# ARCHETYPES OF RURAL USERS IN SSA FOR LOAD DEMAND ESTIMATION

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LEAP-RE
Long-Term Joint EU-AU Research and Innovation Partnership on Renewable Energy

The LEAP-RE project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

# Relevance of Load Demand in Energy Planning

**Energy Modelling** has proved to be a key element in assisting **energy planning** and in supporting scientifically sound **energy policy** decisions

Minigrid Sizing

Energy System Modelling (Off-Grid System)

- **HOMER®**
- **iHoga**
- **DER-CAM**
  Moretti et al. 2019
- **MicroGridsPy**
  Balderrama et al. 2019

Strategy Selection

Geospatial Electrifcation Modelling

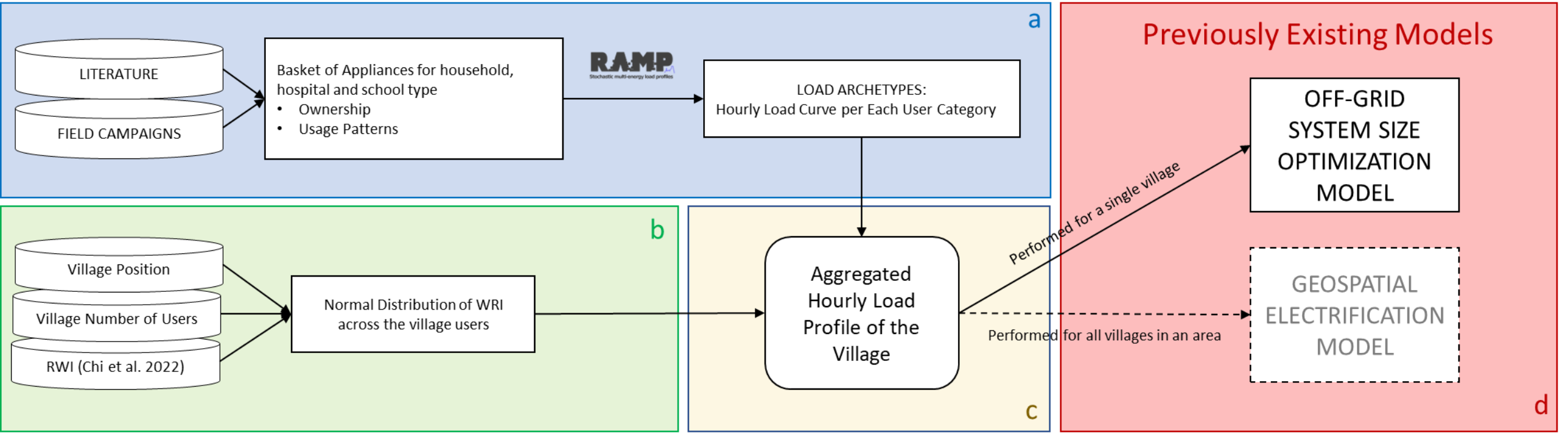
- **RE$^2_n$AF**
  Szabò et al. 2016
  Moner-Girona et al. 2019
- **OnSSET**
  Mentis et al. 2017
- **REM**
  Ciller et al. 2019
  Lee et al. 2019

They all rely on the same principle:

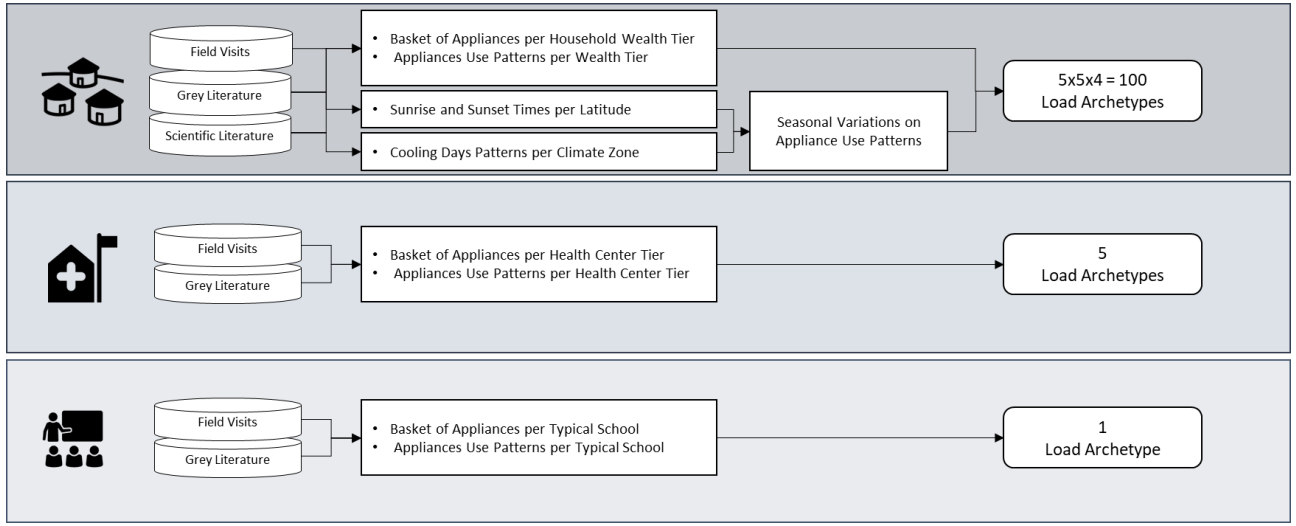
$$\sum Supply = \sum Demand$$

- Demand is Exogenous to the models
- Majority of Research has focused on characterization of supply
- **How much does demand influence the results?**

# Logical Framework



# Definition of Users Archetypes




| | |
|---|---|
| NC | No Cooling |
| AY | All Year Cooling |
| OM | Cooling from October to March |
| AS | Cooling from April to September |

**Variable 1 - Wealth Tier of the household**

**Variable 2 - Latitude of the village**

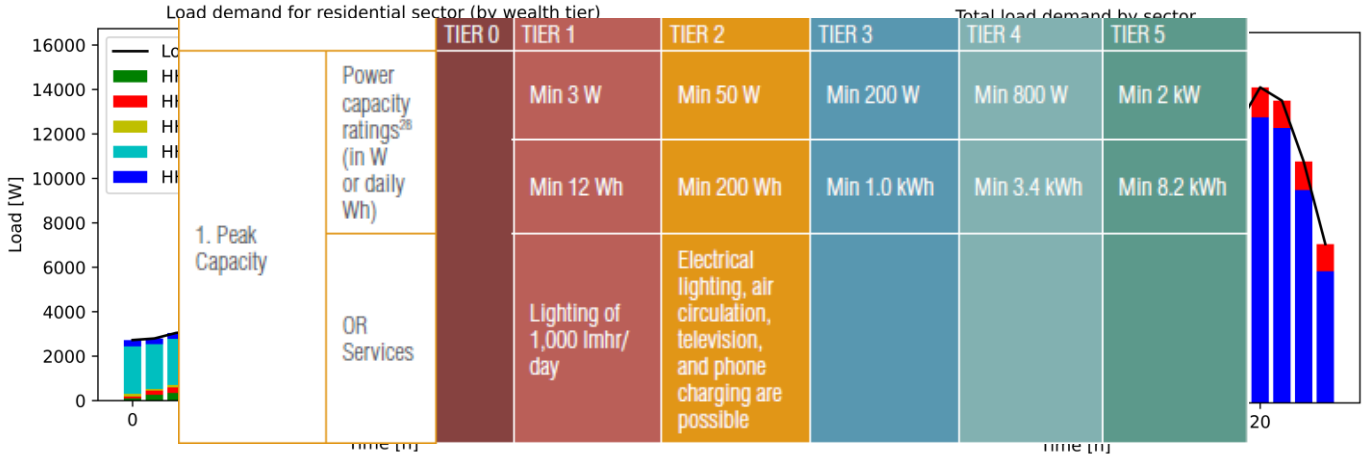
**Variable 3 - Cooling days of the area**

| | Wealth 1 | Wealth 2 | Wealth 3 | Wealth 4 | Wealth 5 |
|---|---|---|---|---|---|
| Lat [10;20] | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS |
| Lat [10;-10] | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS |
| Lat [-10;-20] | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS |
| Lat [-20;-30] | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS |
| Lat [< -30] | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS | NC\|AY\|OM\|AS |

# Aggregation into Load Curves

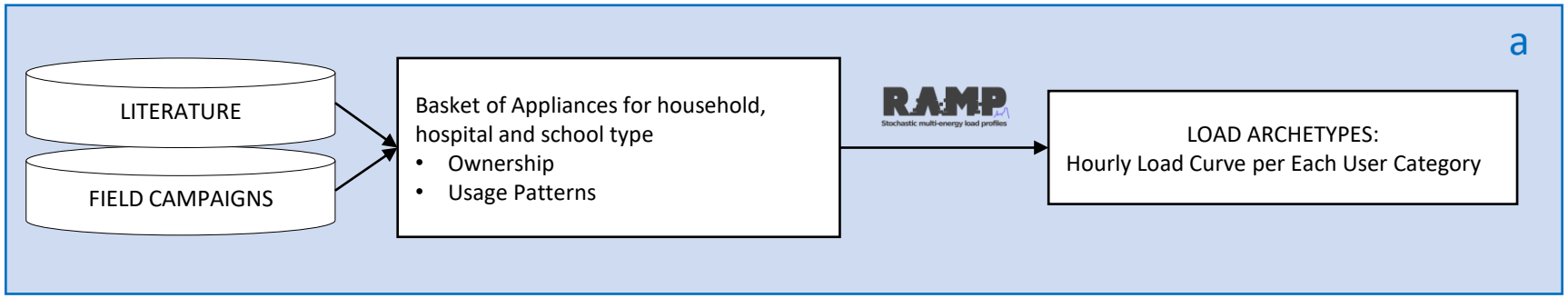
$$D_{village} = \sum_{i=1}^{5} n_{HH_i^{xy}} D_{HH_i^{xy}} + n_{H_i} D_{H_i} + n_S D_S$$

Standard Approach:
Top-Down assignation of daily consumption tiers

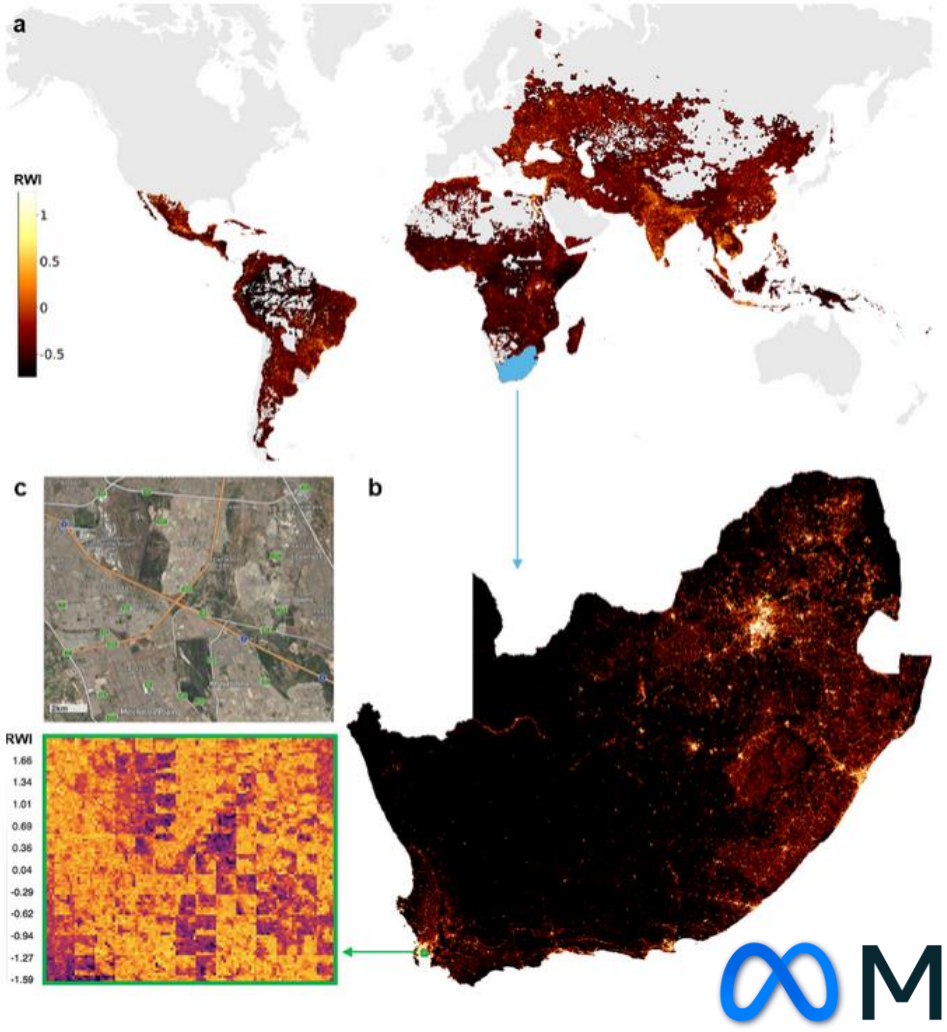



Novel Approach:
Top-Down assignation of archetypical load profiles with a Bottom-Up construction

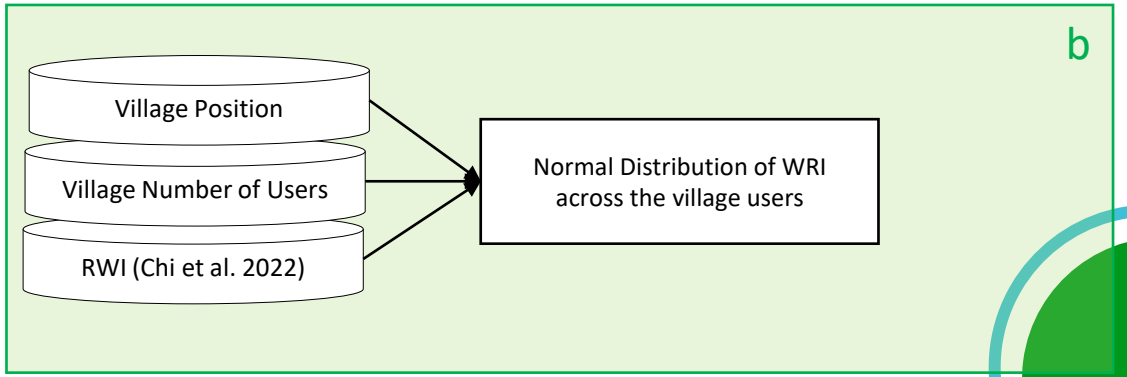
https://github.com/SESAM-Polimi/MicroGridsPy-SESAM



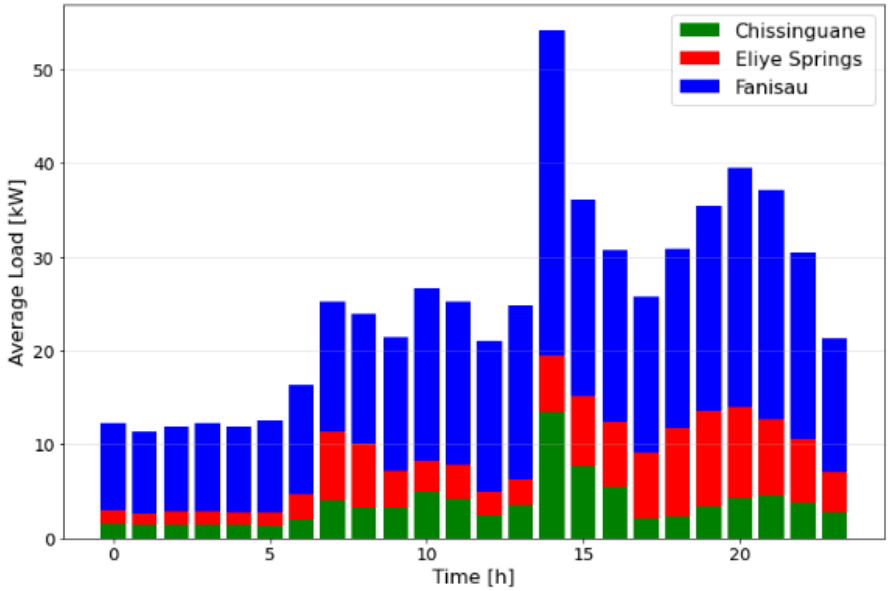
# Village Demand Estimation




- The selected village-specific RWIs have been assumed to represent the mean of a normal probability distribution, with a standard deviation approximated by the RWI data related to the village district.
- The five wealth tiers have been represented by five RWI intervals in the range [-2,+2].
- The probability of RWI lying in each tier has been calculated from each village-specific normal distribution and applied to the total number of households to populate each wealth tier.



# Preliminary Results




Aggregated Hourly Load Profile of the Village

C

| Village | Tier 1 | Tier 2 | Tier 3 | Tier 4 | Tier 5 |
|---|---|---|---|---|---|
| Fanisau | 0 | 1 | 32 | 124 | 68 |
| Eliye Springs | 0 | 37 | 162 | 7 | 0 |
| Chissinguane | 0 | 2 | 37 | 3 | 0 |

| Village | PV Capacity [kW] | Storage Capacity [kWh] | LCOE [USD/kWh] | Curtailment Share [%] |
|---|---|---|---|---|
| Fanisau | 264 | 284 | 0.9 | 41 |
| Eliye Springs | 35 | 88 | 0.94 | 67 |
| Chissinguane | 45 | 74 | 1.15 | 65 |

# Conclusions

- Load Demand is a key aspect of energy modelling, often disregarded or assigned a-priori
- We developed a set of archetypes, with geographical validity of SSA, for rural users characterization
- Coupling such archetypes with Geographically Referenced Data represents a tool for load curve estimation for potentially any rural village in SSA
- The ease of use and vast applicability of this approach makes it a good first approximation for national energy acess planning strategies

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