LIGHTING UP THE WORLD
THE FIRST GLOBAL APPLICATION OF THE OPEN SOURCE, SPATIAL ELECTRIFICATION TOOL (ONSSET)

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Presentation:
Alexandros Korkovelos
Introduction

Nowadays:

- About 2.7 billion people have no access to modern energy services.
- Over 1.3 billion people do not have access to electricity.
- The majority live mainly in rural areas of developing Asia and sub-Saharan Africa.
- Access to energy is crucial for human well-being & a country's economic development.
Sustainable Development Goals

- Agenda 2030 for Sustainable Development by United Nations.
- There are 17 SDGs that are intended as universal goals aiming to develop people, economy and society and to sustain nature, life support and community.
- 7th SDG: Ensure access to affordable, reliable, sustainable and modern energy for all by 2030.
Objective

The main objectives of our research are:

- To develop a methodology to approach the UN 7th Sustainable Development Goal in a comprehensive and quantitative way.
- To introduce a toolkit in order to come up with the optimal infrastructure and generation mix for electrification.
- To apply this tool in all countries that do not have 100% access to electricity (i.e. developing Africa, Asia, Latin America and middle East).
- Support the energy planning for sustainable transition in these counties.
Importance of energy planning

• Energy planning is essential in order to match demand and supply.
• Cost minimization is a primary objective.
• Considerable modifications in the energy infrastructure are needed.

However...

• These modifications are inherently motivated by geospatial questions.
• Ground level geospatial data are of key importance to help identify the most effective electrification strategy.
• In developing countries, there is a lack of reliable energy-related data.
Why Geographic Information Systems?

The use of GIS serves multiple purposes:

**Location based assessments:** GIS tools enable assessments to analyse energy related geospatial information.

**Remote sensing:** The use of GIS tools facilitates the integration of remote sensing techniques to derive resource availability & energy potentials in cases where such data are not (publically) available.

**Illustration of results:** GIS is used to illustrate results in interactive maps, providing an effective science – policy interface.

The integration of GIS in energy system models is still in its infancy.
ONSSET Toolkit for:

- Identification of most economic electrification mix (technology type)
- Quantification of investment
- Geospatial illustration of national electrification targets
Methodology

**1st step**
- Population projection
- Distance for existing/planned grid
- Cost assumptions

On Vs Off Grid spit

GIS data needs
- Population data
- Administrative areas
- Transmission Grid
- Power plants
- Others

World Bank
Different levels of electrification

Geospatial analysis 1st step
- Projection
- MV/HV expansion

Electrification model
- Assigning costs
- Electrification algorithm

Optimal split
- On Grid
- Off Grid

Geospatial analysis 2nd step
- On grid – mini grid – stand-alone options
- Technology selection
- LCOE

Results
- Maps
- Tables
- Graphs

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Cost based electrification model

World Bank tiers of electrification:
The analysis is carried out for all the 5 levels of electricity access in order to compare how the optimal electrification mix alters with different energy rates.

<table>
<thead>
<tr>
<th>Level of access</th>
<th>Tier-0</th>
<th>Tier-1</th>
<th>Tier-2</th>
<th>Tier-3</th>
<th>Tier-4</th>
<th>Tier-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicative appliances powered</td>
<td>Torch and Radio</td>
<td>Torch lighting +</td>
<td>Phone charging or Radio</td>
<td>General Lighting +</td>
<td>Air circulation +</td>
<td>Television, Cooking, printing</td>
</tr>
<tr>
<td>Consumption (kWh) per household per year (recommended from the WE framework)</td>
<td>&lt;1</td>
<td>3–66</td>
<td>67–321</td>
<td>922–1,318</td>
<td>1,318–2,121</td>
<td>&gt;2,121</td>
</tr>
<tr>
<td>Consumption (kWh) per household per year – as calculated in [17]</td>
<td>-</td>
<td>22</td>
<td>224</td>
<td>693</td>
<td>1,500</td>
<td>2,193</td>
</tr>
</tbody>
</table>

Technologies compared for energy access:
For each GIS settlement, the cost of each electrification technology is evaluated with a cost model, calculating the LCOEs of the compared technologies.

For the LCOE calculations, four parameters are considered and connected to costs:
- Population density
- Target level and quality of energy access
- Local grid connection characteristics and the national cost of grid electricity
Methodology

1st step
• Cost assumptions
• Population projection
• Distance for existing/planned grid

2nd step
• Renewable resources availability
• Diesel cost estimations

Geospatial analysis
1st step
• Projection
• MV/HV expansion

Electrification model
• Assigning costs
• Electrification algorithm

Optimal split
• On Grid
• Off Grid

World Bank
Different levels of electrification

GIS data needs
• Population data
• Administrative areas
• Transmission Grid
• Power plants
• Others

Geospatial analysis 2nd step
• On grid – mini grid – stand-alone options
• Technology selection
• LCOE

Results
• Maps
• Tables
• Graphs

On vs Off Grid split

Wednesday, November 18, 2015
Geospatial resources assessment (1/4)

**Spatial wind power mapping**
- Global wind power capacity factor
- 20 year average wind speed data
- 0.5 degrees spatial resolution
- Source: NASA - GES DISC
Geospatial resources assessment (2/4)

**Spatial solar availability**

- Global Horizontal Irradiation
- 20 year average data
- 1 degree spatial resolution
- Source: Langley Atmospheric Science Research Center (SSE – NASA LaRC POWER Project)
**Spatial LCOE for Diesel gensets**

- Global coastlines
- Characterization of a country as landlocked or coastal
- Travel distance to major cities
- International diesel price (current and projected)
Spatial Mini Hydropower potential

- Global Runoff data (GSCD – EU JRC)
- Global River Network (HydroSHEDS)
- Global Digital Elevation Maps (USGS/NASA SRTM)
- 0.5 degrees spatial resolution
- Sources: EU JRC, WWF, CGIAR-CSI
Methodology

1st step
• Cost assumptions
• Population projection
• Distance for existing/planned grid

2nd step
• Renewable resources availability
• Diesel cost estimations
• LCoE for each technology

On vs Off Grid split

Most economic electrification option
Results - Graphical Representation

- Administrative areas
- Population data/Demand
- Existing Transmission Network
- Power plants & Mines
- Expansion of HV/MV lines
- Resources potentials
- Optimal Split
- LCoE
## Results – Tabular representation

<table>
<thead>
<tr>
<th>Item</th>
<th>Related physical unit</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural access target</td>
<td>150</td>
<td>kWh/capita/year</td>
</tr>
<tr>
<td>Urban access target</td>
<td>300</td>
<td>kWh/capita/year</td>
</tr>
<tr>
<td>Grid distribution</td>
<td>7,844</td>
<td>Settlements</td>
</tr>
<tr>
<td>Grid distribution</td>
<td>25,424,842</td>
<td>Households</td>
</tr>
<tr>
<td>Grid distribution</td>
<td>127,124,209</td>
<td>People</td>
</tr>
<tr>
<td>Planned grid expansion (Transmission with HV lines)</td>
<td>5,431</td>
<td>km</td>
</tr>
<tr>
<td>Grid extensions for those gaining access (Transmission with MV lines)</td>
<td>36,343</td>
<td>km</td>
</tr>
<tr>
<td>Grid extensions for those gaining access (Distribution with MV &amp; LV lines)</td>
<td>513,407</td>
<td>km</td>
</tr>
<tr>
<td>Mini grids distribution</td>
<td>915</td>
<td>Settlements</td>
</tr>
<tr>
<td>Mini grids distribution</td>
<td>791,739</td>
<td>Households</td>
</tr>
<tr>
<td>Mini grids distribution</td>
<td>3,958,695</td>
<td>People</td>
</tr>
<tr>
<td>Mini grids power generation capacity</td>
<td>0.34</td>
<td>GW</td>
</tr>
<tr>
<td>Mini grids power generation</td>
<td>0.84</td>
<td>TWh</td>
</tr>
<tr>
<td>Stand alone systems</td>
<td>1060</td>
<td>Settlements</td>
</tr>
<tr>
<td>Stand alone systems</td>
<td>131,353</td>
<td>Households</td>
</tr>
<tr>
<td>Stand alone systems</td>
<td>656,767</td>
<td>People</td>
</tr>
<tr>
<td>Stand alone systems power generation capacity</td>
<td>0.032</td>
<td>GW</td>
</tr>
<tr>
<td>Stand alone systems power generation</td>
<td>0.086</td>
<td>TWh</td>
</tr>
</tbody>
</table>
Publications

- IEA World Energy Outlook 2014 (Nigeria, Ethiopia)
- IEA World Energy Outlook 2015 (India)
- Elsevier Energy for Sustainable Development: “A GIS based approach for electrification planning – A case study on Nigeria”.
- Elsevier Energy: “A Cost Comparison Of Technology Approaches for Improving Access to Electricity Services”.

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Conclusions

• The 7th Sustainable Development Goal mandates an electrification expansion in many countries.

• The proposed methodology is an attempt to optimize various electrification efforts in the targeted countries with a spatial reference.

• This is a complementary approach to already existing energy planning models that do not consider geospatial characteristics.
Future work

• Carry out country specific case studies according to national targets.

• Perform the analysis considering higher resolution maps, in order to achieve more representative results.

• Make use of additional geospatial data to identify energy related characteristics (NASA Nighttime light maps).

• Launch an interactive and online database with data for all the unelectrified countries (available in February 2016).
For further questions please refer to

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Thank you