

The Growth of Decentralized Power Systems in the Developing World: *Physics, Governance and Markets*

Robert Stoner

Deputy Director for Science and Technology, MIT Energy Initiative

Founding Director, MIT Tata Center for Technology and Design

Co-Director, MIT Universal Energy Access Lab

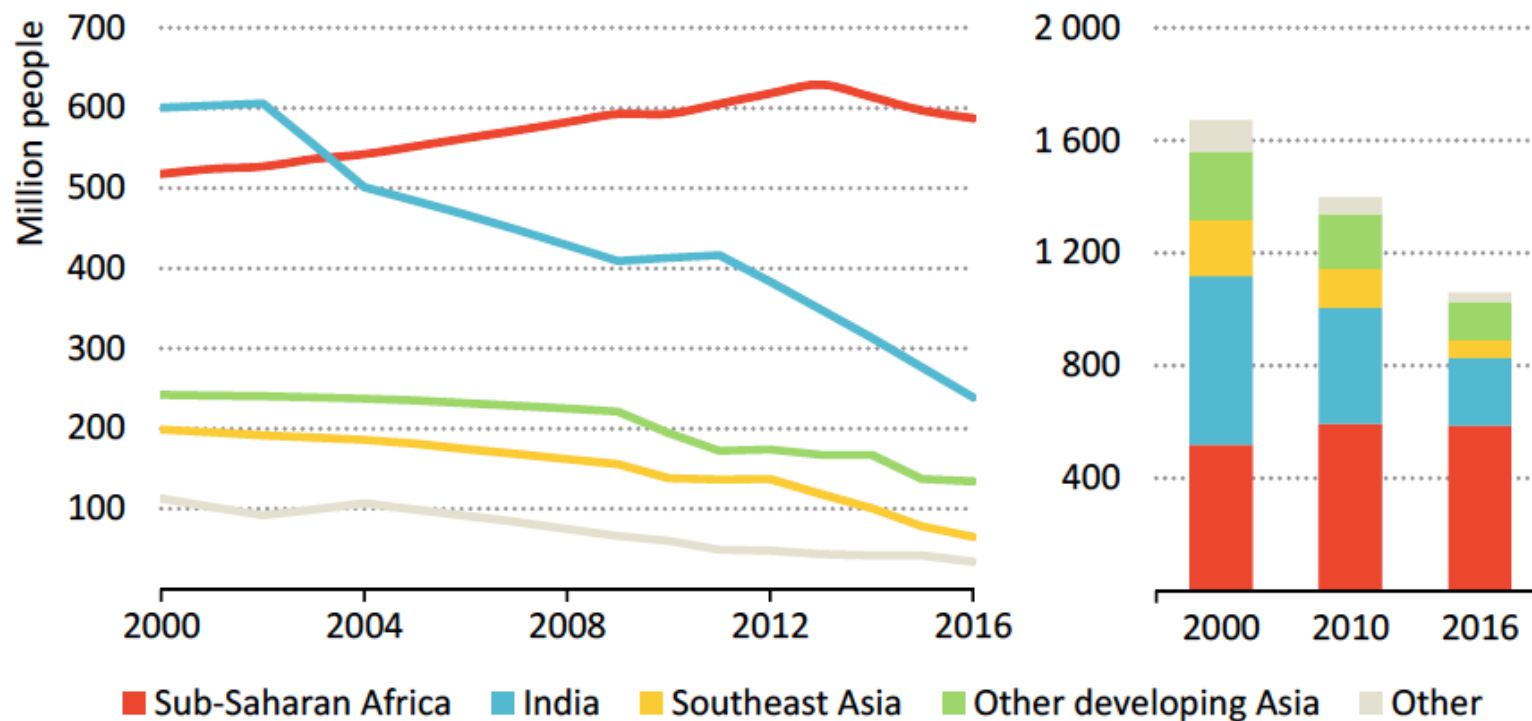
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The Developing World Advances Toward Universal Access, but sub-Saharan Africa hits a Rural Wall.

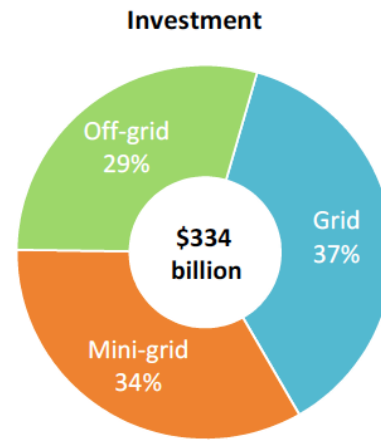
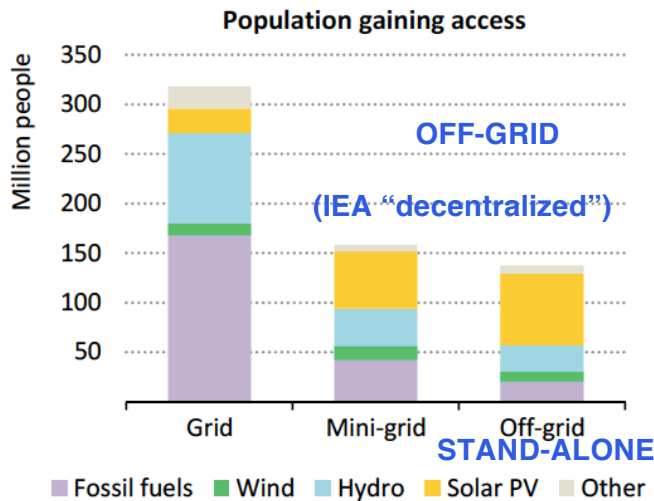
Having “access” means having the ability to procure a reliable, affordable, sufficient and expandable supply. 1.1B people lacked access in 2016 (IEA)



Source: IEA WEO 2017 Special Report – Energy Access Outlook

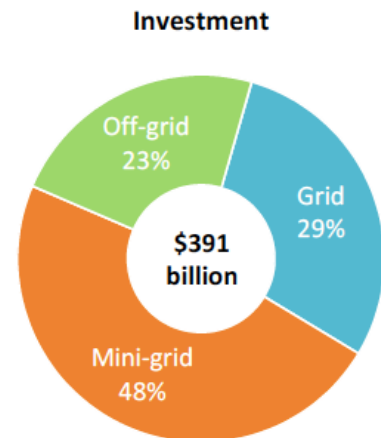
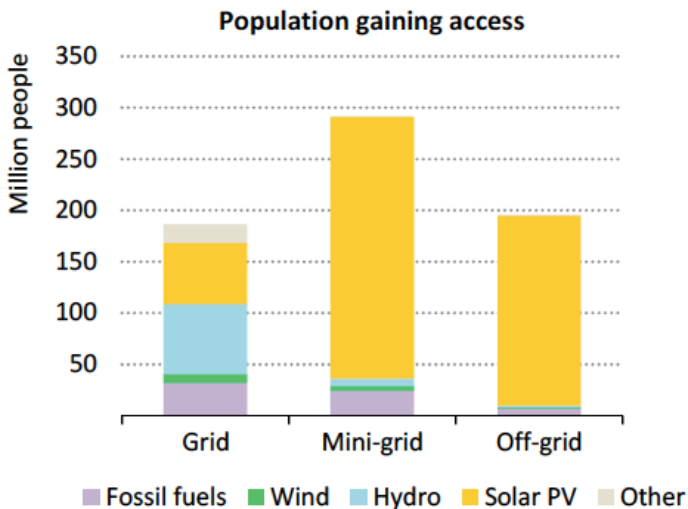
Under IEA’s New Policy Scenario 0.675B lack access by 2030, almost entirely in SSA, now at 43%. 99% of connections in India, and 97% overall since 2000 have been via grid extension.

IEA's projected new connections 2017-2030



New Policies scenario

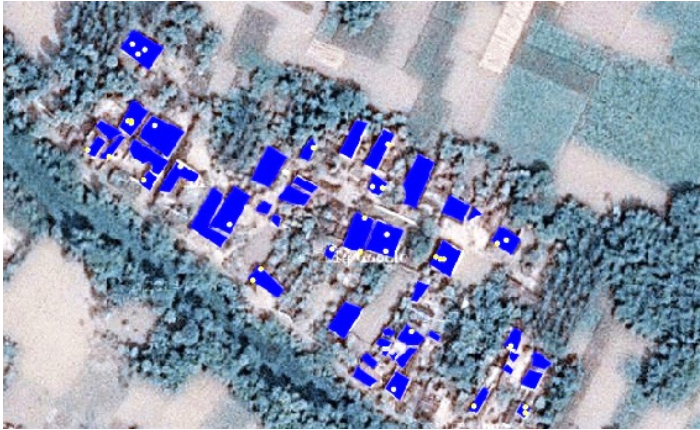
Increased solar and increased “mini-grids” and “off-grid” systems results from investment consistent with stated government policy.



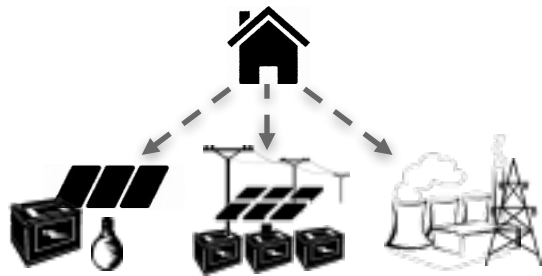
Energy for All relative to New Policies scenario

Large amount of solar results almost entirely from electrifying remaining remote rural areas in Africa.

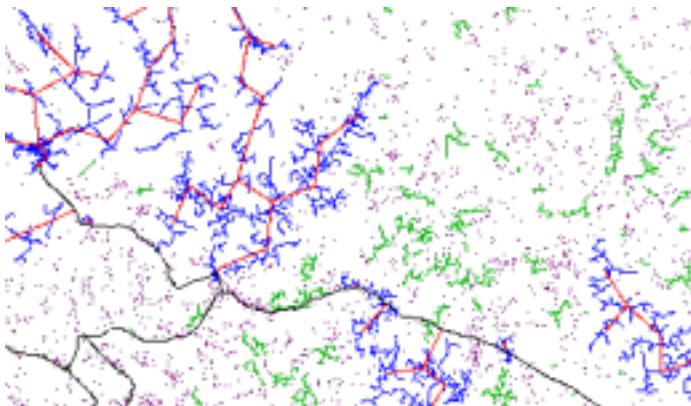
The Reference Electrification Model (REM)



1. Identification of customers and associated characteristics

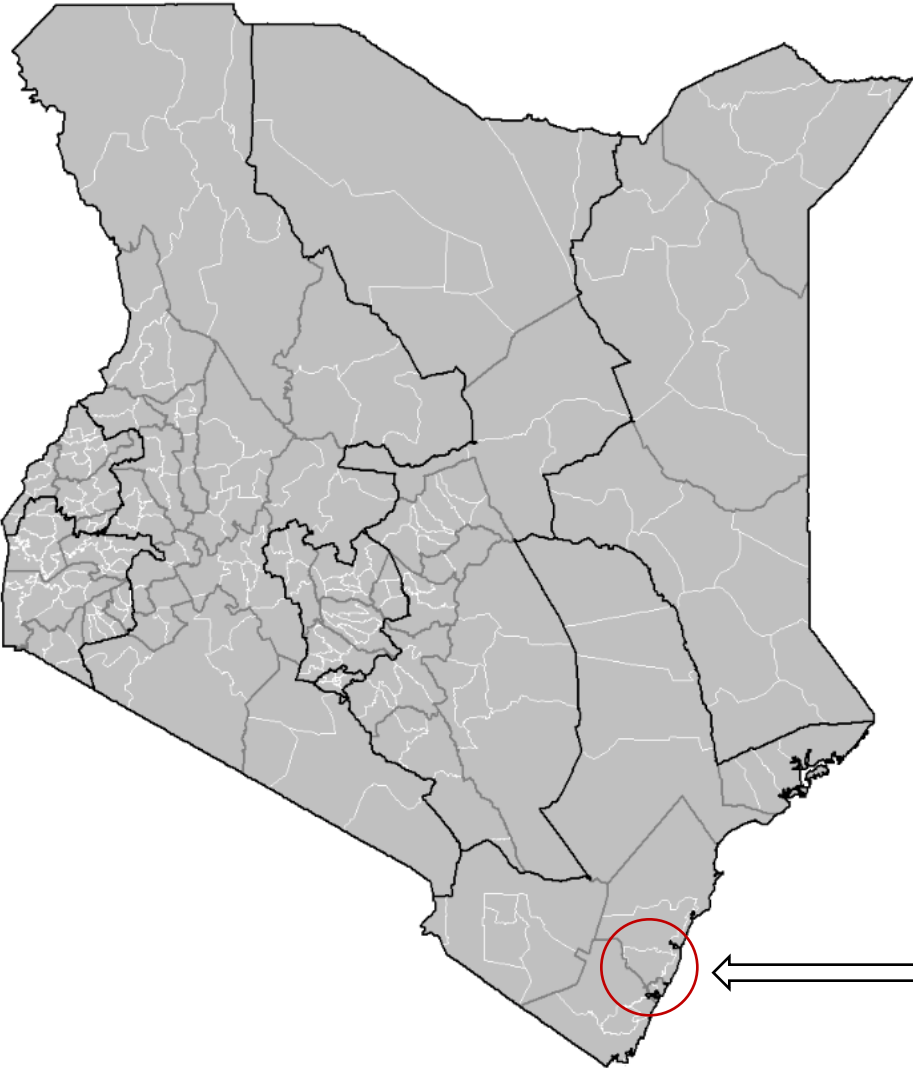


2. Clustering of customers and selection of technology



3. Network and generation design

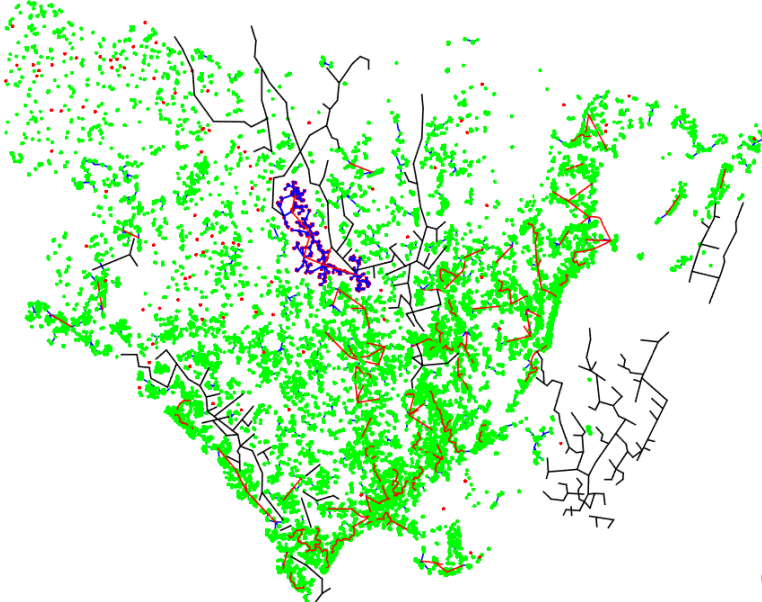
Kaloleni district *(Kilifi County, Kenya)*



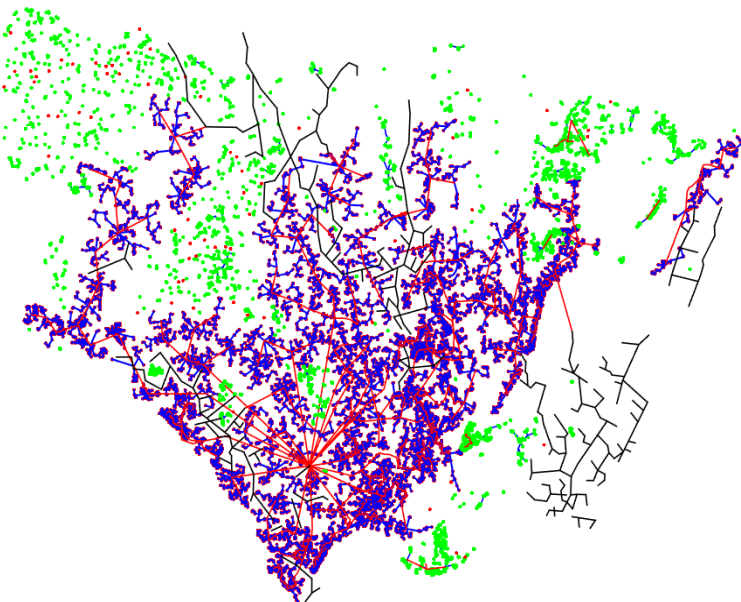
42,755 unelectrified households in Kaloleni

Sensitivity to grid reliability

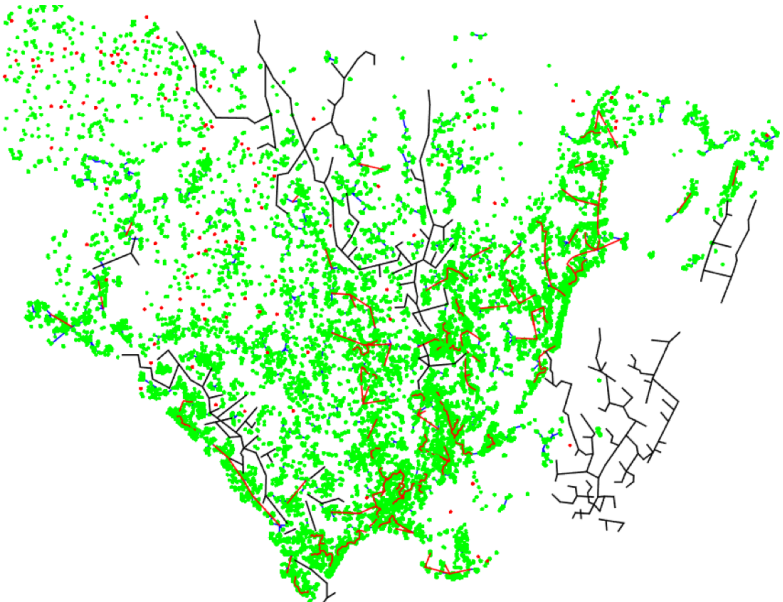
Grid reliability = 93.75%



Grid reliability = 100%

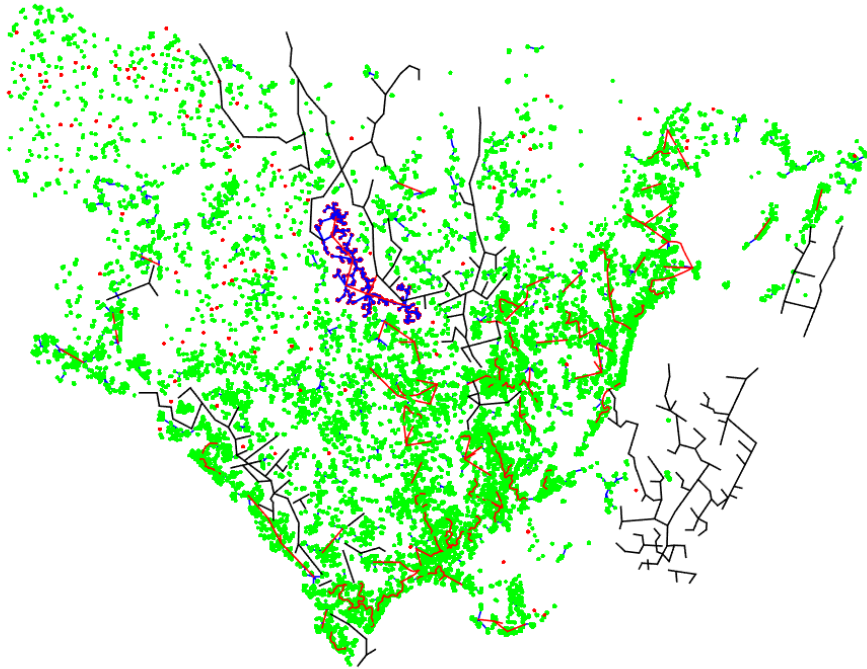


Grid reliability = 50%

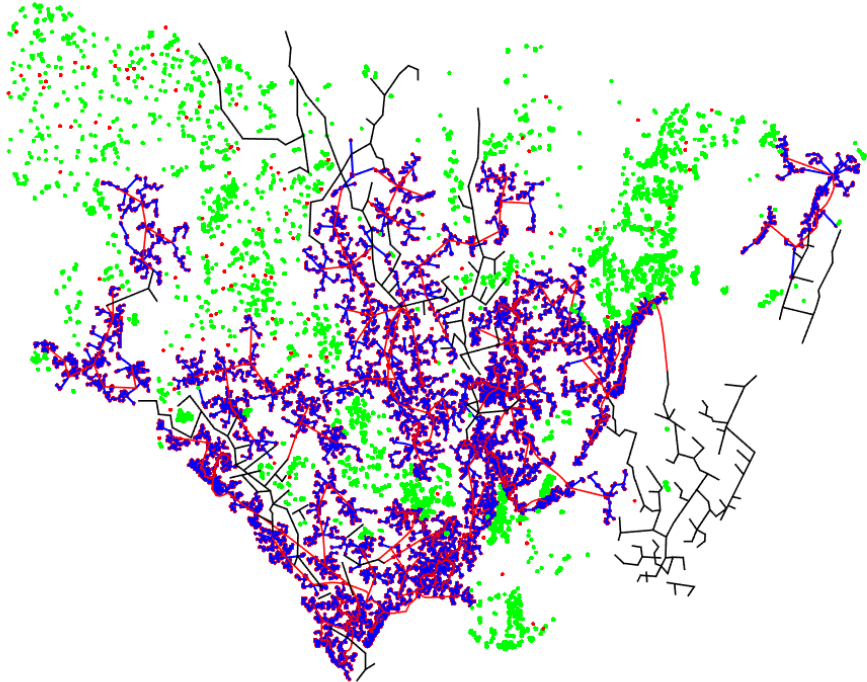


● SAS ● Microgrid ● Grid extension — Existing 11kV — New 11kV — New 415V

Sensitivity to diesel price (at 93.75% reliability)



Diesel price = \$1/liter



Diesel price = \$2/liter