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Renewable Energy Planning, Analysis, and the Data that Make Them Possible: An Assessment for Lao PDR

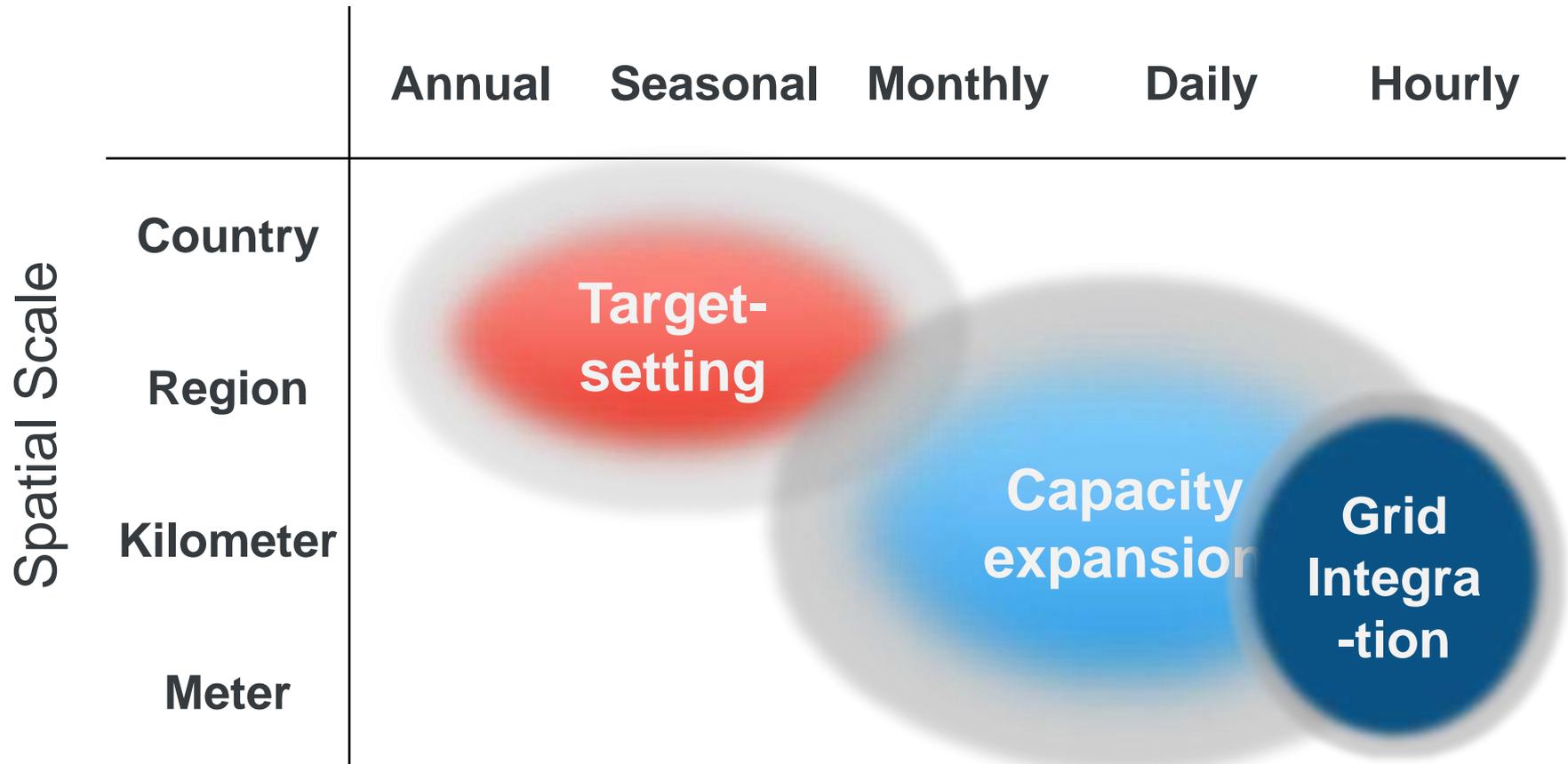
Anthony Lopez, Jessica Katz, and Ricardo Oliveira, April 2017

Purpose of Assessment

- To facilitate the informed use of existing data by highlighting applications for these data as they relate to priority RE analyses (and energy analysis generally)
- To inform future investments in data collection and development by identifying significant data gaps and providing guidance on how to fill these gaps
- To produce an accompanying detailed report and workbook

Space and Time: The Key Dimensions of Data

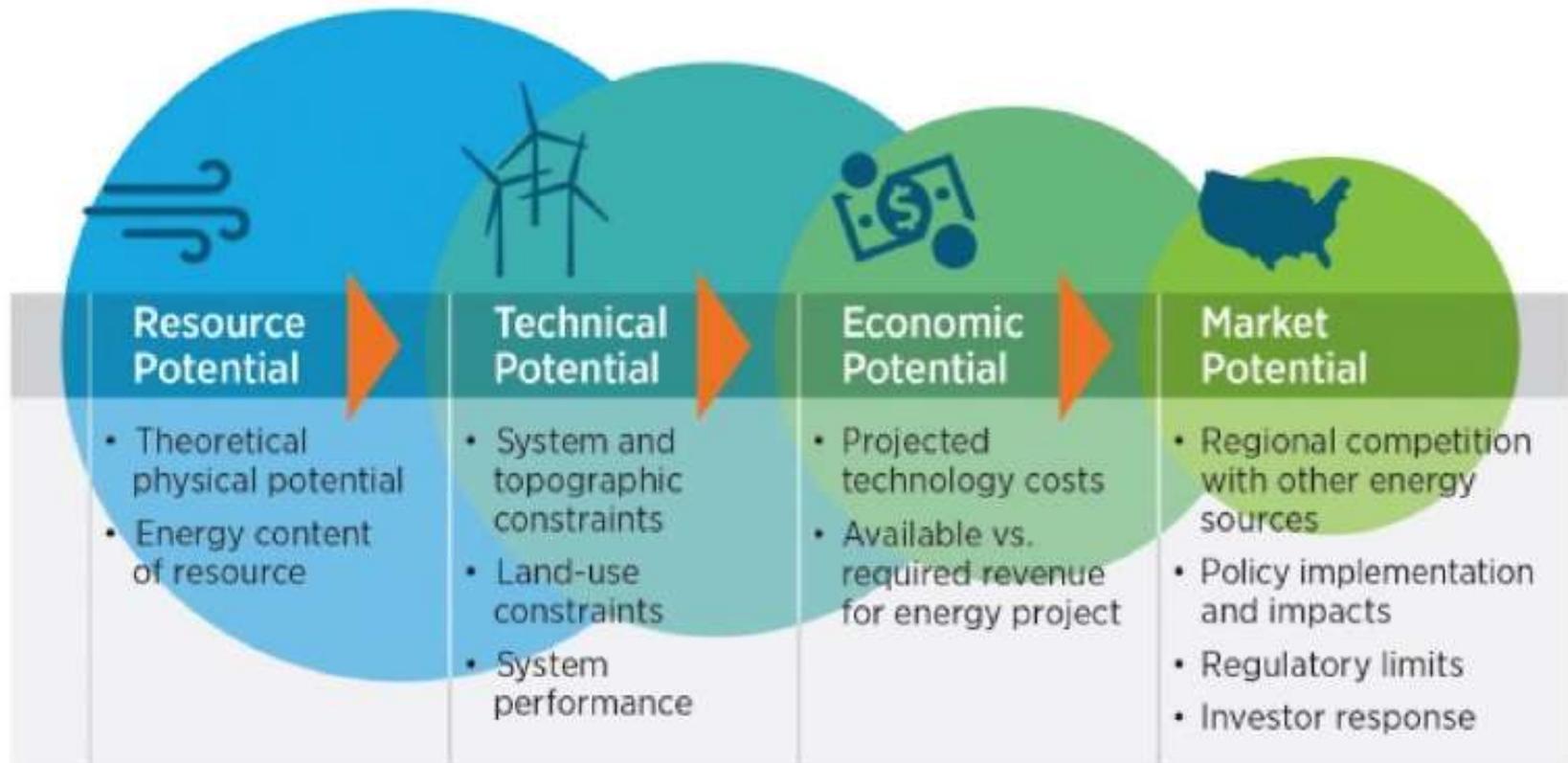
Temporal scale



Priority Analysis Topics

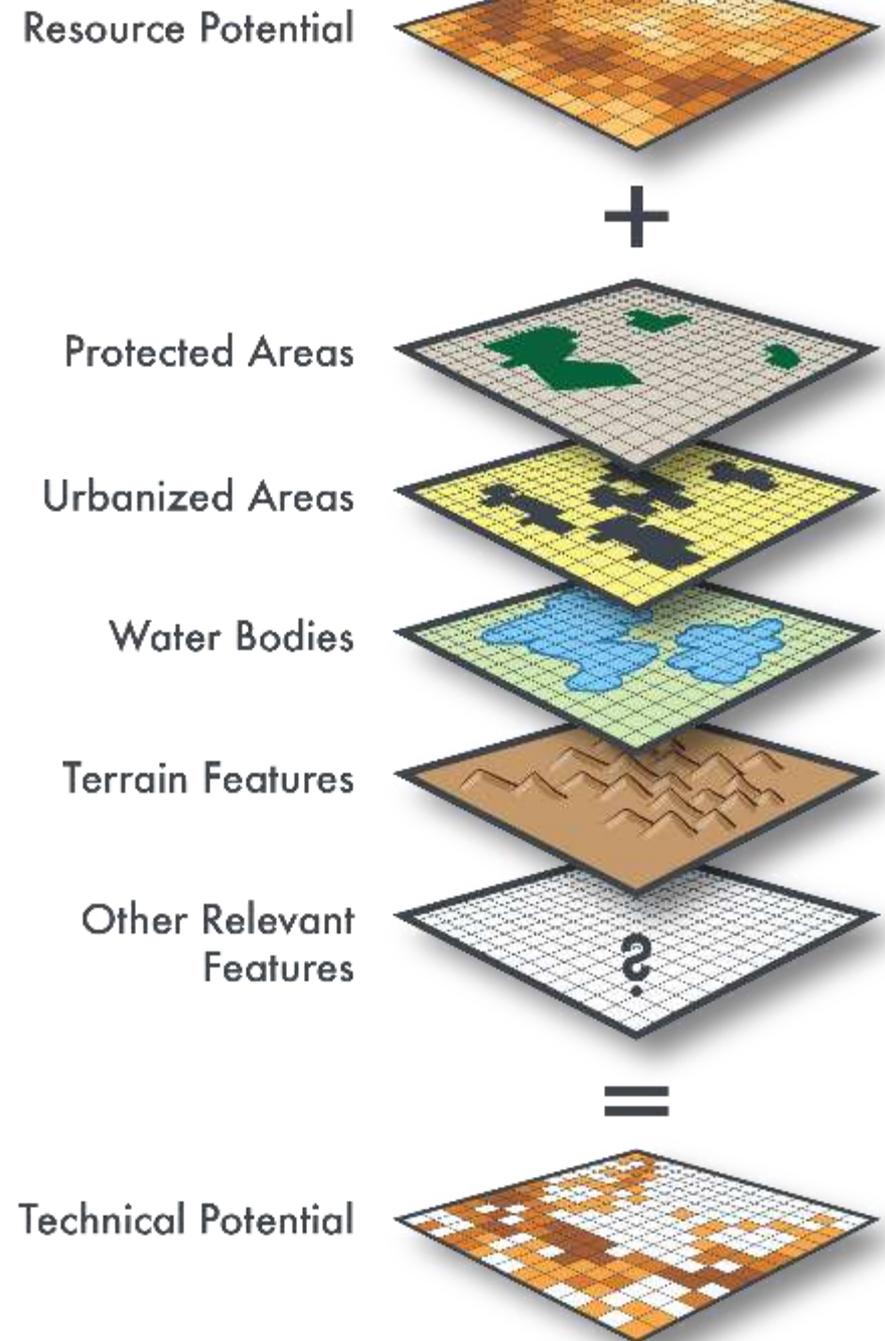
- Technical potential
- Economic potential
- RE Zones
- Grid integration studies
- Distributed solar PV
- Resilience/risk
- Energy access

What is “Energy Potential”?



Technical Potential

- The achievable energy capacity and generation of a particular technology given system performance, topographic limitations, environmental, and land-use constraints
 - *Does not consider technology costs*

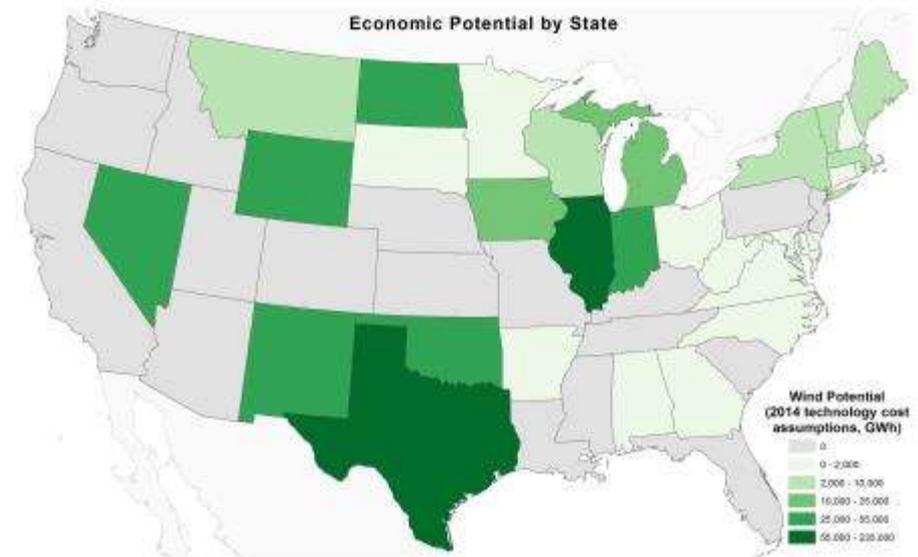
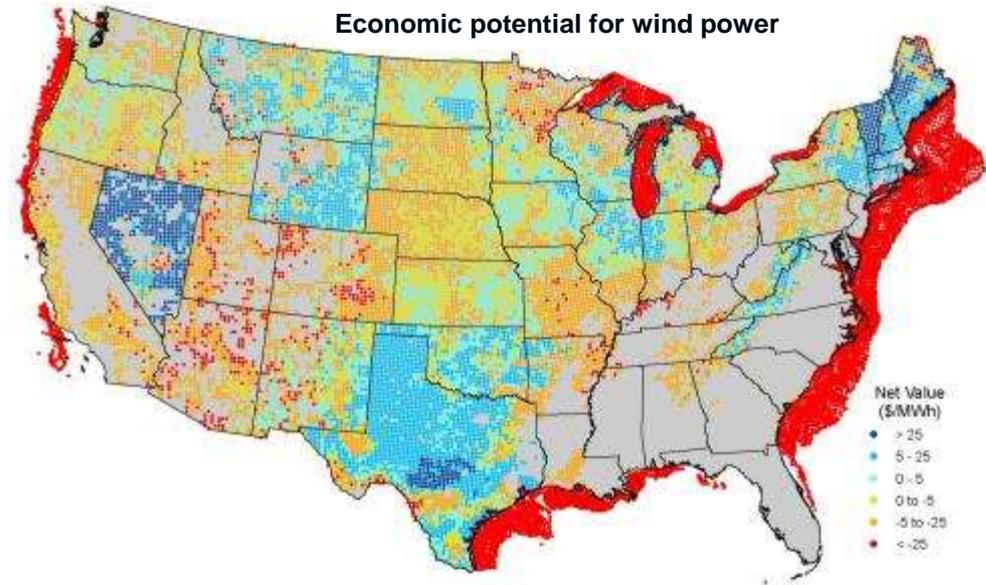


Technical Potential – Data Requirements

- **Resource** (*annual average temporal resolution sufficient**)
 - Annual average solar (~10km), wind (<2km*), biomass (province, district, on-site), geothermal, hydro, etc.
- **Environmental**
 - Land-use, land-cover, protected areas, sensitive flora and fauna, rivers, lakes, topography, elevation
- **Other**
 - Population, land ownership, technology assumptions

Economic Potential

- Economic potential is defined as the subset of the available resource technical potential where the cost required to generate the electricity is below the revenue available in terms of displaced energy and displaced capacity



Economic Potential – Data Requirements

- **Same requirements as technical potential, plus:**
 - **Hourly solar and wind resource**
 - **Seasonal data for biomass resources**
 - **Levelized Cost of Energy (LCOE) for each technology**
 - Plant construction cost
 - Operations and maintenance cost
 - Fixed operating cost
 - Variable operating cost
 - Fixed charge rate
 - Intra-regional transmission cost
 - **Levelized Avoided Cost of Energy (LACE)**
 - Marginal generation or wholesale energy market price
 - Projected energy price

Renewable Energy Zones

- What are RE Zones?
 - Areas with a high concentration of high-quality, easily-developable renewable energy potential
 - A tool for transmission planning



Renewable Energy Zones – Data Requirements

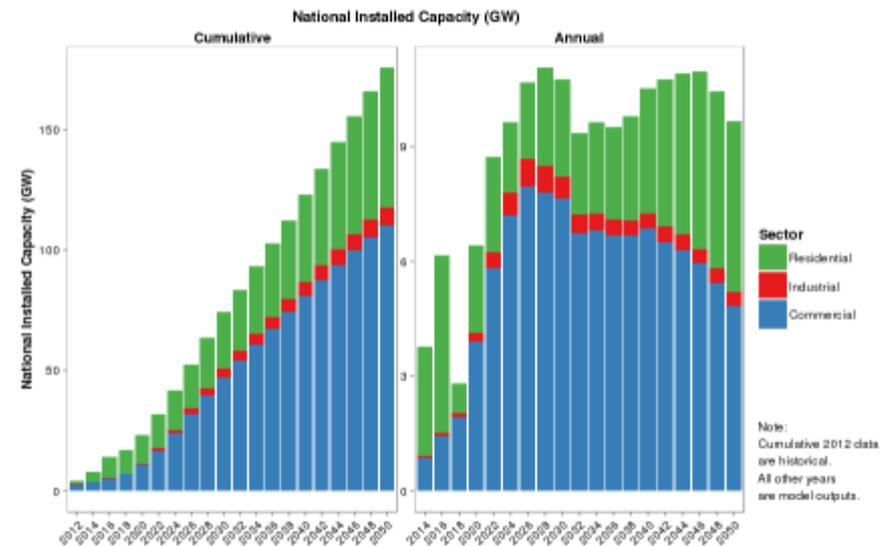
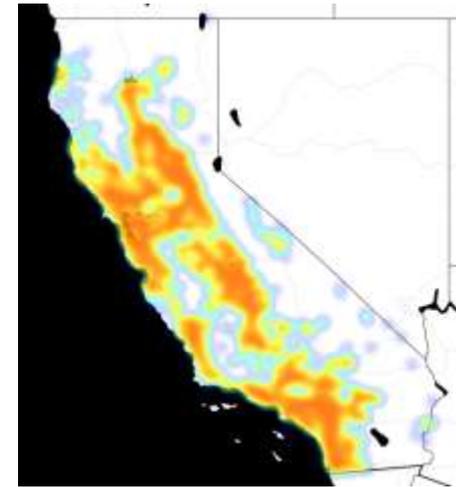
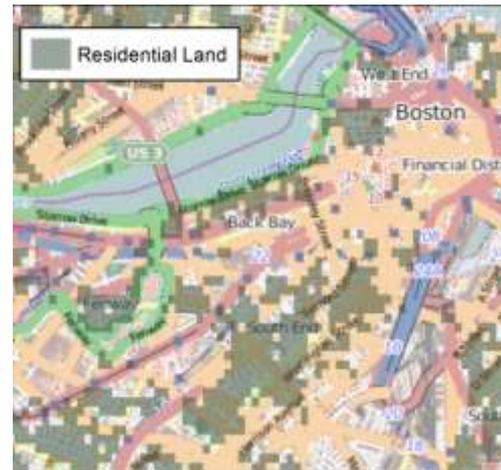
- **Same requirements as technical potential, plus:**
 - **Infrastructure**
 - Electric transmission lines [detailed, non-hypothetical]
 - Electric substations [detailed, non-hypothetical]
 - Roads
 - Rail
 - Navigable rivers
 - Ports
- **Economic potential requirements are helpful**
(*not necessarily required**)

Grid Integration – Data Requirements

- **Same requirements as technical potential, plus:**
 - Hourly (or sub-hourly) solar and wind resource
 - Seasonal data for biomass resources
 - Hourly (or sub-hourly) load
 - If the focus is on capacity expansion, need load and RE resource profiles for a typical year*
 - If the focus is on operations, need load data and RE resource data that are *time-synchronous* (same year and time-steps)
 - Existing and planned electric infrastructure
 - Transmission lines and nodes
 - Generator locations and operating characteristics (e.g., capacity, minimum stable level, ramp rate, heat rates, outage rates, fuel costs...)

Distributed solar photovoltaic (DGPV)

- Connected to the distribution network of a utility system
- Connected “behind-the-meter”
- Smaller scale in nature
- In most cases, not owned or operated by distribution utility



(Top Left): Evaluate adoption potential for each 200m² cell; (Top Right): Spatial focus permits regional predictions; (Bottom): Results from BAU-Mid Costs Scenario in ITC Extension analysis

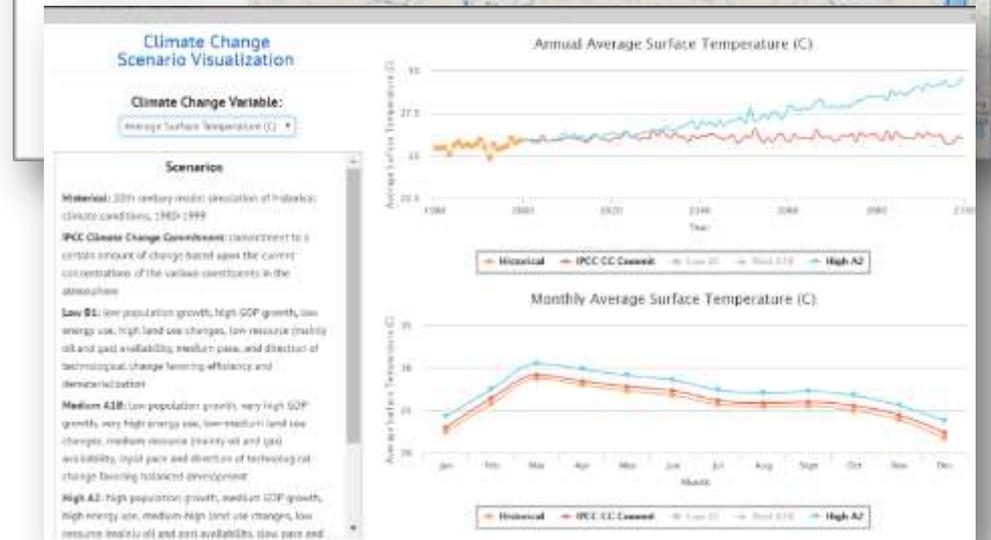
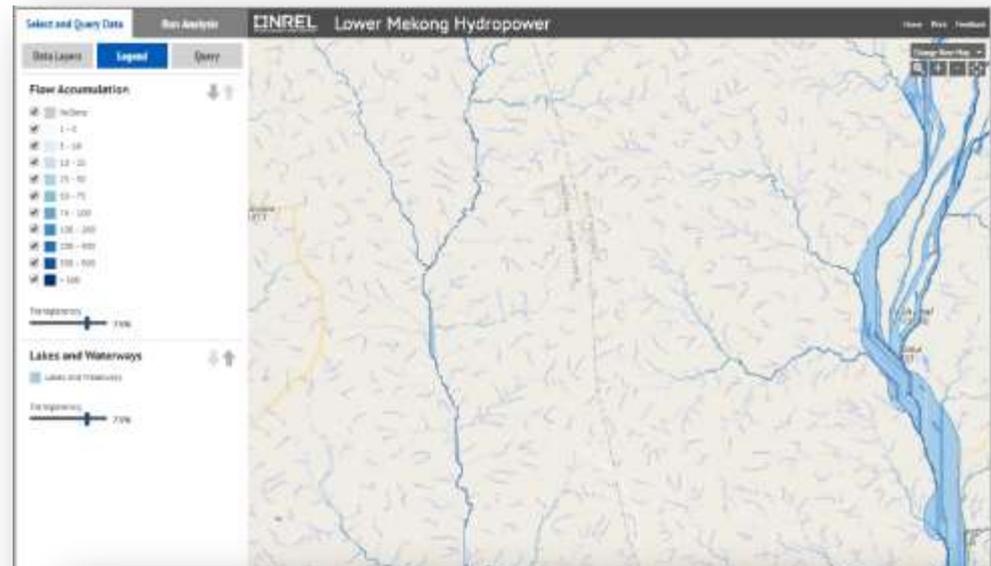
DGPV – Data Requirements

- **If we want to gain a basic understanding of the technical potential...**
 - Hourly solar resource
 - Building Inventory microdata
 - Representation of current and future building stock (counts, building type/area, occupancy rates, roof area, roof suitability)
- **If we want to model DGPV diffusion... (in addition to above)**
 - Hourly current and future Load
 - Representation of end-uses
 - Sectors, applications for DG
 - Current and future retail rate prices
 - Current and future incentives, net metering
 - Financing assumptions
 - Technology cost and performance assumptions
 - Current adoption levels
 - Where, how much

Risk and Resiliency

No standard definition, but example questions include:

- How does energy resource availability vary (e.g., by season or hour)?
- How vulnerable are future generation and infrastructure investments to natural disasters?
- Where can RE deployment potentially contribute to energy reliability (e.g., by providing backup to critical loads)?
- How might energy development impact food and water security?

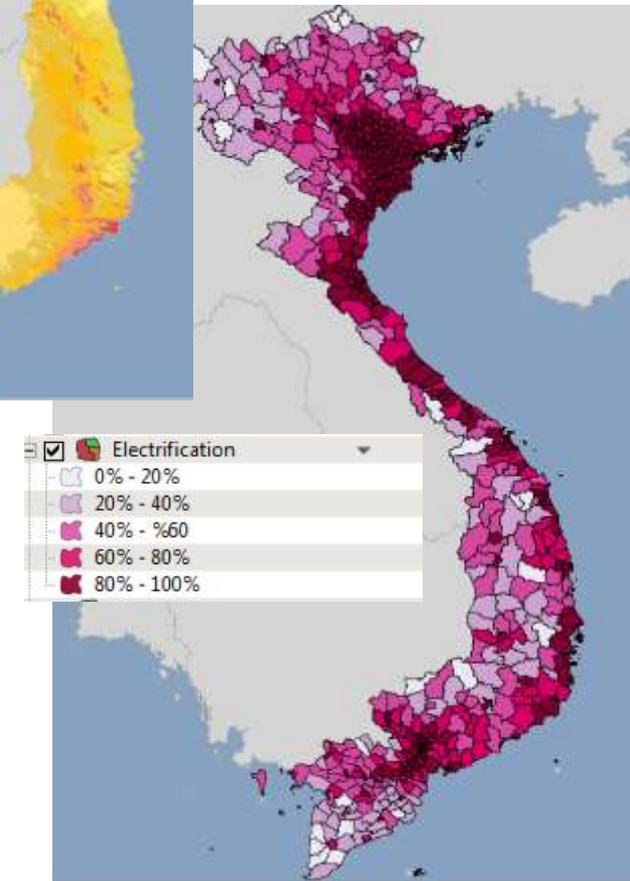
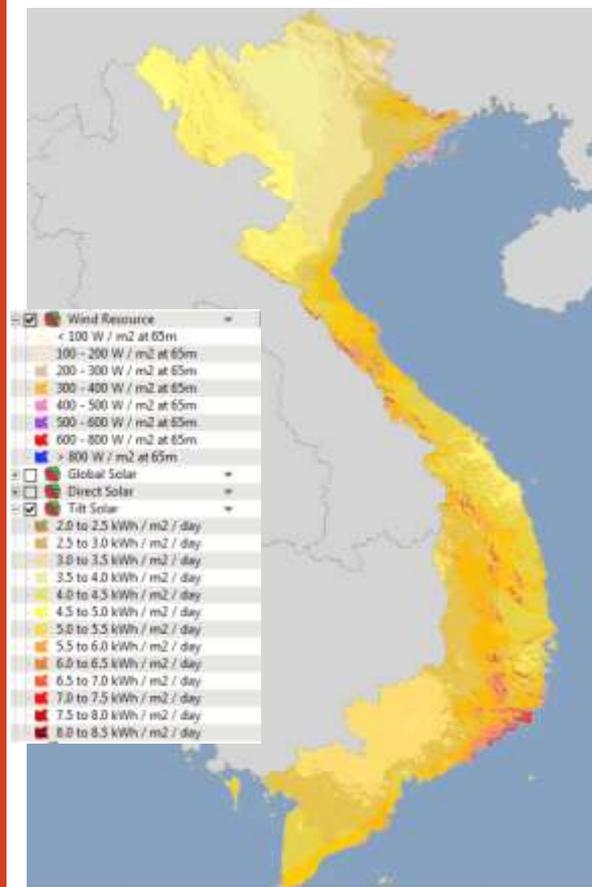


Risk and Resiliency

- **Energy resource availability**
 - E.g., annual, monthly (and hourly*) availability of hydro, biomass, wind, solar, etc.
- **Natural Hazards and Severe Weather**
 - Tsunami frequency, landslide frequency, fire risk, earthquake frequency, drought events, flood risk, heatwave risk, tornadoes risk, etc.
- **Infrastructure**
 - Electric transmission lines, substations, natural gas pipelines, roads, rail, navigable rivers, ports, power plants, critical loads, etc.
- **Food and water security**
 - Productivity of croplands, distribution of population relying on subsistence farming, access to electricity, water and other critical infrastructure, poverty, energy technology footprint, ...

Energy Access

- Where might renewables support the electrification of off-grid communities?



Electrification data requirements

- **Same requirements as technical potential, plus:**
 - Population distribution
 - Poverty rates [district-level or higher resolution]
 - Electrification rates [district-level or higher resolution]
 - Existing and planned transmission lines and substations (*not required if high-resolution electrification rates are available**)

Lao PDR Data Assessment

Organization

- Data collection is organized into the following categories
 - Renewable energy resource (wind, solar, biomass, geothermal, and hydropower)
 - Power network
 - Ancillary meteorology
 - Environmental
 - Market and demand
 - Transportation
 - Administrative other

**This preliminary data assessment is based on our team's efforts to mine primarily publicly-accessible data sources, with some input from Lao stakeholders on other data sources. This list is not exhaustive, and we welcome guidance on additional data sources!*

Resource – Wind

- **Highlights:** Highest quality, freely available wind resource available from the Danish Technical University (DTU)
 - Long-term annual average wind speed at 50m, 80m, 200m
 - Long-term annual average wind power density at 50m, 80m, 200m
- **Analysis Applications (existing data):** Technical Potential, Economic Potential, RE Zones, Resilience and Risk, Electrification
- **Recommendations:** Creation or procurement of hourly wind speed to enable research of existing/future turbine performance/cost, wind power plants, and enable grid integration studies

Resource – Solar

- **Highlights:** Highest quality, freely available solar resource data available from the World Bank (WB)
 - Long-term annual average global horizontal irradiance
 - Long-term annual average direct normal irradiance
 - Long-term annual average optimal-tilt PV electricity
- **Analysis Applications (existing data):** Technical Potential, Economic Potential, RE Zones, Resilience and Risk, Electrification
- **Recommendations:** Creation or procurement of hourly solar irradiance to enable research of existing/future utility-scale PV systems (e.g. 1-axis tracking, fixed-tilt, etc.), rooftop PV (various orientations/tilts), and enable grid integration analysis

Resource – Biomass

- **Highlights:** Freely available, partial biomass resource data from Lao PDR Ministry of Agriculture and Forestry by province
 - Annual crop residues (rice husk, cane bagasse, cassava stock residue, and maize cob)
 - National estimates of livestock production also available from Asian Development Bank (ADB) for assessing biogas potential
- **Analysis Applications (existing data):** Technical Potential, Economic Potential, RE Zones, Resilience and Risk, Electrification
- **Recommendations:** Creation or procurement of more detailed crop residues data (e.g. district, sq.km, on-site), biogas estimates at finer than national level resolution, forest residues data (e.g. logging residues, mill residues).

Resource – Geothermal

- **Highlights:** Geothermal energy resources in Lao PDR have not been assessed for electricity generation. Surface manifestations (ex. – hot springs used for tourists) do exist. These resources are small in size and have water temperatures <70 degrees Celsius (MEM 2011). A total of 59 MW of potential resource capacity has been identified (MEM 2011; IES and Mekong Economics 2016).
- **Analysis Applications (existing data): N/A**
- **Recommendations:** Create a database/list and maps of name and locations of known hot springs and other geothermal anomalies. As a first step, collect and analyze water samples (geothermometry) from all sites and catalogue existing geologic studies. Encourage universities to perform field mapping and geologic analysis of these areas to create a base of knowledge.

Resource – Hydropower

- **Highlights:** While datasets representing the existing Hydroelectric power plant locations were identified, no datasets of hydro resources were found in this preliminary data mining exercise.
- **Analysis Applications (existing data):** N/A
- **Recommendations:** Need to identify or share hydro resource spatial datasets. Hydro resources are limited in what can be assessed by global satellite observations. Suitability is very dependent on site level characteristics (e.g. geology, environment, social considerations, access, etc.)

Power Network

- **Highlights:** Ministry of Energy and Mines maintains data on the locations of existing and planned transmission lines and substations, the latest version of which covers the 2016-2025 planning period. MEM, EDL, and EDL-Generation also collect hourly load data at various spatial resolutions and some information on the characteristics of generators and transmission network elements, though the scope of the latter data is not clear. MEM's power network data—while not public—is likely sufficient to conduct several analysis topics
- **Analysis Applications (existing data):** Economic Potential, RE Zones, Grid Integration Studies, Resilience and Risk, and Electrification
- **Recommendations:** Consider making a limited set of transmission data (e.g., high voltage transmission lines and substations) publicly available to support analysis by private sector developers or investors

Ancillary Meteorology

- **Highlights:** Data is available from NASA Surface meteorology and Solar Energy website, however is spatial course and contains daily averages.
- **Analysis Applications (existing data):** Resiliency and Risk
- **Recommendations:** Depending on procurement of solar and wind data (these can come with met data), hourly ancillary met data could be pulled/processed for free from reanalysis datasets e.g. NCEP Climate Forecast System (CFRS) or NASA Modern Era Retrospective-analysis for Research Applications (MERRA)

Environment

- **Highlights:** Good coverage from diverse regional and global entities
 - Protected Plant (national parks and protected areas)
 - USGS Global Land Cover
 - National Regulatory Authority – Contaminated Lands
 - Drought events from Decide Laos
 - General climate data from Greater Mekong Subregion Information Portal
- **Analysis Applications (existing data):** Technical Potential, Economic Potential, RE Zones, Resilience and Risk, Electrification
- **Recommendations:** Laos has great coverage from global and regional data portals, however is lacking in strictly local datasets that may get at more nuanced land-use and development policies, which would ultimately impact the available supply of renewable energy. One possible path is to work with local stakeholders and experts to identify priority exclusionary locations.

Market and Demand

- **Highlights:** The Electricity Statistics Yearbook from the Energy and Mines and Lao PDR National Sustainable Energy Strategy report provide broad coverage for market and demand data.
 - Commercial/residential/industrial electricity price
 - Peak demand
 - Electricity consumption
- **Analysis Applications (existing data):** Economic potential
- **Recommendations:** Hourly load data is recommended to be able to conduct grid integration studies

Transportation

- **Highlights:** Publicly available transportation data is available through crowd-sourced data on OpenStreetMap (OSM). Unfortunately, the completeness and accuracy is unknown and thus requires validation.
- **Analysis Applications (existing data):** Economic Potential, RE Zones, Risk and Resiliency
- **Recommendations:** Transportation data is important for understanding nuances of RE construction and deployment (among other things). For example, can large turbines be constructed in a location and trucked to the install location? Recommend validating completeness of OSM or identifying local source of information

Administrative / Other

- **Highlights:** Rich database from which to draw the “other” category. Population density can serve as load proxy and is also important for understanding potential development barriers or for understanding populations at risk of natural hazard events. Lao PDR also has a rich statistical database of land use and farms at the national, provincial, and district level hosted by Lao DECIDE
- **Analysis Applications (existing data):** Technical Potential, Economic Potential, REZ Zones, Grid Integration Studies, Distributed Solar PV, Resiliency and Risk, Electrification
- **Recommendations:** To enable detailed distributed Solar PV estimates and analysis, creation of building inventory “microdata” is recommended.

Summary of priority datasets

- Hourly wind, solar, and load to enable detailed analysis of RE potential. Spatially resolved data is ideal for wind and solar, nodal or zonal (e.g. city or district) spatial resolution for load
 - Custom Generator modeling
 - Distributed rooftop PV assessment
 - Grid integration studies
- Detailed biomass information at the district or site level

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