Prototype Overview – Energy Development Index (EDI)

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Overview

This mini project came together over a few long commutes, reworking parts of an older prototype into something I thought could be interesting to explore. It's a lightweight proof of concept showing how satellite imagery and socioeconomic data might reveal mismatches between electricity use and population/economic growth.

In short, the Energy Development Index (EDI) helps surface two key patterns:

- **Latent demand**: regions where grid infrastructure hasn't scaled with rising population and GDP.
- **Energy poverty**: communities with persistently low electrification despite economic potential.

While early-stage, this framework hints at how a more advanced version could support energy planners, investors, and policy teams working towards equitable and sustainable energy transitions.

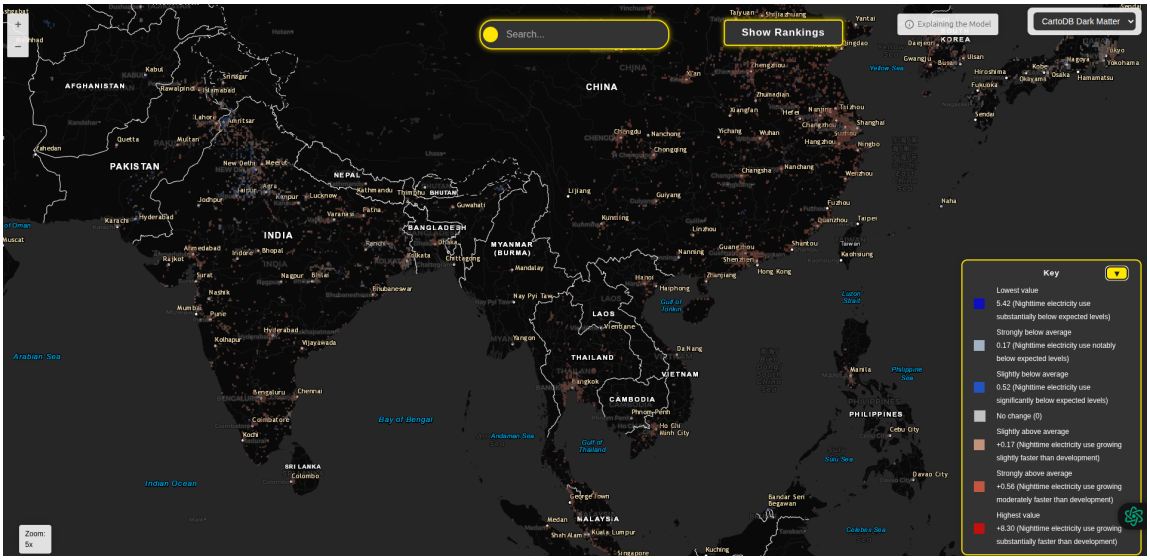

Figure 1: Prototype map interface showing ΔEDI across South and East Asia. Color scale indicates nighttime electricity use relative to expected levels based on population and GDP per capita.

View Interactive Prototype Here

Potential Applications

The Energy Development Index provides a geospatial decision-support layer that could drive sustainable growth and energy transition efforts. Three primary applications:

1. Identifying Latent Demand for Energy Infrastructure

The EDI highlights regions where electricity access lags behind socioeconomic development, enabling organizations to:

- Prioritize countries or subnational regions for renewable energy investment (solar, wind).
- Identify areas for decentralized microgrid deployment in off-grid communities.
- Estimate potential market size for energy access solutions.

2. Supporting LNG and Grid Strategy

The EDI can inform downstream energy strategy by:

- Spotting high-growth regions where LNG or grid upgrades could bridge energy gaps.
- Guiding infrastructure planning and investment decisions in emerging economies.
- Helping B2B marketing teams engage governments/utilities in markets with unmet energy needs.

3. Enabling Energy Transition Planning

For policy and strategy teams, the EDI acts as a geo-socioeconomic lens to:

- Prioritize regions where clean energy projects would deliver the most socio-economic impact.
- Align initiatives with sustainability goals (Net Zero, UN SDG 7).
- Support ESG reporting by demonstrating contributions to energy equity.

Conceptual Foundation

The Energy Development Index estimates relative energy development for each geographic unit by combining:

- **Nighttime light intensity** (L_t) – a proxy for aggregate electricity use.
- **Population count** (P_t) – proxy for potential energy consumers.
- **GDP per capita** (G_t) – proxy for economic capacity to demand energy.

The core insight: electricity consumption depends not only on population but also on economic capacity.

Mathematical Formulation

For a given tile t at time t:

$$EDI_t = \frac{\log(L_t)}{\log(P_t)} \cdot \log(G_t)$$

Where:

- $\log(L_t)/\log(P_t)$: Electricity use relative to population.
- $\log(G_t)$: Amplifies demand potential based on income levels.

This highlights areas where rising GDP may unlock latent energy demand.

Temporal Dynamics: ΔEDI

Change in EDI over time (ΔEDI) offers insight into electrification trends:

- **Positive** ΔEDI: Electricity use outpaces population and GDP growth $\rightarrow$ rapid electrification.
- **Negative** ΔEDI: Electricity use lags $\rightarrow$ possible infrastructure gaps or persistent energy poverty.

Map Interpretation and Key

The prototype map visualizes ΔEDI using a color-coded scale:

- **Blues**: Nighttime electricity use below expected levels.
- **Reds**: Nighttime electricity use growing faster than expected.
- **Grey**: Areas showing minimal change.

This helps identify regions for:

- Grid-scale electrification and infrastructure upgrades.
- Decentralized energy solutions in underserved communities.
- Demand-side management in high-income zones with negative ΔEDI.