Building Capacity: Solar Photovoltaics Site Assessment and Feasibility Study

While Bhutan is abundant with clean energy hydropower, solar energy could reduce expensive power imports and bolster Bhutan's energy resilience and independence in the winter months. As the country explores solar photovoltaic (PV) development as an option for achieving that goal, utilities, grid planners, and renewable energy experts are partnering with the South Asia Group for Energy to determine the benefits and challenges of building solar energy systems in Bhutan.

Bhutan's motivation for conducting solar PV feasibility studies is primarily aimed at understanding how the country might increase solar production in the winter months to offset reduced hydropower production and achieve life-cycle savings through solar projects. Ultimately, such studies could determine whether building PV arrays is fiscally and technologically possible, help pinpoint potential barriers to installing PV, and mitigate risks by increasing transparency throughout the process.

PV system feasibility studies typically focus on items like:

- **Location assessments** for PV system components and resource availability
- **Solar resource analyses** to determine a given area's generation potential
- **Land requirements** to determine what type of PV arrays can be installed and whether land use conflicts may exist
- **Grid interconnection** capabilities to determine whether a PV system can connect to the current grid
- **Technical feasibility** to evaluate the availability of suitable PV technology
- **Financial analysis** exploring costs and potential revenue generation over the lifetime of the system
- **Regulatory and permitting requirements** to understand local, regional, and national procedures, permits, and approvals needed to build PV systems
- **Market demand analysis** to assess market demand for electricity generated by PV systems
- **Engagement with stakeholders** to address concerns, gain support, and ensure compliance
- **Risk analysis** to identify potential market, regulatory, technological, environmental, and other risks, and develop contingencies and mitigation strategies
- **Environmental impact analysis** to evaluate the potential impact of PV systems on their local environments
- **Social and economic benefits analysis** to determine the advantages PV systems can bring to communities (i.e., job creation, energy independence, and development)
- **Comparisons of alternative energy sources** to determine PV's viability against other renewable energy sources (i.e., wind, hydro, or geothermal)
- **Long-term sustainability assessments** evaluating predicted PV system lifespan, recycling options, and potential technology upgrades in the future.

Methods for Conducting PV Feasibility Studies

Performing a feasibility study entails multiple steps, and each element of the overall feasibility study requires its own procedures. Four main groups of steps must be considered during such a study.

1. Overall project delivery

Among the most important steps in the feasibility study process is site screening. At this stage in the study, surveyors, stakeholders, and researchers explore potential solar PV array locations and ascertain any necessary procurement and construction specifications.

Another key part of the process involves determining operational and maintenance costs, as well as disposal and recycling methods for PV system components as they reach the end of their life cycles.

2. Technical feasibility

The site-screening procedure for solar PV arrays helps determine what engineering complexities may arise at a given location. Solar resource at location would be determined by considering several factors, such as:

- For roof-mounted PV:
  - Roof age
  - Roof condition
  - Structural integrity.
- For ground-mounted PV:
  - Ground slope
  - Soil condition.
- Road access to installations
- Electrical interconnection locations and capacities
- Local utility policies and regulations.

Assessing these factors helps determine potential yield forecast based on solar resources and equipment efficiencies, PV module characteristics and rack orientation, specifications for inverter and electrical component configuration, installation methods, guarantees and warranties, operations and maintenance, and ongoing plant management.

3. Economic feasibility

Assessing economic and financial viability of solar PV projects is also a crucial step in any feasibility study. This portion of the study evaluates:

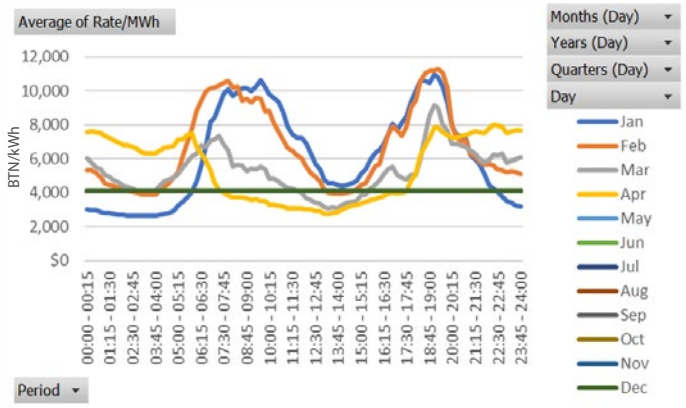
- Initial cost
- Operations and maintenance costs
- Utility and power sales revenue

Access to roads and transmission power lines is an important aspect of solar PV project feasibility. Photos show the road to Dagana candidate site and transmission line access at Jela Dzong near candidate sites in Paro, Bhutan. *Photos by Andy Walker, NREL.*

- Life cycle cost
- Levelized cost of energy
- Available incentives
- Availability and interest rates of financing.

Calculating the life cycle cost is the most important part of studying economic feasibility. Life cycle cost analyses examine every cost associated with a particular technology—in this case, solar PV over the course of its lifetime. The levelized cost of energy is calculated by adding the initial cost to the life cycle operations and maintenance cost, divided by the life cycle production of the PV plant.

The data collected and the calculations made in the economic feasibility study could provide a clearer picture of the costs and benefits of solar PV installation in Bhutan relative to power imports from India and hydropower production.



Graph showing generation valued at price of import from India valued as high as 10,000 BTN/kWh at peak times during the day, and the case of marginal hydroelectric price valued at 4,200 BTN/kWh at all times of day. *Figure by Jal Desai, NREL.*

4. Legal and compliance issues

The final major component of a feasibility study investigates legal logistics surrounding PV, such as:

- Permits for construction and operation
- Land-use planning and zoning
- Environmental concerns
- Utility agreements
- Maintenance and insurance contracts
- Cultural and historical resource concerns.

Exploring these legal and compliance issues is ensures adherence to regulatory requirements. This is particularly important in the solar PV industry, where evolving policies, safety standards, and environmental regulations can significantly impact project viability, operational efficiency, and long-term sustainability goals and plans.

Benefits of Solar PV

In Bhutan, the knowledge gained through solar feasibility studies could help planners and other stakeholders make the best possible decisions on potential solar PV installation. Bhutan could reap several potential benefits through solar PV installation, such as:

- Accommodating daytime load growth without requiring expensive power imports
- Reducing carbon emissions from fossil fuel use
- Stabilizing the energy market against conventional electric price volatility and reducing costs for consumers

Druk Green Power engineers preparing Solmetric Suneye to measure shading. *Photos by Andy Walker, NREL.*

- Helping utilities create more efficient transmission and distribution systems that are more resistant to losses
- Creating new jobs for the installation and maintenance of PV arrays
- Creating educational opportunities for local schools, universities, and visitors.

Understanding the feasibility of solar photovoltaic systems is crucial for Bhutan as it aims to enhance its energy resilience and reduce reliance on power imports during the winter months. These feasibility studies not only identify the practical and economic viability of solar projects but help pave the way for sustainable energy solutions that can provide long-term benefits to the country. A more diverse energy mix promises to advance Bhutan's goals of energy independence, environmental sustainability, and economic growth.

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The South Asia Group for Energy can work with USAID Missions and other country stakeholders to identify solutions, experts, and work programs that fit their unique needs and priorities. Learn more at www.nrel.gov/usaid-partnership/project-south-asia.html.

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