



INTERNATIONAL
Microgrid
SYMPOSIUMS

Pakistan

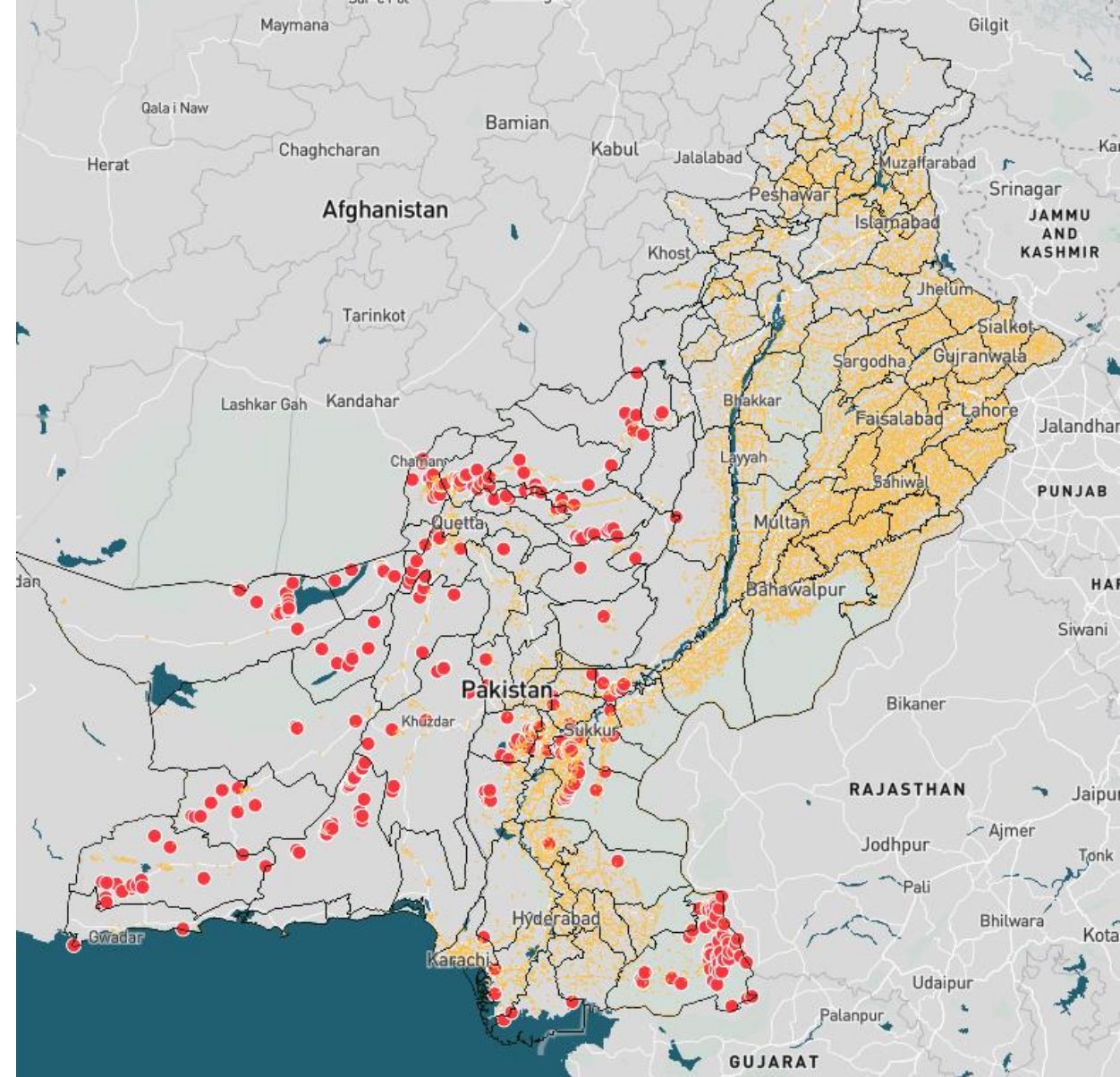
Least-Cost Electrification Study and mini-grid portfolio assessment

Roger Sallent

TTA Regional Team Leader for Asia-Pacific

roger.sallent@tta.com.es

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tta

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2. Project Background

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1. ABOUT TTA

 Trama
TecnoAmbiental

www.tta.com.es

ABOUT TTA

- ✓ **Engineering and Consulting** Firm, in business since 1986 (+35 years experience)
- ✓ Specialized in **energy access** and **renewable energy distributed generation**.
- ✓ Headquarters in **Barcelona (Spain)**.
- ✓ Around **35 full-time staff**.



CONSULTANCY

- Energy **planning**
- Development of **Policy and regulatory** frameworks
- Definition of **delivery models**
- **Transaction** Advisory



ENGINEERING

- Technical and financial **feasibility studies**
- Concept and detailed **engineering designs**
- **Owner's Engineering**



KNOWLEDGE HUB

- Tailor made training and **capacity building**
- Conference on Solar Technologies & Hybrid Mini Grids (**S-@ccess Conference**)



WORKS

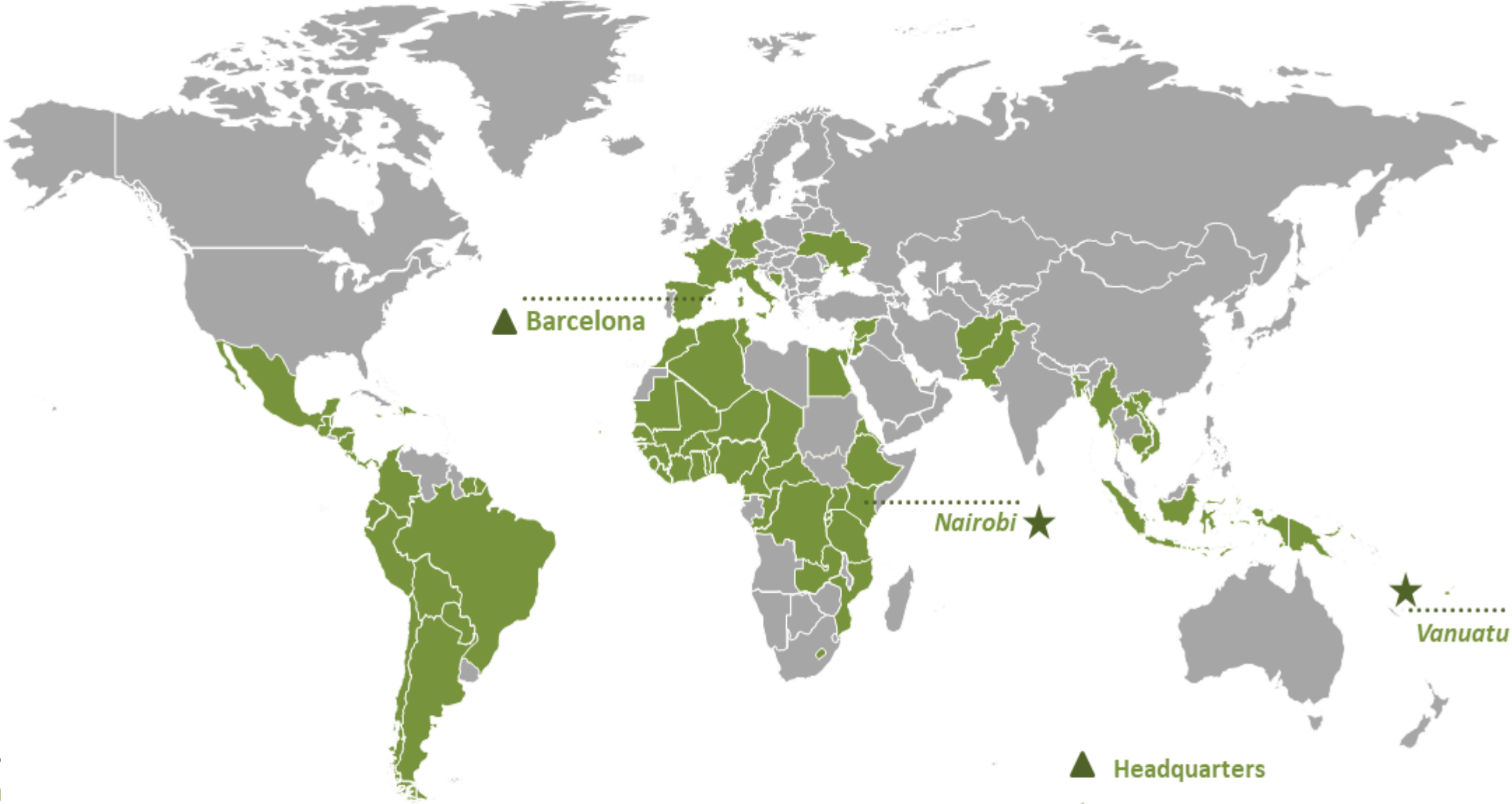
- **Supervision** of Construction Works
- **EPC**
- **Operations & Maintenance**



PRODUCT DEVELOPMENT

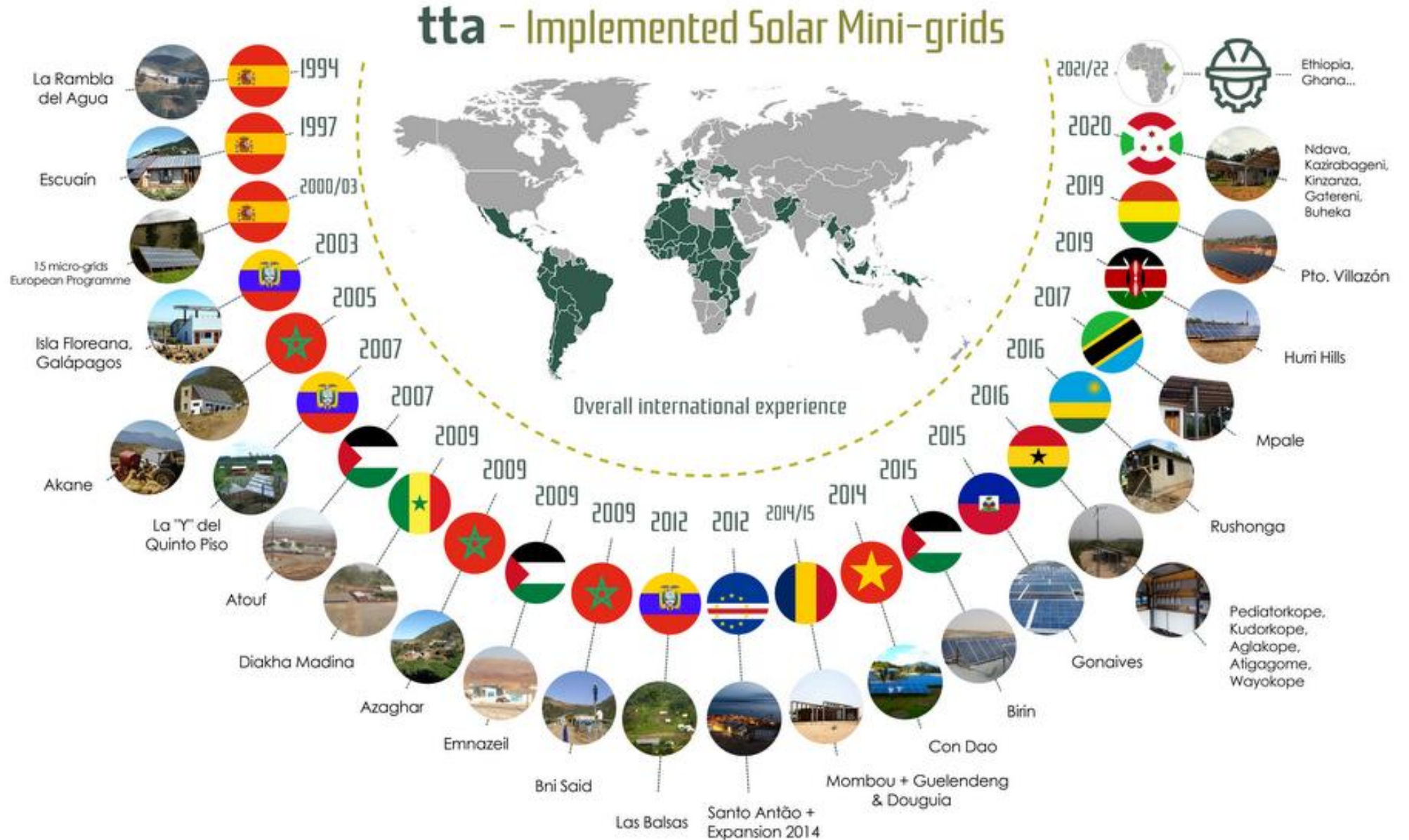
- **Research & Development**

ABOUT TTA: GLOBAL EXPERIENCE



www

ABOUT TTA: EPC WORK IN MINI-GRIDS



S-@CCESS CONFERENCE



SAVE THE DATE !

Solar Technologies & Hybrid Mini Grids to improve energy access

- 4th edition -

www.energy-access-conferences.com

Palma de Mallorca, Spain

April 26-28, 2023

2. BACKGROUND

ABOUT THE TEAM

CLIENT:

- The World Bank
- Funding from the Energy Sector Management Assistance Program (ESMAP)



CONSULTANT CONSORTIUM :

- Instituto de Investigación Tecnológica (IIT) + Waya Energy → *Reference Electrification Model (REM)*
- TFE Energy → *Village Data Analytics (VIDA)*
- Trama TecnoAmbiental, S.L → *Subject Matter Expertise*
- PITCO → *Local Knowledge*



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ABOUT THE PROJECT

CONTEXT

- **Electrification of Pakistan**
 - Pakistan adopted the SDG as its own national goals in 2016.
 - The government targeted universal energy access by 2030. Current electrification rate around 71% (uncertain).
- **WB's engagement** on energy access in Pakistan was limited due to gaps in the analytical work needed to inform their engagement with the GoP and the Provincial Governments on policy development and energy access projects in the country.

Approach:

- National Energy Survey
- Least-Cost Electrification Study + Mini-Grids Portfolio Assessment.

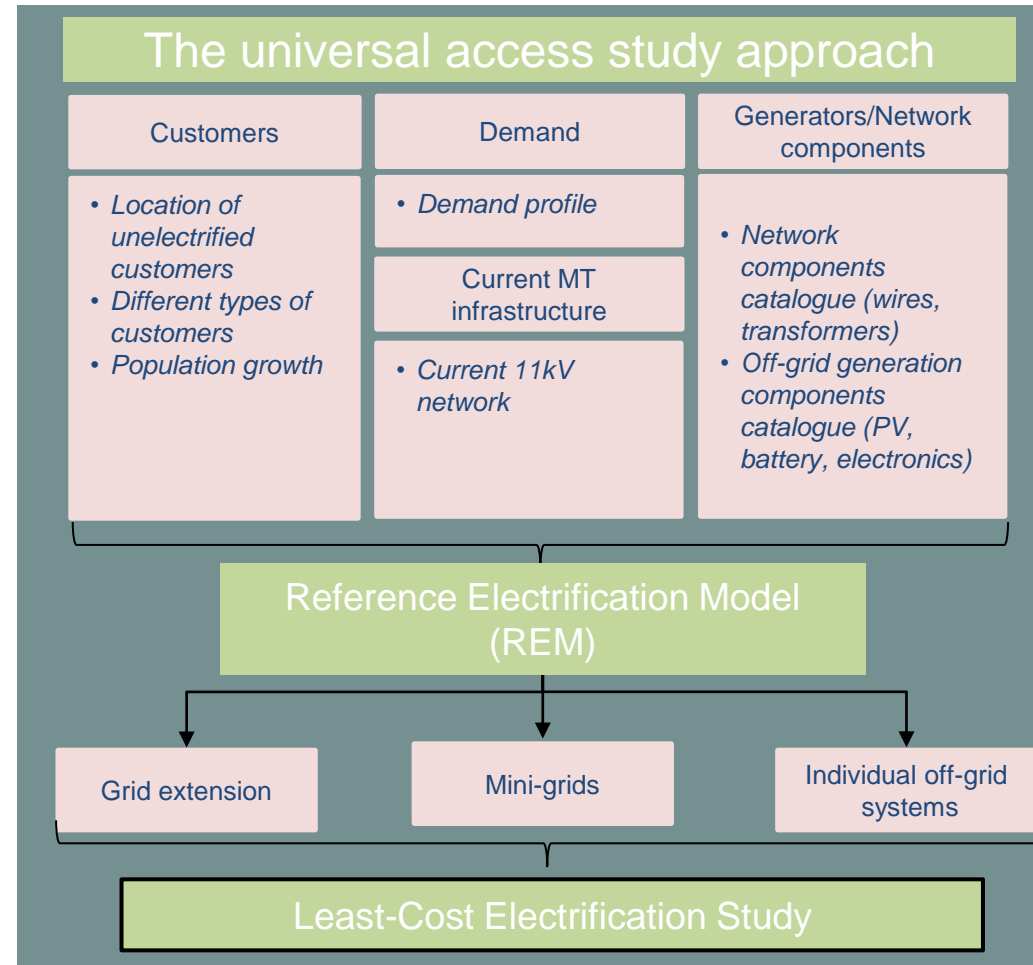


3. LEAST-COST ELECTRIFICATION STUDY

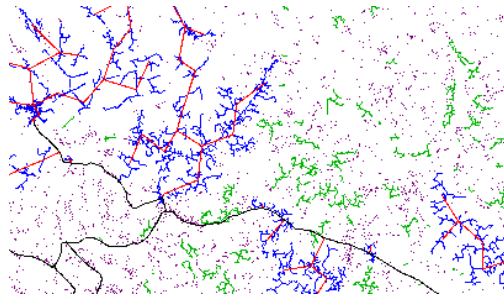
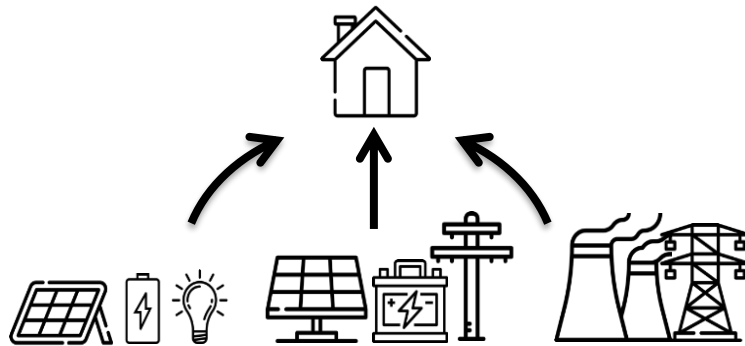
LEAST-COST ELECTRIFICATION STUDY

- The objective of the Least-cost Electrification Study (LCES) is to establish the
 - distribution MT network least-cost plan along with off-grid options
 - that meets the forecast electricity demand (2030) – long term planning horizon
 - and provides access to all unelectrified customers by 2030
 - at the *lowest economic* cost
- The plan evaluates the mix of
 - grid and off-grid systems
 - that results in the lowest cost in present value.

REFERENCE ELECTRIFICATION MODEL (REM)



REFERENCE ELECTRIFICATION MODEL (REM)



1. Identification

Machine vision and A.I. to identify customers and the associated characteristics in unmapped areas

2. Optimization

Large-scale optimization to design the appropriate infrastructure for each consumer

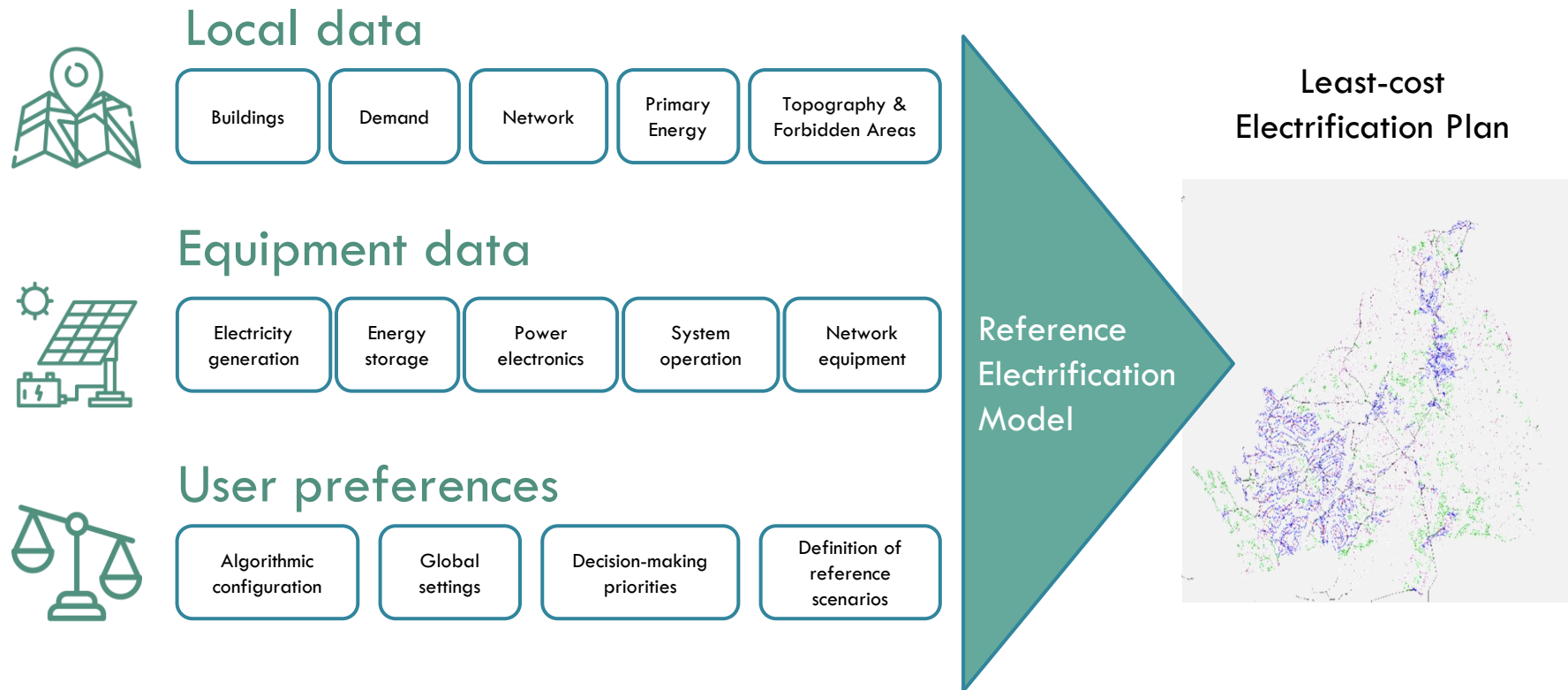
- Solar Home Systems
- Minigrids
- Utility Expansion (Distribution level)

3. Designs and Outputs

Governments, Utilities, and Private firms use detailed system designs to implement solutions in the field

INPUT DATA REQUIREMENTS

- REM model runs on a mix of local data, techno-economic catalog of components, and other parameters related to the client and user's preferences.



PAKISTAN PROVINCES



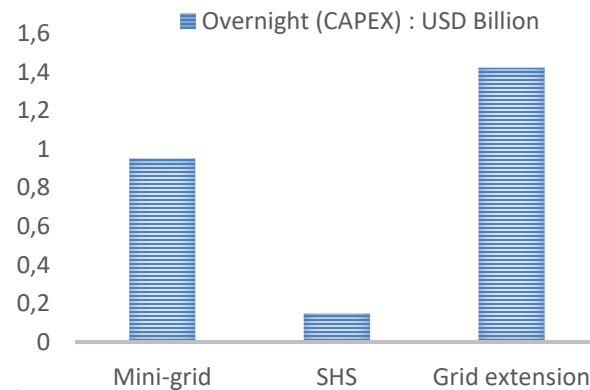
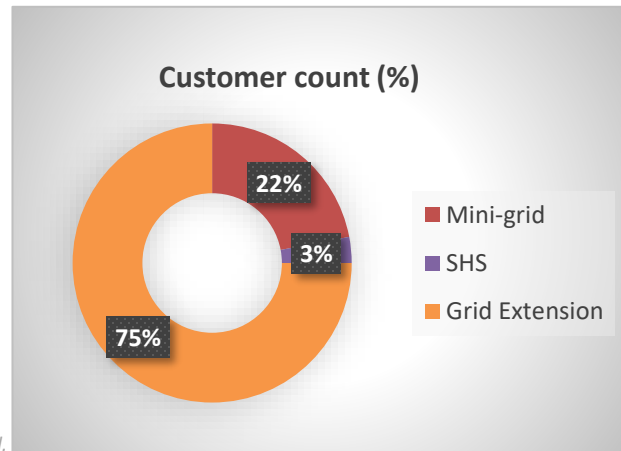
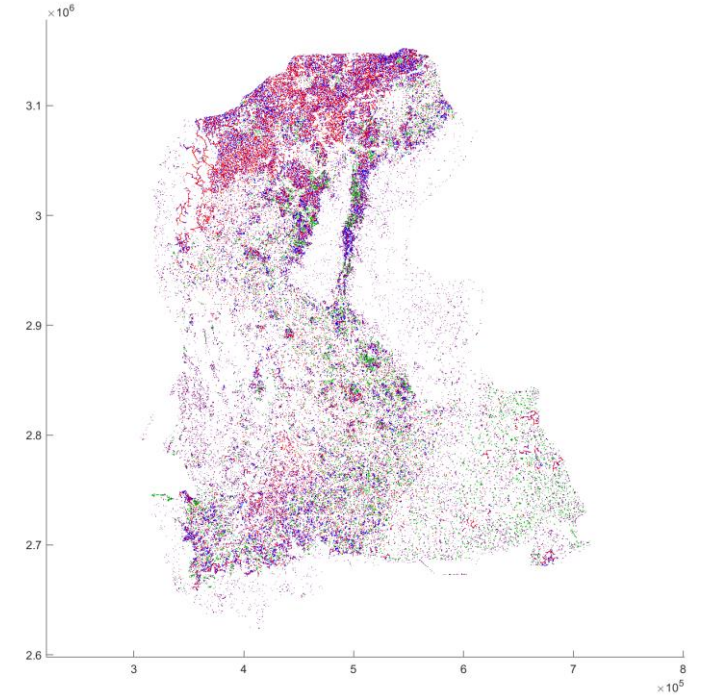
ELECTRIFICATION STATUS

Province	Population (2020) Based on 2017 census	Population estimate (2030)	Number of electrified household (2020) Based on utility data/nightlight data	Electrification rate	Number of new additional customers by 2030 **	Grid densification customers (2030) Within 500 m from current MT network	Rest of the unelectrified households (2030)
Sindh	36,819,551	46,004,932	1.56 million	24%	6.5 million	3.7 million	2.8 million
Balochistan	13,012,832	18,297,457	477,757	25%	2.2 million	0.7 million	1.5 million
Punjab	120,113,612	152,162,447	16.1 million	86%	6.9 million	4.3 million	2.6 million
Khyber Pakhtunkhwa	38,656,473	51,362,296	2.75 million	56%	3.8 million	0.9 million	2.88 million

- ▶ Any customers within 500m of the current grid network (11kV) is considered either electrified or for grid densification
- ▶ Customers outside 500m of current grid network are considered for REM simulation to find the least-cost solution between grid extension and off-grid options

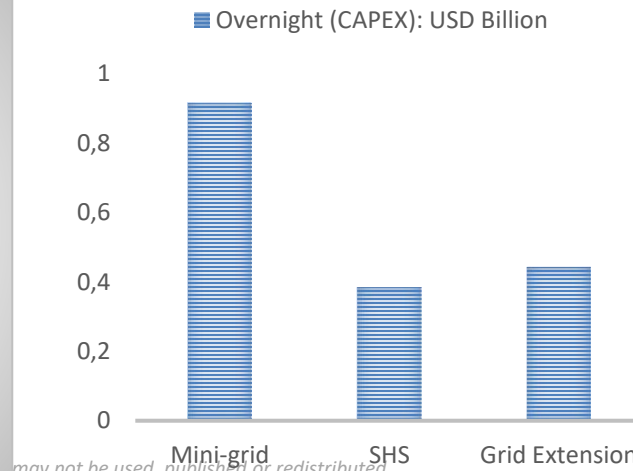
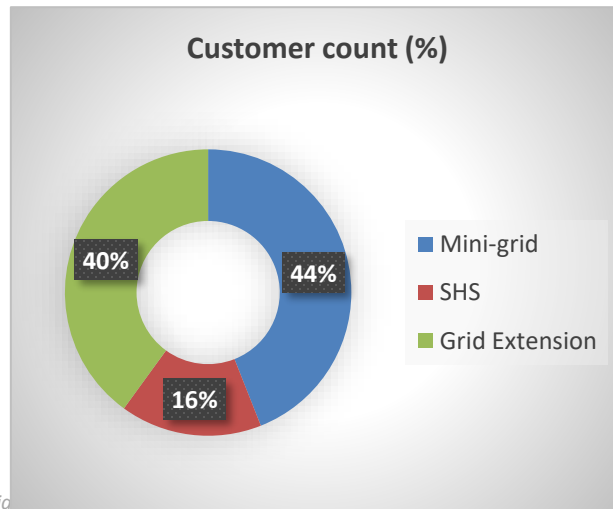
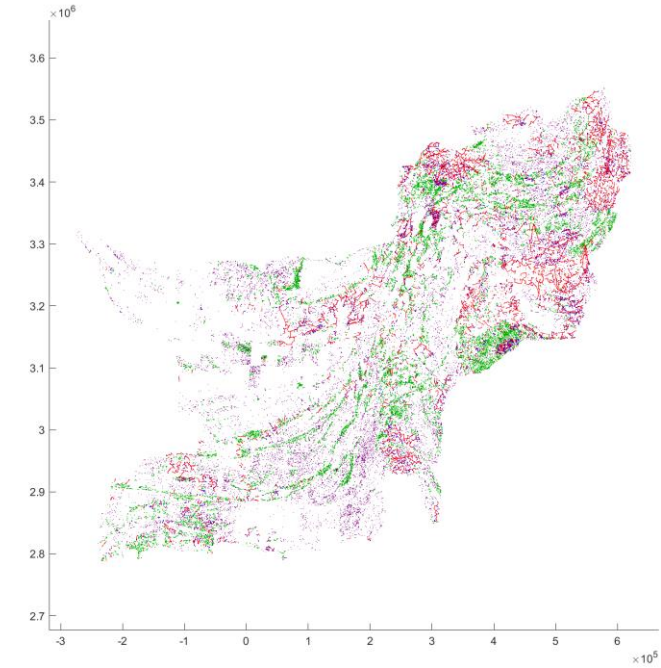
REM RESULTS (2030 ESTIMATION): SINDH

Indicator		Individual system	Mini-grids	New Grid Extensions	Total
Number of new customers	## hh	89,743	610,366	2.1 million	2.8 million
Fraction of New Customers		0.03	0.22	0.75	1
Cost Per kWh of Demand Served	\$/kWh	0.33	0.22	0.18	
Annual energy demand	GWh	114	792	3,710	4,616
Overnight Capital Cost:					
Total CAPEX	\$ (USD)	0.15 Billion	0.95 Billion	1.4 Billion	2.5 Billion
Avg. CAPEX per customer	\$/customer	1,688	1,555	672	



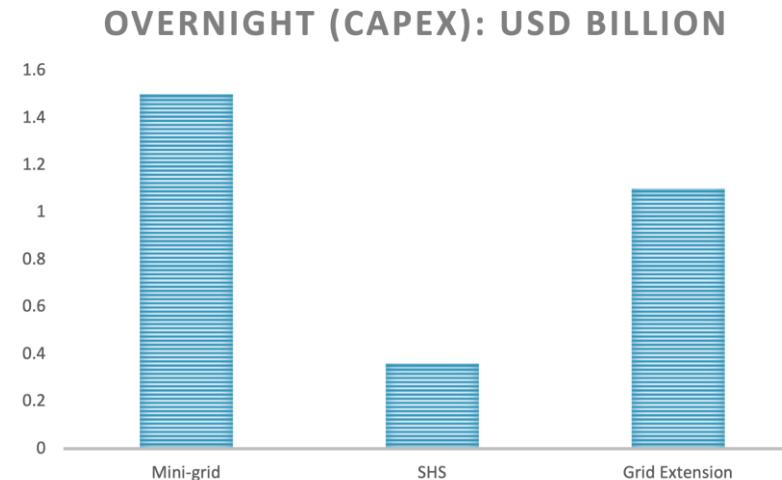
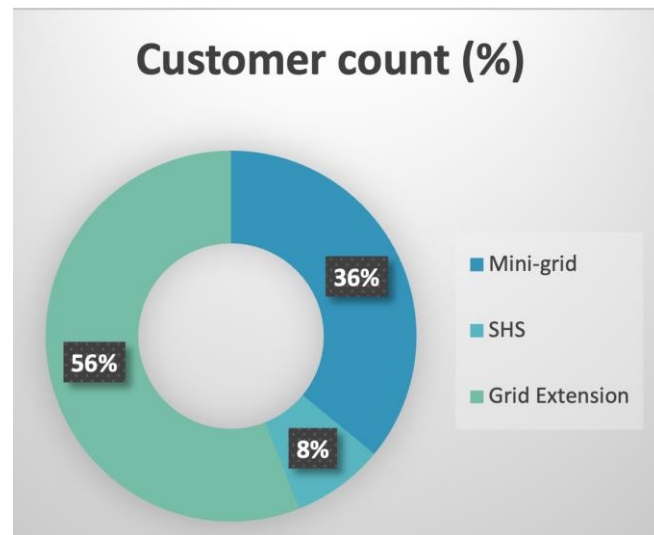
REM RESULTS (2030 ESTIMATION): BALOCHISTAN

Indicator		Individual system	Mini-grids	New Grid Extensions	Total
Number of new customers	## hh	252,624	670,210	599,635	1.5 million
Fraction of New Customers		0.16	0.44	0.4	1
Cost Per kWh of Demand Served	\$/kWh	0.34	0.22	0.19	
Annual energy demand	GWh	295	718	1,012	2,020
Overnight Capital Cost:					
Total CAPEX	\$ (USD)	0.406 billion	0.925 Billion	0.44 Billion	1.77 Billion
Avg. CAPEX per customer	\$/customer	1,610	1,380	739	



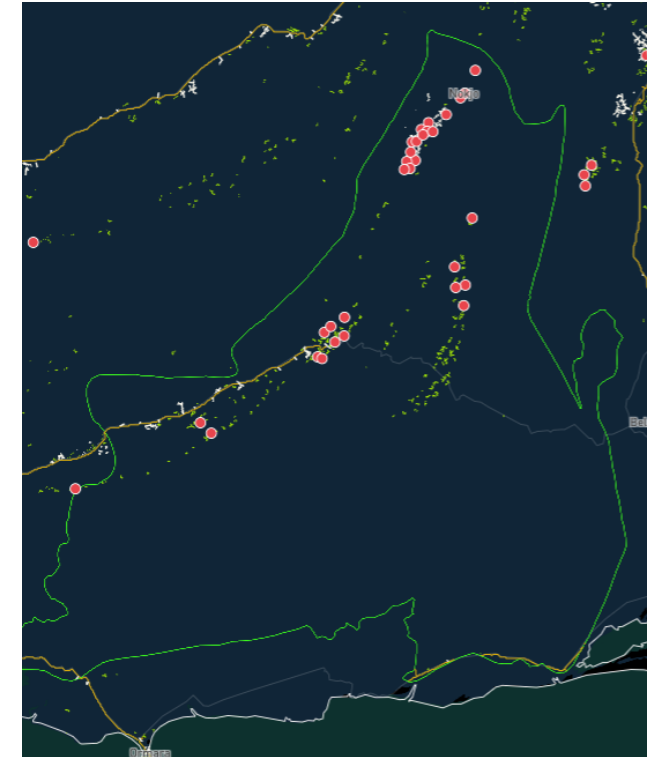
REM RESULTS (2030 ESTIMATION): PUNJAB

Indicator		Individual system	Mini-grids	New Grid Extensions	Total
Number of new customers	## hh	210,267	938,705	1,462,010	2.6 million
Fraction of New Customers		0.08	0.36	0.56	1
Cost Per kWh of Demand Served	\$/kWh	0.32	0.22	0.19	
Overnight Capital Cost:					
Total CAPEX	\$ (USD)	0.36 billion	1.5 Billion	1.1 Billion	3 Billion
Avg. CAPEX per customer	\$/customer	1,715	1,622	778	



REM RESULTS (2030 ESTIMATION): AWARAN

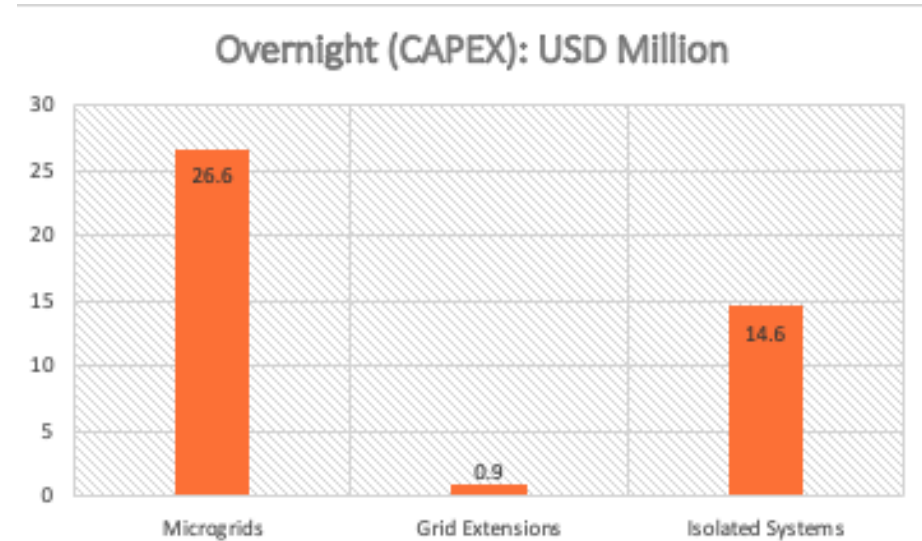
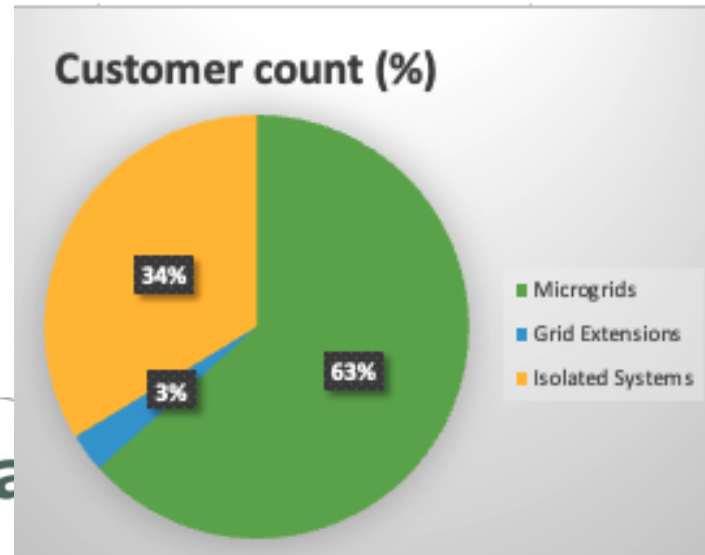
Indicator		Individual system	Mini-grids	New Grid Extensions
Number of new customers	## hh	11,056	20,773	859
Cost Per kWh of Demand Served	\$/kWh	0.38	0.24	0.33
Annual energy demand	GWh	10	19	0.8
Overnight Capital Cost:				
Total CAPEX	\$ (USD)	14.6 Million	26.6 Million	0.9 Million
Avg. CAPEX per customer	\$/customer	1,319	1,280	1,035



30 High priority electrification sites

3 sites have more than 2000 people

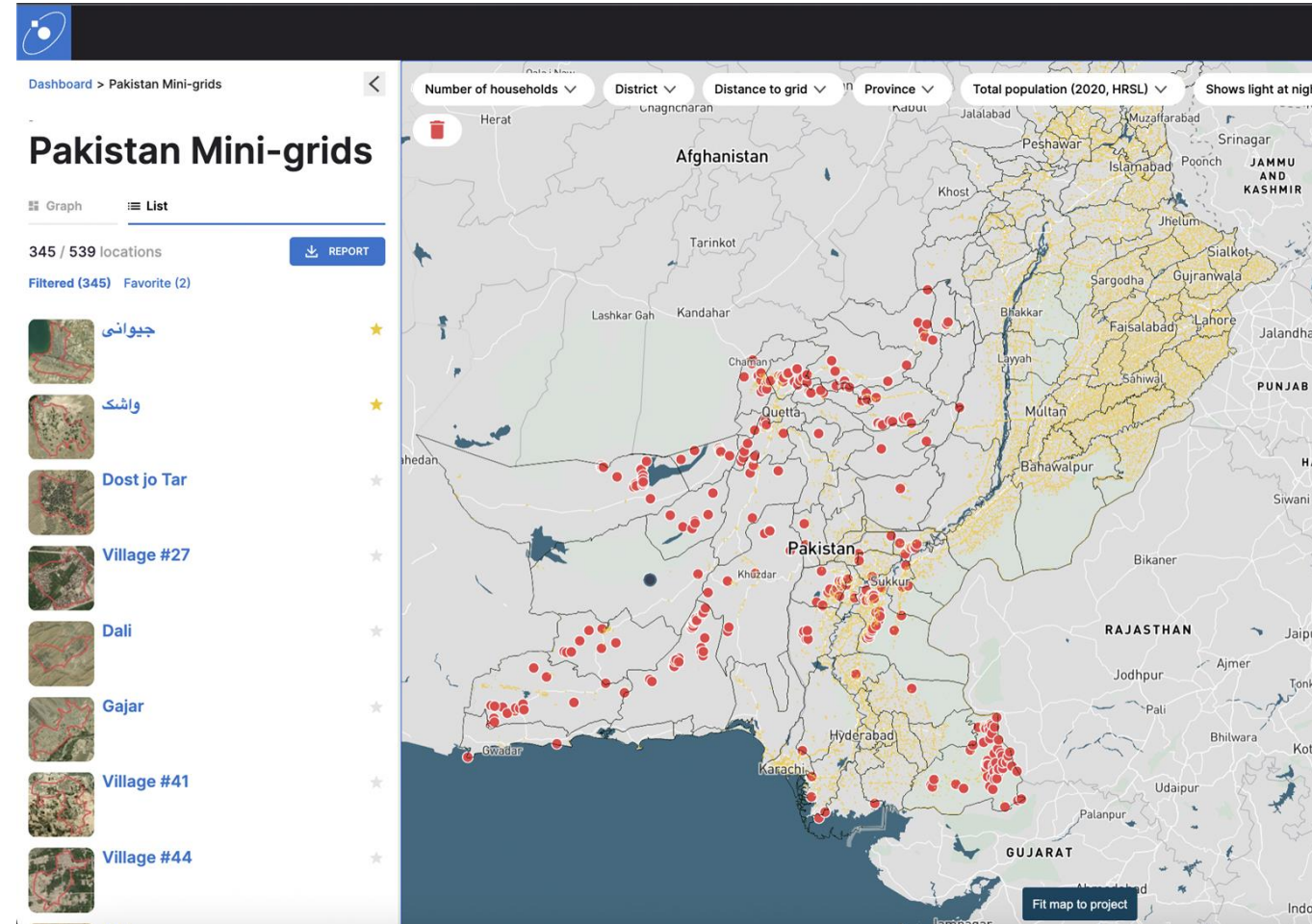
23 sites have 500-2000 people



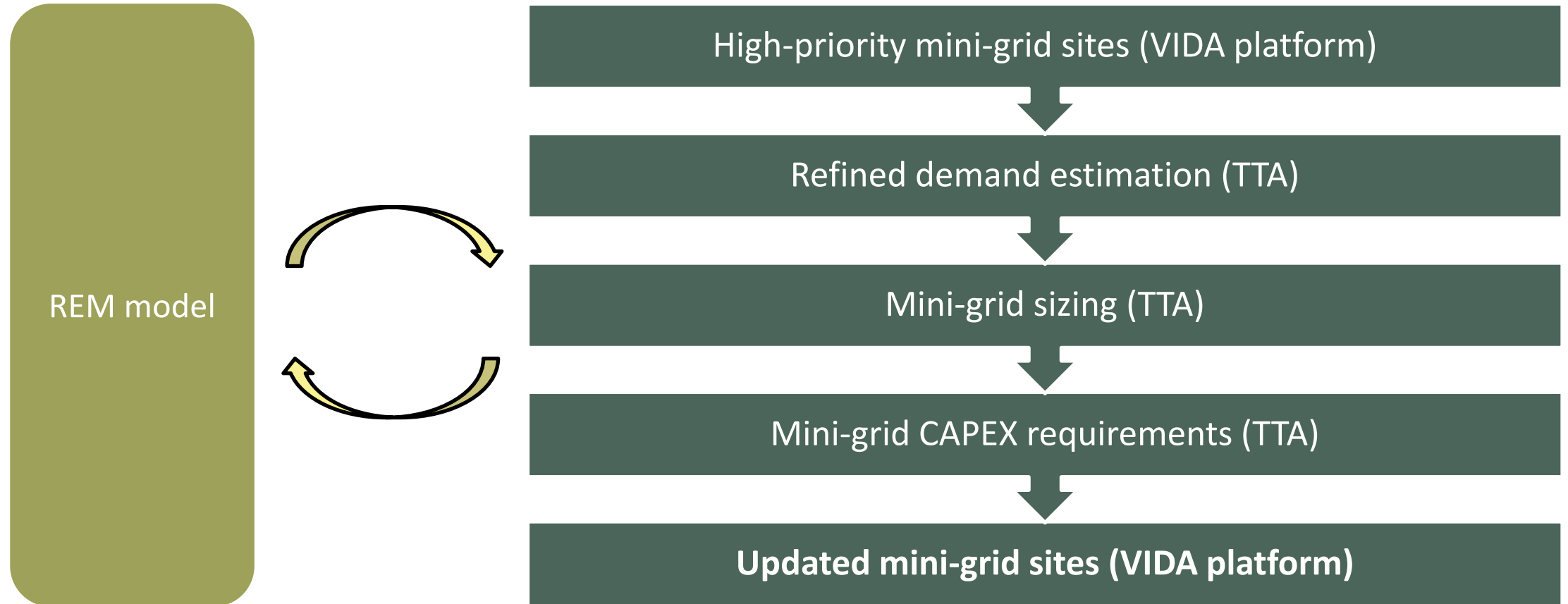
4. MINI-GRID PRIORITIZATION AND ASSESSMENT

MINI-GRID ASSESSMENT

- Beyond looking at the national electrification plan, we have used **Village Data Analytics (VIDA)** to identify potential high-priority electrification sites across the country.
- These sites are considerable in size and can benefit from isolated electrification today (2022). These sites can potentially be interconnected with grid in the future.
- TTA's expertise in mini-grid viability analysis information is integrated to provide granular information about the sites



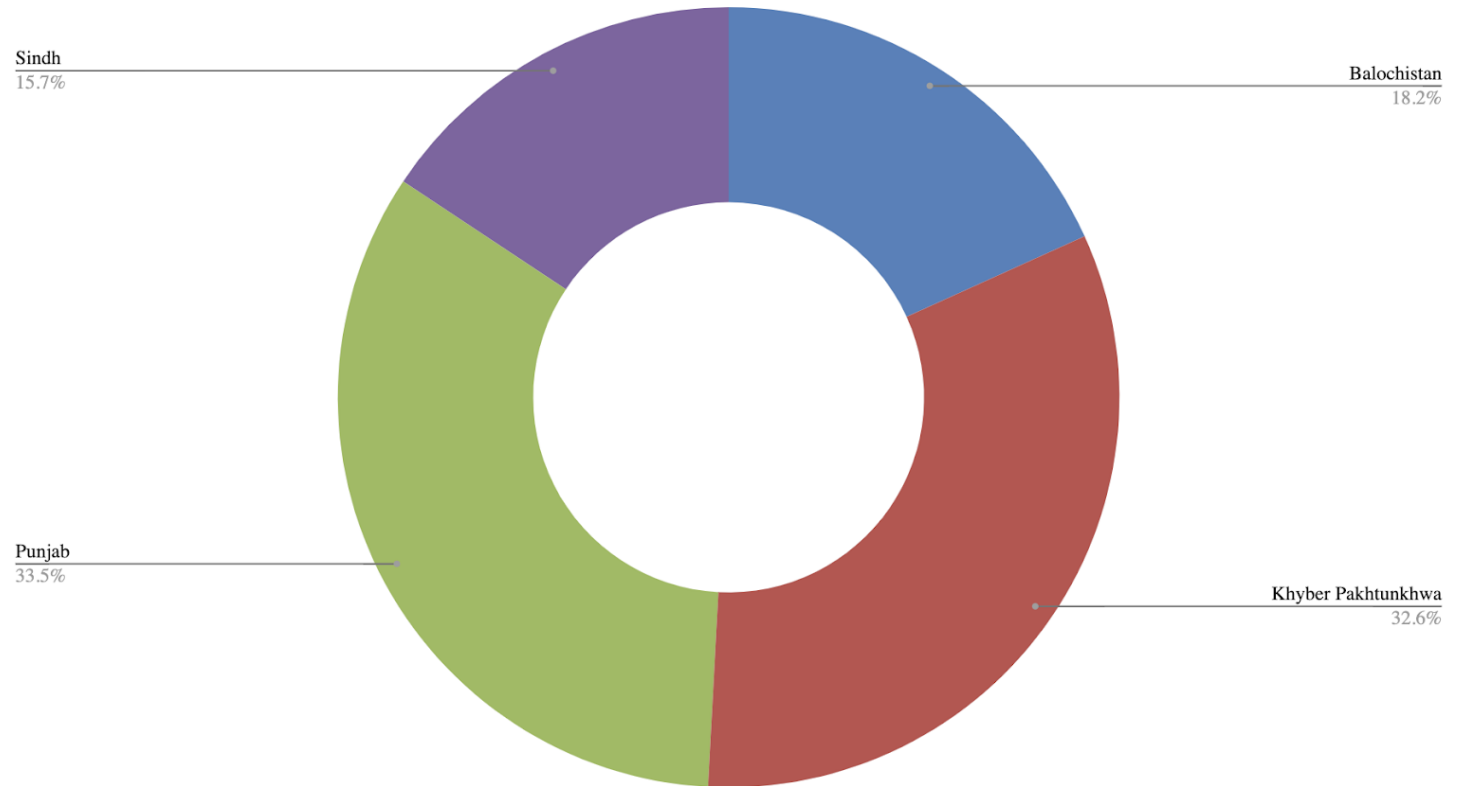
METHODOLOGY



VIDA ANALYSIS

Using VIDA's clustering algorithm, VIDA identified **1,015 potential mini-grid sites** in the country, distributed across the four provinces as follows: 159 in Sindh, 185 in Balochistan, 331 in Khyber Pakhtunkhwa, and 340 in Punjab

Number of potential mini-grid sites



VISUALIZATION PLATFORM

Dashboard

LEAST-COST MINI-GRID ELECTRIFICATION

Pakistan Mini-grids

1,015 / 1,015 locations

DOWNLOAD

All (1,015) Favorite (0)



پيپل کھڑھی

COUNTRY RANK: 1



Village #2

COUNTRY RANK: 2



باڑھ

COUNTRY RANK: 3



Village #4

COUNTRY RANK: 4



خار

COUNTRY RANK: 5



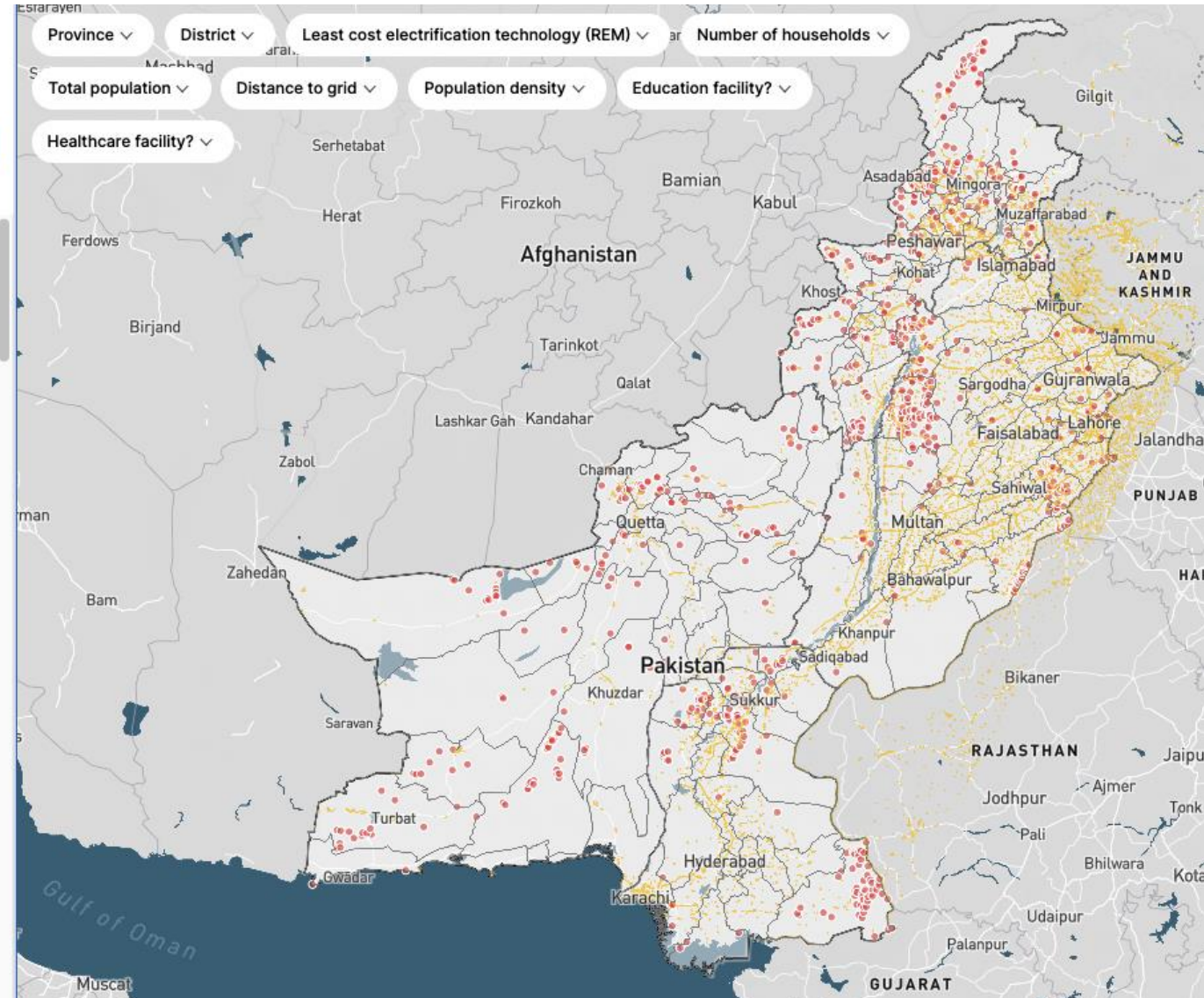
Village #6

COUNTRY RANK: 6



جیوانی

COUNTRY RANK: 7



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VISUALIZATION PLATFORM

Dashboard > Pakistan Mini-grids

جيوانی
25.0455, 61.7474

Country Rank: 7

SETTLEMENT STATISTICS

Province	Balochistan
District	Gwadar
Village area	2.9 km ²
Number of households	2,048
Total population	13,314
Population density	4,524 ppl/km ²
Shows light at night	no
Distance to grid	3.9 km
Least cost electrification technology (REM)	mini-grid

ACCESSIBILITY

Name of closest regional hub	جيوانی
Distance to closest regional hub	0 km

SOCIAL INFRASTRUCTURE

Number of health centers	1
Number of schools	6

AGRICULTURE

Top-5 dominant crops	wheat, rest_of_crops, banana, tropical_fruit, cotton
Total agricultural area	13 ha
Total yield	6,200 kg/ha

OTHER

Annual average temperature	26 °C
Poverty Index	0.6

[Edit data](#)

Layers

- Electricity Access
 - Existing 11kV national grid
 - Electrified areas
- Village
 - Minimum spanning tree
 - Village Hulls
 - Village Centroids
- REM Results
 - Potential grid extension network
 - Potential grid extension sites
 - Potential mini-grid sites
 - Potential mini-grid network
- Road
 - OSM Roads
- Social Infrastructure
 - Healthcare Facilities
 - Education Facilities
- Other
 - Districts

Mapbox

5. QUESTIONS AND ANSWERS

Thank You

Roger Sallent

TTA Regional Team Leader Asia-Pacific

Roger.sallent@tta.com.es