

METHODOLOGY FOR REACTIVE ENERGY ACCOUNTING BETWEEN INDIA AND BHUTAN

1. Background

- 1.1. India and Bhutan shares unique and exemplary bilateral relations, which are based on mutual trust, goodwill and understanding. Mutually beneficial hydro-power cooperation with Bhutan is a key pillar of bilateral economic cooperation. An Agreement between the Government of the Republic of India (GOI) and the Royal Government of Bhutan (RGoB) concerning Cooperation in the field of Hydroelectric Power was signed on 28th July, 2006 and its Protocol was signed in 2009. Four hydro-electric projects (HEPs) namely Tala, Chhukha, Kurichhu and Mangdechhu, totalling 2,136 MW are supplying electricity to India under Government to Government (G2G) mode. Further, Dagachhu HEP and Basochhu HEP are supplying power to Indian entities/Indian power exchanges through separate agreements. From past few years, Bhutan is also importing electricity during the winter months from Indian Power Exchanges. The methodology for compliance of Deviation Settlement Mechanism (DSM) w.r.t. active power has already been agreed between India and Bhutan during 4th meeting of JTT held on 25.04.2024.
- 1.2. As per Clause 7.8 (I) of the aforesaid modalities *"Reactive energy accounting will be done on the basis of meter readings at both ends i.e., interconnecting substations."*
- 1.3. The Clause 7.5 of the said modalities defines the Delivery Point as *"the delivery points for import/export of power by Bhutan shall be at the India-Bhutan border after accounting for the transmission line losses."*
- 1.4. Since transmission losses cannot be applied to calculate the reactive power at physical boundary point, a separate method need to be devised to calculate the reactive power charges between India and Bhutan.
- 1.5. The Royal Government of Bhutan (RGoB) vide Note Verbale No. NGA/3-4A/776 dated 29th July 2024 conveyed that despite the DSM agreement, the Eastern Regional Power Committee (ERPC), India continued to use the previous accounting mechanism, relying only on metre readings on Indian side. RGoB suggested for calculating the reactive energy charges based on meter readings on both sides in keeping with the agreed DSM modalities.
- 1.6. Accordingly, a methodology for accounting of the reactive power exchange between India and Bhutan is being proposed in the subsequent paragraphs of this document.

2. Present methodology adopted by ERPC

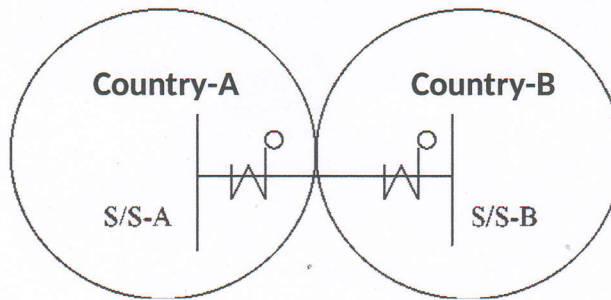
- 2.1. Reactive energy accounting, payment and settlement in India is governed by the extant Indian Electricity Grid Code (IEGC).
- 2.2. Further, regulation 26(4) of the Central Electricity Regulatory Commission (Cross Border Trade of Electricity Regulations), 2019 provides that *"Reactive Energy Charges shall be paid by the Settlement Nodal Agency in accordance with Grid Code, and the said charges shall be collected from the selling entity or buying entity of the neighbouring countries, as the case may be."*
- 2.3. Presently, the accounting of reactive energy is done on the basis of meter readings from Indian side. Accordingly, Eastern Regional Power Committee (ERPC), India issues the account for reactive energy charges.

3. Issues in the Present Methodology

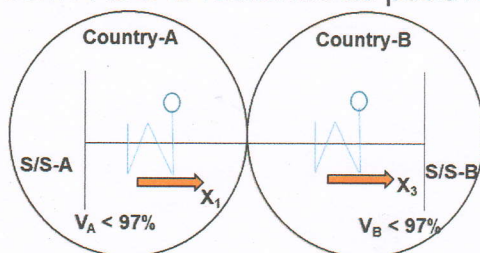
- 3.1. Clause 7.5 of the DSM modalities provides that *"the delivery points for import/export of power by Bhutan shall be at the India-Bhutan border after accounting for the transmission line losses."* Further, as per Clause 7.8 (I) of the modalities *"Reactive energy accounting will be done on the basis of meter readings at both ends i.e., interconnecting substations."*
- 3.2. In the present method of accounting of reactive energy the meters of Indian sides are being used which is not in line with the agreed DSM methodology.
- 3.3. Further, Reactive Energy cannot be calculated by applying transmission losses at the delivery point i.e. physical boundary point of India-Bhutan border.

4. Proposed Methodology for accounting of Reactive Energy Exchange

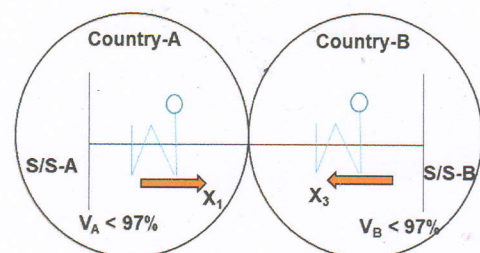
- 4.1. The Reactive Energy accounting, shall be carried out by considering electricity meter data of India and Bhutan side. The delivery point of power between India and Bhutan is physical border point.
- 4.2. As agreed in the DSM modalities, Interface Energy Meters as per class and specifications mentioned in Central Electricity Authority (Installation and Operation of Meters) Regulations shall be installed at locations mentioned in the DSM modalities. According to Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006, the VAr and reactive energy measurement shall be on 3-phase, 4-wire principle, with an accuracy as per class 2 of IEC-62053-23 or better. Further it provides that there shall be two reactive energy registers, one for the period when average Root Mean Square (RMS) voltage is above 103% and the other for the period the voltage is below 97%.
- 4.3. The meters installed at sub-stations of Country-A and sub-stations of Country-B, as given below would be used for reactive energy accounting.



- 4.4. Weekly meter readings (import or export in terms of MWh and MVarh) for actual injection or drawl by exporting generators/importing entity of Bhutan shall be provided to the RLDC(s) /NLDC through Settlement Nodal Agency as per timelines prescribed in IEGC.
- 4.5. Let the readings of reactive energy registers be as given below:
 Net VARh exported from S/S-A, while voltage < 97% = X_1
 Net VARh exported from S/S-A, while voltage > 103% = X_2
 Net VARh imported at S/S-B, while voltage < 97% = X_3
 Net VARh imported at S/S-B, while voltage > 103% = X_4
- 4.6. For the reactive energy charges:
- Country-B pays to Country-A for X_1 or X_3 , whichever is smaller in magnitude, and
 - Country-A pays to Country-B for X_2 or X_4 , whichever is smaller in magnitude.
- 4.7. In the above accounting:
- Net VARh may be positive or negative.
 - In case X_1 is positive and X_3 is negative, or vice-versa, there would be no payment under 4.6(i) above.
 - In case X_2 is positive and X_4 is negative, or vice-versa, there would be no payment under 4.6(ii) above.
- 4.8. The schematic diagram of the above methodology is given below (Flow from A to B is reckoned as positive).



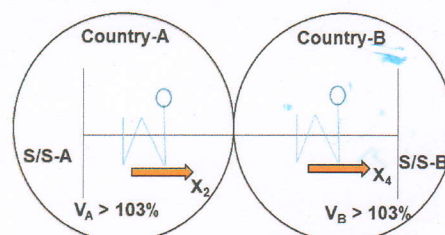
Case1: Country B pays to A for minimum of X_1 and X_3



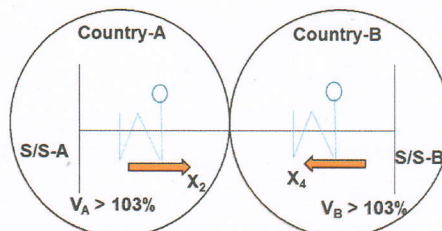
Case2: No payment is applicable in this case



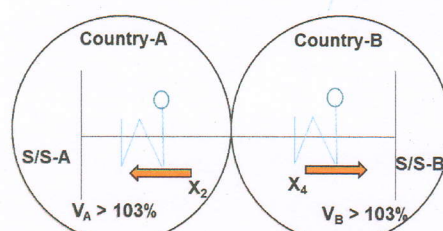
Case3: No payment is applicable in this case



Case4: Country A pays to B for minimum of X_2 and X_4



Case5: No payment is applicable in this case



Case6: No payment is applicable in this case

- 4.9. The reactive energy shall be calculated on daily basis for low voltage (<97%) and high voltage (>103%) separately.

5. Reactive Energy Account and Settlement

- The charge for VARh shall be as per the Central Electricity Regulatory Commission (CERC) IEGC regulations and amendment or re-enactment thereof.
- The charges shall be calculated for each link for high voltage and low voltage conditions separately. The net reactive energy charges shall be calculated after algebraic summation of high voltage and low voltages charges of each link.
- Regional Power Committee (RPC)/ National Power Committee (NPC) Secretariat, India shall issue the reactive energy charges account on weekly basis. The discrepancy, if any noticed by Bhutan shall be intimated to ERPC/NPC within prescribed time schedule.
- The Settlement Nodal Agency (SNA) shall settle the reactive energy charges with the reactive pool of India. SNA in turn will settle the charges with Bhutan.
- The payment terms and conditions shall be in accordance with CERC's IEGC regulations.
- The illustrative example for the calculation of reactive energy charges is attached at **Annexure-I**.

6. Reactive energy accounting in special cases

- In case, the line remains anti-theft charged or idle-charged from either end, the VAR readings of one end would be zero, as such, no charges for reactive energy exchange would be applicable.

- b) Main/check meter readings shall be used for VAR drawl/injection calculations. In the absence of meter readings, reactive energy will be considered as zero as such no charges would be applicable.
- c) Erroneous reading/non receipt of main meter readings shall be promptly reported and resolved by the entity in whose premises the meter is installed.
- d) For radial interconnections, reactive energy accounting shall be carried out considering the meter readings of sending end side.

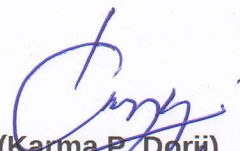
7. Applicability, Review and Revision of the Modalities

The modalities may be reviewed and revised as and when necessary, as mutually agreed by the Bhutan and India sides.

These modalities would be made effective from 1st May, 2026.



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BHUTAN SIDE METE(Plus sign Means Injection towards India & viceversa)																																																			
BINAGURI-TALA-1				BINAGURI-TALA-2				BINAGURI-TALA-4				BIRPAR-CHUKHA-1				BIRPAR-CHUKHA-2				RANGIA-MOTANGA				BINAGURI-MALBASE				BIRPAWA-MALBASE				ALPD-PUNATSANCHU-1				ALPD-PUNATSANCHU-2				ALPD-JIGMELING-1				ALPD-JIGMELING-2							
(TH-01)				(TH-05)				(TH-04)				(CU-01)				(CU-02)				(NE-84)				(NE-88)				(BT-39)				(BT-40)				(MN-17)				(MN-18)				(MN-21)				(MN-22)			
(TH-01)H		(TH-01)L		(TH-05)H		(TH-05)L		(TH-04)H		(TH-04)L		(CU-01)H		(CU-01)L		(CU-02)H		(CU-02)L		(NE-84)H		(NE-84)L		(NE-88)H		(NE-88)L		(BT-39)H		(BT-39)L		(BT-40)H		(BT-40)L		(MN-17)H		(MN-17)L		(MN-18)H		(MN-18)L		(MN-21)H		(MN-21)L		(MN-22)H		(MN-22)L	
X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3	X4	X3								
X1-xx-xxxx	0	0	-9.5	0	-2.9	0	-8.5	0	-6.8	0	-41.8	0	-0.4	0	-2034.2	0	-1935.3	0	-2034.2	0	-1935.3	0	-2034.2	0	-1935.3	0	-2034.2	0	-1935.3	0	-2034.2	0	-1935.3	0	-2034.2	0	-1935.3	0	-2034.2	0	-1935.3	0	-2034.2	0	-1935.3	0	-2034.2	0	-1935.3		
X2-xx-xxxx	0	0	-26.9	0	-4.4	0	-10.8	0	-11	0	-47.1	0	-21.5	0	-2088	0	-1496.7	0	-2088	0	-1496.7	0	-2088	0	-1496.7	0	-2088	0	-1496.7	0	-2088	0	-1496.7	0	-2088	0	-1496.7	0	-2088	0	-1496.7	0	-2088	0	-1496.7	0	-2088	0	-1496.7		
X3-xx-xxxx	0	0	0	0	0	0	-35.6	0	-38.4	0	-21.5	0	-18.9	2.3	-1597.1	0	-1597.1	0	-1597.1	0	-1597.1	0	-1597.1	0	-1597.1	0	-1597.1	0	-1597.1	0	-1597.1	0	-1597.1	0	-1597.1	0	-1597.1	0	-1597.1	0	-1597.1	0	-1597.1	0	-1597.1	0	-1597.1	0	-1597.1		
X4-xx-xxxx	0	0	0	0	0	0	0	0	0	0	1.9	0	-4	12.9	0	-992	0	-992	0	-992	0	-992	0	-992	0	-992	0	-992	0	-992	0	-992	0	-992	0	-992	0	-992	0	-992	0	-992	0	-992	0	-992	0	-992			
X5-xx-xxxx	0	0	0	0	0	0	0	0	0	0	-2.1	0	0	12.7	0	-555.6	0	-555.6	0	-555.6	0	-555.6	0	-555.6	0	-555.6	0	-555.6	0	-555.6	0	-555.6	0	-555.6	0	-555.6	0	-555.6	0	-555.6	0	-555.6	0	-555.6	0	-555.6	0	-555.6			
X6-xx-xxxx	0	0	0	0	0	0	0	0	0	0	-5.8	0	4.1	0	-541.8	0	-541.8	0	-541.8	0	-541.8	0	-541.8	0	-541.8	0	-541.8	0	-541.8	0	-541.8	0	-541.8	0	-541.8	0	-541.8	0	-541.8	0	-541.8	0	-541.8	0	-541.8	0	-541.8				
X7-xx-xxxx	0	0	0	0	0	0	0	0	0	0	-11.6	0	-0.1	14.5	0	-1040	0	-1040	0	-1040	0	-1040	0	-1040	0	-1040	0	-1040	0	-1040	0	-1040	0	-1040	0	-1040	0	-1040	0	-1040	0	-1040	0	-1040	0	-1040	0	-1040			
TOTAL (MVarh)	0	0	-36.4	0	-7.3	0	-54.9	0	-56.2	0	-128	0	-44.9	46.5	0	-8158.5	0	-8158.5	0	-8158.5	0	-8158.5	0	-8158.5	0	-8158.5	0	-8158.5	0	-8158.5	0	-8158.5	0	-8158.5	0	-8158.5	0	-8158.5	0	-8158.5	0	-8158.5	0	-8158.5	0	-8158.5	0	-8158.5			
amount(in Rs.) @ 0.055	0	0	-2002	0	-401.5	0	-3019.5	0	-3091	0	-7040	0	-2469.5	2557.5	0	-448717.5	0	-448717.5	0	-448717.5	0	-448717.5	0	-448717.5	0	-448717.5	0	-448717.5	0	-448717.5	0	-448717.5	0	-448717.5	0	-448717.5	0	-448717.5	0	-448717.5	0	-448717.5	0	-448717.5	0	-448717.5	0	-448717.5			
INR per unit																																																			
Net Total(in Rs.) Receivable (-)/Payable (+) by Bhutan =																								987498				-987497.5																							

Reactive Power Exchange for Billing as per the proposed Methodology (Plus sign Means Injection towards India & viceversa)																											
Date	400 KV BINAGURI-TALA-1		400 KV BINAGURI-TALA-2		400 KV BINAGURI-TALA-4		220 KV BIRPAR-CHUKHA-1		220 KV BIRPAR-CHUKHA-2		132 KV SALAKATI-GELEPHU		132 KV RANGIA-MOTANGA		400 KV BINAGURI-MALBASE		220 KV BIRPARA-MALBASE		400 KV ALPD-PUNATSANCHU-1		400 KV ALPD-PUNATSANCHU-2		400 KV ALPD-JIGMEING-1		400 KV ALPD-JIGMEING-2		
	Min of (X2, X4)	Min of (X1, X3)	Min of (X2, X4)	Min of (X1, X3)	Min of (X2, X4)	Min of (X1, X3)	Min of (X2, X4)	Min of (X1, X3)	Min of (X2, X4)	Min of (X1, X3)	Min of (X2, X4)	Min of (X1, X3)	Min of (X2, X4)	Min of (X1, X3)	Min of (X2, X4)	Min of (X1, X3)	Min of (X2, X4)	Min of (X1, X3)	Min of (X2, X4)	Min of (X1, X3)	Min of (X2, X4)	Min of (X1, X3)	Min of (X2, X4)	Min of (X1, X3)	Min of (X2, X4)	Min of (X1, X3)	Min of (X2, X4)
X1-xx-xxxx	0	0	-9.5	0	-2.9	0	-0.5	0	-6.8	0	-13.8	0	-0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X2-xx-xxxx	0	0	-26.9	0	-4.4	0	-10.8	0	-11	0	-14.5	0	-21.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X3-xx-xxxx	0	0	0	0	0	0	-14.9	0	-27.4	0	-11.6	0	-15.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X4-xx-xxxx	0	0	0	0	0	0	0	0	0	0	1.2	0	-0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X5-xx-xxxx	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X6-xx-xxxx	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X7-xx-xxxx	0	0	0	0	0	0	0	0	0	0	-1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL (MVar/h)	0	0	-36.4	0	-7.3	0	-26.2	0	-40.2	0	-2.5	0	-0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
amount(in Rs.) @ 0.055 INR per unit	0	0	-2002	0	-401.5	0	-1441	0	-2211	0	-2337.5	0	-2123	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Total(in Rs.) Receivable (-)/Payable (+) by Bhutan = -10516																											