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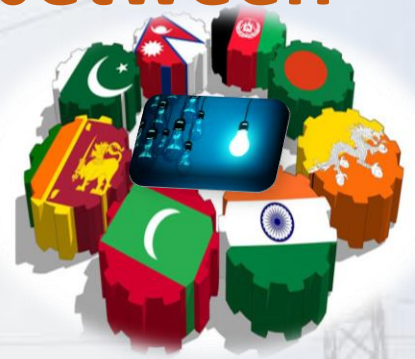
South Asia Regional Initiative for Energy Integration (SARI/EI)

Coordinated interconnection transmission planning and operation: For secure reliable Grid interconnection between India- Nepal



by Mr. Vinod Kumar Agrawal, Technical Director and Rajiv Ratna Panda, Technical-Head
SARI/EI/IRADe

Workshop with Nepal stakeholders on "Enhancing Energy Cooperation between India- Nepal"
11.30 AM - 12.00 PM, 24th July 2019 at Nepal Electricity Authority, Kathmandu, Nepal

Outline

- Hydro Power Potential and future Plan in Nepal.
- South Asia Cross Border Transmission Capacity by the year 2036/2040.
- RE capacity Deployment in India.
- Renewable Integration and Grid Balancing
- India-Nepal : Existing Cross Border Transmission Line and Future Plan
- Current Institutional Mechanisms for Coordination System Planning and operation.
- Regional Coordinated system planning –Institutional Mechanism

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Hydro Power Potential and future Plan in Nepal

Hydro Power Potential in Nepal

Major River Basins	Theoretical Potential in MW			Technical Potential		Economical Potential	
	Major river courses having catchments areas above 1000 km^2	Small river courses having catchments areas 300-1000 km^2	Total	Number of Project Sites	Technical Potential in MW	Number of Project Sites	Economical Potential in MW
Sapta Koshi	18750	3600	22350	53	11400	40	10860
Sapta Gandaki	17950	2700	20650	18	6660	12	5270
Karnali and Mahakali	32680	3500	36180	34	26570	9	25125
Southern River	3070	1040	4110	9	980	5	878
Country Total	**72450**	**10840**	**83290**	**114**	**45610**	**66**	**42133**

Source: Government of Nepal Water and Energy Commission Secretariat Electricity Demand Forecast Report (2015-2040)

Hydro Power Potential in Nepal : Plan and Vision

Government white paper, Generation of Hydropower

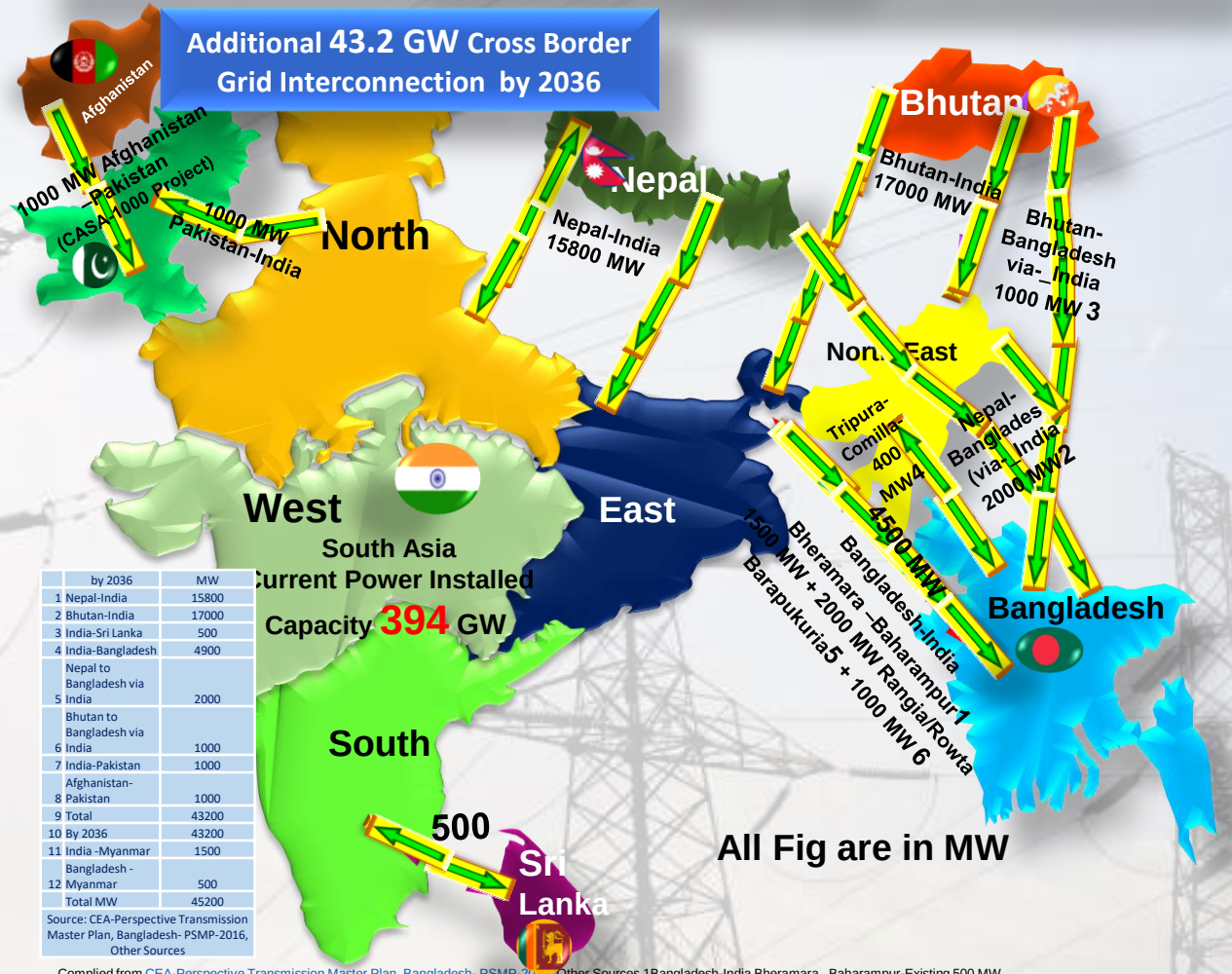
- **Increase the consumption of electricity per person to 700 KWH (Kilo watt per hour) in 5 years and to 1500 KWH in 10 years.**
- **5 GW in 5 years and 15 GW in 10 years.**
- **storage projects are being prioritized.**

South Asia Cross Border Transmission Capacity by the year 2036/2040

Big Picture -South Asia Cross Border Transmission Capacity by the year 2036/2040

- Significant Transmission System Interconnection (Both AC and DC) are Planned and Proposed.
- 43.2 GW additional Cross Border Transmission Inter. Capacity by 2036.
- Large scale hydro power development in Bhutan and Nepal and Renewable Energy (175 GW by 2022) In India.

SOUTH ASIA POWER GRID



	by 2036	MW
1	Nepal-India	15800
2	Bhutan-India	17000
3	India-Sri Lanka	500
4	India-Bangladesh	4900
5	Nepal to Bangladesh via India	2000
6	Bhutan to Bangladesh via India	1000
7	India-Pakistan	1000
8	Afghanistan-Pakistan	1000
9	Total	43200
10	By 2036	43200
11	India -Myanmar	1500
12	Bangladesh - Myanmar	500
	Total MW	45200

Source: CEA-Perspective Transmission Master Plan, Bangladesh- PSMP-2016, Other Sources

Complied from CEA-Perspective Transmission Master Plan, Bangladesh- PSMP-2016, Other Sources 1Bangladesh-India Bheramara –Baharampur-Existing 500 MW
2 From Nepal 1,000 by 2030 Power import by using Case 3 T/L (upgrade to 765kV AC) and From Nepal (Purnea -Barapukuria), 1,000 by 2025, Power import by using Case 3 T/L (initially 400kV AC) **3** Bhutan-Bangladesh via-_India 1000 MW-Bongaigaon/Rangia -Jamarpur1,000 by 2030-Power import from Bhutan
4 400 MW by 2020 (100 MW existing) Construction of HVDC (500MW) in Comilla Construction of HVDC (500MW) in Comilla S/S. Some load (100 MW) in Comolia (N) S/S will be disconnected from Indian System **5** 1000 MW by2023 and 1000 MW by 2025 (Power Import Using Case 2 T/L (± 800KV HVDC) **6** 1000 MW by 2030 Bibiyana-Meghalaya (PSPP)
7 At the Proposal Stage , detailed planning to be done.

Source:- Bhutan Plant Schedules as per the http://cea.nic.in/reports/monthly/hydro/2018/bhutan-03.pdf

RE capacity Deployment in India

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RE capacity Deployment in India

Current All India Gen.* Capacity

Total : 350 GW

Coal : 191 GW
Lignite : 6.26 GW
Gas : 24.93 GW
Diesel : 0.63 GW

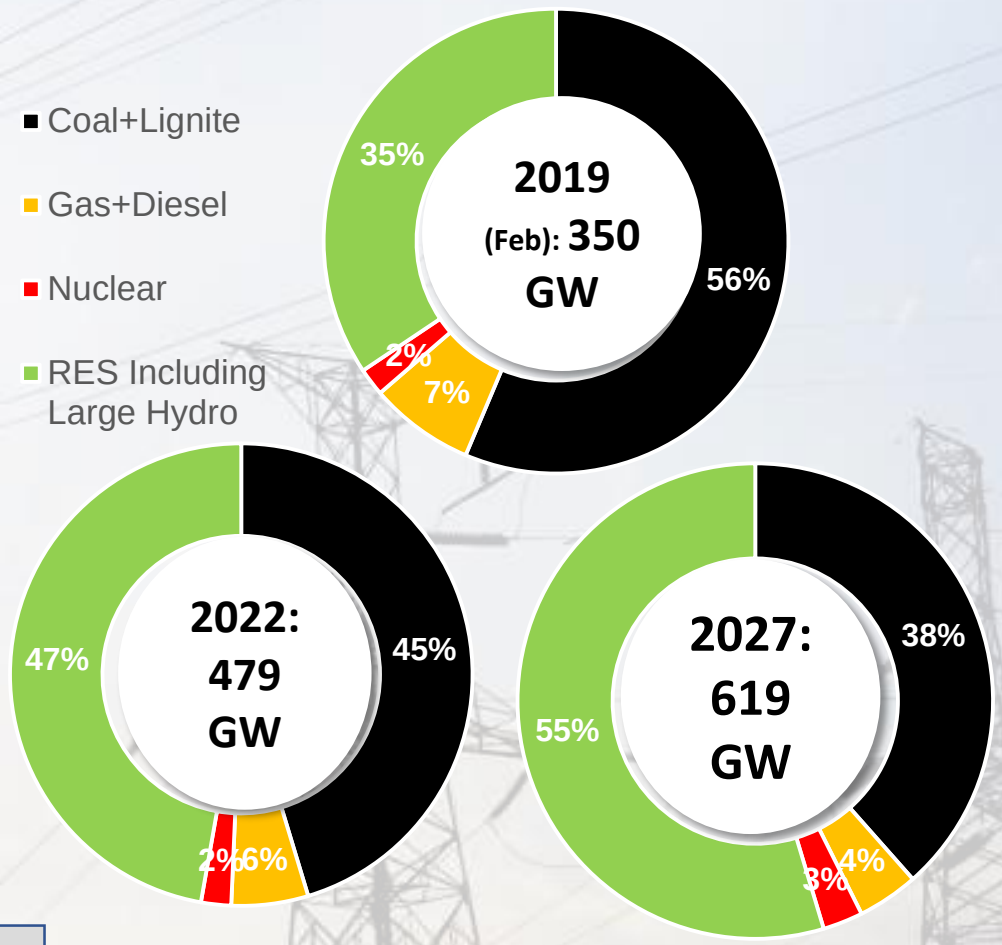
Thermal
222 GW (64 %)

Nuclear : 6.7 GW (2 %)
Hydro : 45.39 GW (13%)
RES : 75.05 GW (21%)

Current Status RE* : 75.02 GW

Wind : 35.28 GW
Solar : 26.02 GW
Biomass : 9.07 GW
Smaller Hydro : 4.52 GW
Waste to Power : 0.13 GW

India Power installed capacity mix



INDIA's NDCs: By the year 2040, the **40 percent** of its total installed capacity will be from non-fossils Fuel (Hydro, Nuclear and Renewable Energy Sources variety) ; By 2030, a concurrent reduction in emissions intensity of GDP by **33-35 %** from a 2005 baseline:

* RES include Solar and Wind Energy, SHP, Bio Power, U&I (Urban & Industrial Waste Power) ** Hydro, Nuclear and Renewable Energy Sources

Source : https://powermin.nic.in/sites/default/files/webform/notices/Report_of_the_Committee_on_optimal_energy_mix_in_power_generation_on_medium_and%20long_term_basis.pdf

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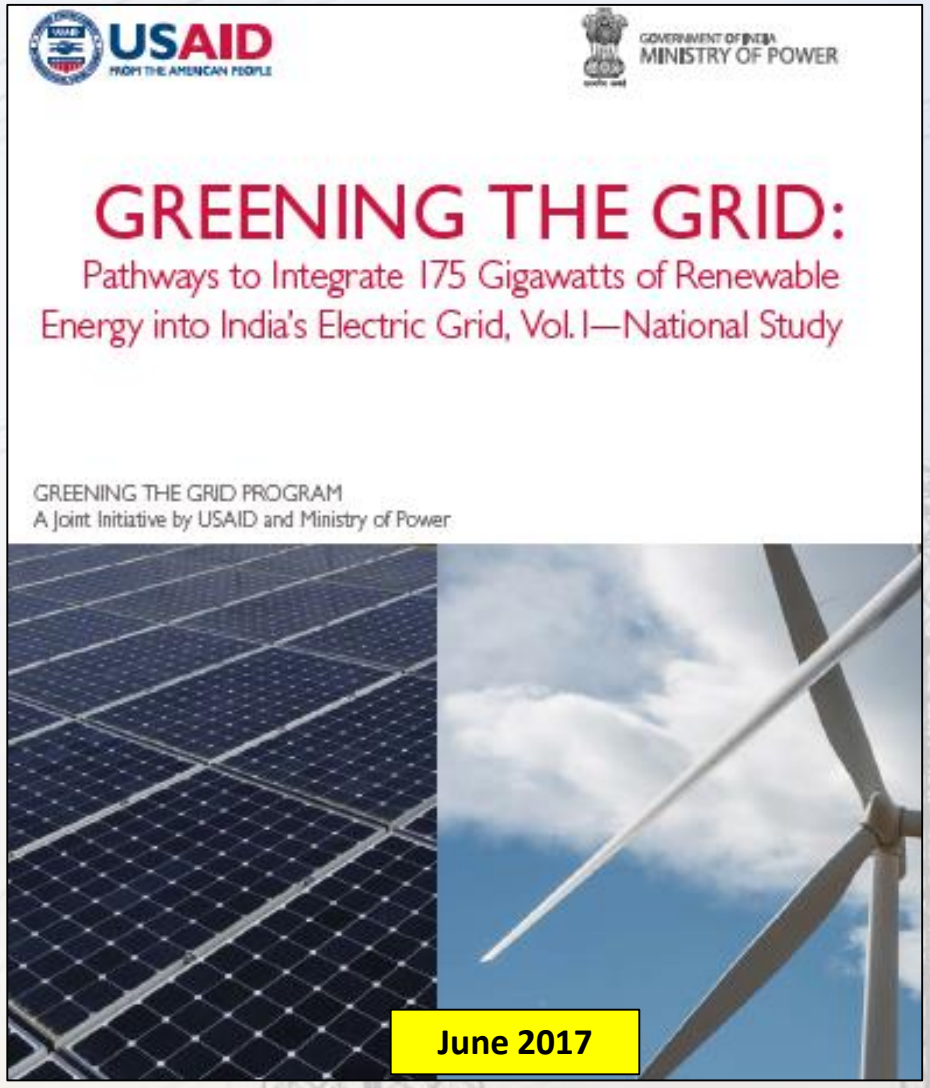
Renewable Integration and Grid Balancing

GtG Report _ Some of the salient features & findings:

- Simulation Objective …… Cost Optimization;
- Primary tool …… Detailed production Cost Model;
- RE penetration by quantum …… 370 TWH;
- RE penetration by %……. 22% of electricity consumed;
- RE Curtailment ……. 1.4%;
- Peak Ramp ……. 32 GW/Hour;
- Report can form basis to further explore (Exclusions) :
  …. Optimal renewable resources;
  …. Intrastate transmission siting and;
  …. System stability during contingencies;



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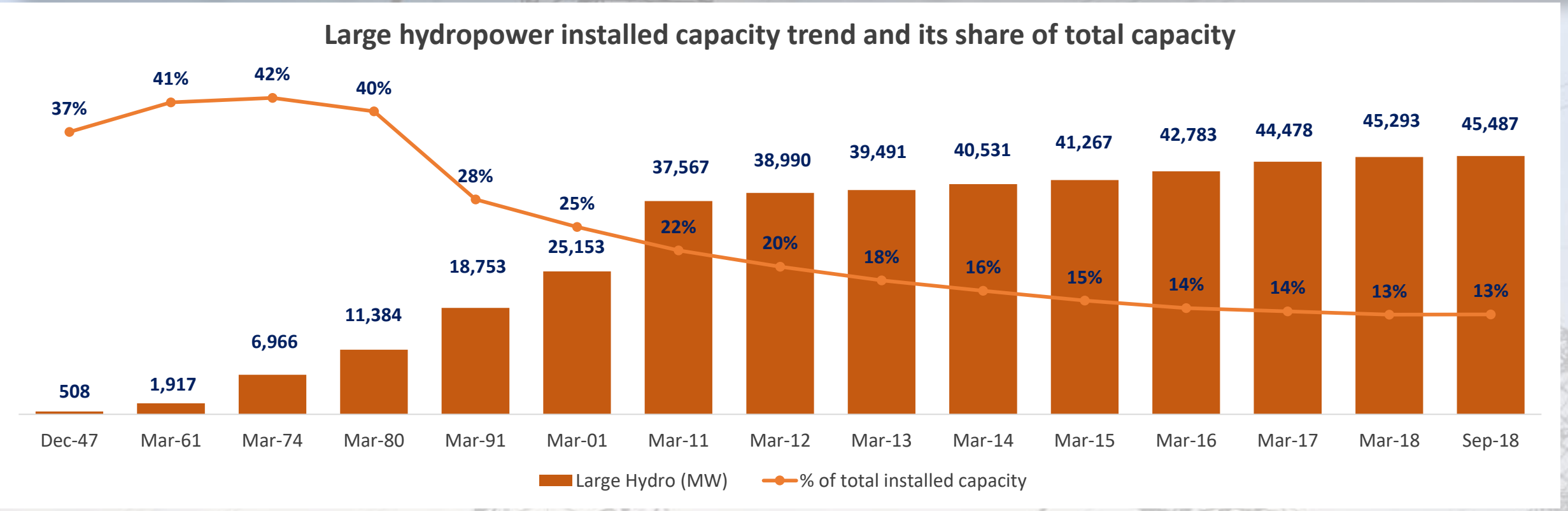
Hydropower: Slow capacity addition in India



During FY2017-18, only 815 MW(1) of capacity addition of large hydro has been achieved against the target of 1,305 MW. This also suggests that target itself is very conservative

Contracting share in overall generation mix due to higher capacity addition from other sources of power generation

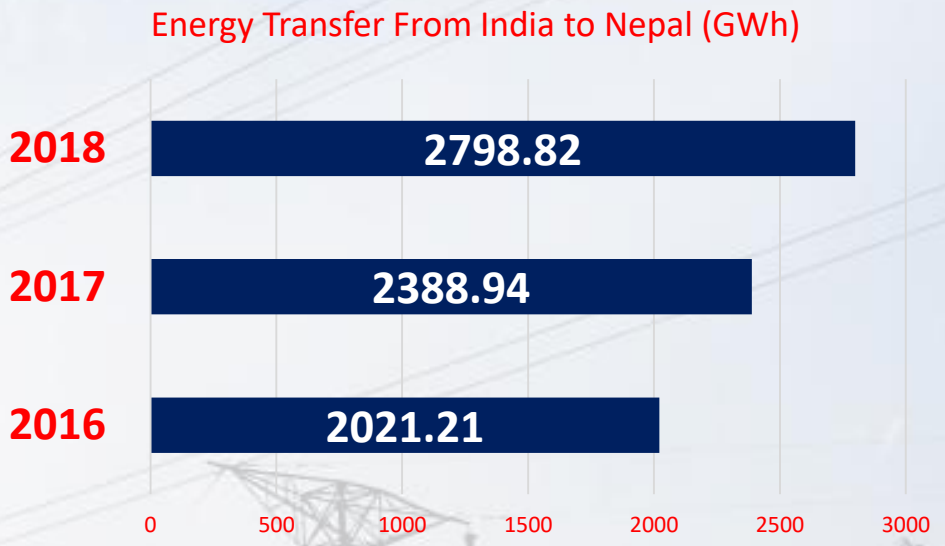
(1) Total capacity of small hydro is 4,507 MW as on September 2018; Total capacity of all hydro is 49,994 MW.

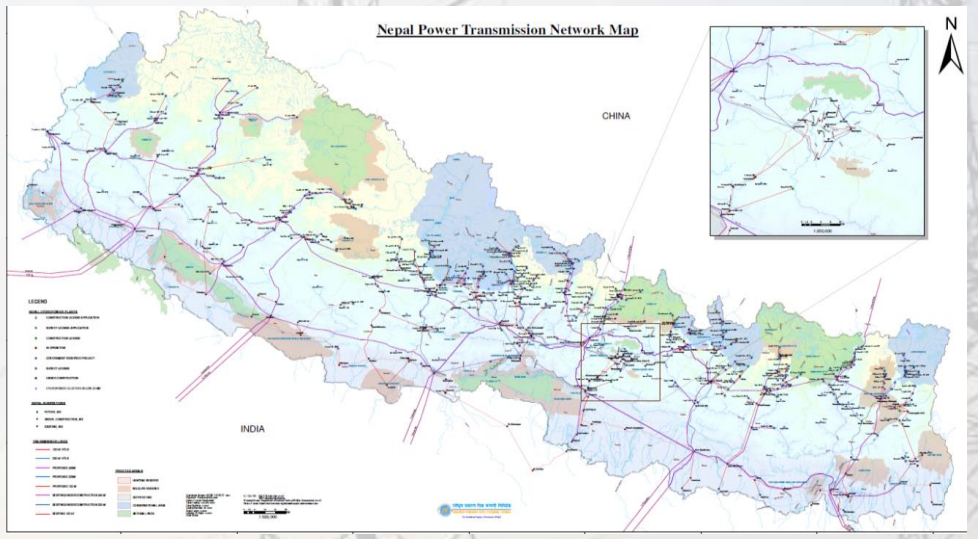
Source : https://powermin.nic.in/sites/default/files/webform/notices/Report_of_the_Committee_on_optimal_energy_mix_in_power_generation_on_medium_and%20long_term_basis.pdf

India-Nepal : Existing Cross Border Transmission Line and Future Plan

India-Nepal : Existing Cross Border Transmission Line and Future Plan

- Nepal–India Cross Border line -to exchange the power between two countries through various lines operating at various voltage levels from 11kV to 220kV.
- Total 14 no of Interconnections
- Presently Nepal is importing power from India (432 MW).
- The TRANSMISSION SYSTEM DEVELOPMENT PLAN OF NEPAL has identified six locations for cross-border power line (400 KV level) with India.
- The cross-border location is proposed in such way that the load center and generation hub is closer to each





India-Nepal : Proposed Cross Border Transmission Line

S.N.	400 kV Transmission Line	Configuration	Length Circuit km
A	**Cross Boarder interconnection with India**		
1	Inaruwa-Purniya (India)	Double	132
2	New Dhalkebar- Muzzafarpur	Double	199
3	New Butwal - Gorakhpur	Double	131
4	Phulbari (Lumki)- Lucknow	Double	180
5	Dododhara- Barelly	Double	600
6	Attariya-Bareli	Double	260
Total			**1501**
B	**Cross Boarder interconnection with China**		
7	Ratmate-Chilime Hub- Kerung	Double	110
8	Arun 3- U Arun - Latse	Double	127
	Total		**237**
S.N.	**400 kV Transmission Line (East- West)**	**Configuration**	**Length Circuit km**
1	Damak-Duhabi-Inaruwa	Double	130
2	New Hetauda- New Butwal	Double	300
3	New Butwal-Phulbari-Mainatara-Dododhara-Attariya-(Rupalgadh)-Pancheswor	Double	800
Total			**1230**

Importance of Coordination System Planning and Operation in South Asia

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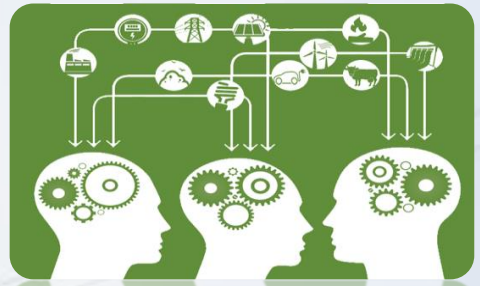
Importance of Coordination System Planning and Operation in South Asia

- Power system integration in South Asia can bring potential large technical, operational, economic power system benefits in the Region.



- Coordinated system planning, operation is a very fundamental exercise for effective power system integration and expansion in South Asia.
- Ensure safe, secure and reliable South Asia power system integration and expansion.

- Importantly such coordinated consultative planning process also build a sense of consensus among the South Asian Countries.
- In future, with large penetration of Renewable (wind and solar), changing energy mix, DSM, Smart Grid, Electric vehicles and storage calls for a more integrated and coordination planning for most economic & technical planning of power system.

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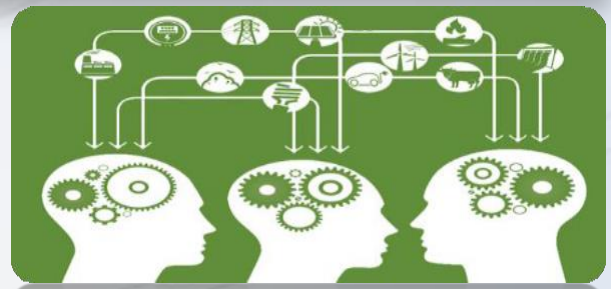
Current Institutional Mechanisms for Coordination System Planning and Operation

Current Institutional Mechanisms for Coordination System Planning and Operation



- Joint Steering Committee and Joint Technical Team at bilateral level among South Asia Countries which takes care for planning coordination.
- Joint Technical Team comes up with the various transmission interconnection option/feasibilities.

- System operation and scheduling and dispatch:- Load Dispatch Centres coordinates among each other for cross border transactions.
- Coordinated System operation and scheduling essential for secure and reliable South Asia grid.

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Need for South Asia Technical Institutional Mechanism
International Best Practices of Technical Institutional Mechanism

Need for South Asia Technical Institutional Mechanism
International Best Practices of Technical Institutional Mechanism

entsoe
Reliable Sustainable Connected

European Union
ENTSO-E's responsibilities in enhancing the cooperation between its 41 member TSOs across the EU to assist in the development of a pan-European electricity transmission network

- Developed the Network codes on System operation, connection and capacity allocation etc.
- System Development Committee
- System Operation Committee
- Market Committee
- Research Development Committee

SAPP

Southern African Power Pool
Aim to provide the least cost, environmentally friendly and affordable energy and increase accessibility to rural communities.
It is a Inter-Utility organisation established through Inter-Utility MOU

- *Operational Subcommittee*
- *Planning Subcommittee*
- *Environment Subcommittee*
- *Operating Guidelines*
- *DAM Book of Rules*
- *DAM Legal Agreement*

pjm

PJM is a regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of 13 States and the District of Columbia.

- *Operating Agreement*
- *Operating Committee (OC)*
- *Planning Committee (PC)*
- *Market Implementation Committee (MIC)*
- *Markets and Reliability Committee (MRC)*
- *Other Sub Committees and Task Forces*
- *Transmission Owners Agreement*

West African Power Pool

West Africa Power Pool: Integrate the operations of national power systems into a unified regional electricity market. Inter Utility Organisation, WAPP Utility Members (26)

- Engineering and Operating Committee (EOC)
- Strategic Planning & Environmental Committee
- Operation Manual-WAAP
- Regional Market Rules for the WAPP
- Transmission Tariff Methodology
- 2012-2015 WAPP Business Plan

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System Operation in India

- **Independent System Operation is important for Integration of power grids.**
- **Safe , Secure, Reliable Integration Development of Power Market and Market Operation.**
- **India followed a gradual and systematic approach towards a independent system Operators.**

Forum of Load Despatchers envisions being a catalyst in reliable, efficient and economic operation of the Indian bulk electric power supply system.

- Promoting technological excellence and harmonization of practices
- Promoting compliance to Reliability Standards
- Facilitating development of Ancillary Services in power system
- Promoting capacity building in Power System/Market Operation
- Developing Code of Ethics for Load Despatchers in India

- before 1914: RLDC & CEA
- 1994 Onwards: PGCIL& RLDC
- 2003: Functional separation and Ring Fencing of System Operation
- 2009: FORUM OF LOAD DESPATCHERS, INDIA
- 2010: Financial separation POSOCO wholly owned subsidiary
- 2015: POSOCO Separate Independent System Operator

PGCIL
RLDC
PGCIL
POSOCO
PGCIL
POSOCO

Forum of Load Despatchers i.e. FOLD is a forum of organisations carrying out System Control activities in India. It has been created vide reference no.: 15/8(1)/2008-FoR/CERC dated 02.01.2009 on the basis of the decision arrived at in the ninth meeting of FoR held at Bhubaneshwar on 14th & 15th November 2008.

Way forward

- Building new transmission line
- Focusing on Storage projects, taking advantage of Renewable energy Development in India.
- As AC interconnection increases
  - N-1, N-2 Transmission planning
  - Strengthening Nepal's Internal Power System
  - Developing isolated system and protection scheme.
  - Taking steps to have black start
- Developing various Regulations operational and planning aspects of CBET.
- Improving Project execution
- Building Institutional Mechanism such South Asia Forum of Transmission utilities and South Asia Forum of System Operators
- Planning for Trilateral and Multilateral Power Trade

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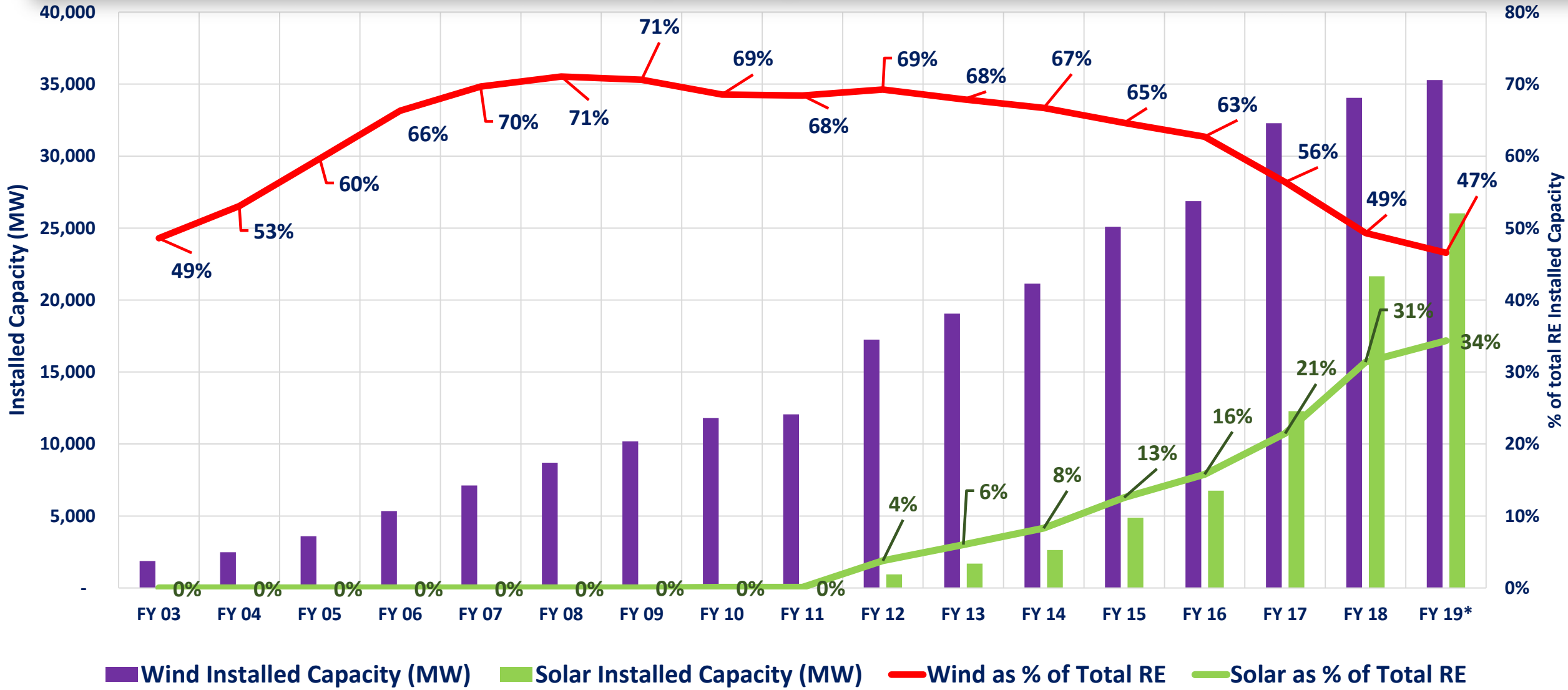
India-Nepal : Proposed Cross Border Transmission Line

Name of the Link	Key Features of the Line	Associated generation projects
Attariya-Bareily	Single line of double circuit 400kV quad Moose transmission line of distance about 140 KM	From export-oriented HPP in the Mahakali, Karnali and Seti corridors in Zone-1 area of Nepal
Dododhara–Bareily	2 No. of double circuit 400kV quad Moose transmission line of distance about 200 KM	From export-oriented HPP in the Mahakali, Karnali and Seti corridors in Zone-1 area of Nepal
Phulbari–Lukhnow	2 No. of double circuit 400kV quad Moose transmission line of distance about 200 KM	Evacuating the power from Nalsyau Gad, Bheri Corridor in Zone-2 of Nepal to Lukhnow, India
New Butwal–Gorakhpur	2 No. of double circuit 400kV quad Moose transmission line of distance about 125 KM	Evacuating the power from Marsyandi, Kaligandaki and Gandaki Corridor in Zone-3 of Nepal to Gorakhpur
Dhalkebar – Muzzafarpur	2 No. of double circuit 400kV quad Moose transmission line of distance about 130 KM	evacuating the power from Khimti, Tamakoshi and Dudhkoshi Corridor in Zone-4 of Nepal to Muzafarpur
Inaurwa – Purnea	2 No. of double circuit 400kV quad Moose transmission line of distance about 110 KM	evacuating the power from major corridor likes Arun and Koshi in Zone-5 of Nepal to Purnea, India

Solar and Wind Capacity Additional Trend in India



Template South Asia Power Supply Position Report - Dashboard Utility

South Asia Regional Power Supply Position

Daily Power Supply Position Report For Dated : 27.06.2019
(Date of Issue : 28.06.19)

A. Installed Capacity

(All Figures show values in MWs)

Sources\Country	India	Bangladesh	Sri Lanka	Bhutan	Nepal
Coal					
Gas					
Diesel					
Nuclear					
Hydro					
Renewable					
Total					

*Note: Installed Capacity figures indicate the grid connected Generation Capacity

B. Actual Generation

(All Figures show values in Mus)

Sources\Country	India	Bangladesh	Sri Lanka	Bhutan	Nepal
Coal					
Gas					
Diesel					
Nuclear					
Hydro					
Renewable					
Total					

C. Demand Met

Country ->	India	Bangladesh	Sri Lanka	Bhutan	Nepal
Max. Demand Met (MW) At (Time)					
Min. Demand Met (MW) At (Time)					
Energy Met (MU)					
Shortage (MU)					

*Note: Time period corresponds to the Local time of the respective countries

D. Frequency Profile

	India	Bangladesh	Sri Lanka	Bhutan	Nepal
Day Avg. Freq. (Hz.)					
Day Max. Freq. (Hz.)					
Day Min. Freq. (Hz)					

E. Diversity Factor

Regional Demand Diversity factor at Evening Peak (at 18.00 Hrs. IST)	
Regional Demand Diversity factor at Night Off Peak (at 03.00 Hrs. IST)	
Regional Demand Diversity factor during Day time (at 13.00 Hrs. IST)	

F. Rates and Volume Transacted at Power Exchange (IEX) on the previous day

Total Cleared Volume (MWH)	
Price Avg. RTC (Rs.₹/MWH)	
Price Peak (Rs.₹/MWH)	
Price Non-Peak (Rs.₹/MWH)	
Price Day (Rs.₹/MWH)	
Price Night (Rs.₹/MWH)	
Price Morning (Rs.₹/MWH)	

G1. Regional Power Transfer

From India To -> (+ve denotes export by India & -ve Import by India)	**Bangladesh**	**Sri Lanka**	**Bhutan**	**Nepal**
Energy (Mus)				
Max. Transfer in MW				

G2. Regional Power Transfer

From Bangladesh To -> (+ve denotes export by BD & -ve Import by BD)	**Sri Lanka**	**Bhutan**	**Nepal**	**India**
Energy (Mus)				
Max. Transfer in MW				

G3. Regional Power Transfer

From Sri Lanka To -> (+ve denotes export by S.L & -ve Import by S.L)	**Bhutan**	**Nepal**	**India**	**Bangladesh**
Energy (Mus)				
Max. Transfer in MW				

G4. Regional Power Transfer

From Bhutan To -> (+ve denotes export by Bhutan & -ve Import by Bhutan)	**Nepal**	**India**	**Bangladesh**	**Sri Lanka**
Energy (Mus)				
Max. Transfer in MW				

G5. Regional Power Transfer

From Nepal To -> (+ve denotes export by Nepal & -ve Import by Nepal)	**India**	**Bangladesh**	**Sri Lanka**	**Bhutan**
Energy (Mus)				
Max. Transfer in MW				

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Demand Met in the Countries in South Asia Region

Details of the 'Demand Met' in MW in the different South Asian Countries on ……..

(All figures show the Demand Met in MW)

Country -> Time (Hrs.)*	India	Bangladesh	Sri Lanka	Bhutan	Nepal
00:15					
00:30					
00:45					
01:00					
01:15					
01:30					
01:45					
02:00					
02:15					
02:30					
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21:45					
22:00					
22:15					
22:30					
22:45					
23:00					
23:15					
23:30					
23:45					
24:00					
Maximum					
Minimum					
Average					

*Note: Time period corresponds to the Local time of the respective countries

Inter – Regional Exchange of Power in South Asia Region

Details of Power Exchange on Inter – Regional Lines in South Asia Region on Dated ……:

Line Details	From	To	Max. Export (MW)	Max. Import (MW)	Export (MU)	Import (MU)	Net Export (MU)
Baharampur – Bheramara 400 KV AC D/C feeding to HVDC Back-to-Back link	India	Bangaldesh					
Surajmaninagar – Comilla 500 KV HVDC Back to Back Link (Currently operated at 132KV AC D/C)	India	Bangladesh					
Chukha HEP - Birpara 220 KV (3 circuits)	India	Bhutan					
Kurichu HEP - Geylephu -Salakati 132kV S/C	India	Bhutan					
Tala HEP- Siliguri 400kV HVDC (one ckt. via Malbase in Bhutan)	India	Bhutan					
Dhalkebar-Mujaffarpur (Currently operated at 220 kV and finally to be charged at 400 kV)	India	Nepal					
Kataiya — Kusaha 132KV AC S/C	India	Nepal					
Kataiya - Kusaha II 132KV AC S/C	India	Nepal					
Raxaul-Parwanipur 132KV AC S/C	India	Nepal					
Ramnagar-Gandak 132KV AC S/C	India	Nepal					
Tanakpur-Mahendranagar 132KV AC S/C	India	Nepal					
Kataiya Rajbiraj (Under Kosi Agreement) 33KV AC S/C	India	Nepal					
Jaynagar-Siraha 33KV AC S/C	India	Nepal					
Nanpara-Nepalgunj 33KV AC S/C	India	Nepal					
Sitamadi-Jaleshwor 33KV AC S/C	India	Nepal					
Raxaul-Birgunj 33KV AC S/C	India	Nepal					

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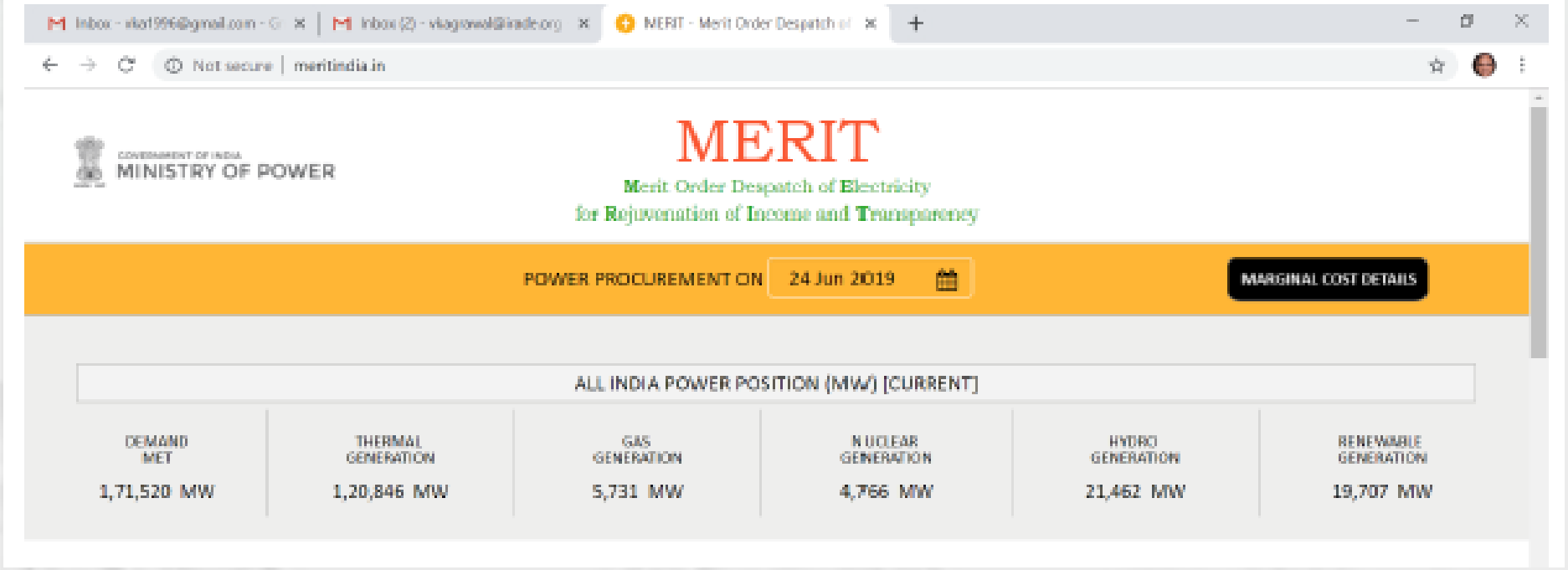
Real Time Data from India

http://meritindia.in/



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Real Time Data from Nepal

https://www.nea.org.np/

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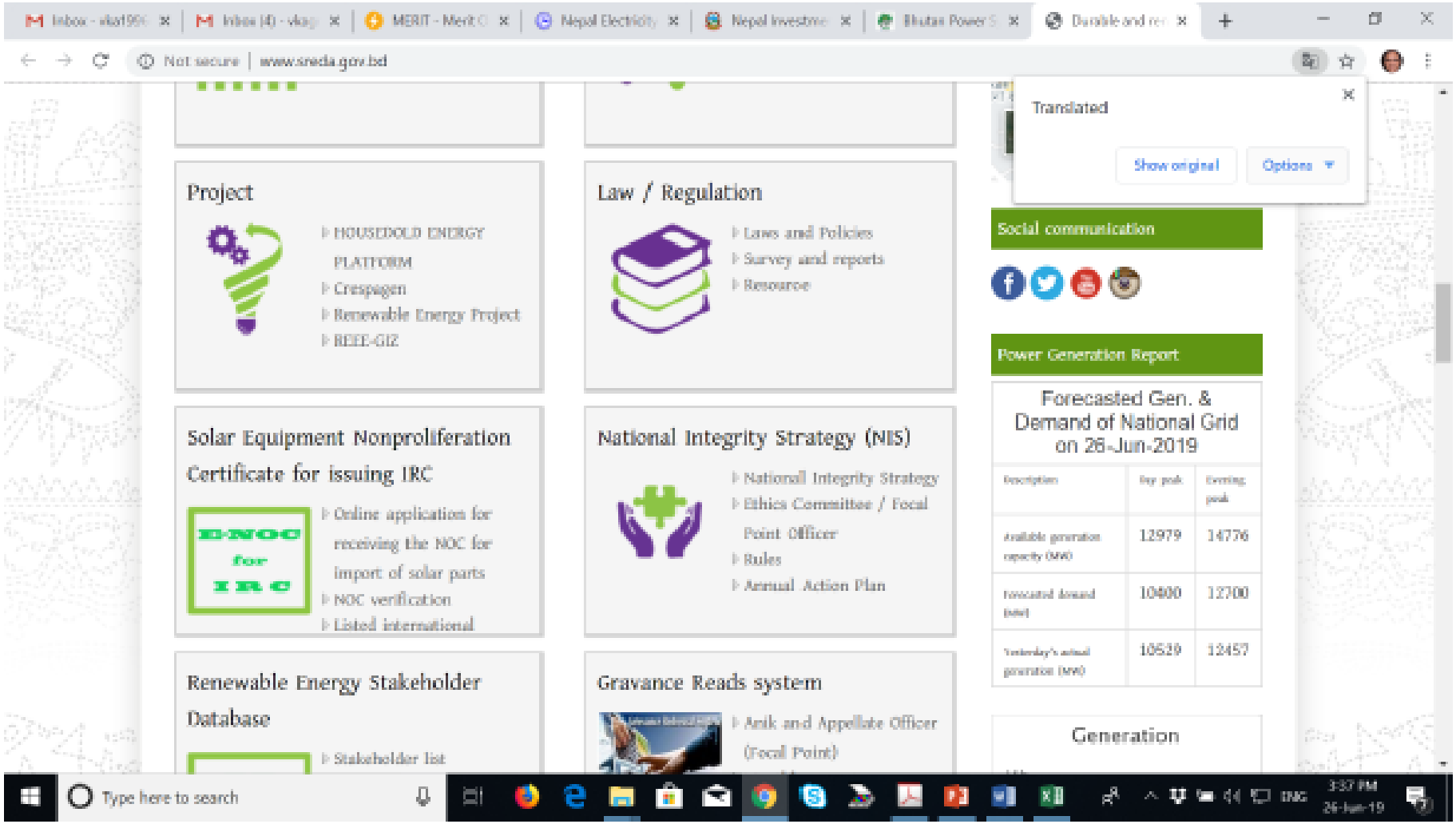
Real Time Data from Bhutan

http://bpso.bpc.bt/



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Real Time Data from Bangladesh

http://www.sreda.gov.bd/

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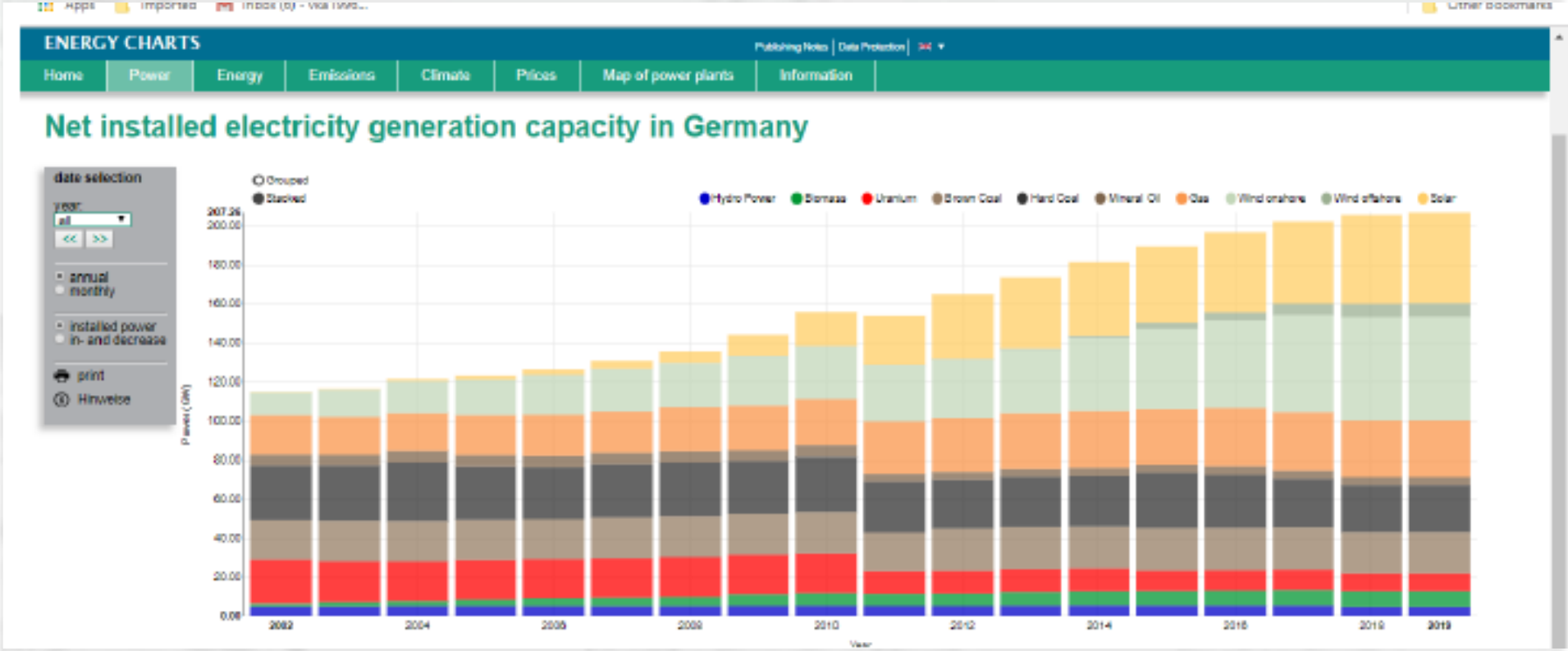
Sample Report – Year wise/Source wise Details of installed Gen. Capacity



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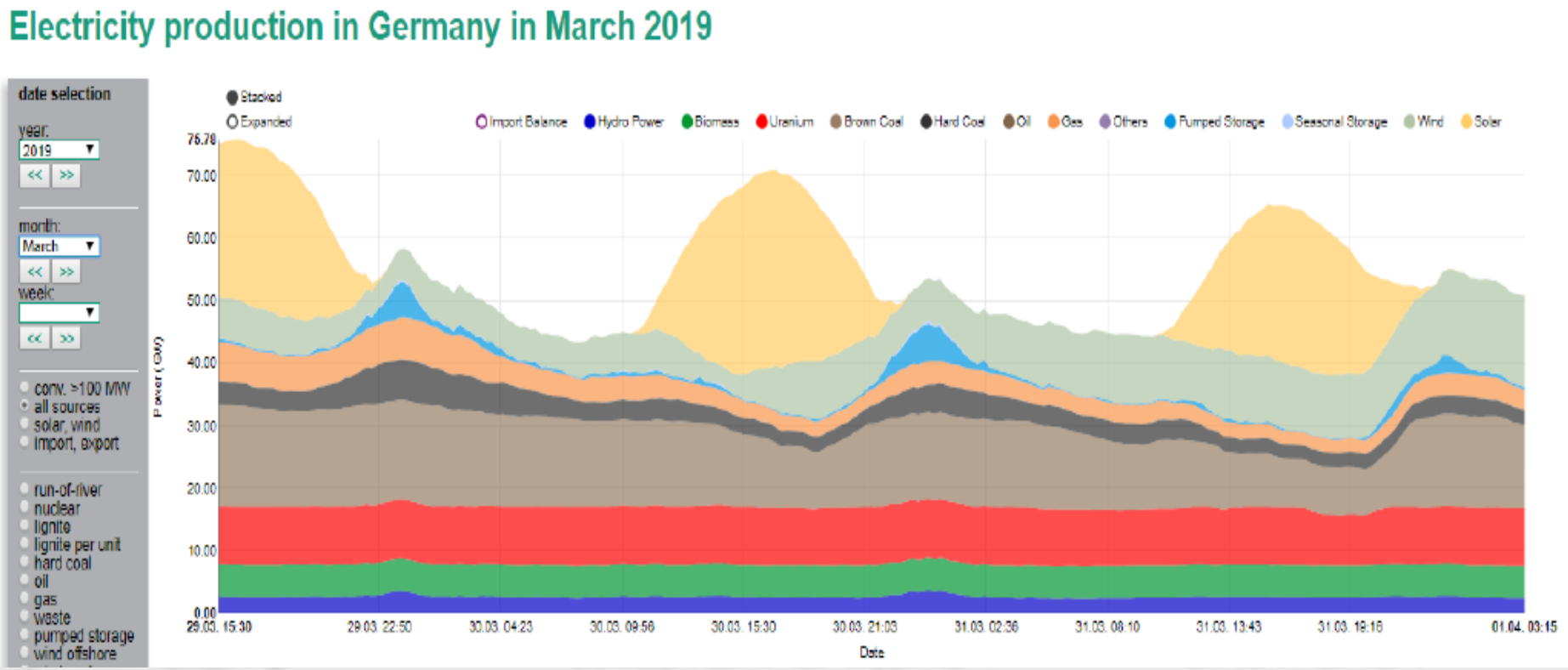
Sample Report – Daily Source wise Generation Composition



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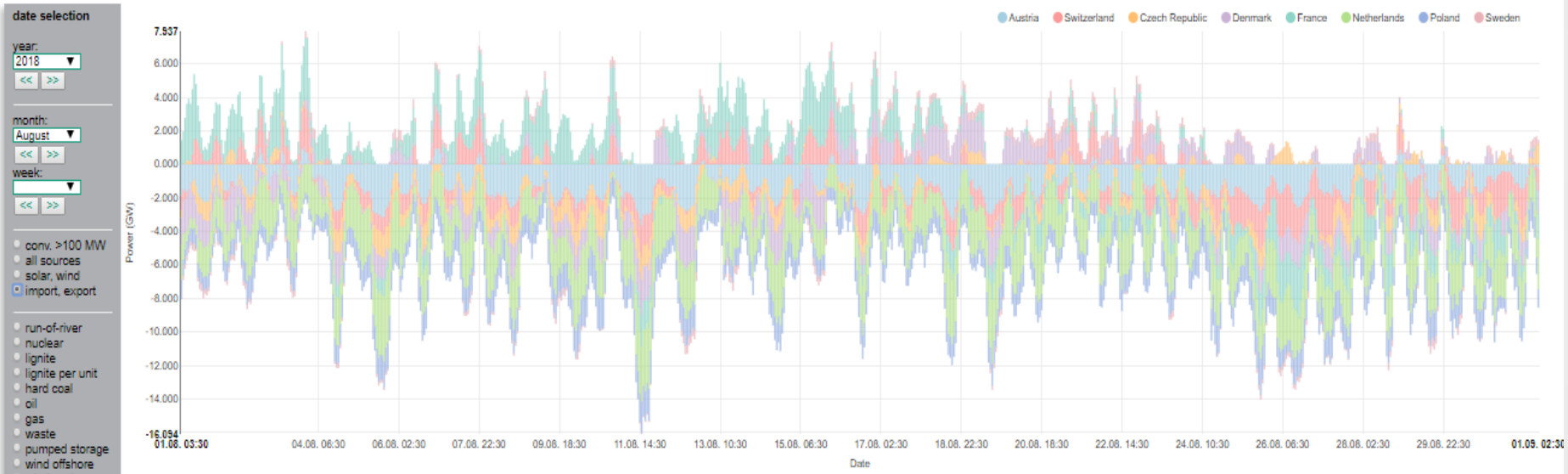
Sample Report – Daily Cross-border transactions during a month

Electricity production in Germany in August 2018



Source	Minimum Power (GW)	Date	Maximum Power (GW)	Date
Austria	-3.862	11.08.18 15:30	0.999	03.08.18 22:30
Switzerland	-3.067	27.08.18 01:30	2.786	22.08.18 22:30
Czech Republic	-1.738	10.08.18 15:30	1.379	26.08.18 08:30
Denmark	-2.134	12.08.18 12:30	1.909	18.08.18 11:30
France	-2.983	26.08.18 15:30	4.121	13.08.18 10:30
Netherlands	-4.394	05.08.18 20:30	-0.059	09.08.18 09:30
Poland	-2.14	10.08.18 14:30	-0.294	03.08.18 22:30
Sweden	-0.494	12.08.18 15:30	0.608	06.08.18 01:30

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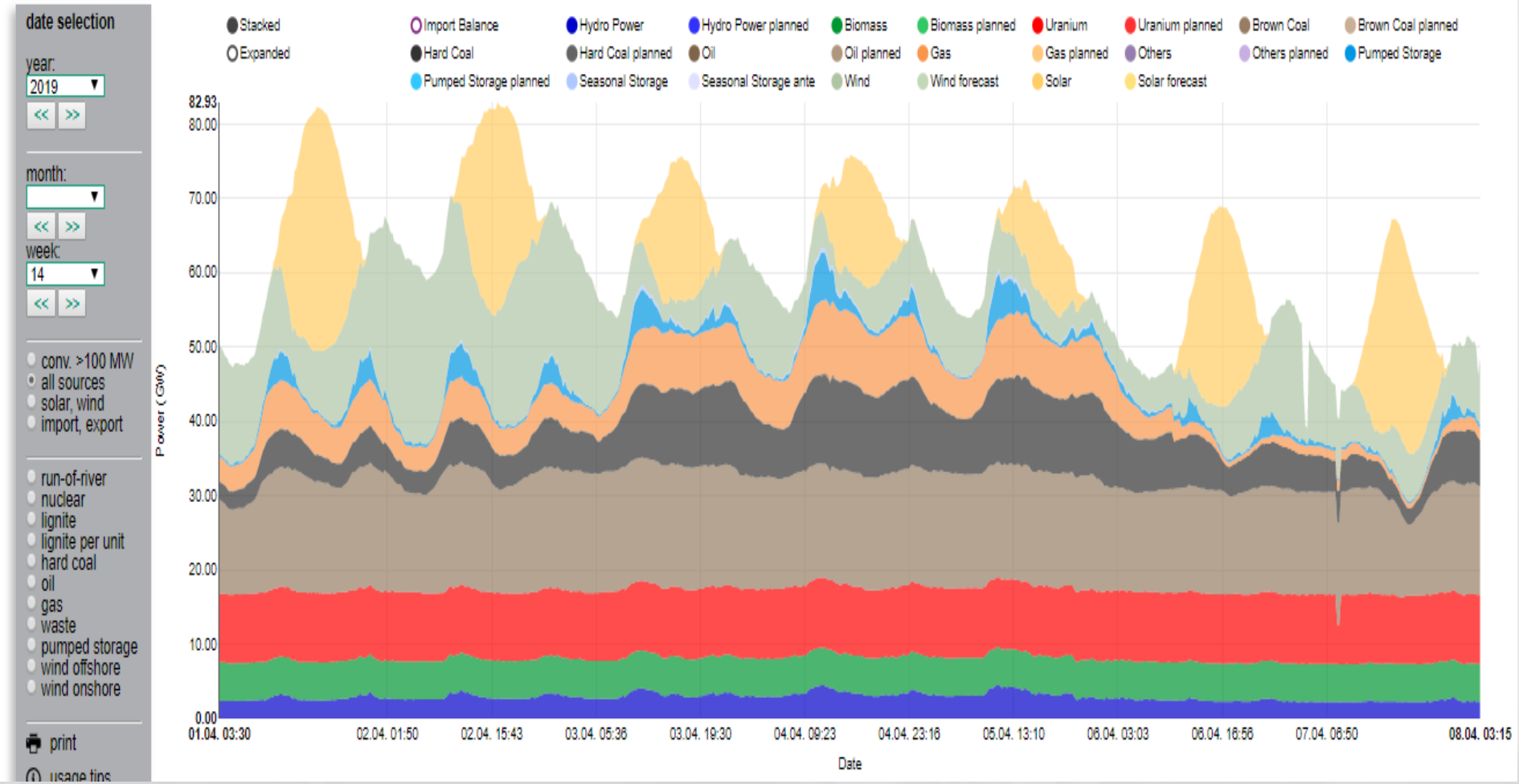
Sample Report – Daily Gen. Composition during a typical week

Electricity production in Germany in week 14 2019



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Thank You

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India-Nepal : Proposed Cross Border Transmission Line

Name of the Link	Key Features of the Line	Associated generation projects
Attariya-Bareily	Single line of double circuit 400kV quad Moose transmission line of distance about 140 KM	From export-oriented HPP in the Mahakali, Karnali and Seti corridors in Zone-1 area of Nepal
Dododhara–Bareily	2 No. of double circuit 400kV quad Moose transmission line of distance about 200 KM	From export-oriented HPP in the Mahakali, Karnali and Seti corridors in Zone-1 area of Nepal
Phulbari–Lukhnow	2 No. of double circuit 400kV quad Moose transmission line of distance about 200 KM	Evacuating the power from Nalsyau Gad, Bheri Corridor in Zone-2 of Nepal to Lukhnow, India
New Butwal–Gorakhpur	2 No. of double circuit 400kV quad Moose transmission line of distance about 125 KM	Evacuating the power from Marsyandi, Kaligandaki and Gandaki Corridor in Zone-3 of Nepal to Gorakhpur
Dhalkebar – Muzzafarpur	2 No. of double circuit 400kV quad Moose transmission line of distance about 130 KM	evacuating the power from Khimti, Tamakoshi and Dudhkoshi Corridor in Zone-4 of Nepal to Muzafarpur
Inaurwa – Purnea	2 No. of double circuit 400kV quad Moose transmission line of distance about 110 KM	evacuating the power from major corridor likes Arun and Koshi in Zone-5 of Nepal to Purnea, India