Sure As The Wind Blows

Gauging off-grid suitability for wind power in Ethiopia

Electricity Access in Ethiopia

Energy services play a pivotal role in the socioeconomic and industrial development of every nation, and the development of energy generation and distribution provides a great opportunity for synergy within a sustainable development agenda far beyond fulfilling the goals of SDG 7. This connection has led many nations, including Ethiopia, to create policy reflecting goals of carbon neutrality and universal electrification. Ethiopia currently has an electricity access rate of 45%; 34% percent of the population has access to the centralized grid, while 11% of its population already have access through decentralized solutions. However, rural and urban access to the grid differ drastically, with urban grid access between 80 and 90 percent, while rural grid access ranges from five percent to 20 percent. In addition to overall low electricity access rates, the grid electricity can also be unreliable, with the majority of grid-connected customers experiencing between four and 14 power outages a week. This presents the opportunity for both off-grid and on-grid possibilities for energy generation, distribution, and ultimately, access to sustainable solutions.

Wind power, along with solar photovoltaic arrays and hydropower, are an important component of Ethiopian's off-grid renewable energy portfolio moving forward. Addressing the intermittency issues of renewable energy, wind power is a good complement to hydropower in that the dry season is also the windy season in Ethiopia. The goal of this project is to determine the optimal areas for off-grid wind electricity potential in Ethiopia.

Spatial Questions Considered

Where is grid-connected electricity available in Ethiopia?

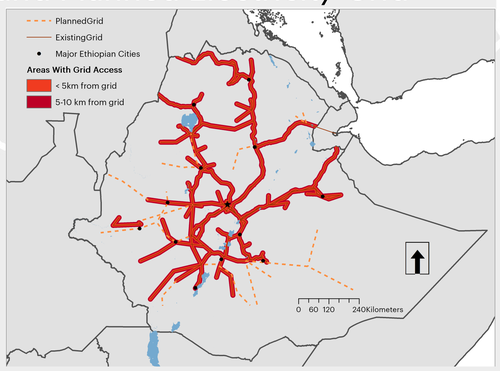
What is the population density across Ethiopia that resides outside of grid connectivity?

Within off-grid wind power zones, which zones have the highest potential for wind power generation and transmission?

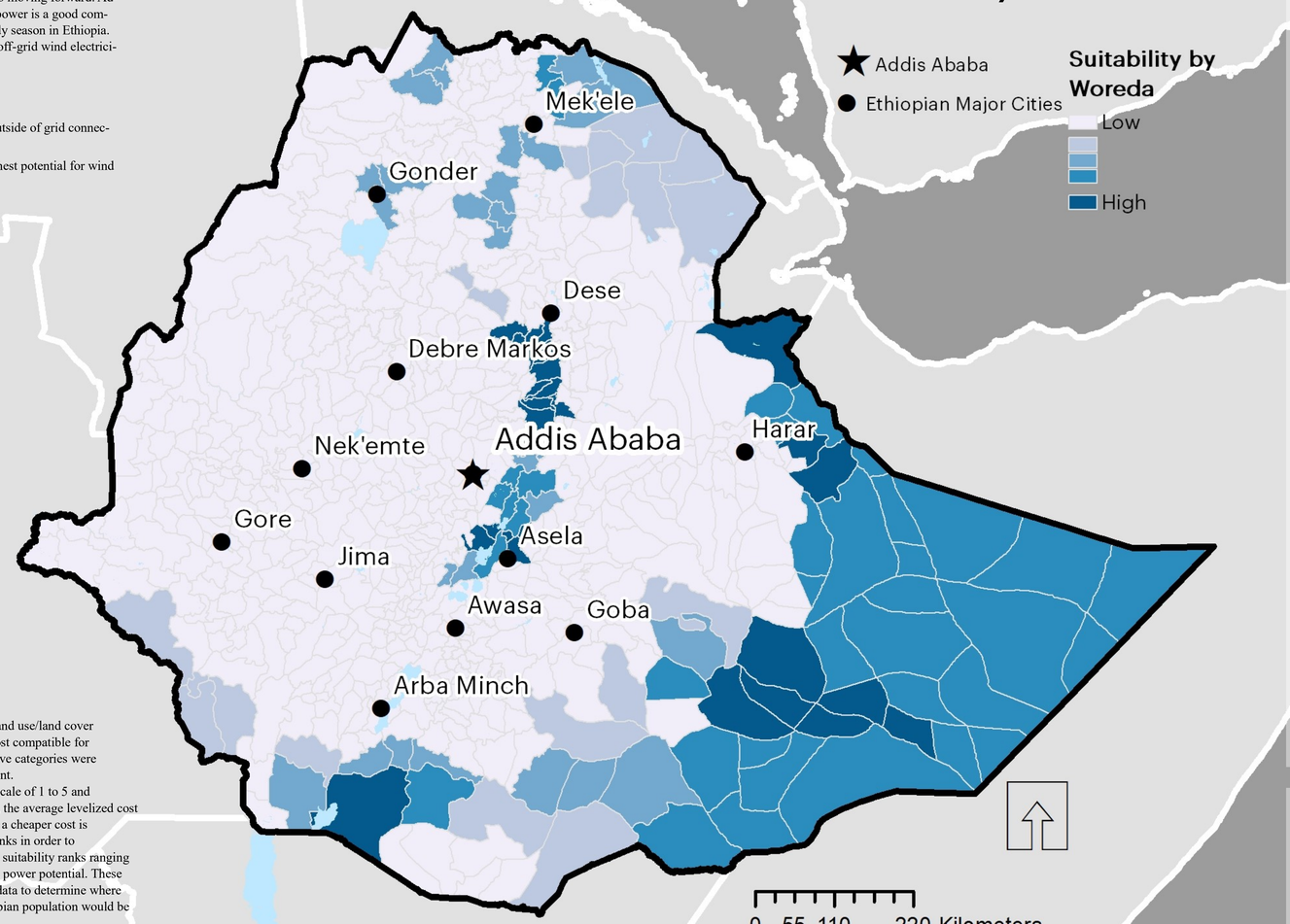
Ethiopia's Existing and Planned Electricity Grid

Distance from Grid	Number of Woredas	Population
0—5km	2	720,619
5— 10km	79	18,844,072
10km or more	608	91,936,970

Approximately 91, million, or 79% of Ethiopians live more than 10km from the centralized grid and would require decentralized grid solutions.



Off-Grid Wind Power Potential by Woreda



Results and Analysis

This analysis allows for a closer look at the regions most suited for off-grid wind power development compared to the original study completed by IRENA and the Lawrence Berkeley National Laboratory. This is needed information, as resources are limited for off-grid energy development, and policy decision-makers within the domestic and international space need to allocate said resources with the greatest efficiency. is increasingly important to support renewable energy development in locations where it will be most productive so that infrastructure can prevent non-renewable technological lock-in and promote regional energy systems in a more structural way instead of on a project by project basis. This analysis shows that the opportunities for off-grid wind potential are greatest in the eastern and southwestern regions of the country, where populations are farthest from the centralized grid. These woredas should be prioritized for new off-grid wind power development projects, as the top two ranks have approximately 9.5 million people in total, almost 9% of the Ethiopian population.

In order to build upon this analysis and determine the most suitable zones for a portfolio of renewable energy development, a similar set of questions could be asked for off-grid solar development within Ethiopia. This analysis will also shift in the future as Ethiopia develops more extensive infrastructure through their planned extensions to the current grid. Limitations to this analysis include the lack of data on the quality of electrification guaranteed, since there are multiple tiers to energy access. Being connected to the grid or even securing off-grid solutions does not guarantee reliability, capacity, or affordability, and this guarantee is especially questionable when it comes to rural connections. Reliability refers to the number of blackout days, capacity refers to the services (charging a phone vs. running an air conditioner) that can be completed with the connection, and affordability refers to the capability of services to be financially accessible to the population. These dimensions should be further investigated, as there is a tension between access to grid or off-grid solutions and access to the needed energy services.

Methods

Using the Euclidean Distance tool to determine the population that resides outside of grid connectivity, each distance increment from the grid was analyzed in terms of woreda population. Woredas are Ethiopia's smallest administrative unit and there are 690 in total.

IRENA and the Lawrence Berkeley National Laboratory determined the zones outside the grid-connected areas that are most suitable for renewable energy development. Within these zones, I aimed to find the highest suitability within these renewable energy zones, where they are located, and how much of the population would be impacted by wind power generation and transmission within these zones.

To determine the zones with greatest wind power potential, this project involved analyzing five categories of data: average levelized cost of electricity (in USD/MWh, using the Class II turbine), installed potential capacity (in MW, assuming a 90% and 75% land use discount factor), distance to nearest transmission line (in km), mean human footprint metric (0 – least human impact; 100 – most human impact), and a land use/land cover metric (mean score for land use/land cover categories in the zone, ranging from 1 to 5, with 1 being most compatible for energy development and 5 being least compatible). These five categories were weighted as the most significant for wind power development.

Using the Field Calculator, each category was ranked on a scale of 1 to 5 and represent the high and low suitability ranking. For example, the average levelized cost of electricity ranged from $52.9/MWh to $129/MWh, since a cheaper cost is preferable. This data was then aggregated into composite ranks in order to determine overall off-grid wind power suitability, with total suitability ranks ranging from 7 to 22, with 22 representing the highest off-grid wind power potential. These ranks were then rendered alongside the woreda population data to determine where wind power potential is highest and how much of the Ethiopian population would be affected by this development.

Cartographer: Emelia Williams
Projection: WGS 1984, UTM Zone 37N
Source: IRENA, Lawrence Berkeley National Laboratory, ESRI DataMaps 2018, The World Bank, OCHA Ethiopia, WorldPop
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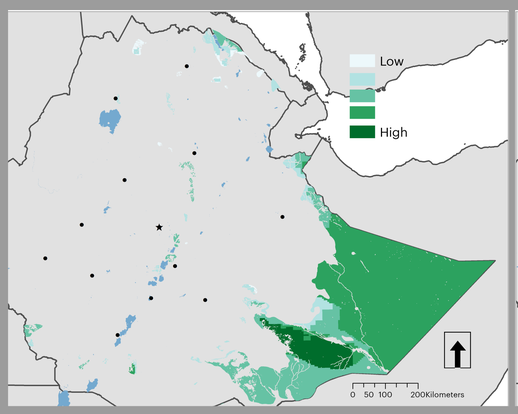
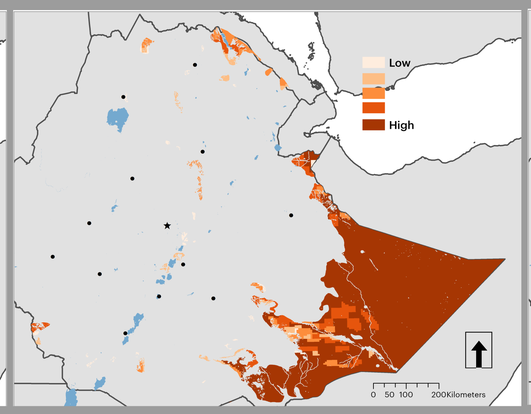
The Fletcher School
Tufts University

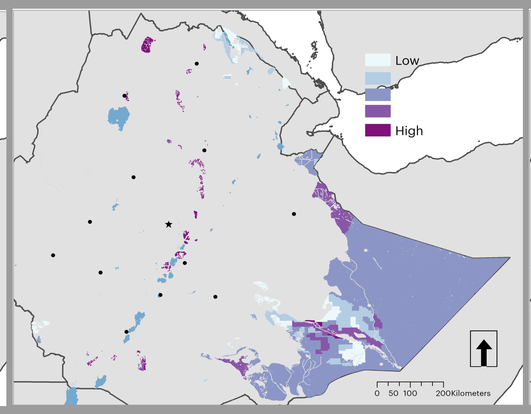
Off-Grid Wind Power Suitability Indicators



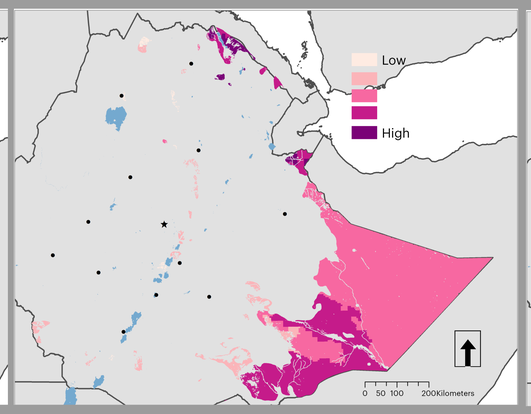
Levelized Cost of Energy Rank



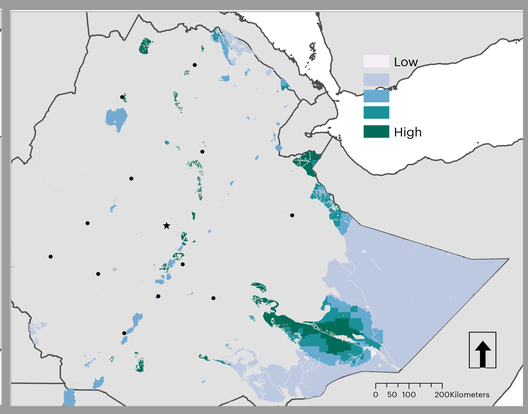
Installed Capacity Rank



Human Footprint Rank



Land Use Land Cover Rank



Distance to Transmission Rank