Estimating lost dividends from incomplete energy access transitions

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- Modern energy access as a conduit of opportunity, growth, and well-being

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  - Universal electrification and clean fuel access by 2030
  - Improved efficiency and renewables share
- Electricity contributes to poverty reduction, health improvements, sustainable settlements, gender equality (Boateng et al., 2020; Chakravorty et al., 2014; Gertler et al., 2017; Irwin et al., 2020)

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- Significant advances in electrification to reach 90% with at least basic access (IEA, 2021)
  - Prompts consideration of dimensions of electricity access (Groh et al., 2016; Nerini et al., 2015)

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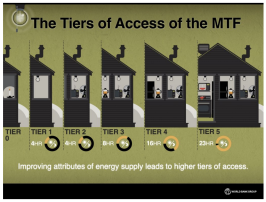

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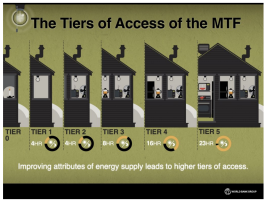

- The **Energy Access Dividend** (EAD) quantifies the electrification benefits forgone over a country's business-as-usual electrification transition

Estimating the EAD

$$EAD = \sum_{t=0}^{T_s} \sum_{y=1}^{Y} \sum_{\forall g \in G} (1+\delta)^{-y} (B_{t_0,t_1=T_s,y,g}) \cdot f_{t_0,t_1=T_s,y,g} \cdot H_{y,g} \tag{1}$$

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- $B_{t_0,t_1=T_s,y,g}$: benefits of electricity access
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- $H_{y,g}$: total number of households
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- δ: discount rate
- Flexible framework that can be adjusted based on context and data availability
  - Applied to a case study in Honduras, 2021-2050

Achieving universal electrification in Honduras

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- Electrification rate 91% nationally
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- Main generating sources mix of fossil fuels (55%), hydro (33%), and rewnewables (12%)
- Residential accounts for a little under half of all energy consumption
- Grid services most of the west
  - Low population density, challenging terrain in the east

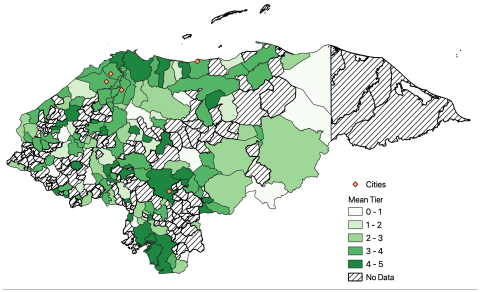

Figure 1: Mean electricity access tier by municipality

Electrification trajectories

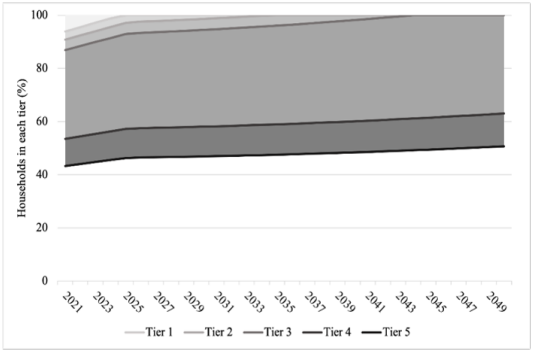

Figure 2: Baseline 1: Slower tier progression

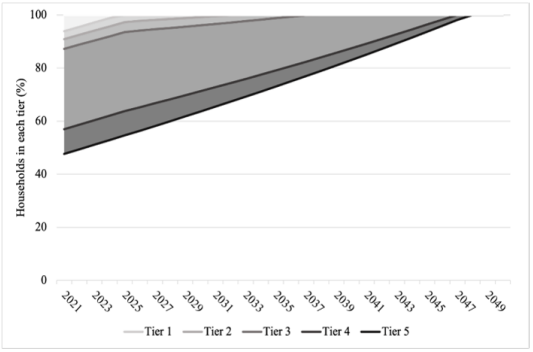

Figure 3: Baseline 2: Faster tier progression

Characterizing electrification scenarios

Table 1: EAD Scenarios

Scenario	Process	Time frame	Policy relation
Electrified EAD	Immediate tier 1 transition	2021-2028/36	Universal access
Tier 5 EAD	Immediate tier 5 transition	2021-2050	Universal grid
Tier 3 EAD	Immediate tier 3 transition	2021-2050	Microgrid and renewables
Hybrid EAD	Immediate tier 5 (urban) or tier 3 (rural) transition	2021-2050	Combination

Quantification and monetization of benefits

- Included benefits
  - **Lighting:** Reduced expenditures on kerosene
  - **Mobile phone charging:** Reduced expenditures on phone charging outside the home
  - **Emissions:** Reduced emissions from more highly polluting lighting fuels (Jeuland et al., 2018) and monetized using the social cost of carbon
  - **Study time:** Changes in study time valued using wage returns to education
  - **Assets:** Changes in asset (fan, radio, tv, refrigerator) ownership valued using consumer surplus
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- Regression used to estimate significant differences in expenditures between electricity access tiers

MTF household survey for Honduras

- Survey characeristics
  - 2800 households across rural and urban Honduras
  - Identification of electricity access tiers
  - Household energy access and use across a variety of sources
  - Socio-demographic characteristics, assets, income-generating activities, time use

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- Use MTF data to estimate

$$Y_i = \alpha + \beta_1 T_i + \beta_2 T_i \times U_i + \rho X_i + \varepsilon_i \tag{2}$$

  - Outcomes include: kerosene consumption, cell phone charging expenditures, study time (boys, girls), asset ownership (radio, fan, tv, refrigerator), business expenditures due to power outages

Estimated benefits by tier

Table 2: Electrification benefits by tier

Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
• Lighting	• Phone charging^{R}	•Study time (B)^{U}	•TV	•Study time (G)^{U}
•Phone charging	•Study time (G)^{U}	•TV	•Business expenditures	•TV^{U}
•Emissions	•Fan	•Refrigerator		
•Radio^{U}	•TV			
	•Refrigerator			

Parameterization, cont.

- Descriptive statistics from MTF data
  - Household size, number of children
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  - Kerosene price
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  - Emissions global warming potential and social cost of carbon
  - Wage returns to education
- Consumer surplus calculations for assets owned
  - Panama (2008) LSMS
  - Elasticities from the literature

Household annual EAD

Table 3: Household annual EAD

	Electrified EAD		Tier 5 EAD		Tier 3 EAD		Hybrid EAD	
	(1) Urban	(2) Rural	(3) Urban	(4) Rural	(5) Urban	(6) Rural	(7) Urban	(8) Rural
Non-tiered	43.35	51.44						
Tier 0			129.99	105.59	74.11	56.66	129.99	56.66
Tier 1			117.28	79.57	61.40	30.65	117.28	30.65
Tier 2			81.89	59.27	26.01	10.34	81.89	10.34
Tier 3			55.88	48.93	0	0	55.88	0
Tier 4			3.21	0	0	0	3.21	0
Tier 5			0	0	0	0	0	0

Cumulative EAD

Table 4: Cumulative EAD

	Business-as-Usual		Electrified EAD		Tier 5 EAD		Tier 3 EAD		Hybrid EAD	
	(1) Urban	(2) Rural	(3) Urban	(4) Rural	(5) Urban	(6) Rural	(7) Urban	(8) Rural	(9) Urban	(10) Rural
Non-tiered	0.70	0.76	1.71	15.46						
Baseline 1	1078.6	725.0			797.7	385.5	39.4	59.4	797.7	59.4
Baseline 2	1200.9	732.0			394.7	302.1	20.9	49.4	394.7	49.4

EAD contributions by benefit type

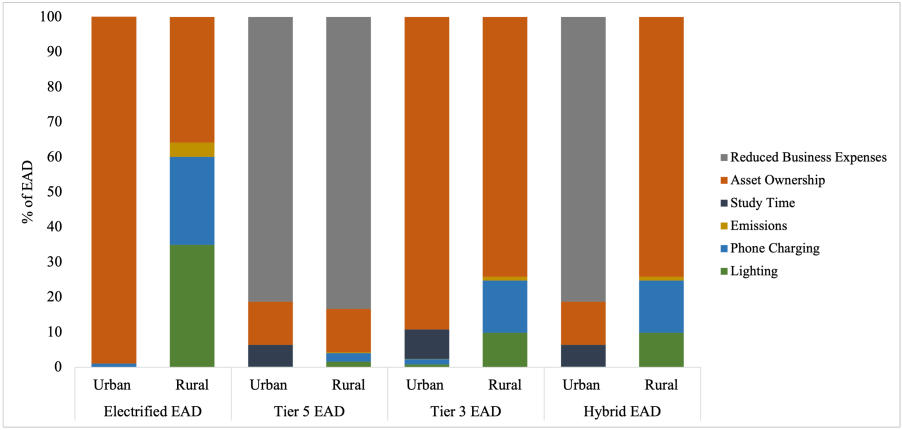

Figure 4: Distribution of benefits

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  - Focus on all energy sources and fuel types
- Capturing a point in time
- Comparability across countries is a key strength
  - Context-specific, relevant energy policy
- Speaking to benefits beyond the household, especially the operation and growth of firms
- Costs of enhanced electricity access—for households and society

Policy impact of the EAD

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- Need for policymakers to develop electrification plans that confront the trade-offs of different electrification trajectories

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