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Scenario analysis for energy banking between Nepal & India from Nepali perspective

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Abstract

Government of Nepal has agreed with India on energy banking with aim to enhance the energy security of respective national grids. The general concept of this banking is that the surplus energy available in Nepal during the wet months is absorbed by the power system of India and Nepal will retrieve the much needed banked energy during dry months. However, major challenge to quantify the energy being transacted and bring this into feat is, the hydro generation projects being not completed in scheduled time and uncertainties in the domestic consumption. Even the authentic reports from different governmental agencies contradict each other in estimating future internal electrical energy consumption pattern. The lack of rigid national grid-supply is a key constraint to enhance the domestic demand and seems to be the crucial factor for import/export location & respective line power flow selection. This paper illustrates the prospective scenario analysis for monthly surplus – deficit energy during the period of fiscal year 2077/78 BS to 2084/85 BS from Nepalese prospective. The scenarios viz. commissioning of upcoming generating projects in accordance to Power Purchase Agreement (PPA) concluded date as well as with trending delays are taken into account. The consumption sector with normal energy growth and with intervention like heavy penetration of electric vehicle and electric induction cooking, are considered during the analysis. The modeling of planned INPS and simulation is performed in ETAP. The cross – border transmission line flows and avenues as well as operating behavior of planned INPS are also analyzed.

1. Introduction

Energy banking is accompanied by bidirectional flow of energy within two or more synchronized power system with surplus and deficiencies of energy in different points of time. Nepal, which faced acute energy crisis till 2074 BS (2016 AD), has recently become an almost load shedding free nation with import of energy from India mainly in dry season. Still the deficiency in diversity in both electricity generation and consumption are emerging as a major challenge in national energy market. The actual demand is lagging far behind the forecast and dominated by residential consumption. The upcoming generations are mainly with Run of River (ROR) hydropower along with huge seasonal variation. Since all the upcoming generations from Independent Power Producers (IPP) are round the clock take or pay basis, lacking in demand/supply diversity is a big challenge to the Nepal electricity authority in coming years. Even the authentic reports from different governmental agencies contradict each other in estimating future internal electrical energy consumption pattern. The uncertainties in demand have been realized as a barrier for both consumption growth as well as large hydropower project implementation.

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The large industries are not coming up being scared of energy security and FDI for large storage type generation are not being attractive with thinking of absence of abundant energy market.

On the other hand, India is moving towards with its ambitious plan to reach 100 GW solar and 75 GW wind energy by 2022/23 AD and bring the share of renewable energy installed capacity to 55% by 2030 AD. Heavy penetration of intermittent energy source of electricity will lead to operate the thermal power plant at reduced plant capacity factor. In summer (May to August), In-

Table 1: Average Annual Electrical Energy Growth Rate of Nepal given by Different Agencies

Agencies	Average Annual Electrical Energy Growth Rate	
WECS [6]	11.3% (for year 2025 AD)	9.1% (for year 2030 AD)
IBN [7]	10.52% (from 2020 AD to 2025 AD)	9.16% (from 2025 AD to 2030 AD)
NEA [8]	8.1% (from fiscal year 2013/14 to 2033/34)	
ADB [9]	5.4% (from 2015 AD to 2035 AD)	

dia peak power surges by about 20 GW from 8 pm till midnight. This can be viewed as an additional power demand occurring just for 4 hours and continue in 4 months only [1]. Combined effect is caused to create a situation for increased peaking price of electricity which is already almost 3 times the normal price in free energy market. India has options, either to meet these demands with coal based plant known as base load plant running as peak load plant with increased operational cost or fulfilling this by import. Energy banking is therefore thought to be an effective solution to facilitate the hydro power promotion for Nepal and optimum solution to cater India's summer peak demand and effect of intermittency in supply.

Some studies have been done in the electricity sector of this region. The optimal electricity sector development pathway of Nepal was assessed under various electricity demand and policy scenarios [2] whereas low carbon development of electricity sector for BBIN sub-region is assessed also [3]. The energy sector of the sub-region is reviewed as well [4].

Even saying that, quantifying the amount of monthly / annual energy exchange for future is still a tight spot. Recently published white paper by Ministry of Energy, Water Resources and Irrigation has planned 10000 MW electricity generation for internal consumption by year 2085 BS (2028 AD) [5]. However, Nepal hydro power installed capacity is not seen to meet the exact target, despite in last few years, its pace has improved remarkably. Also, severe inconsistency is seen for the domestic demand forecast by different recognized agencies. A few of them are summarized in Table 1.

In this study, an attempt has been made to explore the surplus/deficit energy for the period from current fiscal year (2077/78) to 2084/85 from Nepalese perspective. Several possible generation/consumption scenarios have been considered into account. Furthermore, the adequacies of INPS and associated cross border transmission lines have been examined. INPS has been modelled for simulation purpose on Zone-wise basis in accordance with Transmission System Development Plan of Nepal [10].

2. Methodology

The historical trend for monthly energy generations from major existing Run of River (RoR) & storage type hydropower projects of NEA and IPPs for fiscal years in between 066/67 to 075/76 have been studied. The monthly energy generations of upcoming projects are then calculated. Following three scenarios for the upcoming generations have been considered in the study;

Normal : commissioning of upcoming projects in accordance to Power Purchase Agreement (PPA) concluded date

Likely : commissioning of upcoming projects with one-year delay for projects coming under Independent Power Producers (IPPs)

Most likely : additional three years' delay in projects coming under Nepal Electricity Authority (NEA) and its sister organization in addition to second scenario

The expected monthly domestic energy consumption is estimated for following five scenarios;

i Normal scenario: Constant per annum energy consumption growth

ii Most likely energy consumption: categorized growth for domestic, commercial, industrial and other categories as per the NEA past consumption trend

iii Intervention with induction Chulo

iv Intervention of Electric Vehicle

v Combined intervention of both Induction Chulo & Electric Vehicle

The mismatch between expected generation and consumption are expressed in terms of expected monthly surplus and deficit energy and S-D ratio. The overall methodology implemented for this study is presented in Fig. 1

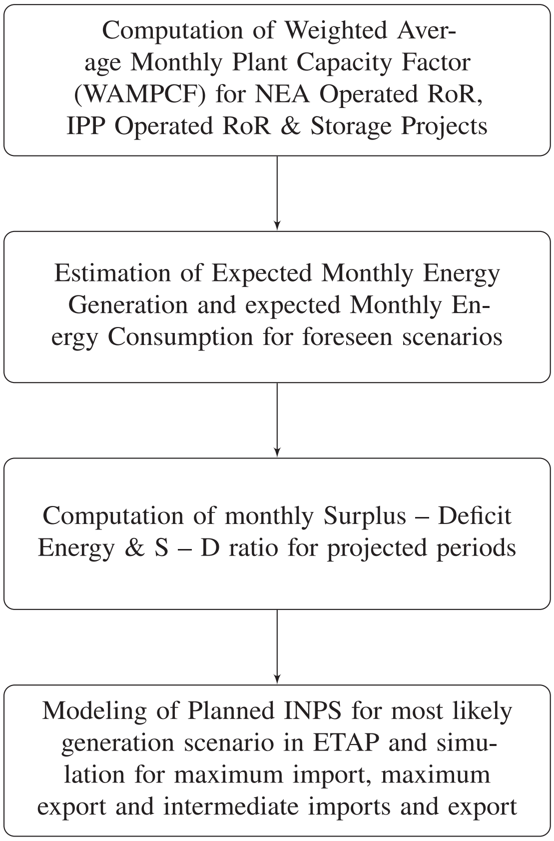


Figure 1: Methodology of Study

3. Mathematical formulation

3.1. Wampcf

Weighted average monthly plant capacity factor for existing hydropower plants are computed by Eq. 1.

$$\text{Wampcf} = \frac{\sum_{i=1}^{n} \text{Pic}_i \times \text{Ampcf}_i}{\sum_{i=1}^{n} \text{Pic}_i} \qquad (1)$$

Where,

Pic_i : Plant Installed Capacity of i^{th} Project

Ampcf_i : Average Monthly Plant Capacity Factor of same project for a particular month

Wampcf : Weightage average monthly plant capacity factor for a group of projects for a particular month

3.2. Expected monthly energy generation (Emeg)

The plant wise expected monthly energy generation for existing and upcoming generations is calculated using Eq.2.

$$\text{Emeg} = \text{Pic} \times \text{Wampcf} \times \text{T} \qquad (2)$$

Where,

T : hours in a month

3.3. Expected monthly energy consumption (Mec)

3.3.1. Mec calculation in normal scenario

The expected monthly energy consumption for Normal scenario is calculated using Eq.3.

$$\text{Mec}_i = \text{Mec}_{base} \times \left(1 + \frac{r}{100}\right)^i \qquad (3)$$

Where,

Mec_{base} : Monthly Energy Consumption of a particular month of base year

Mec_i : Monthly Energy Consumption of same month after i^{th} year from base year

r : Monthly Energy Consumption growth rate per annum

3.3.2. Mec calculation in growth with categorization of consumption scenario

The expected monthly energy consumption for this scenario calculated using Eq.4.

$$\text{Mec}_i = \text{Mec}_{i,d} + \text{Mec}_{i,c} + \text{Mec}_{i,i} + \text{Mec}_{i,o} \qquad (4)$$

Where,

i,d : domestic

i,c : commercial

i,i : industrial

i,o : other

3.3.3. Mec calculation in intervention with induction chulo scenario

$$\text{Mec}_{ic} = \text{Noh} \times \text{Phpdec} \times 30 \qquad (5)$$

Where,

ic : induction chulo

Noh : Number of household

Phpdec : Per house per day energy consumption

3.3.4. Mec calculation in intervention with electric vehicle scenario

$$\mathrm{Mec}_{ev} = \mathrm{Mec}_{ebk} + \mathrm{Mec}_{ecjv} + \mathrm{Mec}_{eb} \tag{6}$$

Where,

ev : electric vehicle

ebk : electric bike

ecjv : electric car, jeep, van

eb : electric bus

Mec ev type = Number of electric vehicle type at start of each month of a fiscal year × N × Energy consumption in One Charging

Number of charging per month (N) is estimated using Eq. 7.

$$N = \frac{\mathrm{AMKR}}{\mathrm{KRVTOC}} \tag{7}$$

Where,

AMKR : Average Monthly Kilometer Run

KRVTOC : Kilometer Run by Vehicle Type in one Charging

3.3.5. Mec calculation in combined intervention with induction chulo & electric vehicle scenario

The additional expected monthly energy consumption due to intervention with Induction chulo is calculated using Eq.8

$$\mathrm{Mec}_{c} = \mathrm{Mec}_{ic} + \mathrm{Mec}_{ev} \tag{8}$$

Where,

c : combined

ic : induction chulo

ev : electric vehicle

3.4. Surplus–deficit (S–D) ratio

This ratio has been defined as an indicative of dominance of surplus or deficit of energy over a fiscal year. The S/D – ratio is formulated as:

$$S/D - ratio = \frac{\mathrm{TESEOY}\ (MWhr)}{\mathrm{TEDEOY}\ (MWhr)} \tag{9}$$

Where,

TESEOY : Total expected surplus energy over a year

TEDEOY : Total expected defecit energy over a year

This S/D – ratio can be interpreted as,

S/D – ratio = 0	There is deficit of energy (MWh) in each month of a year
∞	There is surplus of energy (MWh) in each month of a year
1	Total Expected Surplus energy (MWh) and total Expected Deficit energy (MWh) are equal over a year
> 1	Total Expected Surplus energy (MWh) exceeds total Expected Deficit energy (MWh) over a year
< 1	Total Expected Deficit energy (MWh) exceeds total Expected Surplus energy (MWh) over a year

4. System modeling & simulations

The expected energy consumption growth for the anticipated five consumption scenarios have been considers as follows:

i Constant annual growth rate of 8% [8]

ii Categorized annual growth rates for Domestic, Commercial, Industrial and others consumer as 12.85%, 16.26%, 20.64% and 17.23% respectively [11]

iii The intervention of Induction Chulo is considered as additional 10% of total households each year with daily energy consumption of an Induction Chulo is considered 4 kWh per day [12].

iv The monthly electrical energy consumption of electric bike, car/Jeep/Van and Buses are incorporated as 67.5, 200 and 5514 kWh respectively [13, 14, 15, 16, 17, 18, 19]. Intervention of additional Electric Vehicle are anticipated as an integer multiple of 10% of average yearly new sales resulting to reach up to 55% of total these categories to be electrical in coming ten years.

v Combined intervention of aforementioned Induction Chulo and Electric Vehicle at once

The planned INPS, for most likely generation scenario, has been modeled in ETAP with incorporation of Zone modeling in accordance with Transmission System Development Plan of Nepal [10]. PPA concluded projects till date are connected to the respective buses near the project location for power evacuation in corresponding zones.

As a sample, the Zone – 1 modeling is presented here. Zone – 1 includes upcoming hydropower and transmission projects in different regions of Province – 7 and some regions of Province – 6 of Nepal. Table 2 shows upcoming hydropower projects with corresponding capacity and connected bus for respective projects.

Table 2: Hydropower Projects and Buses in Zone – 1

S.N.	Hydropower Projects	Connected Bus	Capacity (MW)
1.	Chameliya	Balance Hub (132 kV)	30
2.	Upper Chameliya		40
3.	Makarigad		10
4.	Upper Naugadh Gad		8
5.	Api		8.5
6.	Sunigad	Upper Kalangagad Hub (132 kV)	11.05
7.	Kalangad		15.33
8.	Upper Sanigad		10.7
9.	Upper Kalangagad		38.46
10.	Salubyani Gad Small		0.233
11.	Jeuligad Small		0.996
12.	Jadari Gad Small		1
13.	Upper Gaddigad	West Seti (132 kV)	1.55
14.	Ruru Banchu-1	Phukot (400 kV)	13.5
15.	Ruru Banchu Khola - 2		12

Similarly, the transmission line coming under operation by 2025 AD in Zone – 1 is listed in Table 3.

Table 3: Transmission Projects in Zone – 1

S.N.	Transmission Project	Voltage Level (kV)	Conductor	Length (Km)
1.	Dododhara – Phukot	400	Quad Moose	80
2.	Balanch – Upper Kalangagad	132	Bison	54
3.	Upper Kalangagad – West seti	132	Bison	64

Similar to Zone 1, other zones viz. zone – 2, 3, 4 and 5 are also modeled. The zone wise installed capacity of generation projects based on most likely generation scenario for fiscal year 084/85 are considered as follows:

Zone 1 : 201.319 MW

Zone 2 : 15.15 MW

Zone 3 : 1244.48 MW

Zone 4 : 2369.901 MW

Zone 5 : 631.762 MW

The general block diagram representation for INPS modeling is depicted in Fig. 2.

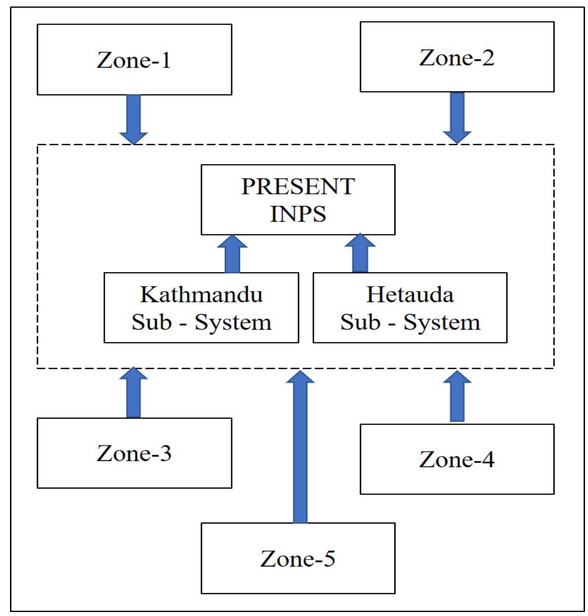


Figure 2: Block diagram of planned INPS

5. Results & discussions

5.1. Monthly generation trends

Fig. 3 depicts the Weighted average monthly plant capacity factor for NEA operated RoR, IPP operated RoR and Storage projects from the historical trend of generation data in between fiscal years 066/67 and 075/76. It has been observed that monthly Wampcf for NEA Operated RoR projects vary in the range of 0.8273 (Ashad) and 0.3963 (Falgun). The same for IPP Operated RoR projects vary in the range of 0.9236 (for Ashoj) and 0.3905 (Falgun).

5.2. Upcoming generation computation validation

The Wampcf results presented in A have been used to compute the generation scenario for each month of year 2076 BS. Based on this, the percentage variation in required computed monthly import and actual import for the year is presented in Fig.4. It can be observed that the variation error is as minimum of 0.34% (Magh) to a maximum up to 14.89% (Shrawan). The possible reason for relatively wider variation especially during

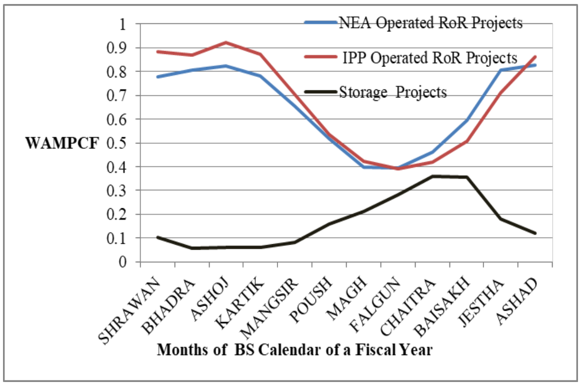


Figure 3: Wampcf vs Months of BS calendar of a fiscal year

wet months may be due to additional import to meet system peak where as some spill energy during midnights.

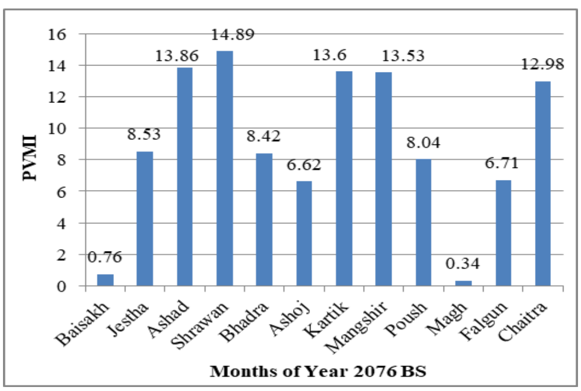
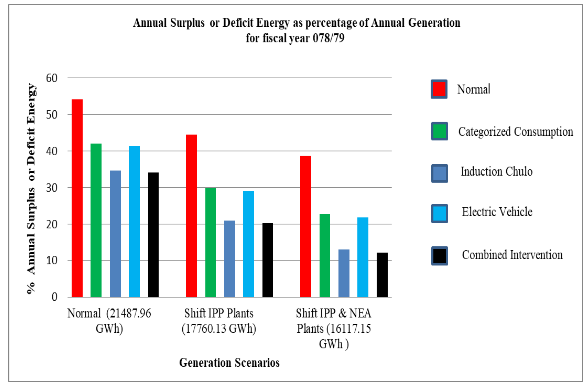


Figure 4: Percentage variation in monthly import (PVMI) in months of year 2076 BS

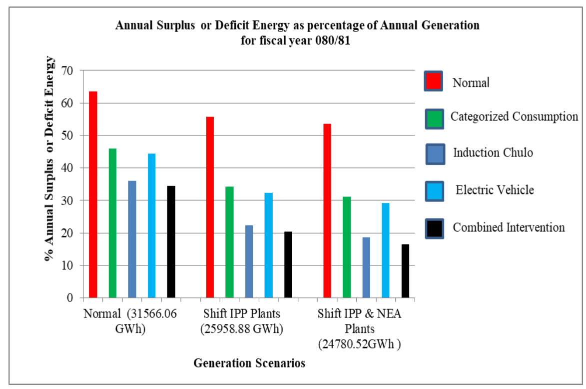
5.3. Expected monthly surplus & deficit energy

Fig. 5 depicts the expected net annual energy surplus and deficit for three fiscal years during the study period. It is to be noted that fiscal year 078/79 will have annual surplus in each of the scenario. In terms of energy, there will be largest surplus energy as 54% of generation energy (21487.96 GWh)for combination of normal generation scenario and constant per annum growth in energy consumption scenario. Similarly, lowest surplus energy as 12.2% of generation energy is observed in Shift IPP & NEA Plants scenario of generation and combined intervention scenario of consumption. Fiscal year 080/81 is expected to follow similar surplus energy trend with relatively higher percentage of energy surplus in comparison to fiscal year 078/79.

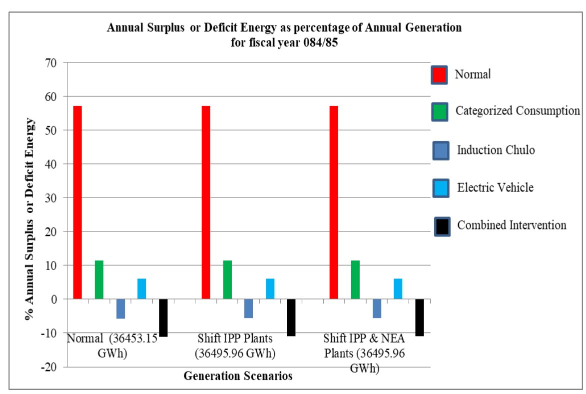
For fiscal year 084/85, annual surplus and deficit of



(a) For fiscal year 078/79



(b) For fiscal year 080/81



(c) For fiscal year 084/85

Figure 5: Annual surplus or deficit energy as percentage of annual generation for fiscal year 078/79, 080/81 & 084/85

energy varies widely depending upon generation and consumption scenario. This year is expected to observe net annual surplus energy for three of the consumption scenarios viz. normal, growth with categorized and intervention with electric vehicle consumptions. However, there will be net annual deficit of energy in intervention with induction Chulo and combined intervention scenarios. The expected S – D ratio for respective fiscal years is presented in Table 4.

Table 4: S – D Ratio for fiscal years 078/79, 080/81 & 084/85

Generation/ Consumption Scenario		I	II	III	IV	V
FY 078/079	A^*	∞	∞	∞	∞	∞
	B^*	∞	146.16	11.21	108	9.70
	C^*	∞	18.56	3.68	14.72	3.34
FY 080/081	A^*	∞	∞	∞	∞	∞
	B^*	∞	∞	12.73	592.28	8.86
	C^*	∞	363.19	6.97	1.66	0.37
FY 084/085	A^*	∞	2.79	0.61	1.66	0.37
	B^*	∞	2.83	0.62	1.68	0.37
	C^*	∞	2.83	0.62	1.6	0.37

A^* Normal Generation
B^* Shit IPP plants
C^* Shift IPP & NEA Plants

The expected monthly surplus & deficit energy for the same fiscal years viz. 078/79, 080/81 & 084/85 for most likely generation scenario is presented in Table 5.

Table 5: Expected Monthly Surplus and Deficit energy (GWh) for fiscal years 078/79, 080/81 & 084/85

5a. For fiscal year 078/79

Months/ Scenario	I	II	III	IV	V
Shrawan	643.4	411.5	281.2	405.5	275.3
Bhadra	686.2	449.7	319.4	442.9	312.7
Ashoj	940.4	729	598.7	721.4	591.1
Kartik	933.9	731.7	601.5	723.3	593.1
Mangshir	685.6	502.2	372	493	362.7
Poush	284.8	79.1	-51.1	689.5	-64.3
Magh	141.1	-47.5	-177.7	-58.4	-188.7
Falgun	79.7	-112.5	-242.7	-124.3	-254.6
Chaitra	162.2	-33.6	-163.9	-46.3	-176.5
Baishak	219.4	-14.5	-144.7	-28	-158.2
Jestha	546.2	289.5	159.2	275.1	144.9
Ashad	924.9	671.4	541.1	656.2	525.9

5b. For fiscal year 080/81

Months/ Scenario	I	II	III	IV	V
Shrawan	1378.8	882.8	622.3	8507	590.2
Bhadra	1466	960.1	699.6	926.4	665.8
Ashoj	1740.1	1287.2	1026.7	1251.7	991.2
Kartik	1699.8	1267.4	1006.9	1230.3	969.7
Mangshir	1396.6	904.5	644.05	865.7	605.1
Poush	728.1	288	27.4	247.4	-13.05
Magh	482.1	78.6	-181.8	36.4	-224.1
Falgun	389.9	-21.3	-281.8	-65.2	-325.7
Chaitra	491.2	72.3	-188.1	26.7	-233.8
Baishak	641.8	141.6	-118.8	94.3	-166.1
Jestha	1187.2	638.2	377.6	589.2	328.7
Ashad	1767.3	1225.1	964.5	1174.3	913.8

5c. For fiscal year 084/85

Months/ Scenario	I	II	III	IV	V
Shrawan	2546	1058.8	537.8	913.5	392.5
Bhadra	2467	949.7	428.7	801.1	280.1
Ashoj	2846	1486.3	965.2	1334.2	813.2
Kartik	2676	1379	858.01	1223.6	702.5
Mangshir	2043	867.1	346.07	708.3	187.2
Poush	1168	-152	-673	-314.1	-835.2
Magh	775.1	-435.2	-956.1	-600.7	-1122
Falgun	618.1	-615.1	-1136	-783.9	-1305
Chaitra	738.4	-517.9	-1039	-690.2	-1211
Baishak	920.6	-579.8	-1101	-755.5	-1277
Jestha	1687	403.08	-480.7	-1388	-659.7
Ashad	2350	723.8	202.8	541.3	203.5

Fiscal year 084/85 will experience saturation of generation megawatts in INPS based on current PPA concluded dates. For this year, in normal scenario of consumption, for month of Ashoj resulting into maximum possible export from INPS. For the same year the month of Falgun intermediate import will be needed in INPS if most likely consumption is anticipated. However, if intervention of Electric Vehicle is considered for the month of Ashoj, intermediate export from INPS will be necessary. INPS will experience maximum import in Falgun in combined intervention of both Induction Chulo and Electric Vehicle.

5.4. Load flow simulation

The Load flow simulation has been performed in planned INPS for months of Ashoj and Falgun of fiscal year 084/85. The generation capacity in INPS for these two months is 5622.8 MW and 2427 MW respectively. Five scenarios each from one consumption scenario are considered for simulation purpose. Normal and Intervention with Electric Vehicle scenarios are considered in the month of Ashoj to study maximum export and intermediate export scenarios respectively. Similarly, Combined Intervention with Induction Chulo and Electric Vehicle in the month of Falgun is considered to study maximum import in INPS. Also, Growth with Categorization of Consumption and Intervention with Induction Chulo scenarios are considered for month of Falgun to study intermediate import scenarios in INPS. These import and export cases are summarized as follows:

I. Maximum export : Normal energy consumption

Ashoj
Expected monthly energy consumption: 1280003.2 MWh
Corresponding monthly peak demand: 2285.94 MW

II. Maximum import : Combined intervention with induction chulo and electric vehicle – Falgun)
Expected monthly energy consumption: 3084460.54 MWh
Corresponding monthly peak demand: 6139.39 MW

III. Intermediate import : Growth with categorization of consumption – Falgun
Expected monthly energy consumption: 2394500.2 MWh
Corresponding monthly peak monthly demand: 4766.08 MW

IV. Intermediate import : Intervention with induction chulo – Falgun
Expected monthly energy consumption: 2915523.882 MWh
Corresponding monthly peak demand: 5803.14 MW

V. Intermediate export : Intervention with electric vehicle – Ashoj
Expected monthly energy consumption: 2791364.118 MWh
Corresponding monthly peak demand: 4985.07 MW

5.4.1. Cross-border power flow

i Export Avenues
For intermediate export, only Muzzafarpur – Dhalkebar 400 kV line will be sufficient as 594.1 MW cross border power flow. However, for maximum export by fiscal year 085/85, Dhalkebar – Muzzafarpur and Butwal – Gorakhpur 400kV Lines must be utilized as around 1200 MW and 2093.9 MW power flow have been observed from theses Lines respectively.

ii Import Avenues
Four transmission lines in accordance with cross – border planning has been observed to accommodate the total import peak power demand based on their capacity for intermediate import for growth with categorization of consumption scenario. The import of 100 MW from Tanakpur, 1110 MW from Butwal – Gorakhpur 400 kV line, 1000 MW from Dhalkebar – Muzzafarpur 400 kV line, 129 MW from Kusaha – Kataiya 132 kV line will be required to meet the monthly peak power import of around 4766 MW. For month of Falgun for consumption with intervention of Induction Chulo and also for consumption with combined intervention of Induction Chulo and Electric Vehicle, six cross - border transmission lines viz. Tanakpur import, Butwal – Gorakhpur 400 kV line, Dhalkebar – Muzzafarpur 400 kV line, Kusaha – Kataiya 132 kV, Parwanipur – Raxaul 132 kV line and remaining Duhabi – Purnea 400 kV has been seen essential. The import of 100 MW from Tanakpur import, 1200 MW from Butwal – Gorakhpur 400 kV line, 150 MW from Parwanipur – Raxaul 132 kV line, 1200 MW from Dhalkebar – Muzzafarpur 400 kV line, 150 MW from Kusaha – Kataiya 132 kV line and remaining 907 MW from Duhabi – Purnea 400 kV line is expected to flow to meet the peak power demand of around 6139 MW for maximum import scenario. The simulation studies indicate the need of capacitive compensation in Birgunj loop of INPS with increased level of import power.

5.4.2. Operating status of planned INPS

i The power transformers at Balaju, Bhaktapur, Chapali, Dhalkebar, Hetauda, Suichatar, Khimti and Parwanipur grids have been found critically overloaded in all the consumption scenarios considered.

ii The 66 kV and 132 kV transmission lines of Kathmandu sub – system and Amlekhgunj – Kamane – Pathlaiya – Parwanipur – Birgunj – Simara – Amlekhgunj sub – system have been found critically overloaded in all scenarios.

iii Majority of 66 kV and 132 kV buses have been found to operate with bus voltage far from standard limit in planned INPS by fiscal year 2084/85.

6. Conclusion

Nepal will have surplus energy for all months of the study period in normal consumption scenario. The maximum and minimum monthly surplus energy of about 2845.62GWh and 618.17 GWh are concluded for month of Ashoj and Falgun respectively for fiscal year 084/85. If energy consumption follows the growth as per categorized consumption, there will be deficit of energy in months from Poush to Baisakh in latter part of projected period. The maximum monthly deficit of about 615 GWh energy has been observed for month of Falgun in fiscal year 084/85. The intervention with electric vehicle and Induction Chulo individually follow almost same patterns as that of growth with categorized consumption but with greater deficit of energy in corresponding months. However, in combined intervention, in year 084/85, six months (Poush – Jestha) of year will experience deficit of energy and remaining months will experience surplus energy. The maximum surplus and maximum deficit of about 813.2 GWh and 1305 GWh energy are concluded for months of Ashoj and Falgun respectively for this year.

Provided the planned cross – border transmission lines are constructed by exact time, estimated import export for projected periods can be achieved through these lines. However, 66 kV and 132 kV transmission lines of Kathmandu sub – system and Amlekhgunj – Kamane – Pathlaiya – Parwanipur – Birgunj – Simara – Amlekhgunj sub – sytem of planned INPS have been found critically overloaded in all scenarios. Similarly, Majority of 66 kV in planned INPS is expected to suffer from critical under voltage problem for fiscal year 084/85. The lowest under voltage of 34.61 kV has been observed for Sunkoshi bus for intermediate import with Growth with categorization of consumption for month of Falgun. Similarly, the 132 kV buses in planned INPS is expected to suffer from critical overvoltage (179.28 kV in Marsyangdi Bus in third import scenario) and under voltage (up to 85.59 kV in Mahendranagr Bus in fifth export scenario) problem for fiscal year 084/85. Under this condition, transformers of Balaju, Bhaktapur, Chapali, Dhalkebar, Hetauda, Suichatar, Khimti and Parwanipur grids have been found overloaded in all the scenarios considered.

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