern Africa.**
- Access to electricity has some other **co-benefits**: switching from kerosene to electric lighting reduce black carbon emissions.
- In SSA, climate mitigation policies could offset the projected GHG increase due to efficiency improvements and a shift to RES.

2nd Tradeoff: Climate Change and Energy Prices

- Climate mitigation policies can negatively impact energy access by **increasing energy prices.**
- This has a higher impact on **energy poors** in developing countries.
- In SSA, the highest increase in energy prices happens in those regions with large share of fossil fuels in their electricity mix.

2nd Tradeoff: Sub-Saharan Africa

- ✓ Energy price increase by 40% in **southern Africa** by 2030 (due to dependency on natural gas in Angola, Mozambique and Tanzania. South Africa is dependent on coal).
- ✓ Price increase by 35% in **western and central Africa** by 2030 (natural gas and hydro).
- ✓ **Eastern Africa** has the lowest price increase (25% by 2030) due to the largest share of RES (geothermal, hydro and wind energy).

Results and Conclusions

- Providing universal access in SSA is expected to have a **negligible impact on global CO2 emissions.**
- Climate mitigation policies could offset this increase by:
  - A **shift to renewable energies**, especially solar PV, wind and geothermal, would allow for a more sustainable and resilient energy supply, affordable energy access and a more efficient water use.
  - A coherent **carbon pricing policies** and consistent low carbon energy investments would allow SSA countries to meet their climate targets, to cope with climate change impacts, and to fill their energy access gap.

Concrete Solutions to WEF-C nexus challenges

- Enhancing **off-grid systems** (e.g., **mini-grids** based on hydro, solar, and wind) in remote and low-density settlements (the so-called “last-mile” challenge).
- Shifting from fossil fuels to renewable energy, e.g., using **photovoltaic for water desalination or to produce hydrogen.**
- Using **seawater electrolysis** could reduce freshwater use and be more energy efficient.
- Reducing freshwater demand in energy production by using marginal water, e.g., **brackish water**.
- Developing **multi-use reservoirs** to increase the total water use efficiency of hydropower as compared to traditional dams for power generation only.
- Climate change challenge can provide opportunities for overcoming technological lock-in and promoting the use of RES in SSA.

European University Institute

ROBERT SCHUMAN CENTRE FOR ADVANCED STUDIES

FLORENCE SCHOOL OF REGULATION CLIMATE

Thank you for your attention

Isabella.Alloisio@eui.eu