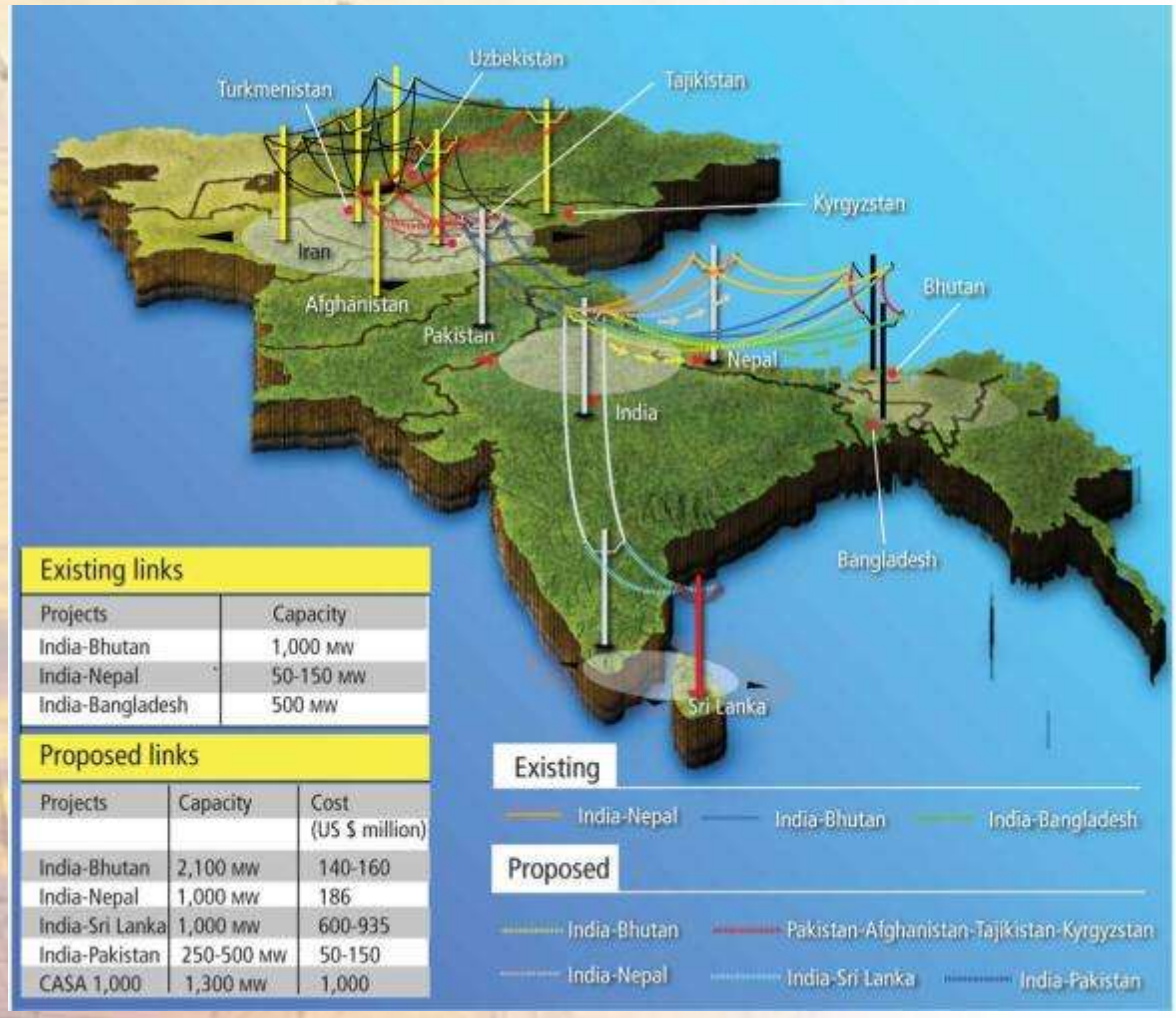
# Export Oriented Hydropower Projects in South Asia




**Existing links**

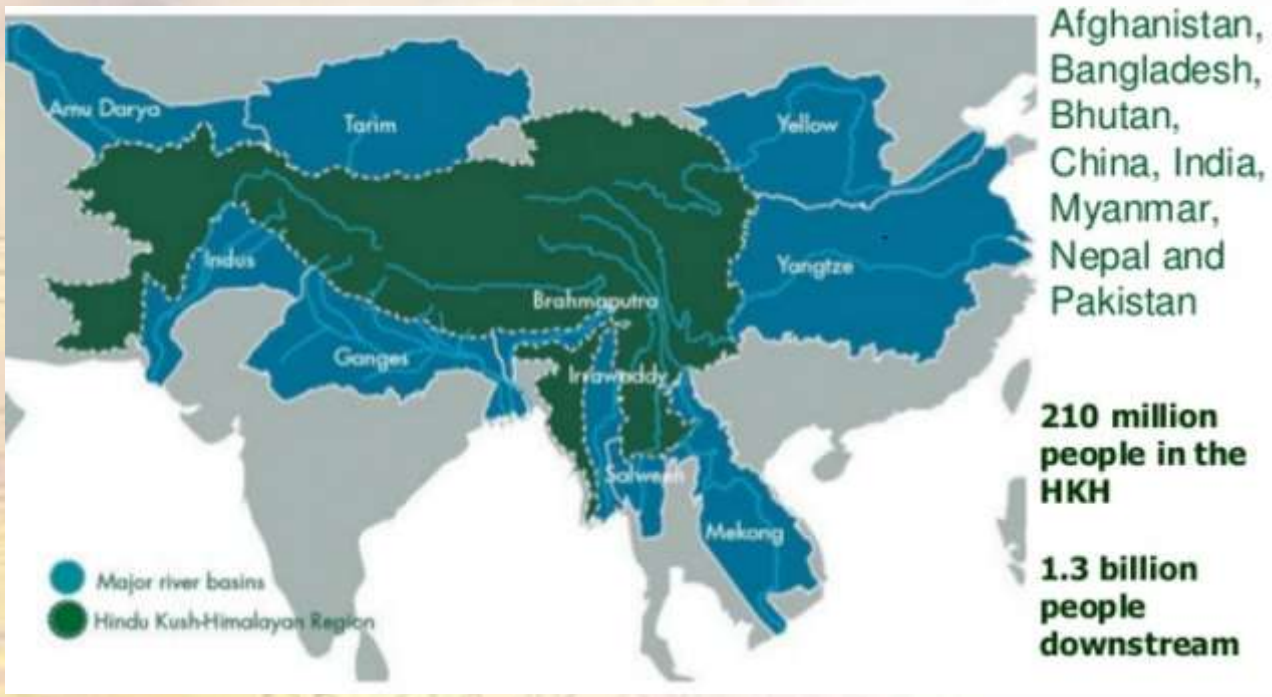
| Projects | Capacity |
|---|---|
| India-Bhutan | 1,000 MW |
| India-Nepal | 50-150 MW |
| India-Bangladesh | 500 MW |

**Proposed links**

| Projects | Capacity | Cost (US $ million) |
|---|---|---|
| India-Bhutan | 2,100 MW | 140-160 |
| India-Nepal | 1,000 MW | 186 |
| India-Sri Lanka | 1,000 MW | 600-935 |
| India-Pakistan | 250-500 MW | 50-150 |
| CASA 1,000 | 1,300 MW | 1,000 |

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

# Water Resources in South Asia

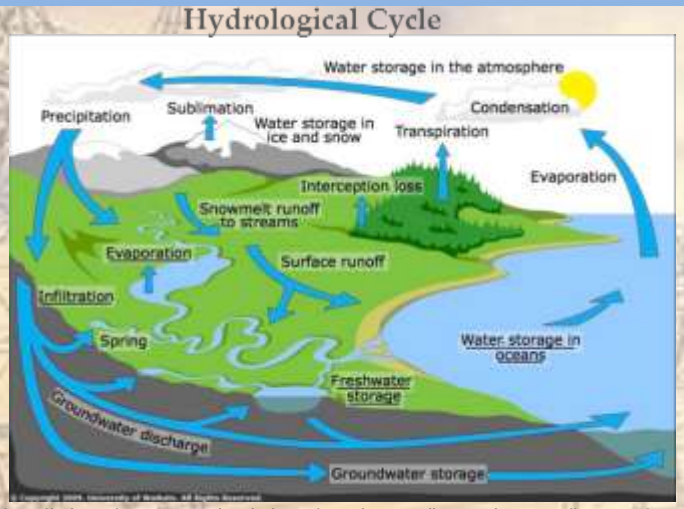



Source: International Centre from Integrated Mountain Development (ICIMOD)

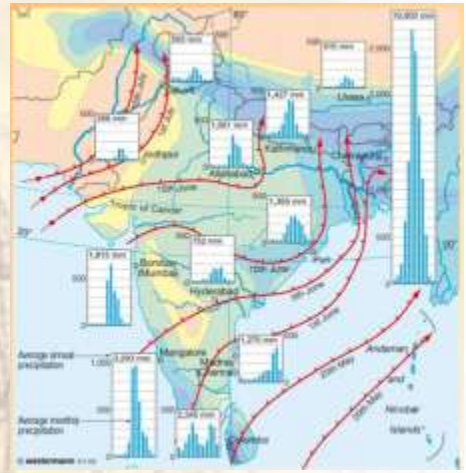
## Hindu Kush Himalaya Major Hydropower Resource in South Asia:

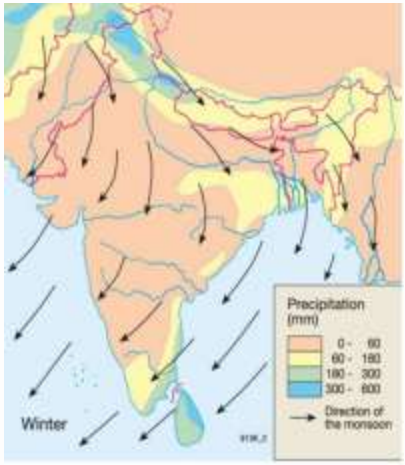
- Himalayas - 35,110 $km^2$ snow and ice cover (containing 3,735 $km^3$ of snow and ice);
- 3,500 km long Himalaya is the source of 10 large Asian river systems;
- Large river systems in South Asia: Amu Darya, Indus, Ganges and Bramhaputra ;
- Huge hydropower potential in Himalaya abut Afghanistan, Bhutan, India, Nepal and Pakistan;

# Hydrological Cycle "Himalayan Catchments"




http://sciencelearn.org.nz/var/sciencelearn/storage/images/contexts/h2o-on-the-go/sci-media/images/the-water-cycle/123045-8-eng-NZ/The-water-cycle.jpg

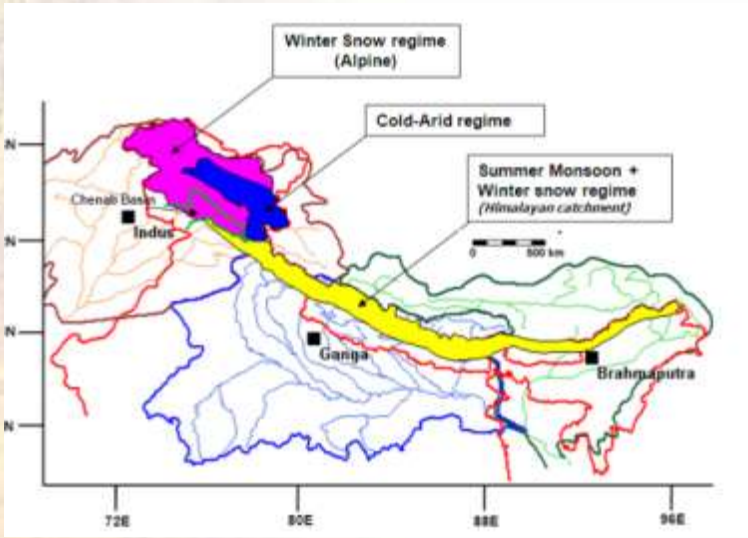





http://media.diercke.net/omeda/800/10913E_2_Indien_Monsune.jpg

## Hydrological Cycle "Himalayan Catchments":

- **Summer Monsoon (Wet Monsoon) blowing from the South-West - Dominates the hydrology of "Himalayan catchments" (July to mid September );**
- **Winter Monsoon (Dry Monsoon): blows from the northeast (October to April);**

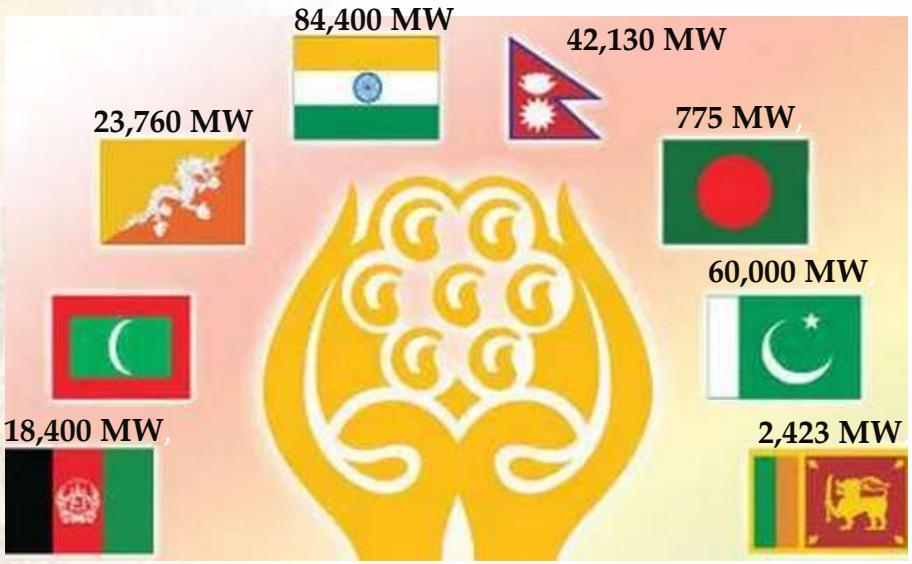



http://www.the-cryosphere.net/4/115/2010/tc-4-115-2010.pdf

# Hydropower Potential, Installed Capacity and Export Potential

## Export Potential:

- Afghanistan and Nepal - Badly under utilized hydropower (major indigenous resource);
- Bangladesh - Limited hydropower potential and economic potential almost tapped (no export prospect)
- Bhutan - Only country in the region to export electricity.
- Bhutan and Nepal - Huge hydropower potential in excess of their demand for electricity;
- Sri Lanka - Limited hydropower potential and economic potential almost tapped (no export possibility);
- India and Pakistan - Huge hydropower potential (but there would not be surplus for export);




Total Potential 231,888 MW

| Hydropower Potential and Capacity | | | | | |
|---|---|---|---|---|---|
| S. No. | Country | Potential | Economic Potential | Present Generation | Percentage |
| 1 | Afghanistan | 23,000 MW | 18,400 MW | 298 MW | 1.62% |
| 2 | Bangladesh | 1,897 MW | 775 MW | 220 MW | 28.39% |
| 3 | Bhutan | 30,000 MW | 23,760 MW | 1484 MW | 6.25% |
| 4 | India | 150,000 MW | 84,400 MW | 40,195 MW | 47.62% |
| 5 | Nepal | 83,000 MW | 42,130 MW | 743 MW | 1.76% |
| 6 | Pakistan | 100,000 MW | 60,000 MW | 6,928 MW | 11.54% |
| 7 | Sri Lanka | 4,000 MW | 2,423 MW | 1,628 MW | 67.19% |
| | Total | 391,897 MW | 231,888 MW | 51,496 MW | 22.21% |

# Power Generation in Bhutan

**Bhutan is rich in water resources, but has no coal, gas or oil deposits.**

## Present Hydropower Generation:

| Hydropower Plant | Generation Capacity (MW) |
|---|---|
| Tala (2006-2007) | 1,020 MW |
| Basochhu | 64 MW |
| Kurichhu | 60 MW |
| Chhukha | 336 MW |
| Micro/Mini | 8 MW |
| Total | 1,488 MW |

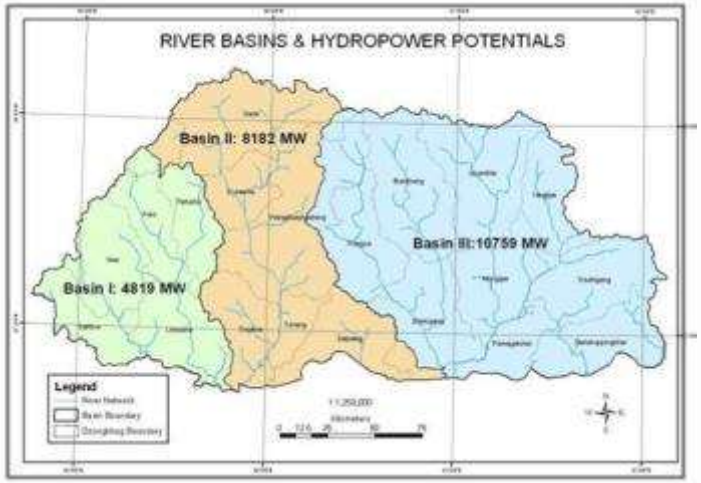
http://www.bea.gov.bt/dgpc/

- Low generation capacity - 5% of potential.
- Bhutan plans to develop 13 hydropower projects to generate additional 10,334 MW power by 2020.
- Further planning is being done to develop 14,270 MW beyond 2020.
- In 2013, Bhutan generated 7,531 GWh and exported to India 5,557 GWh which is 74% of the generation.

# Hydropower Potential of Bhutan

**Bhutan has a hydropower potential of 30,000 MW. Of which 23,760 MW is techno-economically feasible.**

- **Rivers in Bhutan originate from mountains in the north and flow through deep valleys down to the south;**
- **Bhutan, only South Asian country, that exports surplus electricity to India**




## River Basin-wise Hydropower Potential

| River Basin | Catchment | Schemes | Potential | Energy |
|---|---|---|---|---|
| Amochhu (Basin I) | 2,400 km$^2$ | 6 | 2,060 MW | 9,656 GWh |
| Wangchhu (Basin I) | 4,689 km$^2$ | 10 | 2,740 MW | 11,139GWh |
| Punatsangchhu (Basin II) | 10,355 km$^2$ | 19 | 8,099 MW | 25,495 GWh |
| Mangdechhu/Manas West (Basin III) | 7,392 km$^2$ | 17 | 3,889 MW | 18,322 GWh |
| Drangmechhu Manas-East (Basin III) | 9,207 km$^2$ | 20 | 6,692 MW | 33,422 GWh |
| Jaldhaka, Mau, Nyeraamari, Dhansiri | 2,750 km$^2$ | 4 | 280 MW | 1,213 GWh |
| Total | 36,793 km$^2$ | 76 | 23,760 MW | 99,247 GWh |

ris.org.in/images/RIS_images/ppt/R-DORJI.ppt

# Hydropower Projects in Bhutan by 2020

**Bhutan and India Under "10,000 MW by 2020" Bilateral Cooperation have agreed to phase wise develop projects (Druk Green Annual Report 2013):**

- 180 MW Bunakha Reservoir Scheme with THDC;
- 770 MW Chamkharchhu I with NTPC;
- 600 MW Kholongchhu HEP with SJVN; and
- 570 MW Wangchhu HEP with SJVN.

## Revised and Updated List of Projects by 2020:

| Sl. No. | Name of HEP | Initial Installed capacity (MW) | Revised capacity with addl. projects (MW) | Year of commissio-ing | DPR |
|---|---|---|---|---|---|
| 1. | Punatsangchhu-I | 1200(6x200) | 1200(6x200) | 2015 | WAPCOS |
| 2. | Punatsangchhu-II | **990(6x165)** | **1020(6x170)** | 2017 | WAPCOS |
| 3. | Mangdechhu | 720(4x180) | 720(4x180) | 2017 | NHPC |
| 4. | Sankosh Main HEP | **4000** | **2500** | 2020 | THDC* |
| 5. | Sankosh LB HEP | **60** | **85** | 2020 | THDC* |
| 6. | Kuri-Gongri | **1800** | 1800/**3400**' | 2020 | NHPC* |
| 7. | Wangchhu | **600** | **570(4x142.5)** | 2019 | SJVNL |
| 8. | Bunakha Reservoir | 180(3x60) | 180(3x60) | 2020 | THDC |
| 9. | Kholongchhu | **486** | **600(4x150)** | 2018 | SJVNL |
| 10. | Chamkarchhu-I | **670** | **770(4x192.5)** | 2018 | NHPC |
| 11. | Amochhu RS | **600** | **540(4x135)** | 2018 | NTPC |
| 12. | Nikachhu | 210 | **210**/140 | 2020 | DGPC* |
| 13. | Bindu Khola | 13 | 13 | 2020 | DGPC* |
| 14. | Dagachhu | **114** | **126(2x63)** | 2020 | DGPC & Tata |
| Total | | **11420** | **10334** | | |

National Transmission Grid Master Plan (NTGMP) for Bhutan, Central Electricity Authority, India,

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

**Pre-feasibility Study**

# Hydropower Project Construction beyond 2020 and up to 2030

| Wangchhu Basin | | |
|---|---|---|
| S. No. | Project Name | Capacity |
| 1 | Bemengchhu | 14 MW |
| 2 | Cherichhu | 76 MW |
| 3 | Hachhu | 17 MW |
| 4 | Parochhu | 104 MW |
| 5 | Pipingchhu | 55 MW |
| 6 | Thimphucchu | 57 MW |

| Amochhu Basin | | |
|---|---|---|
| S. No. | Project Name | Capacity |
| 1 | Amochhu I | 747 MW |
| 2 | Amochhu II | 500 MW |
| 3 | Cherchhu | 45 MW |
| 4 | Pachhu | 77 MW |
| 5 | Samchhu | 71 MW |

| Drangmechhu Basin | | |
|---|---|---|
| S. No. | Project Name | Capacity |
| 1 | Gamrichhu I | 64 MW |
| 2 | Gamrichhu II | 79 MW |
| 3 | Gamrichhu III | 80 MW |
| 4 | Gamri/Yamkhari | 81 MW |
| 5 | Komachhu | 326 MW |
| 6 | Bambichhu | 22 MW |
| 7 | Ngargangchhu | 24 MW |
| 8 | Shongarchhu | 107 MW |
| 9 | Gobarichhu | 43 MW |
| 10 | Bomdeling | 130 MW |
| 11 | Kuri/Rothpasang | 1,230 MW |
| 12 | Manas Reservoir I | 1,800 MW |
| 13 | Manas Reservoir II | 1,000 MW |

| Punasangchhu Basin | | |
|---|---|---|
| S. No. | Project Name | Capacity |
| 1 | Punasangchhu III | 595 MW |
| 2 | Cherchhu | 25 MW |
| 3 | Dagachhu II | 135 MW |
| 4 | Dangchhu I | 150 MW |
| 5 | Dangchhu II | 78 MW |
| 6 | Darachhu I | 79 MW |
| 7 | Darachhu II | 115 MW |
| 8 | Darachhu III | 153 MW |
| 9 | Darachhu IV | 212 MW |
| 10 | Mochhu I | 658 MW |
| 11 | Mochhu II | 403 MW |
| 12 | Pochhu | 132 MW |
| 13 | Samachhu | 16 MW |
| 14 | Sichhu | 78 MW |

| Mangdechhu Basin | | |
|---|---|---|
| S. No. | Project Name | Capacity |
| 1 | Burgangchhu I | 69 MW |
| 2 | Burgangchhu II | 70 MW |
| 3 | Chamkharchhu I | 97 MW |
| 4 | Chamkharchhu II | 992 MW |
| 5 | Chamkharchhu III | 1890 MW |
| 6 | Chamkharchhu V | 162 MW |
| 7 | Ghijam/Lirigang | 53 MW |
| 8 | Ghumthang | 108 MW |
| 9 | Krissa | 32 MW |
| 10 | Shergarchhu | 27 MW |
| 11 | Rimjigangchhu | 46 MW |
| 12 | Thampochhu | 95 MW |
| 13 | Wachi | 24 MW |
| 14 | Kheng (Shinghkar) | 570 MW |

| Other Basins | | |
|---|---|---|
| S. No. | Project Name | Capacity |
| 1 | Aiechhu (L) | 64 MW |
| 2 | Aiechhu (S) | 22 MW |
| 3 | Sherichhu | 36 MW |
| 4 | Jaldhaka | 19 MW |
| 5 | Dhansiri | 73 MW |
| 6 | Nyera Amari I | 142 MW |
| 7 | Nyera Amari II | 300 MW |
| 8 | Yangtse/Kholong | 94 MW |

National Transmission Grid Master Plan (NTGMP) for Bhutan, Central Electricity Authority, India,

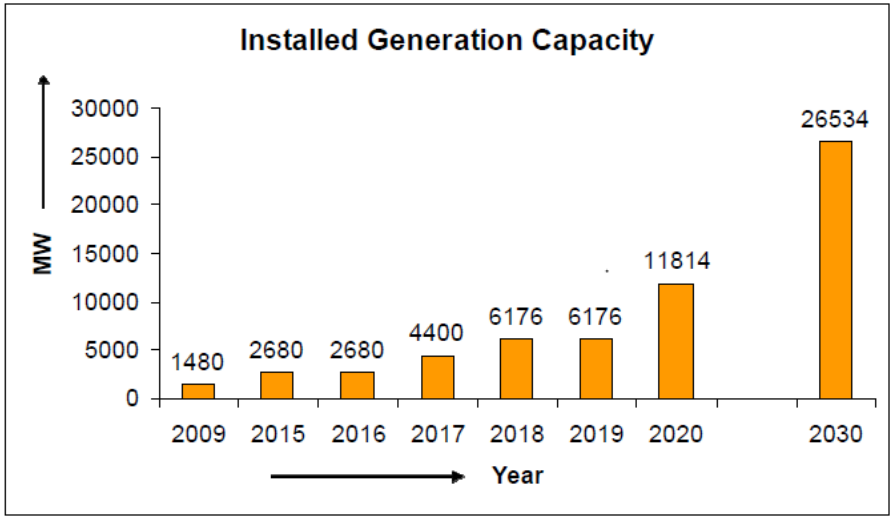
**Development of a Potential Regional Hydropower Plant in South Asia:**

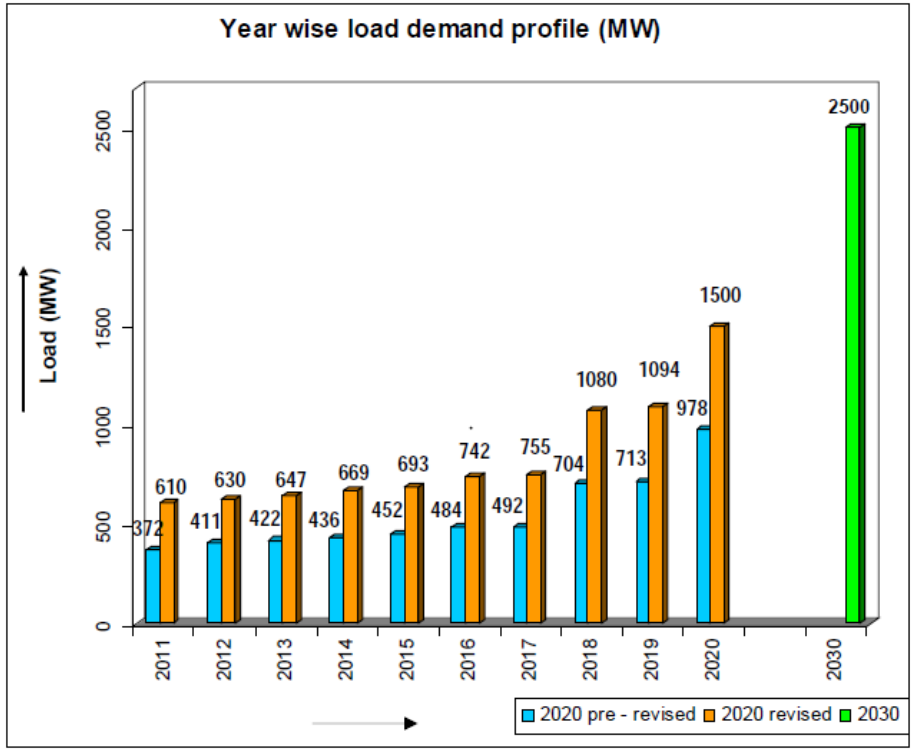
**Pre-feasibility Study**

# Bhutan's Load Demand and Surplus Electricity for Export

## Bhutan's Generation Capacity Addition by 2020:

| Existing Installed Capacity | Capacity Addition by 2020 | Installed Capacity at the end of 2020 | Capacity Addition during 2020-2030 | Installed Capacity at the end of 2030 |
|---|---|---|---|---|
| 1,480 MW | 10,334 MW (14 HEPs) | 11,814 MW | 14,720 MW (61 HEPs) | 26,534 MW |




| Year | Installed Capacity | Load | Export Potential |
|---|---|---|---|
| 2020 | 11,814 MW | 1,500 MW | 10,314 MW |
| 2030 | 26,435 MW | 2,500 MW | 23,935 MW |

National Transmission Grid Master Plan (NTGMP) for Bhutan, Central Electricity Authority, India,

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

# Transmission System Planning in Bhutan

**A National Transmission Grid Master Plan (NTGMP) was prepared by Central Electricity Authority of India;**

- **Grid scenarios for 2020 and 2030 time frames were prepared considering twin moose conductor in 400 kV transmission system.**

**HVDC Transmission Corridors in Bhutan and India**

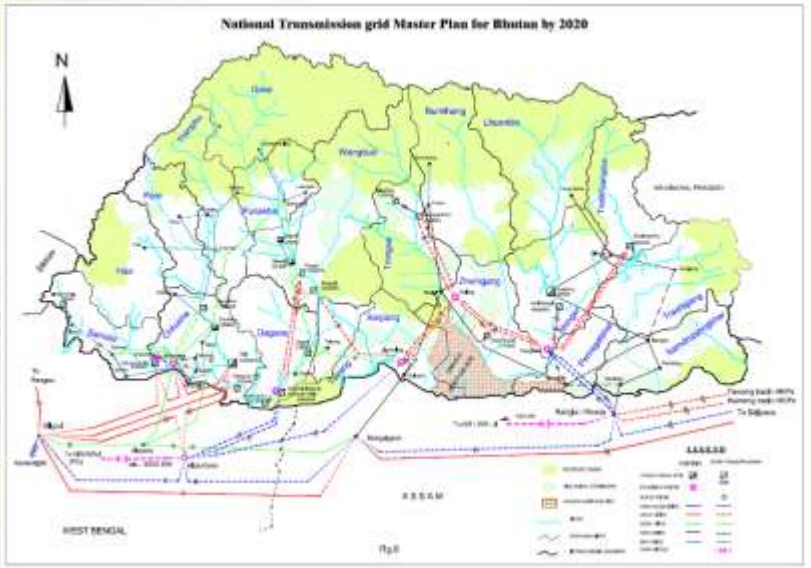
(i) ± 800 kV, 6000 MW HVDC Alipurduar-NR/WR-I (India) HVDC bipole corridor (India) (to materialize by 2020)

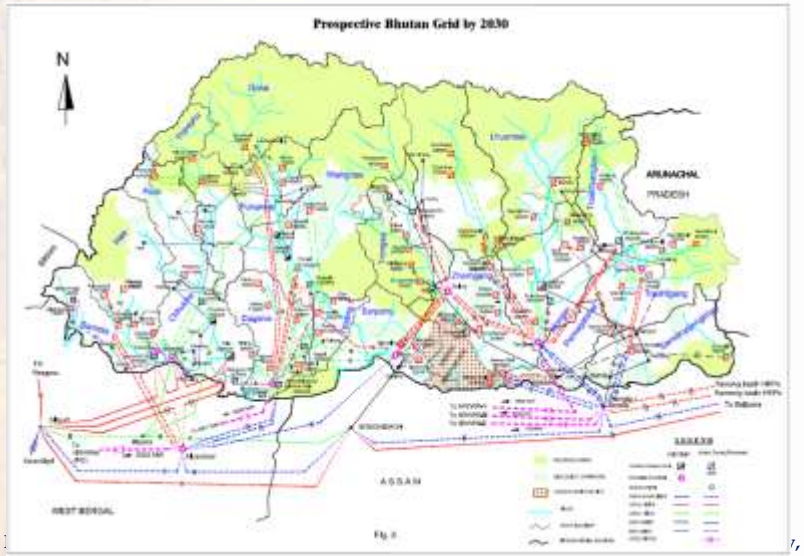
(ii) ± 800 kV, 7000 MW Rangia/Rowta-WR/NR-II (India) HVDC bi-pole corridor (to materialize by 2020)

(iii) ± 800 kV, 6500 MW Rangia/Rowtai-WR/NR-III (India) HVDC 2nd bi-pole corridors (to materialize beyond 2020)

(iv) ± 800 kV, 6000 MW HVDC Sankosh/Lhamozingha – NR/WR IV HVDC bipole corridor ( to materialize beyond 2020)

(v) ± 800 kV, 6500 MW Yangbari-WR/NR-V (India) HVDC bi-pole corridor (to materialize beyond 2020)




, India,

# Power Generation in Nepal

## Present Generation Capacity

| Hydropower Plant Type and Owner | Capacity (MW) |
|---|---|
| NEA's Major Hydropower (11 Nos.) | 459.15 |
| NEA's Small Hydropower (28 Nos.) | 14.24 |
| NEA's Plants (Isolated) | 4.54 |
| NEA's Hydropower (Total) | 477.93 |
| IPPs Hydropower (39 Nos.) | 255.64 |
| Total Hydropower in Nepal | 733.57 |
| NEA's Thermal | 53.41 |
| NEA's Solar | 0.10 |
| Total Installed Capacity | 787.08 |

Source: A Year in Review 2013-14, Nepal Electricity Authority (NEA)

60 MW Kulehani is the only storage scheme in Nepal

https://sambu.co.kr/wwwroot2008/sub02/sub02_01_d04.asp

## Peak Power Demand

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| Peak Demand | 812.50 MW | 885.28 MW | 946.10 MW | 1,026.65 MW | 1,01.65 MW | 1,291.8 MW |

Peak Power Demand of the Integrated Nepal Power System (INPS) in 2014-15 stood at 1,291.8 MW, with 585 MW load-shedding (Kathmandu Post, August 19, 2015).

# Hydropower Potential of Nepal

- Nepal has a hydropower potential of 83,000 MW. Of which 42,130 MW is techno-economically feasible.
- All four major river basin has part of catchment in the Himalaya. Snowmelt rivers are reliable and perennial sources.


https://en.wikipedia.org/wiki/List_of_rivers_of_India#Maharashtra_Coastal_Rivers

## River Basin-wise Hydropower Potential in Nepal

| River Basin | Major Rivers (MW) (Theoretical) | Small Rivers (MW) (Theoretical) | Total (GW) (Theoretical) | Economic Potential (MW) |
|---|---|---|---|---|
| Koshi | 19,000 | 4,000 | 23,000 | 11,000 |
| Gandaki | 18,000 | 3,000 | 21,000 | 5,000 |
| Karnali and Mahakali * | 32,000 | 3,000 | 35,000 | 25,000 |
| Others | 3,000 | 1,000 | 4,000 | 1,130 |
| Total | 72,000 | 11,000 | 83,000 | 42,130 |

* The Capacity is Estimated Half for Border River

http://www.energyhimalaya.com/information-center/facts-and-figures.html

# Hydropower Potential of Nepal

| Eastern River Basin | | |
|---|---|---|
| No. | Project Name | Capacity (MW) |
| E-01 | Dudh Koshi | 300.0 |
| E-02 | Dudh Koshi-2 | 456.6 |
| E-03 | Dudh Koshi-3 | 1,048.6 |
| E-04 | Dudh Koshi-4 | 1,603.0 |
| E-05 | Khimti | 128.1 |
| E-06 | Kokhajor-1 | 111.5 |
| E-07 | Likhu-1 | 91.2 |
| E-08 | Mulghat | 2,647.7 |
| E-09 | Piluwa-2 | 107.3 |
| E-10 | Rosi-2 | 106.5 |
| E-11 | Sankhuwa-1 | 176.0 |
| E-12 | Tama Koshi-3 | 330.0 |
| E-13 | Tamor No.1 | 696.0 |
| E-14 | Tamor (Terahathum) | 380.0 |
| E-15 | Sun Koshi No.1 | 1,357.0 |
| E-16 | Sun Koshi No.2 | 1,110.0 |
| E-17 | Sun Koshi No.3 | 536.0 |
| E-18 | Sun Koshi No.3 | 432.0 |
| E-19 | Sun Koshi No.3 | 190.0 |
| E-20 | Indrawati | 91.2 |
| E-21 | Kankai | 90.0 |

| Central River Basin | | |
|---|---|---|
| No. | Project Name | Capacity (MW) |
| C-01 | Kaligandaki-Modi | 816.4 |
| C-02 | Lower Badigad | 380.3 |
| C-03 | Lower Daraudi | 120.2 |
| C-04 | Seti-Trisuli | 128.0 |
| C-05 | Upper Daraudi | 111.4 |
| C-06 | Kaligandaki-2 | 660.0 |
| C-07 | Budhi Gandaki | 600.0 |
| C-08 | Andhi Khola | 180.0 |
| C-09 | Langrang Khola | 218.0 |
| C-10 | Uttar Ganga | 300.0 |
| C-11 | Madi-Ishaneshor | 86.0 |
| C-12 | Kali Gandaki No.1 | 1,500.0 |
| C-13 | Marsyangdi | 510.0 |
| C-14 | Seti (Gandaki) | 230.0 |
| C-15 | Dev Ghat | 150.0 |
| C-16 | Bhomichok | 200.0 |
| C-17 | Trishulganga | 1,500.0 |
| C-18 | Ridi Khola | 97.0 |
| C-19 | Bagmati MP * | 140.0 |

| Western River Basin | | |
|---|---|---|
| No. | Project Name | Capacity (MW) |
| W-01 | Barbung Khola | 122.9 |
| W-02 | Chera-1 | 148.7 |
| W-03 | Chera-2 | 104.3 |
| W-04 | Humla-Karnali | 467.1 |
| W-05 | Lower Jhimruk | 142.5 |
| W-06 | Madi | 199.8 |
| W-07 | Mugu Karnali | 3,843.8 |
| W-08 | Sani Bhari-1 | 763.5 |
| W-09 | Sani Bhari-2 | 646.9 |
| W-10 | Sharada-2 | 96.8 |
| W-11 | Thuli Gad-2 | 119.7 |
| W-12 | Tila-1 | 617.2 |
| W-13 | Tila-3 | 481.9 |
| W-14 | Thuli Gad | 120.0 |
| W-15 | LR-1 | 98.0 |
| W-16 | BR-3B | 801.0 |
| W-17 | BR-4 | 667.0 |
| W-18 | Surkhet | 600.0 |
| W-19 | Lakarpata | 1,200.0 |
| W-20 | Bhanakot | 810.0 |
| W-21 | Thapna | 500.0 |
| W-22 | SR-6 | 642.0 |
| W-23 | Nalsyagu Gad | 400.0 |
| W-24 | Sarada Babai | 75.0 |
| W-25 | Naumure (W. Rapti) | 245.0 |
| W-26 | Lohare Khola | 67.0 |
| W-27 | Nisti-Panah * | 90.4 |

Source: Nationwide Master Plan Study on Storage-type Hydroelectric Power Development in Nepal, JICA, Electric Power Development Company

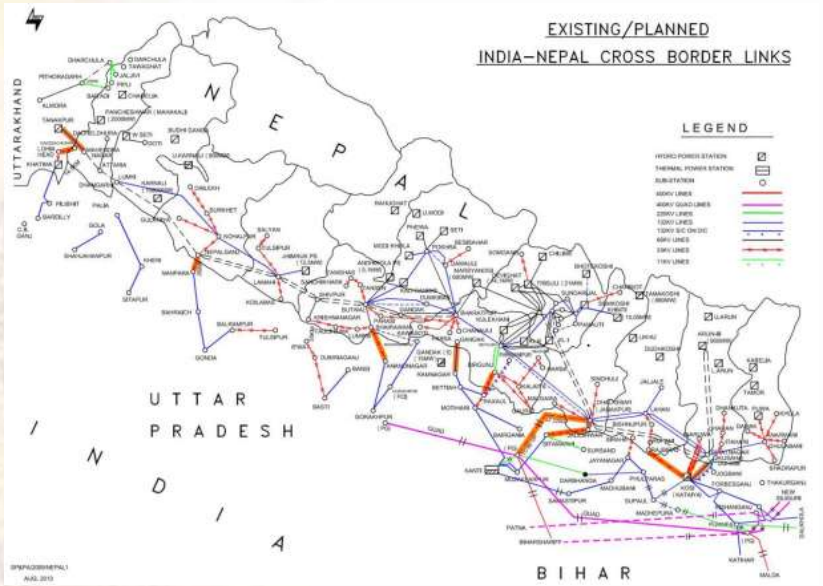
# Project Selection Procedure and Identified Projects

## Project Selection Procedure for the Study:

- Bhutan and Nepal have hydropower potential excess of their demand;
- Hydrological data of rivers and topographical maps of hydropower projects in Bhutan were not available;
- As a result projects in Nepal were chosen for the study;
- Exclusion of projects for which Department of Electricity Development (DoED) has issued survey/generation license to companies.
- Projects were excluded when graphical coordinates of promising projects overlapped with projects holding DoED survey/generation license;
- Further, list of potential projects were evaluated based on technical (for example dam height and geology) and economic aspects;
- Finally, Sunkoshi 2 Storage Project, Sunkoshi 3 Storage Project and Budhi Gandaki Storage projects were identified for the pre-feasibility study.

# Transmission System Planning of Nepal

- NEA is preparing a river basin wise Nepal Transmission System Master Plan for 2015 to 2035.




## Existing Nepal - India Cross Border Links

| Transmission Link | Evacuation Capacity | Traded | Voltage Level |
|---|---|---|---|
| Kusaha – Kataiya | 130 MW | 80 MW | 132 kV |
| Gandak - Rampur | 50 MW | 25 MW | 132 kV |
| Mahendranagar - Tanakpur | 50 MW | 30 MW | 132 kV |
| Katiya - Rajbiraj | 10 MW | 8 MW | 33 MW |
| Raxaul - Birganj | 10 MW | 10 MW | 33 MW |
| Sitamadi - Jaleswor | 10 MW | 8 MW | 33 MW |
| Nepalganj - Nanpara | 10 MW | 8 MW | 33 MW |
| Jayanagar - Siraha | 8 MW | 8 MW | 33 MW |

## New and Planned Nepal – India Cross Border Links

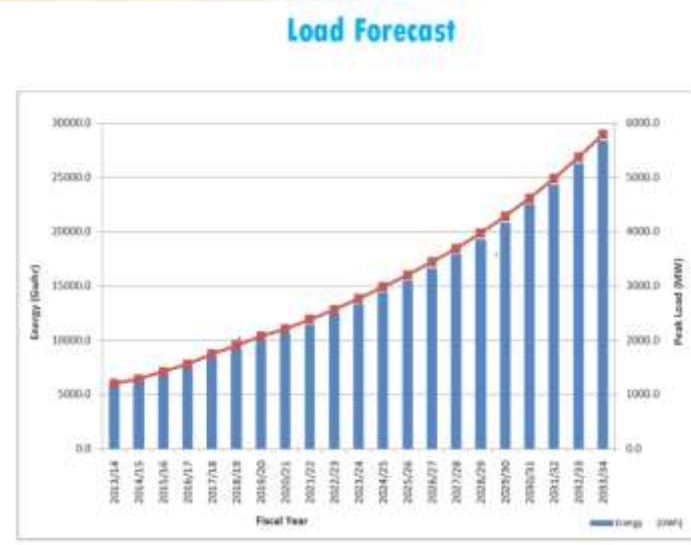
| Transmission Link | Transfer Capacity | Voltage Level | Status |
|---|---|---|---|
| Dhalkebar - Muzzafarpur | 1,200 MW | 400 kV | Complete |
| Bardaghat - Gorakhpur | 1,800 MW | 400 MW | Planned |
| Duhabi - Jogbani | 1,800 MW | 400 MW | Identified and proposed |

National Transmission Grid Master Plan (NTGMP) for Bhutan, Central Electricity Authority, India,

# Load Forecast and Power Development Plan of Nepal

## Power Development Plan:

- Nepal's Electricity Act of 1992 is a milestone in hydropower development in the country. Private developers were allowed to participate in hydropower development.
- NEA prepares load forecast plan for Nepal;
- Department of Electricity Development (DoED) issues survey and generation license to energy project developers;
- Licenses have been issued to individuals, companies and agencies;



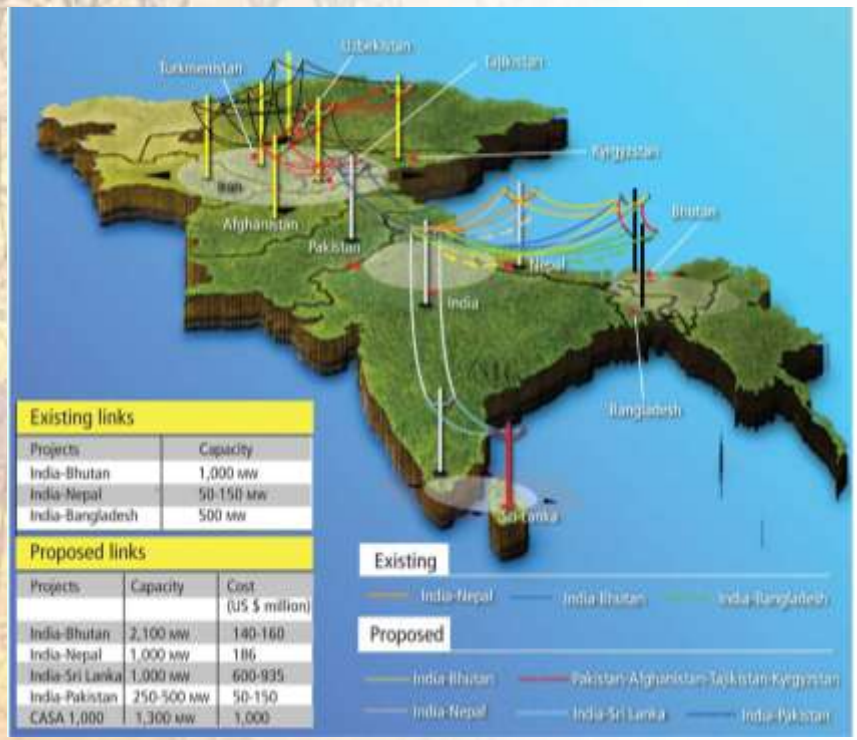

| Fiscal Years | Energy (GWh) | Peak Load (MW) |
|---|---|---|
| 2013/14 | 5989.0 | 1201.0 |
| 2014/15 | 6334.7 | 1286.1 |
| 2015/16 | 6920.4 | 1422.8 |
| 2016/17 | 7491.1 | 1559.7 |
| 2017/18 | 8287.0 | 1742.2 |
| 2018/19 | 9070.2 | 1903.3 |
| 2019/20 | 9889.9 | 2071.5 |
| 2020/21 | 10540.6 | 2203.8 |
| 2021/22 | 11398.9 | 2378.9 |
| 2022/23 | 12299.4 | 2562.1 |
| 2023/24 | 13295.1 | 2764.5 |
| 2024/25 | 14349.2 | 2978.3 |
| 2025/26 | 15460.0 | 3203.0 |
| 2026/27 | 16631.6 | 3439.5 |
| 2027/28 | 17869.0 | 3688.7 |
| 2028/29 | 19275.0 | 3971.7 |
| 2029/30 | 20811.8 | 4280.7 |
| 2030/31 | 22474.7 | 4614.4 |
| 2031/32 | 24274.3 | 4974.9 |
| 2032/33 | 26221.9 | 5364.5 |
| 2033/34 | 28329.9 | 5785.3 |

- In Nepal, hydropower project construction much relies on progress made by developers (project related studies and investigation carried out by them besides project equity arrangement and loan financing );
- Nepal Investment Board (NIB) has the mandate to mobilize, manage and approve Public Private Partnerships (PPPs) and foreign private investment for large projects including hydropower.
- NIB provides one window service for international investors to facilitate investment in Nepal;
- NIB has signed project development agreement (PDA) for 900 MW Upper Karnali Project (GMR Group India) and 900 MW Arun III Hydropower Project with SJVNL of India. Other projects under processing are 650 MW Tamakoshi III, 750 MW West Seti HEP.
- An integrated energy development plan focusing on hydropower is required for the country as the hydropower resource is huge and important.

# Financial and Economic Feasibility

# Socio-economic and Environmental Issues

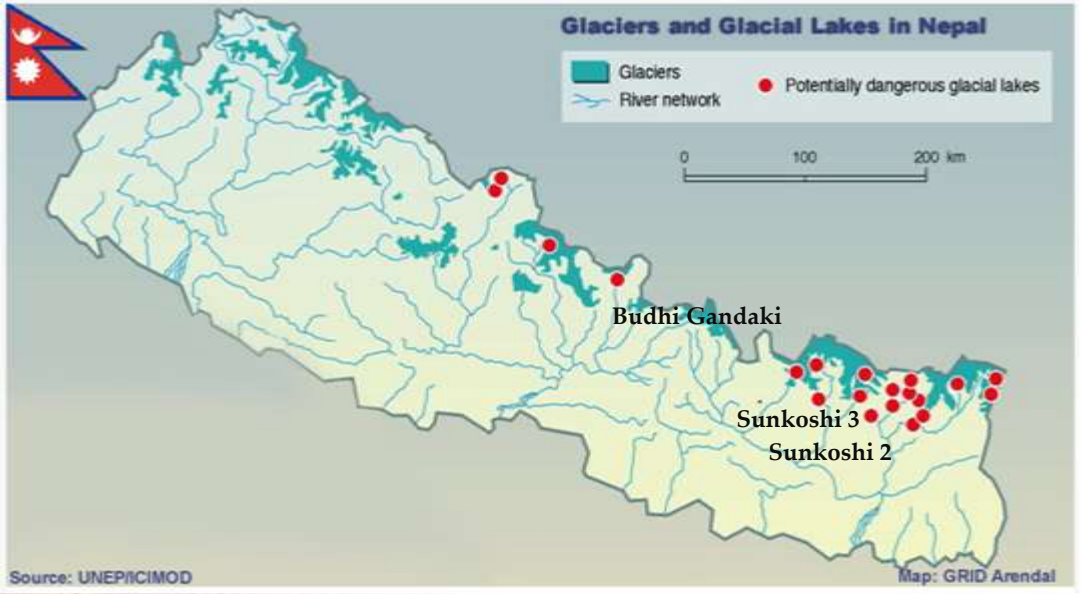
# Conclusion and Recommendations

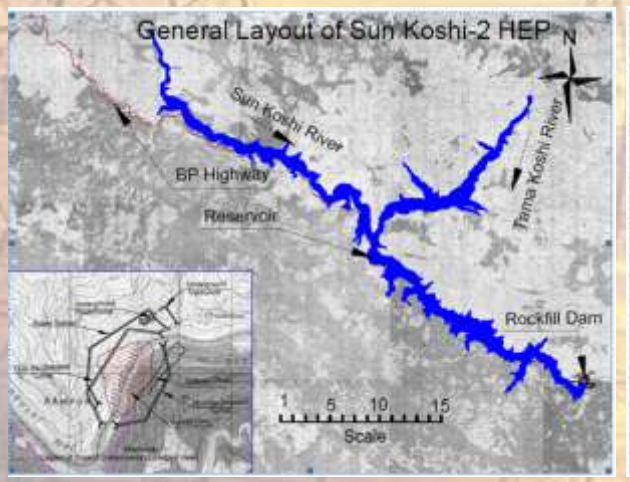


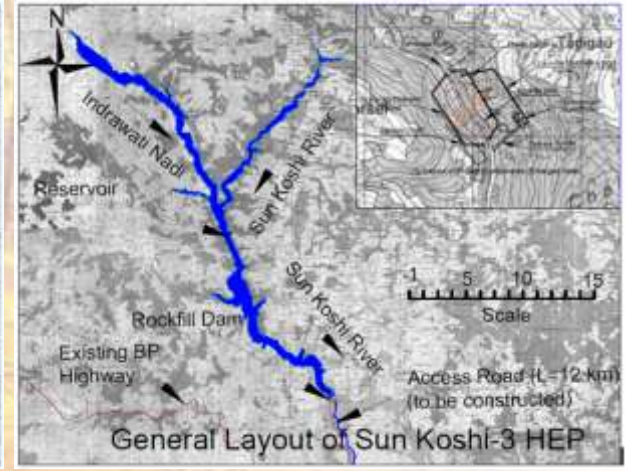

**Development of a Potential Regional Hydropower Plant in South Asia: Pre-feasibility Study**

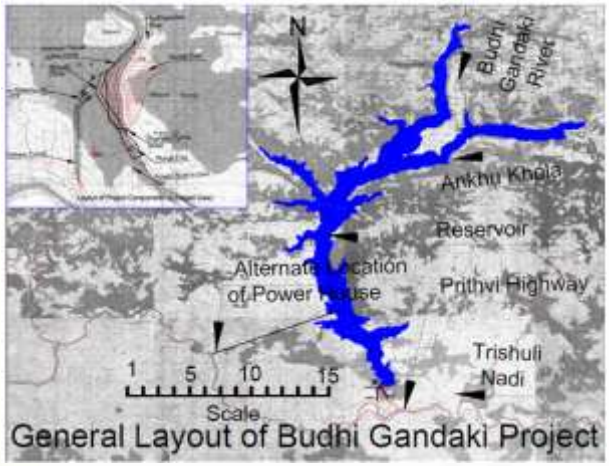
# Projects Identified

- Sunkoshi 2 Storage Project (East of Kathmandu 86 km by road; Dam site near Sindhuli Bardibas road;
- Budhi Gandaki Storage Project (West of Kathmandu 86 km by road); Dam site about 2 km from Prithvi Highway;
- Sunkoshi 3 Storage Project (East of Kathmandu and 25 km upstream of Sunkoshi 2 Storage Project.




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

# Salient Features of Sunkoshi 2 Storage Project

| Reservoir | |
|---|---|
| Full Supply Level (FSL) | El. 560 masl |
| Min. Operation Water Level | El. 505 masl |
| Drawn Down | 45 m |
| Gross Capacity (at FSL) | 3,511 Mil. $m^3$ |
| Effective Storage Capacity | 2,596.1 M $m^3$ |
| Surface Area | 63.02 $km^2$ |

| Hydrology | |
|---|---|
| Catchment Area | 10,222 $km^2$ |
| Long Term Average Flow | 504.73 $m^3/s$ |

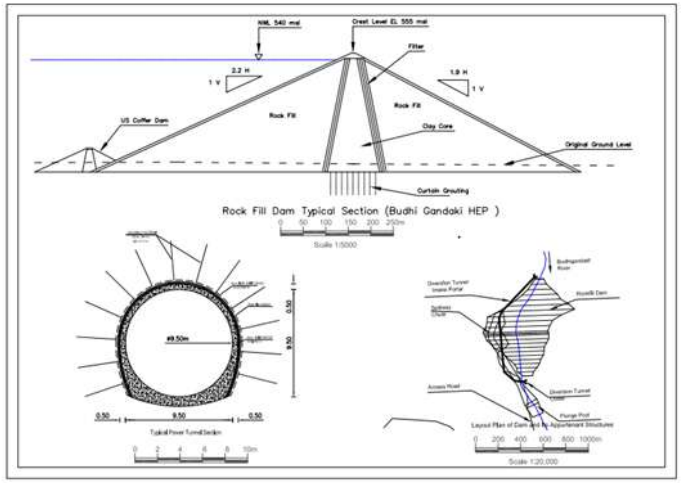
| Dam | |
|---|---|
| Type | Rock Fill |
| Maximum Height | 166 m |
| Crest Length/Width | 523 m / 10 m |
| Upstream Slope | 1 V:2.2 H |
| Downstream Slope | 1 V: 1.9 H |
| Total Dam Volume | 20.15 M $m^3$ |

| Diversion Tunnel (Circular) | |
|---|---|
| Concrete Tunnel Diameter | 18.1 m |
| Number | 2 |

| Waterway and Powerhouse | |
|---|---|
| Intake Structures | Bell mouth |
| Total Rated Discharge | 3 x 331.45 $m^3/s$ |
| Headrace Tunnel (HRT) | 1 |
| HRT Diameter | 15 m |
| HRT Length | 1,066 m |
| Penstock (Circular) | Steel Lined |
| Penstock Diameter | 10.4 m |
| Powerhouse | Underground |
| Transformer Cavern | Underground |

| Generating Equipment | |
|---|---|
| Francis Turbine Vertical | 3 Units |
| Net Head at Rated Water Level | 127.93 m |
| Installed Capacity | 1,100 MW |

| Project Alternatives for Sunkoshi 2 Storage Project | | | |
|---|---|---|---|
| Description | Alternative 1 | Alternative 2 | Alternative 3 |
| Installed Capacity (MW) | 900 | 1,000 | 1,100 |
| Total Project Cost (Thousand US$) | 1,439,699.98 | 1,467,691.56 | 1,485,713.12 |
| 4 Hour Peaking | | | |
| Total Net Peaking Energy (GWh) | 1,258.54 | 1,405.06 | 1,540.67 |
| Total Net Non Peaking Energy (GWh) | 2,161.87 | 2,287.11 | 2,254.42 |
| Total Energy (GWh) | 3,420.42 | 3,692.16 | 3,795.09 |
| Capacity Factor (%) | 43.38 | 42.15 | 39.38 |
| 5 Hour Peaking | | | |
| Total Net Peaking Energy (GWh) | 1,573.00 | 1,754.55 | 1,925.13 |
| Total Net Non Peaking Energy (GWh) | 1,738.44 | 1,929.01 | 1,635.49 |
| Total Energy (GWh) | 3,311.44 | 3,683.55 | 3,560.62 |
| Capacity Factor (%) | 42.00 | 42.05 | 36.95 |
| 6 Hour Peaking | | | |
| Total Net Peaking Energy (GWh) | 1,887.18 | 2,090.77 | 2,200.11 |
| Total Net Non Peaking Energy (GWh) | 1,374.53 | 1,350.61 | 0 |
| Total Energy (GWh) | 3,261.71 | 3,441.38 | 2,200.11 |
| Capacity Factor (%) | 41.37 | 39.29 | 22.83 |




Rock Fill Dam Typical Section and Tunnel Section for Budhi Gandaki Storage Project

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

# Salient Features of Sunkoshi 3 Storage Project

| Reservoir | |
|---|---|
| Full Supply Level (FSL) | El. 695 masl |
| Minimum Operation Water Level | El. 630 masl |
| Drawn Down | 45 m |
| Gross Capacity (at FSL) | 1,262 Mil. $M^3$ |
| Effective Storage Capacity | 658 Mil. $m^3$ |
| Surface Area | 27.39 $km^2$ |

| Hydrology | |
|---|---|
| Catchment Area | 6,190 $km^2$ |
| Long Term Average Flow | 281 $m^3/s$ |

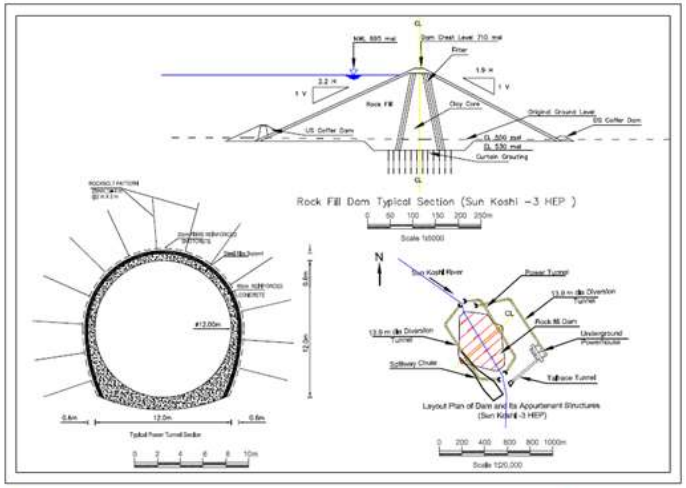
| Dam | |
|---|---|
| Type | Rock Fill |
| Maximum Height | 160 m |
| Crest Length/Width | 480 m / 10 m |
| Upstream Slope | 1 V:2.2 H |
| Downstream Slope | 1 V: 1.9 H |
| Total Dam Volume | 11.37 M $m^3$ |

| Diversion Tunnel (Circular) | |
|---|---|
| Concrete Tunnel Diameter | 13.9 m |
| Number | 2 |

| Waterway and Powerhouse | |
|---|---|
| Intake Structures | Bell mouth |
| Total Rated Discharge | 197.38 x 3 $m^3/s$ |
| Headrace Tunnel (HRT) | 1 |
| HRT Diameter | 12 m |
| HRT Length | 1,092 m |
| Penstock (Circular) | Steel Lined |
| Penstock Diameter | 8.4 m |
| Powerhouse | Underground |
| Transformer Cavern | Underground |

| Generating Equipment | |
|---|---|
| Vertical Francis Turbine | 3 Units |
| Net Head at Rated Water Level | 116.85 m |
| Installed Capacity | 3 x 200 MW = 600 MW |

| Project Alternatives for Sunkoshi 3 Storage Project | | | | |
|---|---|---|---|---|
| Description | Alternative 1 | Alternative 2 | Alternative 3 | Alternative 4 |
| Installed Capacity (MW) | 600 | 550 | 500 | 450 |
| Total Project Cost (Thousand US$) | 877,272.86 | 861,529.31 | 846,751.28 | 832,644.59 |
| 4 Hour Peaking | | | | |
| Total Net Peaking Energy (GWh) | 838.59 | 775.33 | 703.62 | 625.25 |
| Total Net Non Peaking Energy (GWhr) | 1,212.63 | 1,363.05 | 1,310.07 | 1,472.84 |
| Total Energy (GWh) | 2,051.22 | 2,138.38 | 2,013.70 | 2,098.09 |
| Capacity Factor (%) | 39.03 | 44.38 | 45.97 | 53.22 |
| 5 Hour Peaking | | | | |
| Total Net Peaking Energy (GWh) | - | 969.35 | 867.60 | 784.46 |
| Total Net Non Peaking Energy (GWh) | - | 980.48 | 882.31 | 1317.84 |
| Total Energy (GWh) | - | 1,949.83 | 1,749.91 | 2,102.30 |
| Capacity Factor (%) | - | 40.47 | 39.95 | 53.33 |
| 6 Hour Peaking | | | | |
| Total Net Peaking Energy (GWh) | - | - | - | 940.20 |
| Total Net Non Peaking Energy (GWh) | - | - | - | 1,009.03 |
| Total Energy (GWh) | - | - | - | 1,949.23 |
| Capacity Factor (%) | - | - | - | 49.45 |




Rock Fill Dam Typical Section and Tunnel Section for Sunkoshi 3 Storage Project

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

# Salient Features of Budhi Gandaki Storage Project

| Reservoir | |
|---|---|
| Full Supply Level (FSL) | El. 540 masl |
| Minimum Operation Water Level | El. 543 masl |
| Drawn Down | 50 m |
| Gross Capacity (at FSL) | 4,432 Mil. $m^3$ |
| Effective Storage Capacity | 2,596 Mil. $m^3$ |
| Surface Area | 61.46 $km^2$ |

| Hydrology | |
|---|---|
| Catchment Area | 5,005 $km^2$ |
| Long Term Average Flow | 235.48 $m^3/s$ |

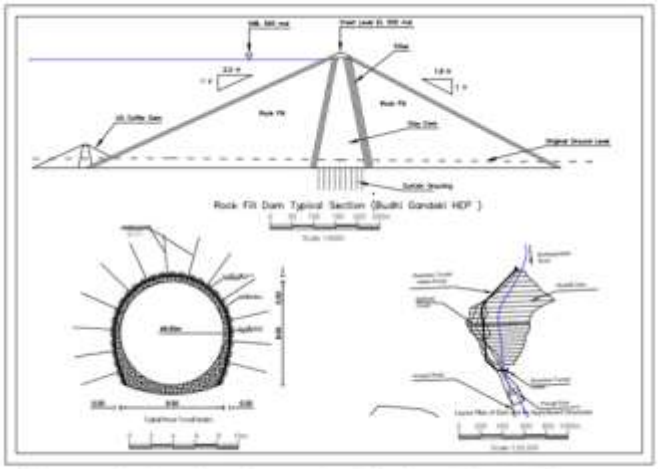
| Dam | |
|---|---|
| Type | Rock Fill |
| Maximum Height | 263 m |
| Crest Length/Width | 700 m / 10 m |
| Upstream Slope | 1 V:2.2 H |
| Downstream Slope | 1 V: 1.9 H |
| Total Dam Volume | 31.69 M $m^3$ |

| Diversion Tunnel (Circular) | |
|---|---|
| Concrete Tunnel Diameter | 12 m |
| Number | 2 |

| Waterway and Powerhouse | |
|---|---|
| Intake Structures | Bell mouth |
| Total Rated Discharge | 130.55 x 3 $m^3/s$ |
| Headrace Tunnel (HRT) | 1 |
| HRT Diameter | 9.5 m |
| HRT Length | 8,000 m |
| Penstock (Circular) | Steel Lined |
| Penstock Diameter | 6.8 m |
| Powerhouse | Underground |
| Transformer Cavern | Underground |

| Generating Equipment | |
|---|---|
| Vertical Francis Turbine | 3 Units |
| Net Head at Rated Water Level | 220.88 m |
| Installed Capacity | 3 x 333.33 MW = 1,000 MW |

| Project Alternatives for Budhi Gandaki Storage Project | | |
|---|---|---|
| Description | Alternative 1 (Powerhouse at Benighat) | Alternative 2 (Powerhouse at Fisling) |
| Total Project Cost (Thousand US$) | 1,919,708.49 | 1,996,588.28 |
| 6 Hour Peaking | | |
| Total Net Peaking Energy (GWh) | 2107.18 | 2090.40 |
| Total Net Non Peaking Energy (GWh) | 1047.78 | 2052.01 |
| Total Energy (GWh) | 3154.96 | 4142.41 |
| Capacity Factor (%) | 36.02 | 47.29 |



Rock Fill Dam Typical Section and Tunnel Section for Budhi Gandaki Storage Project

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

# Energy Generation and Tariff Determination

## Energy Generation:

Peaking energy

- 4 hours Sunkoshi 2 Storage Project;
- 4 hours Sunkoshi 3 Storage Project;
- 6 hours Budhi Gandaki Storage Project.

| Energy Generation | | | |
|---|---|---|---|
| Description | Sunkoshi 2 Storage Project | Sunkoshi 3 Storage Project | Budhi Gandaki Storage Project |
| Peaking Energy (GWh) | 1,540.66 | 838.59 | 2,090.40 |
| Non-peaking Energy (GWh) | 2,254.43 | 1,212.63 | 2,052.01 |
| Total Energy (GWh) | 3,795.09 | 2,051.22 | 4,142.41 |
| Energy (GWh)/MW | 3.45 | 3.41 | 4.14 |

## Tariff Determination:

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

| Tariff Determination | | | |
|---|---|---|---|
| Description | Sunkoshi 2 Storage Project | Sunkoshi 3 Storage Project | Budhi Gandaki Storage Project |
| Installed Capacity | 1,100 MW | 600 MW | 1,000 MW |
| Annual Power Generation | 3,795.09 GWh/year | 2,051.22 GWh/year | 4,142.41 GWh/year |
| Total Project Cost with IDC (at 2015 price level) | US$ 1,638.68 Million | US$ 967.70 Million | US$ 2,202.15Million |
| Debt Equity Ratio | 70:30 | 70:30 | 70:30 |
| Return on Equity | 20% | 20% | 20% |
| Interest Rate | 11% | 11% | 11% |
| Operation and Maintenance (% of Total Project Cost) | 2% | 2% | 2% |
| Auxiliary Power Consumption | 1.0% | 1.0% | 1.0% |
| Electricity Tariff | USc 8.58/kWh | USc 9.38/kWh | USc 10.57/kWh |

## Minimum Tariff:

- USc 8.58/kWh;

# Financial Feasibility

## Objectives of Financial Analysis:

- 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) model;
- Expected return on equity 15% after tax;
- Calculation of Project IRR, NPV, B/C Ratio;

## Assumptions:

- Inflation of foreign currency 3%;
- Inflation of foreign currency 4.8%. (published by IMF for Nepal between 2013 and 2017);
- Project license issued for 30 years.

## Project Costs:

- Civil cost;
- Electromechanical Equipment;
- Access and infrastructure;
- Engineering and management;
- Resettlement and environment;
- Contingencies.

**Data and Assumptions for Financial Analysis (Base Case)**

| Description | Sunkoshi 2 Storage Project | Sunkoshi 3 Storage Project | Budhi Gandaki Storage Project |
|---|---|---|---|
| Project Capacity | 1,100 MW | 600 MW | 1,000 MW |
| Average Power Generation | 3,795.09 GWh/year | 2,051.22 GWh/year | 4,142.41 GWh/year |
| Debt : Equity Ratio | 70:30 | 70:30 | 70:30 |
| Interest Rate | 11% | 11% | 11% |
| Project Cost (at 2015 price level) | US$ 1,485.71million | US$ 877.37 million | US$ 1,996.59 million |
| Total Project Cost (Including IDC) | US$ 1,638.68 million | US$ 976.70 million | US$ 2,202.15 million |
| Equity | US$ 494.12 million | US$ 291.25 million | US$ 660.64 million |
| Debt | US$ 1,152.94 million | US$ 679.59 million | US$ 1,541.51 million |
| Envisaged COD | 2024 | 2024 | 2024 |
| Construction (starting 2019) | 6 years | 6 years | 6 years |

# Financial Feasibility Continued …

**Project Cost Estimate:**

| Description | Sunkoshi 2 Storage | Budhi Gandaki | Sunkoshi 3 Storage |
|---|---|---|---|
| Installed Capacity (MW) | 1,100 | 1,000 | 600 |
| Civil Costs (NRs.) | 92,046,996,438.87 | 134,191,636,517.91 | 57,570,521,406.74 |
| Electromechanical Equipment (NRs.) | 27,500,000,000.00 | 25,000,000,000.00 | 15,000,000,000.00 |
| Access and infrastructure | 2,995,949,262.07 | 1,995,949,261.79 | 388,987,857.63 |
| Engineering and Management (NRs.) | 9,404,699,643.89 | 13,519,163,651.79 | 5,757,052,140.67 |
| Resettlement and Environment (NRs.) | 5,162,162,162.16 | 8,599,765,000 | 2,187,385,252.11 |
| Contingencies (NRs.) | 11,461,504,619.81 | 15,592,312,460.08 | 6,833,338,653.30 |
| Total Project Cost (NRs.) | 148,571,312,125.80 | 198,898,826,890.85 | 87,737,285,910.46 |
| Total Project Cost (Thousand US$) | 1,485,713.12 | 1,996,588.28 | 877,372.86 |

1 US$ = 100 NRs (Nepali Rupee)

# Financial Feasibility Continued …

| Results of Financial Analysis | | | |
|---|---|---|---|
| Indicators | Sunkoshi 2 Storage Project | Sunkoshi 3 Storage Project | Budhi Gandaki Storage Project |
| FIRR | 13.76% | 11.23% | 8.22% |
| NPV at 10% Discount Rate | US$ 112,283 million | US$ 5,494 million | Negative |
| Benefit Cost Ratio | 1.38 | 1.03 | 0.62 |
| Electricity Tariff First Year | USc 8.85/kWh (Average for both Peaking and Non-peaking) | | |
| Electricity Tariff with 3% annual increment after 5 years | USc 9.9/kWh (Average for both Peaking and Non-peaking) | | |

## Results of Financial Analysis:

- Highest FIIR of 13.76%;
- NPV at 10% Discount US$ 112.283 million;
- Benefit Cost Ratio 1.38

| Sensitivity Analysis (Financial Evaluation) | | | |
|---|---|---|---|
| Parameters | Percentage | Sunkoshi 2 Storage Project | |
| | | FIRR | B/C Ratio |
| Energy Generation | -5% | 12.21% | 1.17 |
| | -10% | 10.62% | 0.98 |
| Total Project Cost | +5% | 13.07% | 1.28 |
| | +10% | 12.42% | 1.19 |
| | +15% | 11.81% | 1.11 |
| | +20% | 11.21% | 1.03 |
| | -5% | 14.50% | 1.49 |
| | -10% | 15.29% | 1.61 |
| | -15% | 16.15% | 1.75 |
| | -20% | 17.08% | 1.91 |

# Economic Feasibility

## Objective of Economic Analysis:

- Demonstrate that project implementation justifies efficient use of scarce economic resources;

## Approach:

- Project financial income and costs are compared to situation without the project;
- Analysis is based on discounted cash flow (DCF) modeling;
- Calculation of Project Economic IRR, NPV, B/C Ratio;

## Key Assumptions:

- Emission benefit US$ 23.24/tCO2/year (Synapse Energy Economics Inc. USA);

**Data and Assumptions for Economic Analysis**

| Description | Sunkoshi 2 Storage Project | Sunkoshi 3 Storage Project | Budhi Gandaki Storage Project |
|---|---|---|---|
| Av. Annual GHG Emission Reduction | 3,147,753 $tCO_2$/year | 1,701,337 $tCO_2$/year | 3,435,826 $tCO_2$/year |
| $CO_2$ Levelized Allowance Price | US$ 23.24/$tCO_2$/year | US$ 23.24/$tCO_2$/year | US$ 23.24/$tCO_2$/year |
| Carbon Reduction Revenue | US$ 73.15 million/year | US$ 39.54 million/year | US $ 79.85 million/year |
| Capital Cost of Coal Based Plant1 | US$ 825 million | US$ 450 million | US$ 750 million |
| Fuel Cost | US$ 153.30 million/year | US$ 83.62 million/year | US$ 139.36 million/year |
| O&M (2% of Plant Cost) | US$ 16.5 million/year | US$ 9.0 million/year | US$ 15 million/year |

## Results of Economic Analysis:

- Highest EIIR of 30%;
- NPV at 10% Discount US$ 1,419.83 million;
- Benefit Cost Ratio 1.58

**Results of Economic Analysis**

| Indicators | Sunkoshi 2 Storage Project | Sunkoshi 3 Storage Project | Budhi Gandaki Storage Project |
|---|---|---|---|
| EIRR | 30% | 25.66% | 16.18% |
| NPV at 10% Discount Rate | US$ 1,419.83 million | US$ 704.11 million | US$ 760.08 million |
| Economic B/C Ratio | 1.58 | 1.46 | 1.12 |

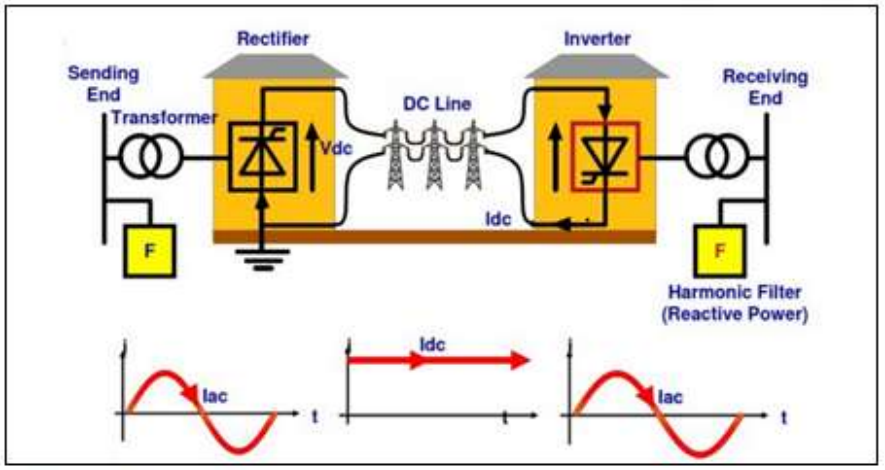
# Electricity Tariff and Transmission Line Cost

## Transmission Line:

- Proposed transmission line is +/- 500 kV HVDC as these lines costs significantly less over long distances compared to conventional AC or low voltage DC;
- Tracks are narrower and right of way is 50 m;

## Electricity Tariff with Transmission Line Cost:

- Afghanistan - Price of electricity supply from neighboring Tajikistan and Kyrgyg Republic is less than USc 5.0/kWh, and the generation cost in the country itself is estimated to be USc 6.0/kWh (CASA 1000 Study);
- Bangladesh, India, and Pakistan - Generation cost of the proposed project is comparable to the prevailing generation cost;




Basic HVDC Transmission Point to Point – Overhead Line
(Source: Introduction to HVDC and HVAC by Sameer Gupta)

Per kWh Electricity Tariff and Transmission Line Cost

| Description | Afghanistan | Bangladesh | India | Pakistan |
|---|---|---|---|---|
| Distance in km. from Proposed Project | 1,850 | 350 | 125 | 1,250 |
| Generation Cost USc/kWh | 6.0 | 6.96 | 8.0 – 13.6 | 13.2 (Peaking) 9.2 (Non-peaking) |
| Electricity Tariff (Proposed Project) USc/kWh | 8.58 | 8.58 | 8.58 | 8.58 |
| Transmission Cost USc/kWh | 5.38 | 1.02 | 0.36 | 3.63 |
| Final Electricity Tariff USc/kWh | 13.96 | 9.60 | 8.58 | 12.21 |

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

# Riskiness in Hydropower Project

## Technical Risk

- Design and Engineering
- Implementation Method Selection
- Construction Risk
- Geotechnical Risk
- Equipment Risk

## Organizational Risk

- Competence of Developer
- Competence of Consultant
- Competence of Contractor
- Competence of Vendors

## Other Risks

- Changes in Government Policies
- Law and order situation
- Social risks
- Transmission line construction risk

## Financial and Economic Risk

- Fund Risk
- Inflation Risk
- Improper Estimation
- Foreign Exchange Risk

## Clearance Risk

- Environmental Clearance
- Forest Clearance
- Others

## Natural Risk

- Natural Calamity (Landslide, flood etc.)
- Hydrological Risk

# Socio-economic and Environmental Issues

## Project Benefits:

- Generation of both direct and induced employment;
- Increased economic activities and its trickledown effect in the project area;
- Tourism and fishery potential in the reservoir after project construction.

## Important Adverse Impacts:

- A total of 7,065 ha of cultivated land, forest, grassland, barren land, flood plains directly affected;
- Likewise 1,221 ha of cultivated land, forest, grassland, barren land, and flood plains will be indirectly affected;
- 13,356 number of population living in 10 VDCs of Sindhuli, 9 VDCs in Kavrepalanchowk, and 1 VDC in Dolakha.

## Environmental Impact Assessment (EIA):

Objectives:

- Ensuring environmental factors considered in the decision-making process;
- Ensuring that possible adverse environmental impacts are identified and avoided or minimized;
- Informing the pubic about the project.

# Financing Sunkoshi 2 Storage Project and Transmission Line

## Financing

- Huge infrastructure and huge investment;
- Given the level of investment required, a strong backing is essential to reduce off-takers and financing risk;
- Rajansthan Sun Technique Concentrated Solar Project model could be useful for replication. Combined debt is from:
  - Foreign public institution
  - Local private investment
- Range of key stakeholders are:
  - Policy framework set by government;
  - Debt from foreign development bank and an export credit agency;
  - A power company (Reliance Power) developed project and provided equity;
  - Areva Solar provided the technology.

JAWAHARLAL NEHRU NATIONAL SOLAR MISSION
Building Solar India

ADB

RELIANCE Power
Anil Dhirubhai Ambani Group

AREVA
forward-looking energy

# Conclusion, Recommendations and Way Forward

- A wide gap exists between supply of electricity generated and demand in South Asia. Cumulative power supply-demand gap in India, Pakistan and Bangladesh is 18, 707 MW.
- This creates huge market for potential power producers Nepal and Bhutan to export power to India, Pakistan and Bangladesh;
- Limited cross-border transmission interconnection exists between SAARC member countries;
- India is the only country having cross-border transmission interconnections with Bangladesh, Bhutan and Nepal. Under sea transmission line is proposed between India and Sri Lanka;
- Three projects identified are Sunkoshi 2 Storage Project, Budhi Gandaki Storage Project and Sunkoshi 3 Storage Project;
- Out of the three projects, the Sunkoshi 2 Storage project with FIRR 13.67% was found to be feasible (equals WACC of 13.7%). B/C ratio is 1.38.
- The financial analysis was done for an electricity tariff USc 8.85/kWh with 3% annual escalation for 5 years making USc 9.9 from 6$^{th}$ year onward.
- Sunkoshi 2 project has the highest EIRR of 30%.
- The project pre-construction work is envisaged to complete in 2 years, followed by 6 years for construction (1,000 MW Karcham Wantoo in Kinnaur completed in 5 years);

# Conclusion, Recommendations and Way Forward

- Prevailing electricity laws and regulations of Bhutan and Nepal has provision for cross-border electricity trade;
- The SAARC Framework Agreement for Energy Cooperation (Electricity) singed by foreign minster during the 18th SAARC Summit held in Kathmandu in 2014 will give impetus to promote cross-border trade in electricity and help the development of a common regulatory mechanism;
- Once the regional regulator is established, SAARC member countries can work towards the development of projects such as Sunkoshi 2 Storage project and its transmission lines;
- If debts are available at terms and interest rates similar to those found in developed countries, cost of renewable energy in developing economies would be 30% lower;
- Rajasthan Sun Technique Solar Project financing model could be useful for replication for Sunkoshi Storage Project;
- The power market model of the existing cross-border trade between India and Bangladesh, Bhutan, and Nepal is a bilateral trade model where a PPA is done for contract duration;
- A regional pool model such as SARPP will improve efficiency in the participating countries' generation, transmission, and distribution system as a result of demand and supply management by integration of power assets.
- Nepal Investment Board can play a key role in financing Sunkoshi 2 Storage Project.

## Way Forward:

**Track I Diplomacy strengthened vis-à-vis Track II Diplomacy Initiative by SEC etc.**

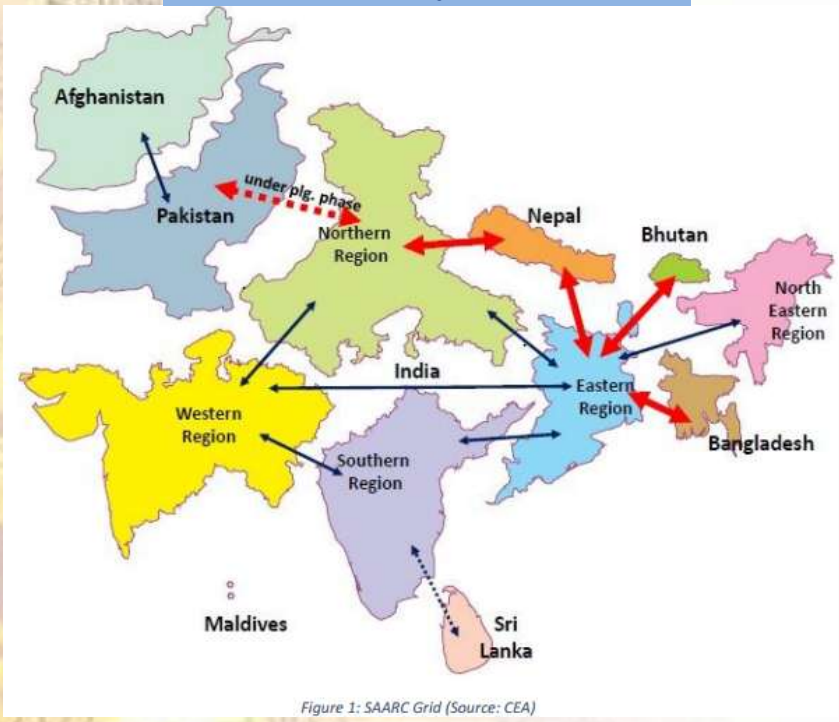



Figure 1: SAARC Grid (Source: CEA)

**http://**indiaenergy.gov.in/docs/ISGF_CBT%20Documentation.pdf

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

# Thank You

Shyam S. Shrestha