Development of a Potential Regional Hydropower Plant in South Asia: A Pre-feasibility Study

Presentation of Pre-feasibility Study Report by Shyam S. Shrestha
Development of a Potential Regional Hydropower Plant in South Asia:
Pre-Feasibility Study

Presentation Outline

- Pre-feasibility study objectives and highlights;
- Methodology;
- Review of electricity laws and regulations in South Asia;
- Power market in South Asia;
- Export oriented hydropower projects in South Asia;
- Economic and financial feasibility;
- Socio-economic and environmental issues;
- Conclusions and recommendations.
Pre-feasibility Study Objective and Scope of Work

Objective:
- Prepare a pre-feasibility study for the development of a potential hydropower plant in South Asia.

Scope of Work:
- Identify at least three suitable hydropower project sites; considering Size (in terms of energy), Access and Location (in terms of site and transmission line);
- Prepare project layout drawings and preliminary plant design;
- Prepare feasibility level cost estimates;
- Develop a typical power purchase agreement (PPA);
- Prepare a business model for regional power sharing;
- Assess proposed sites considering cross-border trade;
- Pre-feasibility level economic and financial evaluation of alternatives;
- Evaluate financing options for project construction.

Development of a Potential Regional Hydropower Plant in South Asia:
Pre-feasibility Study
Pre-feasibility Study

Highlights

Development of a Potential Regional Hydropower Plant in South Asia:
A Pre-feasibility Study
Installed Capacity and Access to Electricity

Population in South Asia:
- 1,649.28 million (1/5th % of world population)

Installed Capacity:
- 276,365 MW (69% is thermal generation);

Access to Electricity:
- Afghanistan 15.6%
- Bangladesh 41%
- Bhutan 60%
- India 66.3%
- Maldives 100%
- Nepal 43.6%
- Pakistan 62.4%
- Sri Lanka 88%

More than 1/3rd (37.5%) or 618.81 Million population in South Asia have no access to electricity;

Development of a Potential Regional Hydropower Plant in South Asia: A Pre-feasibility Study
Low Per Capita Electricity Consumption:

- Afghanistan - 49 kWh/person/year
- Bangladesh - 259 kWh/person/year
- Bhutan - 977 kWh/person/year
- India - 684 kWh/person/year
- Maldives - 521 kWh/person/year
- Nepal - 106 kWh/person/year
- Pakistan - 449 kWh/person/year
- Sri Lanka - 490 kWh/person/year

South Asian Average 517 kWh/person/year and World Average 2,782 kWh/person/year.

Source: IRENA and World Bank Little Green Data Book 2014

http://alabamamaps.ua.edu/contemporarymaps/world/asia/index2.html
Electricity and its Correlation with Economy

Electricity and Economy:

- Electricity demand growth rate has a direct correlation with the growth rate of the country’s economy;

GDP Growth Rate and Electricity Sales:

For example in India - At a GDP growth rate of 8% and 9%, the country needs to add power plant capacity of 203 GW and 275 GW in 2031 and 2032, respectively;

Source: Long Term Generation Expansion Plan 2013 – 2032, Ceylon Electricity Board

Development of a Potential Regional Hydropower Plant in South Asia:
A Pre-feasibility Study
Energy Resources of South Asia

Hydropower Resource:

- 3500 km Hindu Kush Himalaya abut Afghanistan, Pakistan, India, Nepal and Bhutan has huge water resources and the mountain topography with valleys suitable for hydropower development;

- Out of 10 major rivers originating from the Hindu Kush Himalaya, rivers in South Asia are Amu Darya, Indus, Ganga (Padma), and Brahmaputra (Jamuna).

<table>
<thead>
<tr>
<th>Country</th>
<th>Potential</th>
<th>Techno-economically Feasible</th>
<th>Present Generation</th>
<th>Generation Capacity %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>23,000 MW</td>
<td>18,400 MW</td>
<td>298 MW</td>
<td>1.62%</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>1,897 MW</td>
<td>775 MW</td>
<td>220 MW</td>
<td>28.39%</td>
</tr>
<tr>
<td>Bhutan</td>
<td>30,000 MW</td>
<td>23,760 MW</td>
<td>1,484 MW</td>
<td>6.25%</td>
</tr>
<tr>
<td>India</td>
<td>150,000 MW</td>
<td>84,400 MW</td>
<td>40,195 MW</td>
<td>47.62%</td>
</tr>
<tr>
<td>Nepal</td>
<td>83,000 MW</td>
<td>42,130 MW</td>
<td>743 MW</td>
<td>1.76 %</td>
</tr>
<tr>
<td>Pakistan</td>
<td>100,000 MW</td>
<td>60,000 MW</td>
<td>6,928 MW</td>
<td>11.54%</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>4,000 MW</td>
<td>2,423 MW</td>
<td>1,628 MW</td>
<td>67.19%</td>
</tr>
<tr>
<td>Total</td>
<td>391,897 MW</td>
<td>231,888 MW</td>
<td>51,496 MW</td>
<td>22.21%</td>
</tr>
</tbody>
</table>

- The highest percentage is in Sri Lanka (67.19%) followed by India (47.62%)
Energy Resources of South Asia Cont..

Hydropower Export Potential:
- India and Pakistan - Huge hydropower potential (but as per the present demand there would not be surplus for export);
- Nepal and Bhutan - Hydropower potential excess of their demand.

Coal:
- India, Pakistan and Bangladesh has signification coal reserves (others do not have viable quantities);
- India and Pakistan combined has 7% of global total coal reserve;

Natural Gas:
- India (0.7%), Pakistan (0.3%) and Bangladesh (0.1%) - 1.1% of the global total reserve;

Oil:
- India - 0.3% of the global total reserve;


Source: US Energy Information Agency

Development of a Potential Regional Hydropower Plant in South Asia: A Pre-feasibility Study
Energy Resources of South Asia Cont..

Renewable Energy Resources:

<table>
<thead>
<tr>
<th>Renewable Energy Potential</th>
<th>India</th>
<th>Pakistan Range</th>
<th>Sri Lanka</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>45,000 MW</td>
<td>1,100 - 40,000 MW</td>
<td>24,000 MW</td>
</tr>
<tr>
<td>Solar</td>
<td>50,000 MW</td>
<td>Very Large</td>
<td>Large</td>
</tr>
<tr>
<td>Biogas plants</td>
<td>15,000 Units</td>
<td>~ 1,000 Units</td>
<td>300 Units</td>
</tr>
<tr>
<td>Ocean thermal</td>
<td>50,000 MW</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Sea wave</td>
<td>20,000 MW</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Tidal</td>
<td>9,000 MW</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Source: Regional Energy Security for South Asia, Regional Report, SARI/Energy

NA = Not Available

Development of a Potential Regional Hydropower Plant in South Asia: A Pre-feasibility Study
### Power Supply and Demand Gap

<table>
<thead>
<tr>
<th></th>
<th>Afghanistan</th>
<th>Bangladesh</th>
<th>Bhutan</th>
<th>India</th>
<th>Maldives</th>
<th>Nepal</th>
<th>Pakistan</th>
<th>Sri Lanka</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydropower</td>
<td>298 MW</td>
<td>220 MW</td>
<td>1484 MW</td>
<td>40,195 MW</td>
<td>-</td>
<td>743 MW</td>
<td>6,928 MW</td>
<td>1,628 MW</td>
</tr>
<tr>
<td>Nuclear</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4,780 MW</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Renewables</td>
<td>7 MW</td>
<td>-</td>
<td>-</td>
<td>29,463 MW</td>
<td>-</td>
<td>-</td>
<td>50 MW</td>
<td>99 MW</td>
</tr>
<tr>
<td>Thermal</td>
<td>285 MW</td>
<td>8,317 MW</td>
<td>-</td>
<td>163,305 MW</td>
<td>245 MW</td>
<td>53 MW</td>
<td>15,852 MW</td>
<td>1,635 MW</td>
</tr>
<tr>
<td>Total</td>
<td>590 MW</td>
<td>8,537 MW</td>
<td>1,484 MW</td>
<td>237,743 MW</td>
<td>245 MW</td>
<td>787 MW</td>
<td>23,617 MW</td>
<td>3,362 MW</td>
</tr>
<tr>
<td>Grand Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Demand and Supply Gap %

<table>
<thead>
<tr>
<th></th>
<th>Hydro power</th>
<th>Gas and Coal</th>
<th>Hydro power</th>
<th>Coal</th>
<th>Biomass</th>
<th>Hydro power</th>
<th>Gas and lignite</th>
<th>Wind Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand and Supply Gap %</td>
<td>-</td>
<td>About 25%</td>
<td>Significant surplus</td>
<td>&gt;15% Energy Deficit</td>
<td>-</td>
<td>Peak and base deficit</td>
<td>&gt;25% Peak Demand Deficit</td>
<td>Some Deficit</td>
</tr>
</tbody>
</table>


- **Pakistan** - Peak demand deficit >25% (highest in the region).
- **Bangladesh** - Peak and base deficit is 25%.
- **India** - Energy deficit >15%.

### Electricity Supply Demand Gap (2012):

- **India** - Peak shortage 12,159 MW;
- **Pakistan** - Peak shortage 5,500 MW;
- **Bangladesh** - Peak shortage 1,048 MW.

**Cumulative Gap 18,707 MW**

[https://www.youtube.com/watch?v=Em1crnEt45Q](https://www.youtube.com/watch?v=Em1crnEt45Q)
Identified Projects

Firstly Identified Project:

- 10,800 MW Karnali Chisapani Multi-purpose Storage Project (project was not found financially feasible);

<table>
<thead>
<tr>
<th>Project</th>
<th>Installed Capacity</th>
<th>Project Scheme</th>
<th>Water Source</th>
<th>Dam Height</th>
<th>Catchment Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunkoshi 2</td>
<td>1,100 MW</td>
<td>Storage</td>
<td>Monsoon and snowfall</td>
<td>166 m</td>
<td>10,221.88 km²</td>
</tr>
<tr>
<td>Budhi Gandaki</td>
<td>1,000 MW</td>
<td>Storage</td>
<td>Monsoon and snowfall</td>
<td>263 m</td>
<td>6,190.24 km²</td>
</tr>
<tr>
<td>Sunkoshi 3</td>
<td>600 MW</td>
<td>Storage</td>
<td>Monsoon and snowfall</td>
<td>160 m</td>
<td>5,005 km²</td>
</tr>
</tbody>
</table>

- All 3 projects accessible by road;
- Department of Hydrology and Meteorology Nepal river gauging data are available for all 3 projects;
- All 3 projects are located in the middle hills of Nepal.
  - Directly affected population is less (> 15,000 in Sunkoshi 2 Storage Project);
  - 7,000 ha of cultivated land, forest, grassland, barren land will be affected;
  - Resettlement would not be difficult.

Development of a Potential Regional Hydropower Plant in South Asia:
A Pre-feasibility Study

http://www.himalayanriverfun.com/information/riversystem.php
## Cost Estimate and Electricity Tariff

### Cost Estimate and Energy Generation:

<table>
<thead>
<tr>
<th>Project</th>
<th>Cost Estimate</th>
<th>Energy Generation</th>
<th>Energy per MW</th>
<th>Cost per kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,100 MW Sunkoshi 2</td>
<td>US$ 1,639 Million</td>
<td>3,795 GWh/year</td>
<td>3.45</td>
<td>US$ 1,490</td>
</tr>
<tr>
<td>1,000 MW Budhi Gandaki</td>
<td>US$ 2,202 Million</td>
<td>4,142 GWh/year</td>
<td>4.14</td>
<td>US$ 1,967</td>
</tr>
<tr>
<td>600 MW Sunkoshi 3</td>
<td>US$ 968 Million</td>
<td>2,051 GWh/year</td>
<td>3.42</td>
<td>US$ 1,613</td>
</tr>
</tbody>
</table>

### Tariff Determination:

- Electricity tariff was determined by using fixed cost components and standard assumptions;
- Key Assumptions:
  - Debt: Equity Ratio: 70:30;
  - Return on Equity: 20%;
  - Prevailing interest rate: 11%.

### Minimum Tariff:

- USc 8.58/kWh (Average for peaking and non-peaking)
Financial Analysis

Objective:
- Verification of project’s profitability and sustainability, both of which are evaluated from a strictly financial perspective;

Approach:
- Analysis is based on discounted cash flow (DCF) method;
- Calculation of Project IRR, NPV, B/C Ratio and cash flow;

Financial Indicators:

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Sunkoshi 2</th>
<th>Budhi Gandaki</th>
<th>Sunkoshi 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Rate of Return (IRR)</td>
<td>13.76%</td>
<td>11.23%</td>
<td>8.22%</td>
</tr>
<tr>
<td>NPV at 10% Discount Rate</td>
<td>US$ 112,283 Million</td>
<td>US$ 5,494 Million</td>
<td>Negative</td>
</tr>
<tr>
<td>Benefit Cost Ratio</td>
<td>1.38</td>
<td>1.03</td>
<td>0.62</td>
</tr>
</tbody>
</table>
Objective:
- Demonstrate that project implementation justifies efficient use of scarce economic resources;

Approach:
- Analysis is based on discounted cash flow (DCF) method;
- Calculation of Project Economic IRR, NPV, B/C Ratio;

Key Assumptions:
- Emission benefit calculated for 10% electricity use in Nepal and 90% export;
- Carbon reduction revenue at US$ 23.24/tCO$_2$/year (Syanpse Energy Economics Inc.)

Economic Indicators:

<table>
<thead>
<tr>
<th>Description/Indicators</th>
<th>Sunkoshi 2</th>
<th>Budhi Gandaki</th>
<th>Sunkoshi 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average GHG emission reduction</td>
<td>3.15 Million tCO$_2$/year</td>
<td>3.44 Million tCO$_2$/year</td>
<td>1.7 Million tCO$_2$/year</td>
</tr>
<tr>
<td>Carbon reduction revenue</td>
<td>US$ 73.15 Million/year</td>
<td>US$ 79.85 Million/year</td>
<td>US$ 39.54 Million/year</td>
</tr>
<tr>
<td>Capital cost of coal plant</td>
<td>US$ 825 Million</td>
<td>US$ 750 Million</td>
<td>US$ 450 Million</td>
</tr>
<tr>
<td>Fuel cost</td>
<td>US$ 153.30 Million/year</td>
<td>US$ 139.36 Million/year</td>
<td>US$ 83.62 Million/year</td>
</tr>
<tr>
<td>EIRR</td>
<td>30%</td>
<td>16.18%</td>
<td>25.66%</td>
</tr>
<tr>
<td>Economic B/C Ratio</td>
<td>1.58</td>
<td>1.12</td>
<td>1.46</td>
</tr>
</tbody>
</table>
Transmission Infrastructure

Power Transmission Infrastructure:

- **India** - Only country having cross-border inter-connections with Bangladesh, Bhutan, and Nepal;
- **India and Sri Lanka** - Under sea transmission line is under study;
- **India** is in a unique position - Can play key role in the promotion of power trade in South Asia.

Proposed Transmission Infrastructure:

- +/- 500 kV HVDC
  - Transmission losses reduced to 2% for 1,000 km length;
  - Construction cost is less than AC system as right of way is 50 m.

Electricity tariff with transmission cost:

- Feasible - India, Pakistan and Bangladesh;

<table>
<thead>
<tr>
<th>Per kWh Electricity Tariff and Transmission Line Cost</th>
<th>Afghanistan</th>
<th>Bangladesh</th>
<th>India</th>
<th>Pakistan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance in km. from Proposed Project</td>
<td>1,850</td>
<td>350</td>
<td>125</td>
<td>1,250</td>
</tr>
<tr>
<td>Generation Cost US$/kWh</td>
<td>6.0</td>
<td>6.96</td>
<td>8.0 – 13.6</td>
<td>13.2 (Peaking)</td>
</tr>
<tr>
<td>Electricity Tariff (Proposed Project) US$/kWh</td>
<td>8.58</td>
<td>8.58</td>
<td>8.58</td>
<td>8.58</td>
</tr>
<tr>
<td>Transmission Cost US$/kWh</td>
<td>5.38</td>
<td>1.02</td>
<td>0.36</td>
<td>3.63</td>
</tr>
<tr>
<td>Final Electricity Tariff US$/kWh</td>
<td>13.96</td>
<td>9.60</td>
<td>8.58</td>
<td>12.21</td>
</tr>
</tbody>
</table>

Sources: FICCI Lack of Affordable & Quality Power: Shackling India’s Growth Story, Casa 1000 Study, Casa 1000 Study, Energy Sector in Bangladesh Study by IIDS
Summary

- Wide gap exists between supply of electricity generated and demand in the region;

- The cumulative supply and demand gap in India, Pakistan and Bangladesh is 18,707 MW. This creates huge market for potential power producers such as Nepal and Bhutan;

- The Sunkoshi 2 Storage Project has the highest FIRR of 13.67%, which equals to WACC of 13.7%, and the B/C Ratio is 1.38;

- Similarly, Sunkoshi 2 Storage Project has the highest EIRR at 30%;

- Therefore, Sunkoshi 2 Storage Project is both financially and economically feasible;

- It is envisaged that the pre-construction works require 2 years, and another 6 years is required for project completion;

- Rajasthan Sun Technique Concentrated Solar Project financing model could be useful for replication, where combined debt is from foreign public institutions and local private investment;

- SARPP model regional pool will add value to peaking power generation by matching with the region’s peak load demand timings
Study Methodology

Development of a Potential Regional Hydropower Plant in South Asia:
A Pre-feasibility Study
Major River Basins in Nepal:

- Koshi
- Karnali
- Gandaki
- Mahakali

<table>
<thead>
<tr>
<th>River Basin</th>
<th>Area (km²)</th>
<th>River Source</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koshi</td>
<td>60,400</td>
<td>Monsoon and snowmelt</td>
<td>In Nepal 27,863 km², In China 32,537 km²</td>
</tr>
<tr>
<td>Karnali</td>
<td>43,679</td>
<td>Monsoon and snowmelt</td>
<td>In Nepal 41,058 km², In China 2,621 km²</td>
</tr>
<tr>
<td>Gandaki</td>
<td>34,960</td>
<td>Monsoon and snowmelt</td>
<td>In Nepal 29,626 km², In China 5,334 km²</td>
</tr>
<tr>
<td>Mahakali</td>
<td>15,260</td>
<td>Monsoon and snowmelt</td>
<td>In Nepal 5,317 km², In India 9,943 km²</td>
</tr>
</tbody>
</table>

Study Methodology Continued …

Study completely based on published reports, information and maps:

Reports reviewed:
- Master Plan Study on the Koshi River (1985);
- Master Plan Study on Karnali and Mahakali River Basins;
- Master Plan Study on Gandaki River Basin (UNDP Assistance 1979);
- Feasibility Study of Karnali Chisapani Project (1989);
- Nationwide Master Plan Study on Storage Type Hydropower Development in Nepal (2014).

Development of a Potential Regional Hydropower Plant in South Asia: A Pre-feasibility Study
Study Methodology Continued ...

Topographical Maps:

- 1:50,000 scale map produced by the Department of Survey of Nepal Government;

Mapping:

- 1:20,000 scale mapping for layout plan of dam and appurtenant structures;
- 1:5,000 Scale Mapping for design of dam, powerhouse, tunnel, intake etc.

Development of a Potential Regional Hydropower Plant in South Asia: A Pre-feasibility Study
Study Methodology Continued ...

Other Maps:

- Google Earth;
- Maps of South Asian countries (Political, rivers, transmission line etc.).

http://www.sari-energy.org/pagefiles/countries/nepal_energy_detail.asp

Development of a Potential Regional Hydropower Plant in South Asia: A Pre-feasibility Study
River Source:
- Summer monsoon contributes about 80% of annual precipitation in Nepal.
- Snowmelt is the primary source of pre-monsoon flow for rivers with catchment above snowline;

Hydrological and Meteorological Data:
- Data used for the present study are from Department of Hydrology and Meteorology (DHM) of Nepal. The DHM records and publishes meteorological and streamflow data of rivers in Nepal.

Length of Data Stream:
- Budi Gandaki Station at Arughat (from 1963);
- Sunkoshi Station at Khurkot (from 1967);
Review of Electrical Laws and Regulations

Development of a Potential Regional Hydropower Plant in South Asia: A Pre-feasibility Study
## Review of Electricity Laws and Regulations

<table>
<thead>
<tr>
<th>Country</th>
<th>Key Policy</th>
<th>Act</th>
<th>Regulatory Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>Electricity Sector Policy 2003</td>
<td>Law “For Using Electricity” 1986</td>
<td>Draft Electricity Law has proposed Afghanistan Electricity Regulatory Authority (AEFA)</td>
</tr>
<tr>
<td>Bhutan</td>
<td>Bhutan Sustainable Hydropower Development Policy, 2008</td>
<td>Electricity Act, 2001</td>
<td>Bhutan Electricity Authority (BEA)</td>
</tr>
<tr>
<td>India</td>
<td>National Electricity Policy, 2005</td>
<td>Electricity Act, 2003</td>
<td>Central Electricity Regulatory Commission (CERC), and Electricity Commissions in most States</td>
</tr>
<tr>
<td>Maldives</td>
<td>National Energy Policy &amp; Strategy, 2010</td>
<td>Electricity/Energy Act, yet to be formulated</td>
<td>Maldives Energy Authority</td>
</tr>
</tbody>
</table>

Development of a Potential Regional Hydropower Plant in South Asia: Pre-feasibility Study
Evolution of Power Market in South Asia

Development of a Potential Regional Hydropower Plant in South Asia: Pre-Feasibility Study
Regional Power Integration

Legislative and Institutional Barriers:

- Lack of legal provisions governing cross-border electricity trade (except in Nepal and Bhutan);
- Ad hoc bilateral agreements (instead of contractual arrangement). Long term policy needs to be in place for sustainability;
- All SAARC member countries except Afghanistan and Nepal have fully functional autonomous regulators to govern electricity sector.

Infrastructure Constraints:

- Lack of cross-border transmission line in the region as a whole. India has bilateral links with Bhutan, Nepal and Bangladesh. However, volume of trade is minuscule compared to their potential (except in Bhutan);
Development of a Potential Regional Hydropower Plant in South Asia: Pre-feasibility Study

Thank You
Power Market in South Asia

Development of a Potential Regional Hydropower Plant in South Asia: Pre-feasibility Study
Energy Resources of South Asia

Energy Resources:

- **Hydropower Resource:**
  - Huge water resource potential - Himalaya abut Afghanistan, Bhutan, India, Nepal and Pakistan;

- **Coal Resource:**
  - Significant coal reserves - In India, Pakistan and Bangladesh (other’s do not have viable quantities);
  - Proved reserve in India - 60,600 Million Tonnes (6.8% of global total) and Pakistan – 2,070 Million Tonnes (0.2% of global total) BP Statistical Review of World Energy (2015);
  - India - 3rd largest producer of coal in the world (400 million tons) after China (2,000 million tons) and the US (1,000 million tons);
  - Pakistan - Strategic plan to exploit Thar coal and build power plants in nearby areas;
  - Bangladesh - Limited coal reserve compared with India and Pakistan. Plans to exploit coal (Power System Master Plan 2010);

Development of a Potential Regional Hydropower Plant in South Asia: Pre-feasibility Study

http://www.raonline.ch/pages/np/visin/np_rivers1301.html
Energy Resources of South Asia

- Natural Gas Resource:
  - Proved reserves - Bangladesh (0.3 trillion m³), India (1.4 trillion m³), Pakistan (0.6 trillion m³)
  - BP Statistical Review of World Energy 2014;
  - Bangladesh (0.1%), India (0.7%) and Pakistan (0.3%) combined - 1.1% of global total;

- Oil Resource:
  - Proved reserve - India, 5.7 Thousand million barrel (0.3% of global total);

- Renewable Energy:
  - India - Gird interactive power is 38,453 MW
  - (Ministry of New and Renewable Energy 2015)
  - 26,744 MW (Wind) >50% of potential
  - 6,763 MW (Solar) >12% of potential
  - 4,831 MW (Biomass)
  - 115 MW (Waste to energy)

Development of a Potential Regional Hydropower Plant in South Asia:
Pre-feasibility Study
Status of Electricity Sector:

- Insatiable demand for electricity - India, Bangladesh, Sri Lanka, and Pakistan;
- South Asia - Fastest growing region in the world;
- > 35% (618 million) population without access to electricity;
- Low electricity consumption (517 kWh/capita/year);
- Black out “Load shedding” prevalent (except Bhutan);
- Indigenous resources are being used at faster rate;
- Member countries exploring options to import electricity to meet demand;

Power Exchange Opportunities: South Asia

- Nepal and Bhutan’s wet season hydropower surplus matches with India, Pakistan and Bangladesh’s summer peak demand.
- Coal power in India can supply base load.
- Pakistan and India has sizable flexible gas fired generation.


Status of Electricity Sector in Afghanistan

Afghanistan

- Population - 29.8 Million
- Area - 652,225 km²
- Low Population Density - 46 people/km²

Status of Electricity Sector:

- Low access to electricity - 15.6%;
- Low per capita electricity consumption - 49 kWh/year;
- Major indigenous energy resource is hydropower. 18,400 MW techno-economically feasible hydropower potential of which 1.62% or 298 MW exploited;
- Power generating capacity is beginning to grow - After a long period of decline;
- Electricity Import (> 250 MW) - Uzbekistan, Tajikistan, Turkmenistan and Iran.
- Da Afghanistan Breshna Sherkat (DABS) national electric utility manages, operates and maintains the national power system.

Development of a Potential Regional Hydropower Plant in South Asia:
Pre-feasibility Study
Transmission System of Afghanistan

- North East Power System (NEPS) – Linking Kabul, Mazar-e-Shariff, Jalalabad with Uzbekistan (220kV) and Tajikistan (220 kV);

- South East Power System (SEPS) – Linking Kajaki and Kandhar (110 kV);


Herat System – Linking Herat with Iran (132 and 110 kV);

Development of a Potential Regional Hydropower Plant in South Asia:
Pre-feasibility Study
Status of Electricity Sector in Bangladesh

**Bangladesh**
- Population – 154.7 Million;
- Area – 147,570 km²
- Population Density - 1049 person/km²

**Status of Electricity Sector:**
- Access to electricity - 41%;
- Low per capita electricity consumption - 259 kWh/year;
- Rich in water resource. Rivers Jamuna, Padma and Meghna. Flat terrain, limited hydropower potential;
- 775 MW techno-economically feasible hydropower potential of which 220 MW or 29.32% exploited);
- Heavy reliance on indigenous natural gas for power generation (above 85%);
- Supply Demand Gap - < 1,000 MW;
- Electricity to all by 2021;

Development of a Potential Regional Hydropower Plant in South Asia: Pre-feasibility Study
Power Generation in Bangladesh

Total Power Installed Capacity (9,151 MW)

- Natural Gas: 5,370 MW (65.7%)
- Furnace Oil: 1,867 MW (22.9%)
- Diesel: 511 MW (6.3%)
- Coal: 200 MW (2.4%)
- Hydropower: 220 MW (2.7%)

Source: Bangladesh Power Development Board, Annual Report 2012-13

Installed Capacity, Maximum Demand, Maximum Peak Generation and Maximum Load Shedding

<table>
<thead>
<tr>
<th>Year</th>
<th>Installed Capacity (MW)</th>
<th>Addition of Installed Capacity (MW)</th>
<th>Present Capacity MW (Derated)</th>
<th>Maximum Demand (MW)</th>
<th>Maximum Peak Generation (MW)</th>
<th>Maximum Load Shedding (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-09</td>
<td>5,719</td>
<td>518</td>
<td>5,166</td>
<td>6,066</td>
<td>4,162</td>
<td>1,269</td>
</tr>
<tr>
<td>2009-10</td>
<td>5,823</td>
<td>104</td>
<td>5,271</td>
<td>6,454</td>
<td>4,606</td>
<td>1,459</td>
</tr>
<tr>
<td>2010-11</td>
<td>7,264</td>
<td>1,441</td>
<td>6,639</td>
<td>6,639</td>
<td>4,890</td>
<td>1,335</td>
</tr>
<tr>
<td>2011-12</td>
<td>8,716</td>
<td>1,452</td>
<td>8,100</td>
<td>7,518</td>
<td>6,066</td>
<td>1,058</td>
</tr>
<tr>
<td>2012-13</td>
<td>9,151</td>
<td>435</td>
<td>8,537</td>
<td>8,349</td>
<td>6,434</td>
<td>1,048</td>
</tr>
</tbody>
</table>

Source: Bangladesh Power Development Board, Annual Report 2012-13

Development of a Potential Regional Hydropower Plant in South Asia: Pre-feasibility Study

https://en.wikipedia.org/wiki/Electricity_sector_in_Bangladesh
Transmission System in Bangladesh

- Transmission system - Jointly owned by parastatal organization (Bangladesh Power Development Board 75%) and general public;

- Cross-border connection with India
  - 125 km long 400 kV DC line Bheramara and Baharampur in West Bengal, India (capacity up to 1,000 MW);

- Power System Master Plan 2010 - Envisages power import from Bhutan (1,000 MW), India additional 1,000 MW, Nepal (1,000 MW) and Myanmar 500 MW);

Development of a Potential Regional Hydropower Plant in South Asia: Pre-feasibility Study
Power Planning in Bangladesh

- Bangladesh plans to set up 2,000 MW Ruppur Nuclear Power Plant at Rooppur, 200 km northwest of Dhaka in 2018. It is planned to go into operation by 2020; ([https://en.wikipedia.org/wiki/Electricity_sector_in_Bangladesh](https://en.wikipedia.org/wiki/Electricity_sector_in_Bangladesh))

- Bangladesh has prepared a comprehensive Power Sector Master Plan (PSMP) in 2010.
  - As per PSMP peak demand is 17,500 MW (year 2020) and 34,000 MW (year 2030);
  - To meet the peak demand, suggested installed capacities 22,500 MW (year 2020) and 39,000 MW (year 2030).

![Power Demand Forecast 2010-2030](image)

Source: JICA Study Team
Status of Electricity Sector in Bhutan

**Bhutan**

- Population - 742 Thousand
- Area - 38,364 km²
- Low Population Density - 20 person/km²

**Status of Electricity Sector:**

- Access to electricity - 60%;
- Highest per capita electricity consumption in South Asia - 977 kWh/year;
- Huge hydropower potential - Himalayan rivers and large altitudinal variations (Techno-economically feasible 23,760 MW of which 6.25% or 1,484 MW exploited);
- Virtually all electricity hydropower based;
- Policy Goal - Achieve additional 10,000 MW installed capacity by 2020, Tap the remaining by 2030;
- Presently Bhutan - Exports 75% of its total electricity generation to India. During winter it import electricity from India;

---

4 Major rivers in Bhutan
- Torsa (shortest)
- Sunkosh (longest)
- Wangchu
- Manas

---

**Hydropower Projects under Operation in Bhutan**

<table>
<thead>
<tr>
<th>Project</th>
<th>Generation 2013</th>
<th>Installed Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chukha</td>
<td>1,907.44 GWh</td>
<td>336 MW</td>
</tr>
<tr>
<td>Karichhu</td>
<td>378.60 GWh</td>
<td>60 MW</td>
</tr>
<tr>
<td>Basochhu - I</td>
<td>331.77 GWh</td>
<td>24 MW</td>
</tr>
<tr>
<td>Basochhu - II</td>
<td></td>
<td>40 MW</td>
</tr>
<tr>
<td>Tala</td>
<td>4,913.63 GWh</td>
<td>1,020 MW</td>
</tr>
<tr>
<td>Micro/Mini</td>
<td>20.00 GWh</td>
<td>4 MW</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7,551.45 GWh</td>
<td>1,484 MW</td>
</tr>
</tbody>
</table>

Source: Annual Report 2013, Druk Green Power Corporation Limited, Bhutan
Transmission System and Power Sector Structure in Bhutan

- Transmission system circuit length - 1,015 km;
- Internal transmission system - 66 kV and 132 kV
- Cross-border connection with India.
  - 220 kV line - 336 MW Chukha HEP and Birpara in West Bengal, India;
  - 132 kV line - 60 MW Kurichu HEP and Salakati in Assam, India;
  - 400 kV DC line - 1,020 MW Tala HEP and Siliguri in West Bengal, India.

Power Sector Structure of Bhutan.

Existing Transmission Line Between Bhutan and India

<table>
<thead>
<tr>
<th>Project</th>
<th>Capacity</th>
<th>Connection Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>336 MW Chukha HEP</td>
<td>220 kV</td>
<td>Chukha (Bhutan) – Birpara (West Bengal, India)</td>
</tr>
<tr>
<td>60 MW Kurichu HEP</td>
<td>132 kV</td>
<td>Kurichu (Bhutan) – Salakati (Assam, India)</td>
</tr>
<tr>
<td>1020 MW Tala HEP</td>
<td>400 kV</td>
<td>Tala (Bhutan) – Siliguri (West Bengal, India)</td>
</tr>
</tbody>
</table>

Source: National Transmission Grid Master Plan for Bhutan, CEA India, 2012

Development of a Potential Regional Hydropower Plant in South Asia: Pre-feasibility Study
Status of Electricity Sector in India

India
- Population - 1,236.7 Million (17% of world)
- Area - 3,287,240 km²
- Low Population Density - 377 person/km²

Status of Electricity Sector:
- Access to electricity - 66.3%
- Per capita electricity consumption - 684 kWh/year
- India’s power market 4th largest in Asia and 6th largest in the world
- Dominant fuel for power generation - Coal 140,723 MW (about 60%). Coal shortage
- Techno-economically feasible hydropower potential 84,400 MW of which 47.62% (40,195 MW) exploited
- Peak power shortage - 12,159 MW in 2012-13
- Demand Forecast at 8% growth - 425,000 MW (2021-22) and 778,000 MW (2031-32)
- Cross-border interconnection with Bangladesh, Bhutan and Nepal

Development of a Potential Regional Hydropower Plant in South Asia:
Pre-feasibility Study
India’s Total Power Installed Capacity is 237,743 MW (February 2014)

Source: Central Electricity Authority of India, Summary, February 2014

Lately, renewables such as Solar and Wind power are picking up in India.

Development of a Potential Regional Hydropower Plant in South Asia: Pre-feasibility Study
Transmission System in India

- Five grids - Northern grid (NR), Eastern Grid (ER), Western Grid (WR), Southern (SR), North Eastern (NER);
- All five regional grids connected to the central grid through 765 kV transmission line;
- Power transmission and distribution grid in India - Three-tier (Distribution networks, State Grids and Regional Grids);
- Private sector allowed participation in transmission line development (National Electricity Policy 2006) - 3,239 circuit km transmission line commissioned in 2011-12 (Central Electricity Authority).

Source: Global Energy Network Institute (GENI)
Power Demand and Planning in India

Power Peak Demand and Peak Shortage

<table>
<thead>
<tr>
<th>Description</th>
<th>Year 2011-12</th>
<th>Year 2012-13</th>
<th>Change 2012-13 over 2011-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak demand</td>
<td>130,006 MW</td>
<td>135,453 MW</td>
<td>4.2% (Increase)</td>
</tr>
<tr>
<td>Peak demand met</td>
<td>116,191 MW</td>
<td>123,294 MW</td>
<td>6.1% (Increase)</td>
</tr>
<tr>
<td>Peak shortage</td>
<td>13,815 MW</td>
<td>12,159 MW</td>
<td>10% to 9% (Decrease)</td>
</tr>
</tbody>
</table>


Planning Commission of India Projections for Power Demand based on Falling Elasticities

<table>
<thead>
<tr>
<th>Year</th>
<th>Electricity (Falling elasticities)</th>
<th>Total Power Demand Billion kWh</th>
<th>Projected Peak Demand (GW)</th>
<th>Installed Capacity Required (GW)</th>
<th>Installed Capacity Addition (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-12</td>
<td>0.95/0.85</td>
<td>1097</td>
<td>1167</td>
<td>8% 9%</td>
<td>8% 9%</td>
</tr>
<tr>
<td>2016-17</td>
<td>0.85</td>
<td>1524</td>
<td>1678</td>
<td>8% 9%</td>
<td>8% 9%</td>
</tr>
<tr>
<td>2021-22</td>
<td>0.85/0.78</td>
<td>2118</td>
<td>2438</td>
<td>8% 9%</td>
<td>8% 9%</td>
</tr>
<tr>
<td>2026-27</td>
<td>0.78</td>
<td>2866</td>
<td>3423</td>
<td>437 522</td>
<td>575 685</td>
</tr>
<tr>
<td>2031-32</td>
<td>0.78</td>
<td>3880</td>
<td>4806</td>
<td>592 733</td>
<td>778 960</td>
</tr>
</tbody>
</table>

Source: Integrated Energy Policy 2006, Planning Commission of India
Status of Electricity in the Maldives

Maldives

- Population - 338 Thousand
- Area - 300 km² (spread over 859,000 km² area 1,190 coral island and 19 atolls)
- Population density - 1,127 person/km²

Status of Electricity Sector:

- Access to electricity - 100%;
- Per capita electricity consumption - 521 kWh/year;
- Lack of oil, natural gas or coal reserves;
- Largest consumer of fuel - Electricity sector;
- Cannot cost effectively import electricity from neighboring countries;
- Plans for renewable energy resources;
  - Solar
  - Wind
  - Ocean
  - Biomass
- Ensure 50% of power generation in 2025 - Using renewable sources;
- Road map - Integrating diesel based generation with PV and wind to cut generation cost. But, limitations has been land availability and grid stability.

The State Electric Company Limited (STELCO) is an entirely State owned organization responsible for the generation and distribution and sale of electricity to consumers throughout the North Central Province (NCP) of the Republic of Maldives.

Source: Maldives SREP Investment Plan (2013-17), Ministry of Environment and Energy, Republic of Maldives

<table>
<thead>
<tr>
<th>Types</th>
<th>Installed Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhabited Islands</td>
<td>120</td>
</tr>
<tr>
<td>Tourism Resorts (estimated)</td>
<td>105</td>
</tr>
<tr>
<td>Industrial Islands</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>245</td>
</tr>
</tbody>
</table>

Source: Modeling Energy System in the Maldives, Julie Camerlynck

Development of a Potential Regional Hydropower Plant in South Asia:
Pre-feasibility Study
Status of Electricity Sector in Nepal

Nepal
- Population – 27.5 Million
- Area - 147,181 km²
- Low Population Density - 187 person/km²

Status of Electricity Sector:
- Access to electricity – 43.6%;
- Per capita electricity consumption - 106 kWh/year;
- Huge hydropower potential - Large altitudinal variations and 6,000 rivers;
- Low hydropower utilization - About 1.76% (787 MW of 42,130 MW techno-economically feasible hydropower potential);
- Major source of electricity - Hydropower;
- Nepal experiences severe power shortage;
- Power sector bundled, NEA manages generation, transmission and distribution. IPPs involved in hydropower generation.

### Installed Capacity of Power Plants in Nepal

<table>
<thead>
<tr>
<th>Plant Type and Owner</th>
<th>Installed Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEA’s Major Hydropower Stations (11 Nos.)</td>
<td>459.15</td>
</tr>
<tr>
<td>NEA’s Small Hydropower Stations (28 Nos.)</td>
<td>14.24</td>
</tr>
<tr>
<td>NEA’s Plants (Isolated)</td>
<td>4.54</td>
</tr>
<tr>
<td>NEA’s Hydropower (Total)</td>
<td>477.93</td>
</tr>
<tr>
<td>IPPs Hydropower (39 Nos.)</td>
<td>255.64</td>
</tr>
<tr>
<td>Total Hydropower in Nepal</td>
<td>733.57</td>
</tr>
<tr>
<td>NEA’s Thermal</td>
<td>53.41</td>
</tr>
<tr>
<td>NEA’s Solar</td>
<td>0.10</td>
</tr>
<tr>
<td>Total Installed Capacity</td>
<td>787.08</td>
</tr>
</tbody>
</table>

Source: A Year in Review 2013-2014, Nepal Electricity Authority
Transmission System in Nepal

- Total transmission system circuit length - 2,640 km, of which 132 kV is 2,130 km long and remaining 511 km is 66 kV.
- 132 kV circuit length - 2,130 km;
- Major internal transmission system - 66 kV and 132 kV
- Cross-border connection with India.
  - Recently completed 440 kV line between Dhalkebar in Nepal and Muzaffarpur in India;
- Transmission line for power evacuation has been a bottle neck for hydropower project construction in Nepal.
  - Nepal Electricity Authority (NEA) has concluded PPA with 83 private hydropower developers to construct a total of 1,521 MW installed capacity. These are in different stages of construction;
  - In addition, NEA has concluded PPA with 33 private hydropower developers and are in different stages of development;
- NEA is preparing a river basin wise Nepal Transmission System Master Plan for 2015 to 2035.
Status of Electricity Sector in Pakistan

Pakistan

- Population – 179.2 Million (17% of world)
- Area - 881,913 km²
- Low Population Density - 204 person/km²

Status of Electricity Sector:

- Access to electricity - 62.4%;
- Per Capita Electricity Consumption - 449 kWh/year;
- Dominant fuel for power generation - Gas 9,175 MW (about 40%)
- 11.4% or 6,928MW of 60,000 MW techno-economically feasible hydropower potential exploited;

Power Sector Structure of India

<table>
<thead>
<tr>
<th>Apex Body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry of Water and Power</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Statutory Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Electric Power and Regulatory Authority (NEPRA)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water and Power Development Authority (WAPDA) responsible for water and hydropower development</td>
</tr>
<tr>
<td>Pakistan Electric Power Company (PEPCO)</td>
</tr>
<tr>
<td>IPPs</td>
</tr>
<tr>
<td>PAEC</td>
</tr>
<tr>
<td>KESC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Transmission and Power Dispatch Company (NTDC)</td>
</tr>
<tr>
<td>KESC Transmission</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>NESCO</td>
</tr>
<tr>
<td>GESCO</td>
</tr>
<tr>
<td>EESCO</td>
</tr>
<tr>
<td>MEPCO</td>
</tr>
<tr>
<td>EESCO</td>
</tr>
<tr>
<td>HESCO</td>
</tr>
<tr>
<td>QESCO</td>
</tr>
<tr>
<td>TESCO</td>
</tr>
</tbody>
</table>

Development of a Potential Regional Hydropower Plant in South Asia: Pre-feasibility Study

Power Generation in Pakistan

Pakistan’s Total Power Installed Capacity is 23,617 MW (2012-13)

- 6,928 MW (29.3%)
- 787 MW (3.3%)
- 50 MW (0.2%)
- 15,852 MW (67.1%)

3,478 MW Tarbela Dam Largest Hydropower Project in South Asia (US$ 1,497 Mil.)

Development of a Potential Regional Hydropower Plant in South Asia:
Pre-feasibility Study


100 MW Quaid-e-Azam Solar Park in Bahawalpur, Pakistan
Power Planning in Pakistan

- Although, the total installed capacity in the country is 23,617 MW, power plants are so old that they generate about 15,000 MW.
- Pakistan is a huge market for power as it currently has a power deficit of 5,550 MW.
- As a part of Mid Term Development Framework 2005 - 10, Pakistan has prepared an Energy Security Action Plan (ESAP) 2005.

Energy Security Action Plan (ESAP) 2005

<table>
<thead>
<tr>
<th>Year</th>
<th>Hydropower</th>
<th>Nuclear</th>
<th>Coal</th>
<th>Renewable</th>
<th>Gas</th>
<th>Oil</th>
<th>Total</th>
<th>Cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>6,460</td>
<td>400</td>
<td>160</td>
<td>180</td>
<td>5,940</td>
<td>6,400</td>
<td>19,540</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>1260</td>
<td>-</td>
<td>900</td>
<td>70</td>
<td>4,860</td>
<td>160</td>
<td>7,880</td>
<td>27,420</td>
</tr>
<tr>
<td>2015</td>
<td>7,570</td>
<td>900</td>
<td>3,000</td>
<td>800</td>
<td>7,550</td>
<td>300</td>
<td>20,120</td>
<td>39,693</td>
</tr>
<tr>
<td>2020</td>
<td>4,700</td>
<td>1,500</td>
<td>4,200</td>
<td>1,470</td>
<td>12,560</td>
<td>300</td>
<td>24,730</td>
<td>72,720</td>
</tr>
<tr>
<td>2025</td>
<td>5,600</td>
<td>4,000</td>
<td>5,400</td>
<td>2,700</td>
<td>22,490</td>
<td>300</td>
<td>38,490</td>
<td>110,760</td>
</tr>
<tr>
<td>2030</td>
<td>7,070</td>
<td>8,800</td>
<td>6,250</td>
<td>3,850</td>
<td>30,360</td>
<td>300</td>
<td>51,830</td>
<td>162,590</td>
</tr>
<tr>
<td>Total</td>
<td>32,660</td>
<td>8,800</td>
<td>19,190</td>
<td>9,700</td>
<td>83,760</td>
<td>7,760</td>
<td>162,590</td>
<td></td>
</tr>
</tbody>
</table>

Source: Energy Security Action Plan (ESAP) 2005

- Projected Installed Capacity target for 2030 is 162,590 MW.
Transmission System in Pakistan

- Main transmission system - 500 kV north south longitudinal line;
- National Transmission Development Company (NTDC) - Purchases power from Generation Companies (GENCOs);
- NTDC operates - 12 (500 kV), 29 (220 kV) grid stations and 5,077 circuit km of 500 kV and 7,359 circuit km of 200 kV networks;

<table>
<thead>
<tr>
<th>Transmission System Type</th>
<th>Voltage Level</th>
<th>Unit</th>
<th>As on 30 June 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Transmission Lines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>500 kV</td>
<td>c.km</td>
<td></td>
<td>5,143.73</td>
</tr>
<tr>
<td>220 kV</td>
<td>c.km</td>
<td></td>
<td>8,309.20</td>
</tr>
<tr>
<td>132 kV</td>
<td>c.km</td>
<td></td>
<td>14,463.00</td>
</tr>
<tr>
<td>66 kV</td>
<td>c.km</td>
<td></td>
<td>4,153.00</td>
</tr>
<tr>
<td>Total</td>
<td>c.km</td>
<td></td>
<td>32,088.93</td>
</tr>
</tbody>
</table>

Source: NTDC, Power System Statistics 2012-13
Status of Electricity Sector in Sri Lanka

Sri Lanka

- Population – 20.3 Million
- Area - 65,610 km²
- Low Population Density - 310 person/km²

Electricity Sector Overview:
- Access to electricity - 88%;
- Per capita electricity consumption - 490 kWh/year;
- 67.19% or 1,628 MW techno-economically feasible hydropower potential 2,4023 MW exploited;
- Heavy reliance on liquid fuel - Plans for relatively less expensive coal power and renewable energy (wind and Solar);
- Study underway for India-Sri Lanka undersea HVDC cable (Capacity 500 - 1,000 MW);

Source: Ceylon Electricity Board

Power Sector Structure in Sri Lanka

As per the generation expansion plan, 4700 MW coal based plant will be the major source of power for future;

- 231 MW hydropower potential will be exploited by 2022;
- 330 MW Gas based electricity generation will be commissioned before 2017;
- Investment in 720 MW of Non-conventional renewable energy is envisaged before 2032;
- Costly diesel power is least prioritized.
**Transmission System Wind & Solar Resource in Sri Lanka**

**Transmission System:**
- Transmission system circuit length - 2,436 km;
- Internal transmission system - 220 kV (501 km) and 132 kV (1,935 m).

**Proposed Link Sri Lanka - India:**

[Image of map showing proposed link]

**Wind Resource:**

<table>
<thead>
<tr>
<th>Wind Resource Scale</th>
<th>Wind Class</th>
<th>Wind Power at 50 m W/m²</th>
<th>Wind Speed at 50 m m/s</th>
<th>Land Area km²</th>
<th>Lagoon Area km²</th>
<th>Total Area km²</th>
<th>Windy Land</th>
<th>Total Capacity Installed MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>4</td>
<td>400 - 500</td>
<td>7.0 – 7.5</td>
<td>2,341</td>
<td>664</td>
<td>3,005</td>
<td>3.6</td>
<td>15,000</td>
</tr>
<tr>
<td>Good</td>
<td>5</td>
<td>500 - 600</td>
<td>7.5 – 8.0</td>
<td>788</td>
<td>41</td>
<td>829</td>
<td>1.2</td>
<td>4,150</td>
</tr>
<tr>
<td>Good</td>
<td>6</td>
<td>600 - 800</td>
<td>8.0 – 8.8</td>
<td>517</td>
<td>0</td>
<td>517</td>
<td>0.8</td>
<td>2,800</td>
</tr>
<tr>
<td>Good</td>
<td>7</td>
<td>&gt; 800</td>
<td>&gt; 8.8</td>
<td>501</td>
<td>0</td>
<td>501</td>
<td>0.6</td>
<td>2,500</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>4,147</td>
<td>705</td>
<td>4,852</td>
<td>6.4</td>
<td>24,250</td>
</tr>
</tbody>
</table>

Presentations on Land of Solar and Wind Potentials by Klthsiri Dassanayaka PhD, Sri Lanka Sustainable Energy Authority, Sri Lanka

**Development of a Potential Regional Hydropower Plant in South Asia:**

**Pre-feasibility Study**
## Summary of Power Market in South Asia

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>590 MW</td>
<td>1,048 MW</td>
<td>1,750 MW</td>
<td>NA</td>
<td>3,000 MW</td>
<td>NA</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>8,537 MW</td>
<td>11,814 MW (Generation)</td>
<td>22,500 MW</td>
<td>34,000 MW (8%)</td>
<td>39,000 MW</td>
<td>26,534 MW (Generation)</td>
</tr>
<tr>
<td>Bhutan</td>
<td>1,484 MW</td>
<td>NA</td>
<td>1,500 MW</td>
<td>2,500 MW</td>
<td>26,534 MW</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>237,743 MW</td>
<td>323,000 MW (8%) (2022)</td>
<td>425,000 MW (8%) (2022)</td>
<td>592,000 MW (8%) (2032)</td>
<td>778,000 MW (8%) (2032)</td>
<td></td>
</tr>
<tr>
<td>Maldives</td>
<td>245 MW</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Nepal</td>
<td>787 MW</td>
<td>2,204 MW</td>
<td>NA</td>
<td>4,614 MW</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Pakistan</td>
<td>23,617 MW</td>
<td>54,400 MW</td>
<td>72,720 MW</td>
<td>113,700 MW</td>
<td>162,590 MW</td>
<td>9,378 MW</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>3,362 MW</td>
<td>4,000 MW</td>
<td>5,296 MW</td>
<td>7,250 MW</td>
<td>9,378 MW</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>276,365 MW</strong></td>
<td><strong>18,707 MW</strong></td>
<td><strong>404,354 MW</strong></td>
<td><strong>525,516 MW</strong></td>
<td><strong>757,064 MW</strong></td>
<td><strong>988,968 MW</strong></td>
</tr>
</tbody>
</table>


Surplus Export of 10,000 MW from Bhutan would be 1.9% of combined South Asian demand. Similarly Surplus export of 24,000 MW would be 2.5%.
Thank You

Shyam S. Shrestha