CASE STUDY ON NEPAL:
POWER AND PEOPLE: THE BENEFITS OF
RENEWABLE ENERGY

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Nepal has low access and energy shortage amidst high hydro potential

- Nepal is one of the poorest countries in the world, with 70% of its 27 million people residing in rural areas.
- Access is low and inequitable particularly in poor rural areas. Only 30% in rural areas have **access** to electricity
- Rural households are dependent primarily of oil-based and renewable energy alternatives
- Nepal is in energy crisis with a peak demand of 700 MW and serious load shedding
- Only 600 MW of available 83,000 MW potential of hydropower has been exploited so far
- Decentralized service delivery in the form of Micro-hydro (MH) and Solar PV serve 6-7% of Nepal’s population particularly in rural areas
AEPC is the nodal organization responsible for promoting renewable technologies

- Alternative Energy Promotion Center (AEPC), an agency under the Ministry of Environment, has emerged as one of the world’s leading proponents of community and private sector led expansion of renewable energy technologies in rural areas.
- AEPC’s mandate is policy and plan formulation, resource mobilization, coordination and quality assurance.
- AEPC’s programs primarily relate to Micro/mini hydro & Improved Water Mills, Solar energy (PV and thermal), Biogas, Improved cooking stoves, Wind energy, Geothermal.
MH Projects have been contributing to rural electrification

- Micro-hydro (MH) projects are implemented under Rural Energy Development Program (REDP) of AEPC.
- REDP started in 1996 in 5 districts with funding from UNDP. WB joined the effort in 2nd phase in 2003.
- As of June 2011, about 30,000 rural HHs in about 50 districts have been benefitted from MH projects.

![Diagram showing the number of projects, Kw, and HH (No.) from 1998 to 2009.](chart.png)
Benefits of Micro-hydro Projects
Assessing Needs for M & E

Evolution in Rural Electrification Benefits Evaluation

- Economic benefits: Utility revenues = “minimum willingness to pay” + avoided costs
- 40 Years: Consumer Surplus introduced based on kWh usage
- 30 Years: Consumer Surplus refined: Lumens demand based on actual estimates of lighting values
- 20 Years: Expanded approach: Include hard to measure benefits - education, communication, entertainment, etc
- 10 Years: Today - All of the above, but now focusing on end-use demand including productive uses of energy, integration with rural development schemes, and other activities
Poorest MH households in rural Nepal enjoy a consumer surplus of about 12% of income

- Consumer surplus is the difference between willingness to pay and actual pay
- The primary benefit of MH is better quality lighting – for Households & Enterprises.
- Kerosene is 400 times more expensive than MH when measured by lighting intensity.
- Average consumer surplus by switching from kerosene-based lighting to electricity based lighting is 2.2 percent of income.
- Consumer surplus in income decreases consistently from low to high income quintile households.
- The poorest quintile saves almost 50 percent of their income.
## Baseline Sample and Questionnaire

<table>
<thead>
<tr>
<th>Total Sample</th>
<th>2,500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment HHs</td>
<td>1,500</td>
</tr>
<tr>
<td>Control HHs from treatment area</td>
<td>400</td>
</tr>
<tr>
<td>Control HHs from project areas*</td>
<td>300</td>
</tr>
<tr>
<td>Control HHs from non-project area*</td>
<td>300</td>
</tr>
</tbody>
</table>

*Project areas are where MH installation will take place in next 2-3 years, and non-project areas are where no MH installation will take place in foreseeable future.

### Questionnaire

The Household Questionnaire consisted of modules on socio-economic attributes and use of energy. The Community Questionnaire consisted of modules on the community prices of different energy sources and consumer goods; wages of males, females, and children; and community infrastructure. The Enterprise Questionnaire consisted of modules on the energy use pattern of local microenterprises and benefits of MH on the products and services produced by those enterprises.
IE Technique: Randomized Control Treatment

- **Pre-requisite**: Program participation (MH connectivity) is randomly assigned.
- **Assumption**: Treated group is comparable to control group (in terms of pre-treatment characteristics).
- **Impact** = Mean outcome of treated group – Mean outcome of control group
- **Was NOT used because**:
  - Pre-requisite was not satisfied.
  - Households self-selected into program (MH adoption)
  - Treated and control groups are NOT comparable
IE Technique: Instrumental Variable Method

- **Advantage:** If unobserved factors affect program participation and the outcomes (violation of PSM assumption), IV can control for them.
- **Condition:** Implementation depends on finding suitable instrument variable(s) which must satisfy two criteria:
  1) Instrument(s) must directly influence program participation.
  2) Instrument(s) must not directly affect the outcomes, but only indirectly through program participation.
- **Was NOT used because:**
  We could not find any suitable instrument that satisfies the two conditions.
IE Technique: Propensity Score Matching

- **Assumption:** Unobserved factors do not affect participation and outcomes.
- Propensity Score (PS) = Probability of participation (MH connectivity) based on pre-treatment characteristics.
- First, PS is calculated for both treated and control households using a probit/logit regression.
- Second, PS of treated and control households are compared and only those are kept who match one another in terms of their PS.
- Third, Impact = (Mean outcome of treated group – Mean outcome of control group) for the matched sample
- **Was used because:**
  - A reasonably good IE technique when program participation is not randomized, control sample is large and selection of observed characteristics is large.
## Benefits of access to Micro-Hydro Plants
### MH Advantage – Economic Outcomes

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>MH HHs</th>
<th>Non-MH HHs</th>
<th>Difference (%)</th>
<th>PSM estimates (nearest neighbor match)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total income</td>
<td>1,894.4</td>
<td>1,561.4</td>
<td>0.109 (1.56)</td>
<td>0.076 (0.71)</td>
</tr>
<tr>
<td>Farm income</td>
<td>1,029.2</td>
<td>932.2</td>
<td>0.153 (1.43)</td>
<td>0.180 (1.03)</td>
</tr>
<tr>
<td>Non-farm income</td>
<td>865.2</td>
<td>629.2</td>
<td>0.353 (2.53)**</td>
<td>0.110 (1.80)*</td>
</tr>
<tr>
<td>Expenditure</td>
<td>1,456.2</td>
<td>1,263.1</td>
<td>0.039 (1.92)*</td>
<td>0.062 (1.79)*</td>
</tr>
</tbody>
</table>

MH connectivity increased household’s non-farm income by 11 percent and expenditure by 6 percent.
Benefits of access to Micro-Hydro Plants
MH Advantage – Educational Outcomes

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>MH HHs</th>
<th>Non-MH HHs</th>
<th>Difference</th>
<th>PSM estimates (nearest neighbor matched)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys’ completed schooling years</td>
<td>4.53</td>
<td>4.12</td>
<td>0.405</td>
<td>0.024</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1.50)</td>
<td>(0.10)</td>
</tr>
<tr>
<td>Girls’ completed schooling year</td>
<td>4.28</td>
<td>3.73</td>
<td>0.551</td>
<td>0.304</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1.97)*</td>
<td>(1.82)*</td>
</tr>
<tr>
<td>Boys’ evening study (minutes/day)</td>
<td>50</td>
<td>34</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3.63)**</td>
<td>(3.32)**</td>
</tr>
<tr>
<td>Girls’ evening study (minutes/day)</td>
<td>40</td>
<td>30</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2.19)**</td>
<td>(1.81)*</td>
</tr>
</tbody>
</table>

- Boys’ educational outcomes are slightly better than that of the girls regardless of MH connectivity.
- Boys and girls from MH households reveal higher study times than their counterparts from non-MH households.
## Benefits of access to Micro-Hydro Plants

### MH Advantage – Health Outcomes

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>MH HHs</th>
<th>Non-MH HHs</th>
<th>Difference</th>
<th>PSM estimates (nearest neighbor matched)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Respiratory problems</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men (age=&gt;18)</td>
<td>6.2</td>
<td>5.4</td>
<td>0.84 (0.29)</td>
<td>3.01 (1.51)</td>
</tr>
<tr>
<td>Women (age=&gt;18)</td>
<td>5.1</td>
<td>9.7</td>
<td>-4.62 (-0.91)</td>
<td>-6.15 (-1.68)*</td>
</tr>
<tr>
<td>Boys (age&lt;18)</td>
<td>1.4</td>
<td>5.1</td>
<td>-3.63 (-1.75)*</td>
<td>-4.23 (-2.50)**</td>
</tr>
<tr>
<td>Girls (age&lt;18)</td>
<td>1.3</td>
<td>8.2</td>
<td>-6.90 (-1.93)*</td>
<td>-8.09 (-3.03)**</td>
</tr>
<tr>
<td><strong>Gastrointestinal problems</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men (age=&gt;18)</td>
<td>0.9</td>
<td>2.1</td>
<td>-1.18 (-0.70)</td>
<td>-1.41 (-1.65)*</td>
</tr>
<tr>
<td>Women (age=&gt;18)</td>
<td>2.2</td>
<td>4.7</td>
<td>-2.41 (-0.80)</td>
<td>-2.55 (-1.15)</td>
</tr>
<tr>
<td>Boys (age&lt;18)</td>
<td>1.0</td>
<td>0.9</td>
<td>0.10 (0.08)</td>
<td>-0.82 (-0.76)</td>
</tr>
<tr>
<td>Girls (age&lt;18)</td>
<td>0.3</td>
<td>1.7</td>
<td>-1.40 (-0.87)</td>
<td>-0.50 (-0.51)</td>
</tr>
</tbody>
</table>

- Adult males from MH households suffer less (about 1.4 hours less per month) from GI diseases than those from non-MH households.
- MH connectivity lower boys suffering of respiratory diseases by 4 hours and girls suffering by 8 hours.
Benefits of access to Micro-Hydro Plants
MH Advantage – Women Empowerment

- Contraceptive use is slightly better and recent fertility is higher for MH households
- Women from MH households spend more time in income generation and leisure activities than their counterpart women from non-MH households
- MH access has enabled women to use their time more productively in IGA and study, while allowing them more leisure time
- Type 1 mobility of women from MH households is higher than that of women from non-MH households.
- Independence in women’s decision-making is higher in MH households than that in non-MH households.
Benefits of access to Micro-Hydro Plants

MH Advantage – GHG Emissions

- MH Households save on GHG emissions by replacing kerosene
- About 10 million kg of CO$_2$ is saved every year by MH households in Nepal
Key Messages

• The consumer surplus of moving from kerosene to electricity is immense and highest for the poorest quintile as percentage of income.
• Although extent of use of MH by rural households is still very low, its impact is significant on various facets of their lives.
• MH service is unreliable - power outage is frequent and prolonged. The complete potential of MH impacts can be realized if service delivery is improved.
• Lighting-only MH users (the majority of MH households) use electricity for only 4–5 hours during the evening, which results in a low load factor and high effective price (i.e. expensive)
Background Slides
Nepal is guided by many recent legislations in energy sector

- **1975** – Formation of Nepal Electricity Corporation
- **1984** – Nepal Electricity Act
- **1985** – Formation of NEA
- **1992 and 2001** – Hydro Power Development Policy
- **2006** – Rural Energy Policy
- **2006** – Subsidy development Mechanism
- **2006** – Three Year Interim Plan
- **1975** – Small Hydro Development Board
- **1975** – Formation of Rural Electrification Board
- **1984** – Electricity Act, Water Resources Act
- **1985** – Formation of NEA
- **1992** – Electricity Act, Water Resources Act
- **1984** – Nepal Electricity Corporation
- **1985** – Forma
The average electricity consumption of households is close to subsistence levels

- About 96% of energy consumption is from biomass
- Kerosene consumption distinguishes MH from non-MH households
- The average electricity consumption is close to subsistence levels - 4 hours of daily use of three 60-watt bulbs
- MH households use electricity mainly for lighting and only about 10% of the households use it for operating appliances.
- TV is the most common appliance. Only 7.5% of MH households own a TV.
- Average duration of power outage (scheduled & unscheduled) is 9.4 hour/day for households
- MH households primarily use kerosene lamps and candles
Poorest rural households effectively pay more per unit of electricity

- Expenditure on energy rises with rising income, but at a slower rate.
- Energy Expenditure as share of income declines from 22% in Quintile 1 to 6% in Quintile 5 with an average of 11%.
- Highest income households consume almost twice as much electricity as the lowest income households do, by paying only 32% more.