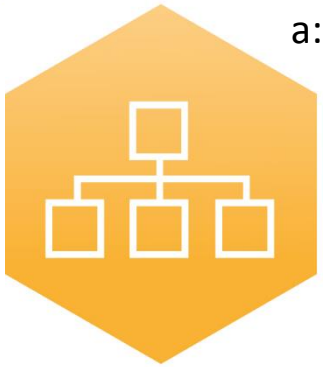
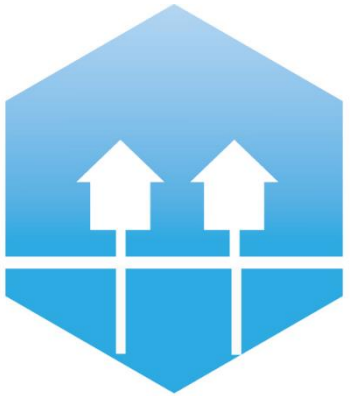
4th International Conference on Smart Energy Systems and 4th Generation District Heating
Aalborg, 13-14 November 2018

Towards Global Spatial Modelling for Identifying Opportunities for Local Smart Energy Systems

Bernd Möller[ab]
Tabitha Karanja[a]
Mominul Hasan[a]
Eva Wiechers[a]
Mary Asare-Addo[a]

a: Centre for Sustainable Energy Systems, Europa-Universität Flensburg, Germany
b: Department of Development and Planning, Aalborg University, Denmark





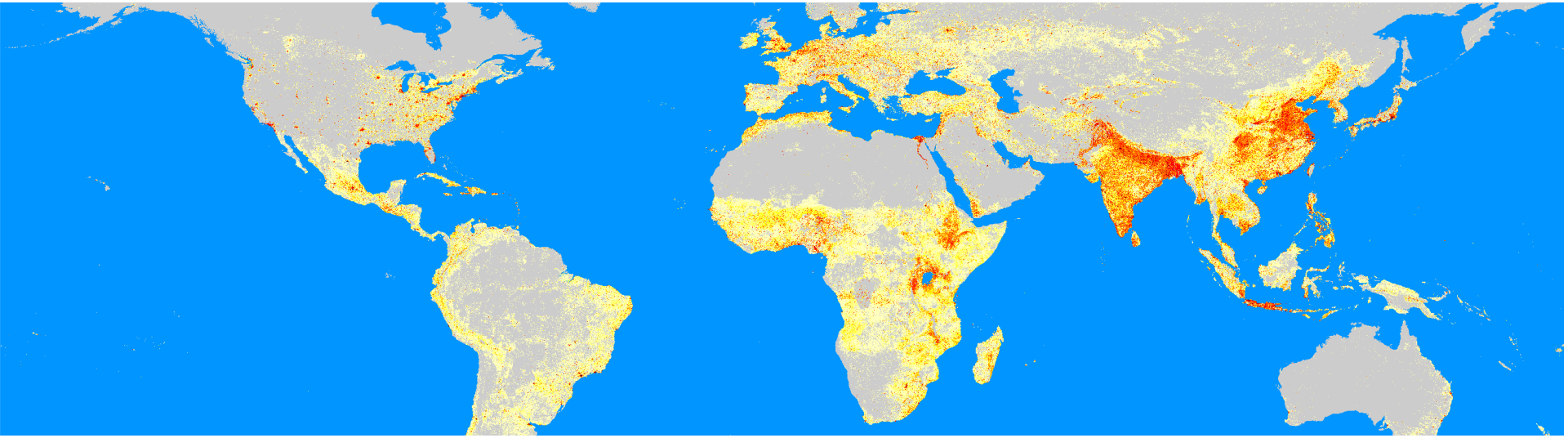
Europa-Universität Flensburg

AALBORG UNIVERSITY
DENMARK

4th International Conference on Smart Energy Systems and 4th Generation District Heating 2018
#SES4DH2018

4DH
4th Generation District Heating Technologies and Systems

World Population and Energy



1.3 B people without electricity access, mostly in sub-Saharan Africa
2.7 B people who use traditional fuels for cooking
0.7 B people live in extreme poverty now, even fewer in the future
+ 2 B more people in Africa and Asia until 2050
4-6 B people may be elevated from low to medium-income levels
2.5 B new city dwellers until 2050
~ 6 B people live in areas with plenty of solar energy

Map data: LandScan 2016, ORNL. Bright EA, Rose AN, Urban ML, McKee JJ, 2017

Major Global Energy Challenges

Transformation towards smart energy systems

Energy efficiency and renewable energy in all sectors and on all levels: demand, infrastructures, supply

Global Sustainable Development Goal #7

Universal access to modern and affordable energy supply in rural and urban areas worldwide

Accelerated Urbanisation and unplanned growth

Urbanisation may comprise the greatest challenge and the biggest opportunity for smart energy systems

Research Drivers

Current energy modelling heavily relies on available statistics, but these have two major problems:

Problem 1: They are historic, empirical and of limited value for assessing future energy systems and disruptive change

Problem 2: They usually contain national, aggregated data, which is of little value to assess local energy systems

Common solution: spatially disaggregate energy data to allow for modelling of local demands, infrastructures and supplies!

Research Agenda

Define localities of local energy systems worldwide

Prospective supply areas for heating, cooling, electricity

Model demand (current and unmet)

Suppressed demand (energy poverty) is one of the major barriers in achieving SDG#7

Map current and potential infrastructures

Access to technologies such as district heating, minigrids etc.

Quantify renewable energy sources

Spatially explicit cost-supply relationships of wind, solar etc.

Localities of Energy Systems Worldwide

Each energy system is connected to a location, by means of demand, energy infrastructures and renewable energy sources

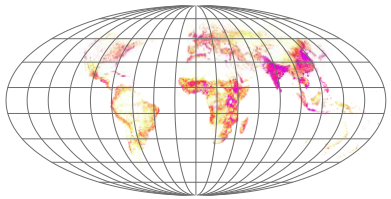
Contrary to fossil energy systems, Smart Energy Systems will be much more geographically defined

In modelling, the challenge is to allow for a sufficient reduction of complexity when mapping energy systems

The result is a geographical delineation of areas, which form the basis for the quantification and localisation of smart energy systems.

PETA
Pan European Thermal Atlas

From „Peta“ to „PEEA“



Pan-European Thermal Atlas

- Heating and Cooling demands
- Delineate Prospective Supply Districts as local heat markets
- Recommended district heating based on resource-economic information
- Suggest local supply based on available heat resources

Planet Earth Energy Atlas*

- Current and suppressed energy demands
- Model required energy infrastructures by supply areas
- Provide access to supply infrastructure on the basis of development costs
- Suggest local supply based on local renewable energy

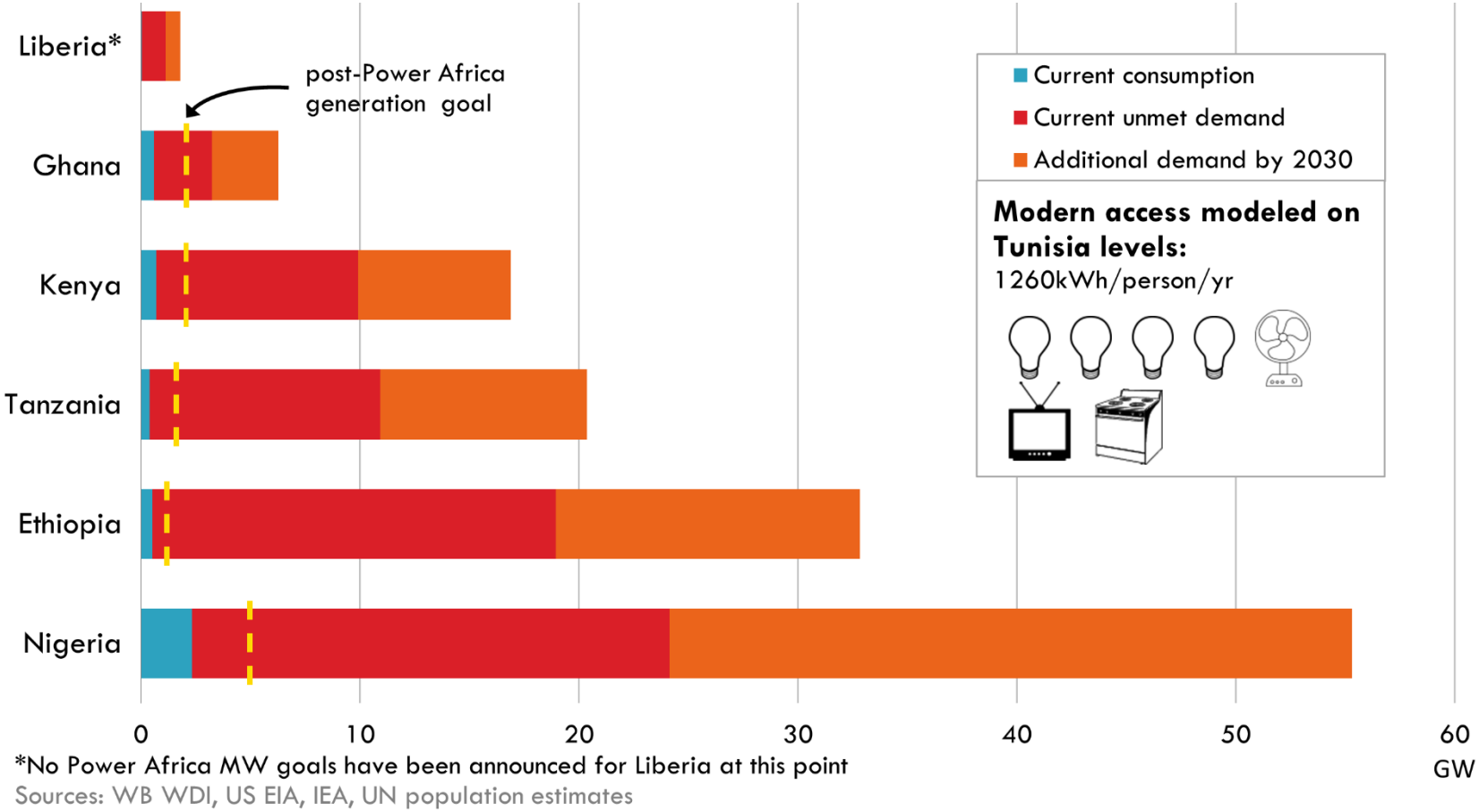
AALBORG UNIVERSITY
DENMARK

Europa-Universität
Flensburg

*Any suggestion for a better name is welcome (speak to you at dinner)!

Current and Unmet Energy Demands

In Africa, less than 20% of electricity demand is met!



Source: Todd Moss, thebreakthrough.org (2014)

ESMAPs Multi-Tier Framework as a Basis for Assessing Suppressed Demand

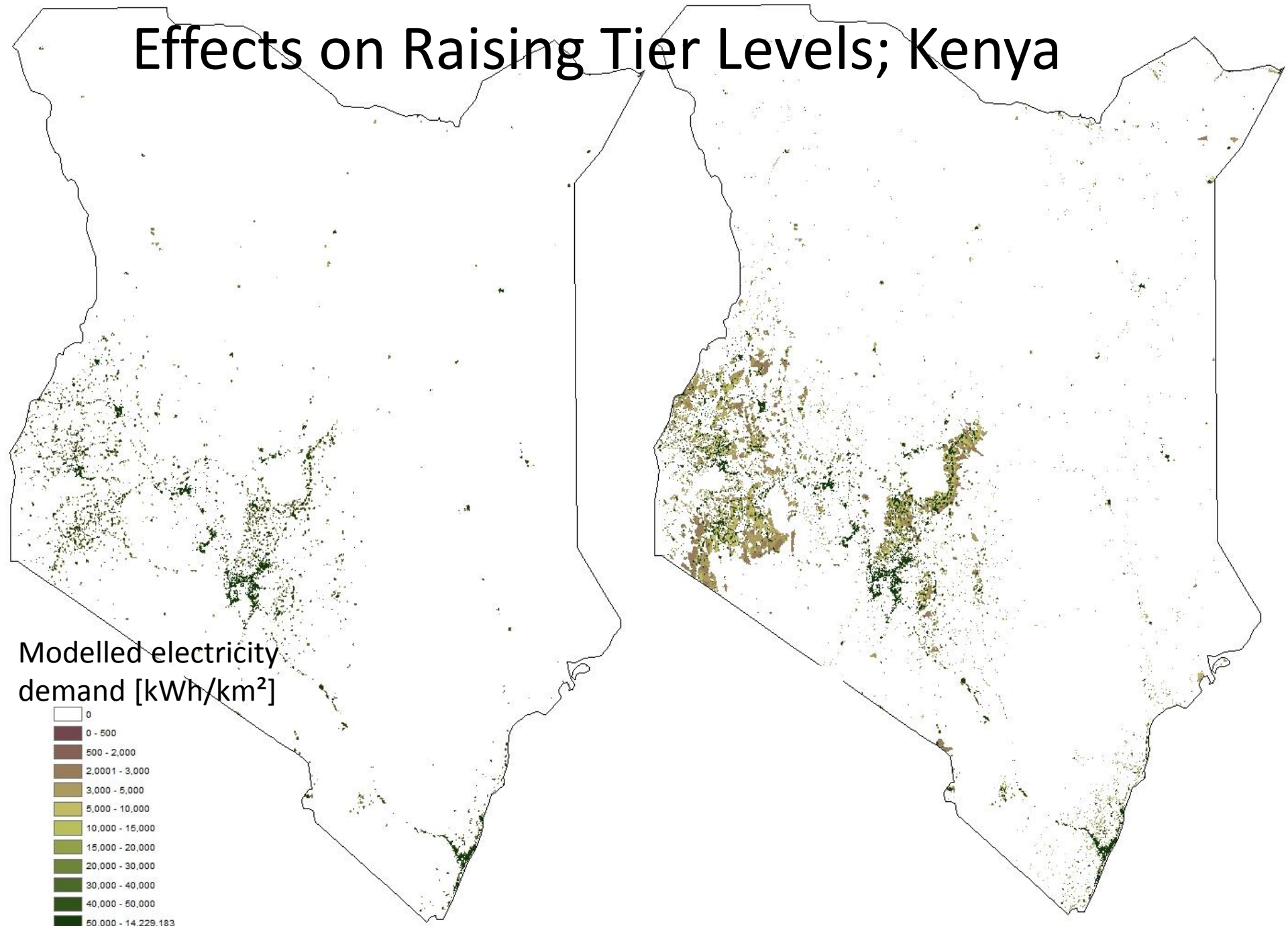
Quantifiable change if households move one tier level up.

Current tier (MTF)	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Current consumption [kWh/HH/a]	0 - 4.5	4.5 – 73	73 – 365	365 – 1,250	1,250 – 3,000	> 3,000

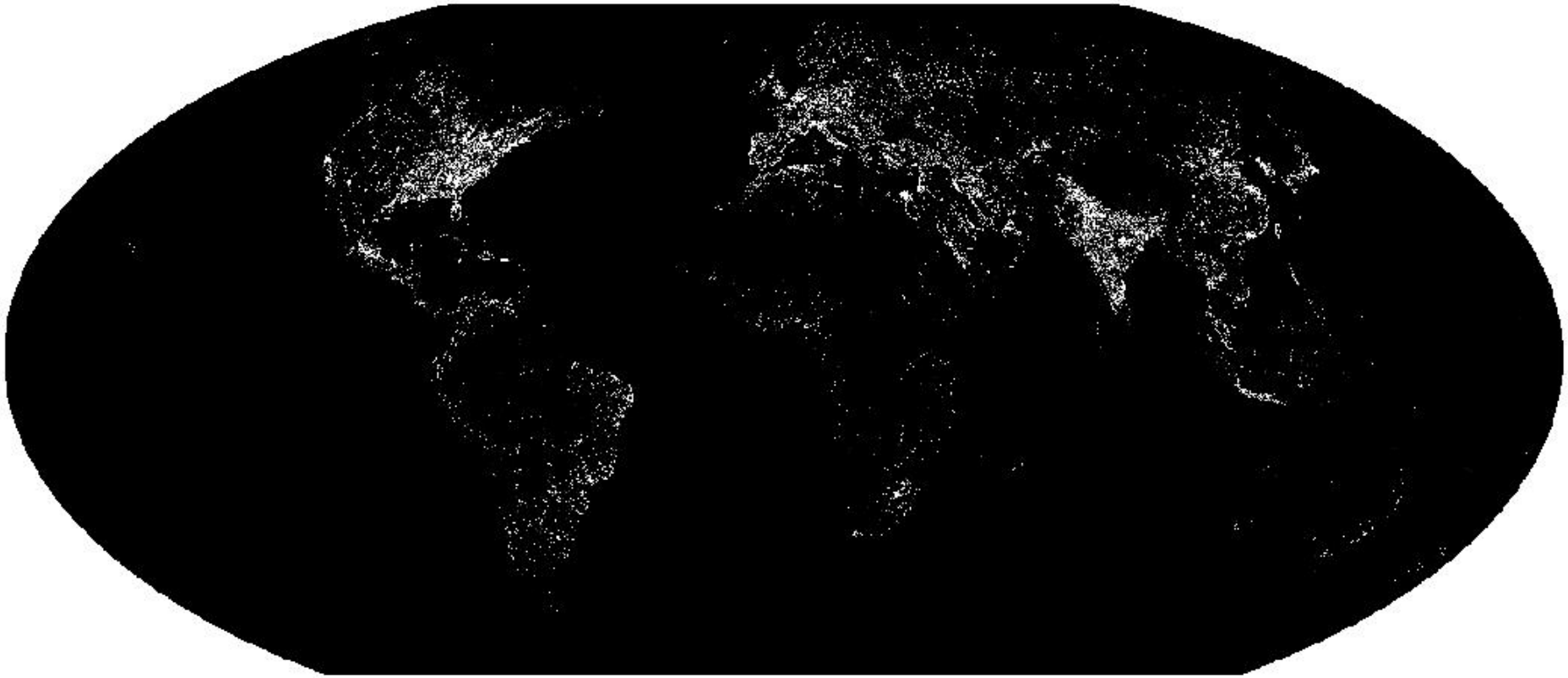
New allocated tier (MTF)	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
New allocated consumption [kWh/HH/a]	34	146	593	875	3500

Bhatia, Mikul; Angelou, Niki. 2015. Beyond Connections : Energy Access Redefined. ESMAP Technical Report;008/15. World Bank, Washington, DC. © World Bank.

Effects on Raising Tier Levels; Kenya

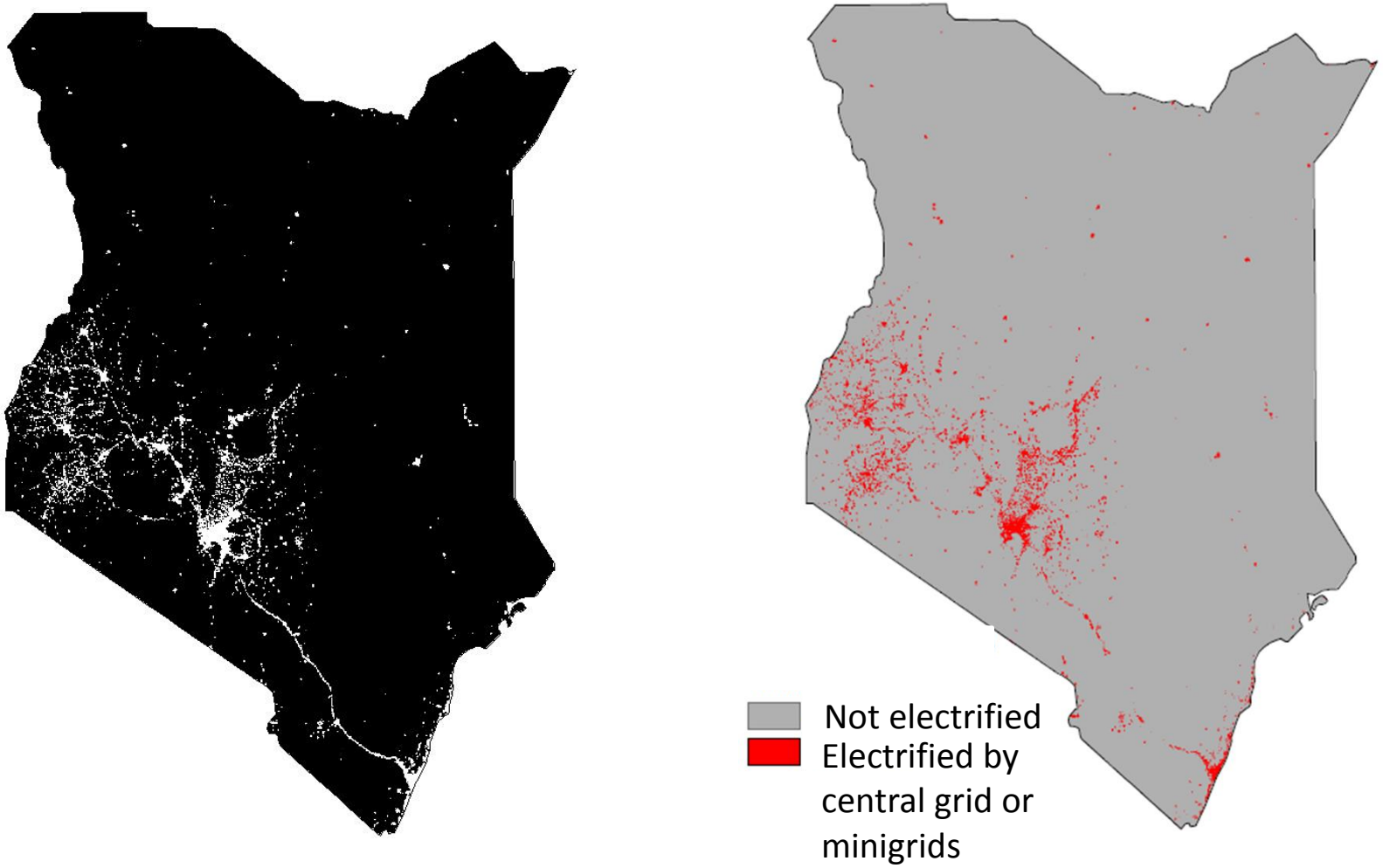


Nightlights for Modelling Energy Access and Intensity

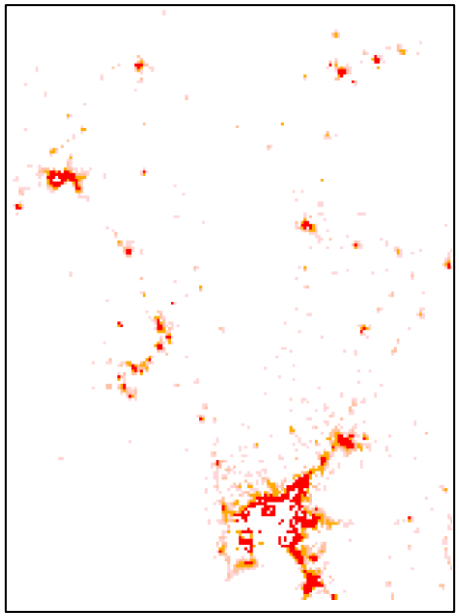


Data source: Earth Observation Group, NOAA National Centers for Environmental Information (NCEI), 2015

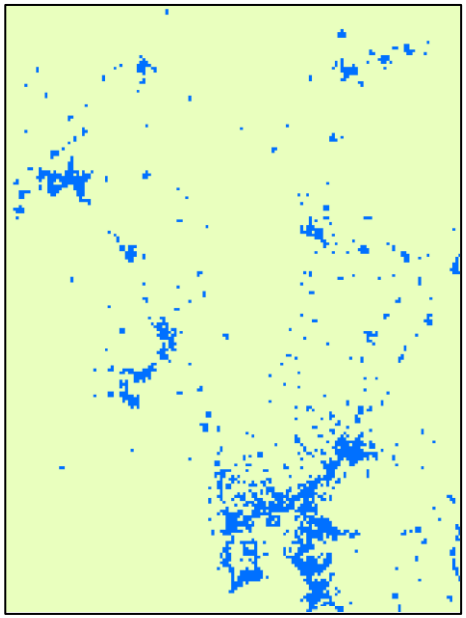
Modelling Required Electricity Infrastructures (Grid extension, minigrids)



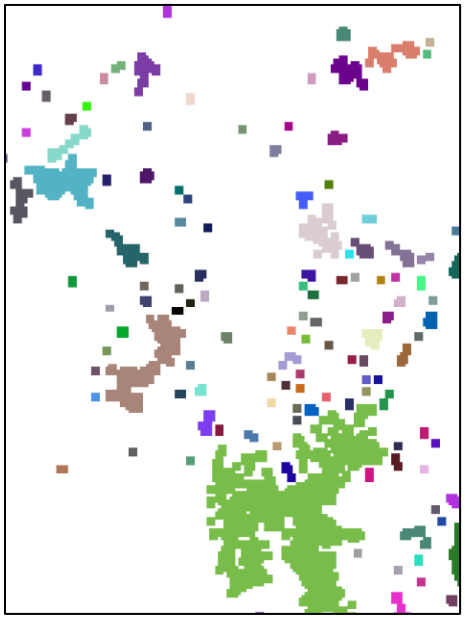
Local Energy System Properties



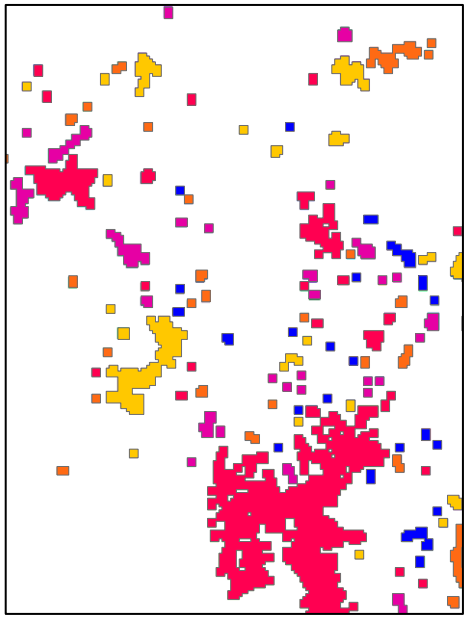
Demands, current and potential



Minimum density criterion

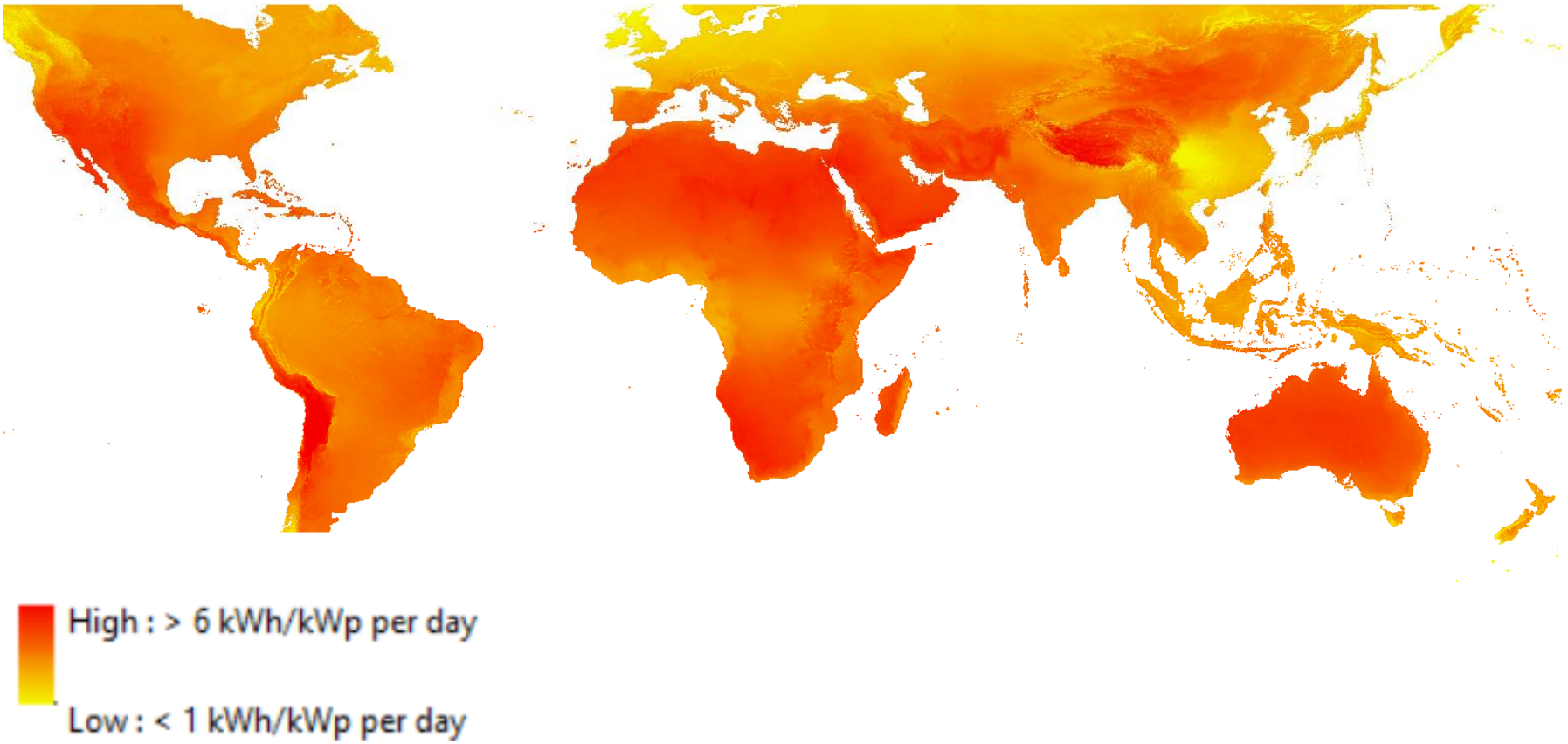


Delineation of supply districts



Spatial statistics of demand and supply

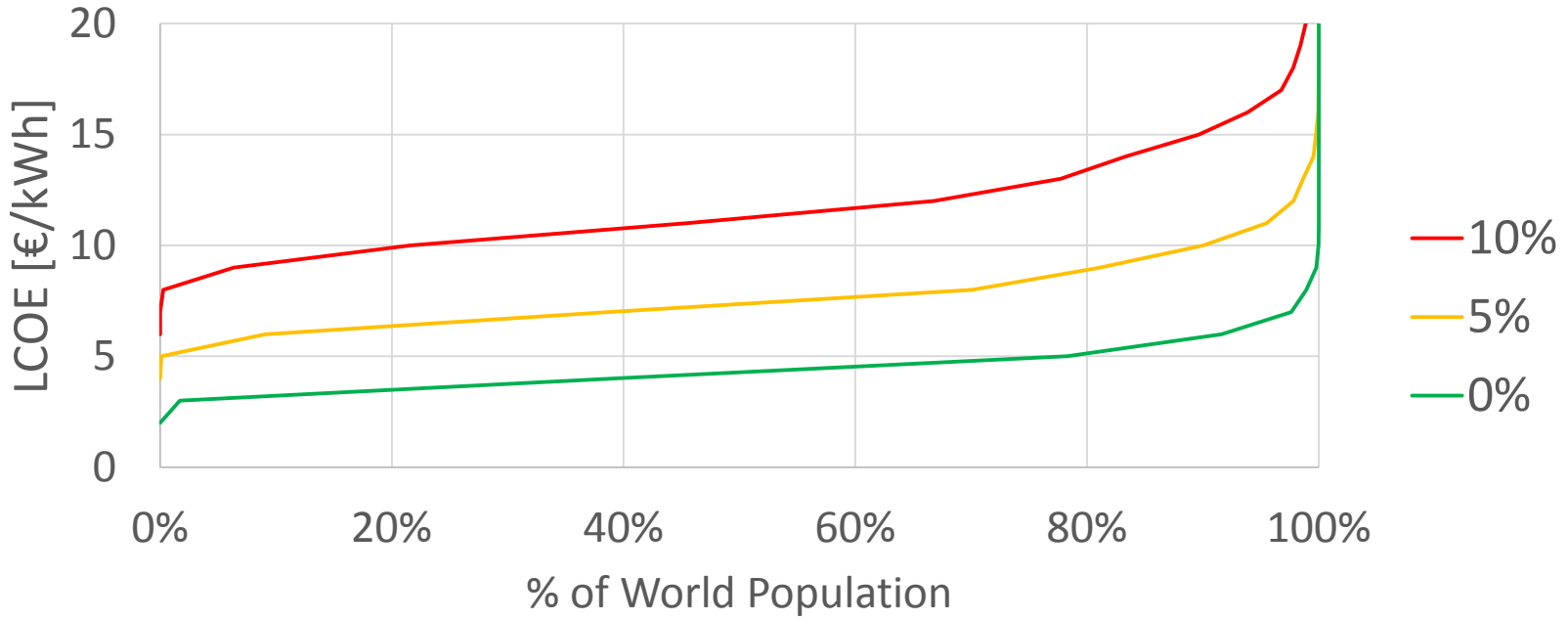
RE Sources by Location and Cost



AALBORG UNIVERSITY
DENMARK

Europa-Universität
Flensburg

Utility-Scale PV, LCOE by Population and Access to Capital (WACC)



Assuming investments of 1.5 €/Wp, O&M of 1% of investment p.a., excluding grid, balance of system etc.
Data sources: LandScan gridded World population 2016, World Bank Global Solar Atlas.

Model Outputs

- For a given country or region, PEEA will provide a multi-dimensional energy overview:
  - Current demands by access status, geography
  - Unmet demands and development perspectives
  - Market potentials for local energy systems: grid access, minigrids, district energy etc.
  - Opportunities to use renewable energy
  - Linkages to other sectors (transport, agriculture) may be provided.

Conclusions

A global Energy Atlas at 1km² resolution is feasible.

A magnitude of spatial energy-relevant data exists.

Suppressed energy demands, access to infrastructure and to renewable energy sources can be mapped.

A coherent planning system emerges, which may help addressing current research needs.

More work needs to be done to hardwire the model.