



Towards a New Measurement of Energy Poverty: A Cross Community Analysis of Rural Communities of Pakistan

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Energy Poverty

- *A state of insufficient energy sources for basic living – energy requirement satisfying human needs range between 1.0 to 1.3 TOE per annum (0.8 HDI) (Pokharel, 2006)*
- *A state where households are spending more than 10 percent of their income (DFID, 2002)*
- *An absence of sufficient choice in accessing adequate, affordable, reliable, high quality, safe and environmentally benign energy sources (Reddy, 2000)*



Rural Communities in Developing Countries

- *Higher proportion of rural population*
- Remote and dispersed
- *More Heterogeneous than often considered*
- *Relationship between Energy and Poverty*
- Different combination of energy sources
- Combinations differs:
 - between rich and poor households (Energy Ladder, Leach 1987, 1992)
 - due to different needs: Cooking & Lighting



Conceptual Framework

- *Energy Inconveniences*
 - *the degree of physical difficulties involved in accessing a particular energy source to meet household energy needs.*
 - Use of traditional energy sources always comes with associated inconveniences
 - Closely linked with the poverty due to higher opportunity costs
 - Zero Inconvenience assumed with the use of electricity and natural gas



Measuring the Energy Inconveniences

- 7 Identified Energy Inconvenience Indicators
 - I. Buying (collection) frequency
 - II. Household Distance covered *
 - III. Means of transport used *
 - IV. Household involvement *
 - V. Time spent on energy collection per week *
 - VI. Household health
 - VII. Children involvement in energy collection *

*= common indicators



Step 1: Computing the Inconvenience Index for each Indicator

- Inconvenience scores allocated to each response based on the degree of inconvenience experienced for each indicator
- General formula for Index (Haq et al., 1990; Sullivan, 2002; Sullivan et al., 2003)

$$X_{cij} = \frac{X_i - X_{i(\min)}}{X_{i(\max)} - X_{i(\min)}}$$

Where X_{cij} = the index for indicator, $X_{i(\min)}$ = minimum value from sample,

$X_{i(\max)}$ = maximum value from sample

C = capita,

i = the type of inconvenience indicator,

j = the type of energy source,



Buying (Collection) Frequency Index (BFI)

- Refers to the number of times household buy or collect a given energy source in one week
- Differentiation between ‘buying’ and ‘collection’
- 90.7% households are firewood users
 - 53.4% buy firewood,
 - 41% collect
 - 5.7% do both, collect and buy firewood.

$$\overline{BFI}_j = \frac{BF_j - BF_{j(\min)}}{BF_{j(\max)} - BF_{j(\min)}}$$

- *hs* dependent variable (bar represents controlled variables)
- Calculated for each household in the sample



Step 2: Computing the Energy Inconvenience Index at Energy Source level

$$EII_{cj} = \frac{\sum_{i=1}^n X_{cij}}{N_i}$$

- EII_{cj} = the *Energy Inconvenience Index* (per capita) for a given energy source j in a given household,
- $\sum_{i=1}^n X_{cij}$ = the sum of inconvenience index for each inconvenience indicator i for a given energy source j .
- N_i = the number of inconvenience indicators relevant for a given energy source (i.e., for traditional biomass $N_i=7$, for kerosene $N_i=6$ and for LPG $N_i=5$).

Step 3: Computing the Energy Inconvenience at Energy Mix level for each household

- Inconvenience controlled for the kilowatt hours produced by a single energy source

$$TEI_c = \frac{\sum_{j=1}^6 KW_{hj}}{\sum KW_{hj}} \times (EII_{cj})$$

- $\frac{KW_{hj}}{\sum KW_{hj}}$ gives us the share of energy in kwh
- Sum of energy inconvenience for a given energy mix gives us TEI_c (per capita)

Step 4: Defining the Energy Inconvenience Threshold level

- Threshold level or Cut-off point required for measuring the energy poverty
- 30% above the sample mean TEI_h (value = 0.249) defined as threshold level
- Using the value of the TEI , The *total energy inconvenience threshold*, $TEIT_h$ is calculated as

$$TEIT_h = 0.249 * 1.3 = 0.323$$

below which rural households are considered to be at acceptable levels of energy inconvenience. Above the threshold level, the inconvenience is an aspect of energy poverty.



Step 5: Defining the *Energy Inconvenience Excess (EIE)* at household level

- For meaningful interpretation, index score difference are converted into percentages

$$EIE_c = \left(\frac{(TEIT_c - TEI_c)}{TEIT_c} \right) \times 100$$

- Where EIE_c refers to the Inconvenience Excess per capita. EIE_c is expressed in percentages. A negative sign indicates that rural households are in the state of excess of inconveniences whereas a positive sign indicates that households are in the state of 'convenience'.



Step 6: Calculating the Energy Shortfall (ES) for households

- Using Pokharel (2006) threshold level of 1TOE/capita/annum, ES is computed using household energy consumption levels
- TOE converted in kwh/week to standardize it with survey data
- All energy sources are converted into kwh using standard energy content (in kwh) for each energy source

$$ES_c = \left(\frac{(AEC_c - TER_c)}{TER_c} \right) \times 100$$

- Where AEC_c = the *actual energy consumption per capita*
- TER_c = the *threshold energy requirements* (in kilowatts) per capita (156.55 kwh per week per capita [based on 0.7TOE])

Note: To control for the negative and positive signs and their subsequent interpretation, we subtracted the TER_h from the AEC_h instead of subtracting the AEC_h from the TER_h . In this way, energy shortfalls per capita are represented by negative values whereas energy excess per capita is represented by positive values.



Step 7: Computing the *Energy Poverty Level (EPL) (per capita)*

- In hand: % values of EIE_c and ES_c
- Giving equal weightage to both composite indicators, we can compute the *Energy Poverty Levels* per capita as following

$$EPI_c = \frac{1}{2} \times (EIE_c + ES_c)$$

- *the energy poverty index is represented in percentages, where positive values indicate that non-energy poor individuals, whereas negative values indicate the energy poor.*

Results: Mean EI scores across Villages and Districts

District	Village	Firewood bought	Firewood Collected	Animal Waste	Plant Waste	Kerosene	LPG
		Mean EI Scores					
Chakwal	Chawintra	0.34	0.31	0.26	0.32	0.31	0.41
	Dhok Wadan	0.35	0.32	0.28	0.36	0.27	0.39
	Mona	0.25	0.36	0.29	0.26	0.25	0.29
Chakwal District Average		0.31	0.33	0.27	0.31	0.27	0.36
	243Roshan Wala	0.30	0.35	0.26	.	.	0.37
	Dasuha	0.34	0.38	0.31	.	0.25	0.30
	Ram Diwali	0.30	0.35	0.31	.	.	0.39
Faisalabad District Average		0.31	0.36	0.29		0.25	0.35
Gujrat	panjoria	0.24	0.21	0.22	.	0.28	0.32
	Bagga	0.32	0.34	0.26	.	0.27	0.38
	Nogaran	0.28	0.28	0.25	.	0.26	0.37
Jhelum District Average		0.30	0.31	0.25		0.27	0.38
	Salam Nagar	0.33	0.34	0.29	.	.	0.31
	Sham ke Bhatiyan	0.29	0.31	0.29	.	.	0.30
Lahore District Average		0.31	0.32	0.29			0.30
Layyah	Ali Alla	0.31	0.33	0.22	0.28	0.38	.
	Bangalwali	0.11	0.25	0.30	0.19	0.34	.
	Basti Tilkan	0.27	0.35	0.31	0.29	0.35	.
Layyah District Average		0.23	0.31	0.28	0.25	0.36	



EII by Energy Sources and Income Groups

	<i>Firewood bought</i>	<i>Firewood Collected</i>	<i>Animal Waste</i>	<i>Plant Waste</i>	<i>Kerosene</i>	<i>LPG</i>	<i>TEI*</i>
	<i>Mean EII Scores</i>						
Lowest Income	0.34	0.35	0.32	0.35	0.36	0.40	2.12
Lower Income	0.34	0.37	0.28	0.35	0.33	0.40	2.07
Middle Income	0.31	0.34	0.28	0.32	0.34	0.35	1.94
Upper Middle Income	0.30	0.32	0.26	0.31	0.32	0.34	1.85
Upper Income	0.29	0.27	0.28	0.22	0.26	0.32	1.64
Total	0.32	0.33	0.28	0.31	0.32	0.36	1.92

The Mean EII is the weighted average of household scores, with the share of energy source in total energy use as weight. The mean value TEI is an unweighted average of household scores.

Lowest Income Group = Rupee (Re) 1. till Rupees (Rs) 3000; Lower Income Group = Rs. 3001-5000; Middle Income Group = Rs. 5001-8000; Upper Middle Income Group = Rs. 8001-12000; Upper Income Group = Rs. 12001 and above

Source: Energy Poverty Survey.



Energy Poverty across income groups

	<i>Energy Inconvenience Excess (EIE)</i>		<i>Energy Shortfall (ES)</i>		<i>Energy Poverty Index (EPI)</i>	
	Mean (%)	HCR(%)	Mean (%)	HCR(%)	Mean (%)	HCR(%)
Lowest Income	11.0	34.1	-70.3	99.3	-29.6	92.8
Lower Income	10.4	32.8	-72.8	97.4	-31.2	95.8
Middle Income	19.4	24.1	-72.4	97.8	-26.5	93.4
Upper Middle Income	30.4	13.6	-69.8	98.5	-19.6	92.6
Upper Income	32.2	11.0	-65.6	97.0	-16.7	91.1
Total*	22.8	19.5	-70.0	97.9	-23.5	92.8

* Sample Mean; Sample Size = 640, total household members = 4816.

Note: Negative percentages denote inconveniences, shortfalls and poverty, whereas positive percentages denote conveniences, excess and prosperity for EIE, Energy Shortfall and EPI respectively.

Energy Inconvenience Threshold Level or Inconvenience Line = 0.323; Energy Shortfall Threshold or Line = 156.55/capita/week (based on 0.7TOE/capita/annum requirements); Lowest Income Group = Rupee (Re) 1. till Rupees (Rs) 3000; Lower Income Group = Rs. 3001-5000; Middle Income Group = Rs. 5001-8000; Upper Middle Income Group = Rs. 8001-12000; Upper Income Group = Rs. 12001 and above

Source: Energy Poverty Survey



Comparison with DFID's Definition

	<i>Energy Expense Excess (%)</i>	<i>HCR (%)</i>	<i>EPI (%)</i>	<i>HCR* (%)</i>
Lowest Income	-21.00	71.5	-29.6	92.8
Lower Income	-15.62	57.5	-31.2	95.8
Middle Income	-15.31	71.5	-26.5	93.4
Upper Middle Income	-10.93	76.5	-19.6	92.6
Upper Income	-4.39	68.4	-16.7	91.1
Total*	-12.12	69.8	-23.5	92.8

* Sample Mean; Sample Size = 640, total household members = 4816.

Note: Negative percentages denote energy poverty, whereas positive percentages denote energy prosperity in Energy Expense Excess and EPI indicator only (and not for HCR columns).

Energy Inconvenience Threshold Level or Inconvenience Line = 0.323; Energy Shortfall Threshold or Line = 156.55/capita/week (based on 0.7TOE/capita/annum requirements).

Lowest Income Group = Rupee (Re) 1. till Rupees (Rs) 3000; Lower Income Group = Rs. 3001-5000; Middle Income Group = Rs. 5001-8000; Upper Middle Income Group = Rs. 8001-12000; Upper Income Group = Rs. 12001 and above.

Source: Energy Poverty Survey

Conclusions

- Devised a new inclusive methodology to analyse the relative energy poverty among rural households in a given community, region or country.
- Provides a quantitative measure to compare the energy poverty level among households and communities
- Also, complements to energy income indicators, much referred in energy and development literature
- Basis for further research on determinants for energy inconveniences and energy poverty



Thank you