

Telephone No. 080 22243926
Fax No. 080 22110134
Website: www.kptcl.com



Email ID: dgmtkptcl@rediffmail.com

KARNATAKA POWER TRANSMISSION CORPORATION LIMITED
CIN No. U40109KA1999SGC025521

Corporate Office
Kaveri Bhavan, K.G Road,
Bengaluru-560 009

KPTCL/B28(a)/CEE/RT&R&D/EEE/20

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CIRCULAR

Sub: Penalty for invalid VAR exchanges by inverter based Generators- reg.

- Ref:**
- 1) CEA [Technical Standards for Connectivity to the Grid] Regulations-2007, (amendment dated 15.10.2013).
 - 2) Karnataka Electricity Grid Code 2015.
 - 3) Note no CEE/RT&R&D/EEE/20 dated 30.05.2017 of the CEE (RT&R&D), KPTCL approved by MD, KPTCL on 21.07.2017.

Preamble:

In an efficient Transmission system, the voltage control and reactive power management are the two aspects of a single activity which influences reliability and facilitates smooth flow of power across the Transmission network at reduced loss. In terms of reactive power management, the Generators as per the statute are obligated either to supply or absorb reactive power in order to improvise the voltage profile at the point of interconnection within the acceptable level depending upon the requirement by the system operator (i.e SLDC) for secured operation of the grid. The monitoring of such requirement of reactive power is being done by the system operator over SCADA in respect of large Generators connected to the grid. However, in case of small Generators, especially, the Inverter based Generators where the reactive power management cannot happen through intervention of system operator in view of the capacity being small and numbers being large, the reactive power management has to happen dynamically and automatically.

In the present system of penalising the Generator for reactive power drawal, only the lag (import) reading recorded in 'Form-B' is considered as a means to thwart the Generators against drawal of reactive power during the period of drawal of active power by the Generators. The inverter based Generating plant makes use of power electronics to achieve various types of customized reactive power management by providing suitable settings in their inverters and one among such types is both voltage and P.F dependent.

There is however, every chance for Generators to operate the Generating plant within certain voltage and P.F range to thwart reduction in the active power delivered at the cost of making the grid to suffer as a result of persisting undesirable voltage profile at the point of interconnection.

Over the years the penetration from renewables especially from wind and solar is on the increase and therefore there is a dire necessity to have system driven automatic dynamic reactive power management backed up by necessary checks and balances which will persuade Generators to be alert in maintaining the voltage profile at the point of interconnection within the stipulated level.

Further, the section 5.3 of Karnataka Electricity Grid Code-2015 (KEGC-2015) insists that all 'Users' (which by definition includes Generating Company including Captive Generating Plant) connected to, or seeking connection to intra-State Transmission system (In-STS) shall abide by CEA (Technical standards for connectivity to the Grid) Regulation-2007 in order to ensure that the integrated grid is not adversely affected. In section 5.9.1 (a) of the aforementioned Regulation, it is stipulated that reactive power compensation and / or other facilities shall be provided by 'Users' connected to In-STS avoiding the need for exchange of reactive power to / from In-STS and to maintain In-STS voltage within the specified range.

The CEA (Technical standards for connectivity to the Grid) Regulations-2007 under section B of Part-II of its notification dated 15.10.2013 stipulates that the Generating station using Inverters (both wind and Solar) shall be capable of supplying dynamically varying reactive power support so as to maintain power factor within limits of 0.95 Lagging to 0.95 Leading.

Also, as per the section 8.6.3 of KEGC-2015, the limit for Voltage at the point of interconnection for exchange of VAR is stipulated to be 95% (0.95pu) to 105% (1.05pu) of the rated voltage.

Considering these requirements for the Grid, the exchange of VAR by the Generators using Inverters shall commensurate with a power factor margin of 0.95 (lag) [though PPA stipulates 0.85 lag] to 0.95 (lead) and voltage margins of 95% to 105% of rated voltage at the point of interconnection. That means to say, the Generating stations under the Regulations, have the obligation of supplying reactive power to the Grid during low voltage conditions and absorbing reactive power from the Grid during high voltage

conditions. The above requirement of the Grid is required to be ensured through relevant settings in the inverter for all the inverter based Generating stations before permitting interconnection.

The settings so kept at the time of interconnection may get disturbed subsequently for whatever reasons (may be intentionally or un-intentionally) resulting in VAR exchanges not to be in accordance with the requirement of the Grid, thus burdening the Transmission system resulting in decreased efficiency in transmission of active power and increased losses.

As such, checks and balances needs to be exercised by both KPTCL/ESCOM to ensure that the Generating stations supply reactive power to the Grid whenever the voltage at the point of interconnection is below the rated value and absorbs reactive power whenever the voltage at the point of interconnection is above the rated value duly verifying the VAR exchange with reference to the voltage value using load survey data on a monthly basis.

The energy meter provided at the interconnection point has the functionality to register:

- a) Lag (import) → which registers reactive energy imported from Grid while importing active energy from the Grid by the Generator *[the import of reactive energy in this case is not all acceptable and is to be totally avoided by the Generator]*
- b) Lag (export) → which registers reactive energy exported to the Grid while exporting active energy to the Grid by the Generator. *[the export of reactive energy is acceptable provided the voltage at the point of interconnection is below the normal value or otherwise has to be reckoned for penalising KVARH injection]*
- c) Lead (import) → which registers reactive energy exported to the Grid while importing active energy from the Grid by the Generator *[the export of reactive energy is acceptable provided the voltage at the point of interconnection is below the normal value or otherwise has to be reckoned for penalising KVARH injection]*
- d) Lead (export) → which registers reactive energy imported from the Grid while exporting active energy to the Grid by the Generator *[the import of reactive energy is acceptable provided the voltage at the point of interconnection is above the normal value or otherwise has to be reckoned for penalising KVARH drawal]*

A Ready reckoner on the extent of VAR to be absorbed / generated by the inverter based Generating station vis-à-vis voltage and power factor variations is appended below as a guide line:

| | Voltage in % of rated voltage | Power Factor | KVAR to be supplied /absorbed by Inverter based Generator expressed as a % of KW generated. |
|--------------------------------------|--------------------------------------|---------------------|--|
| For Voltages below the rated voltage | 95% | 0.95 Lag | 32.87% (from Generator to Grid) |
| | 96% | 0.96 Lag | 29.17% (from Generator to Grid) |
| | 97% | 0.97 Lag | 25.06% (from Generator to Grid) |
| | 98% | 0.98 Lag | 20.30% (from Generator to Grid) |
| DEAD BAND | 99% | 0.99 Lag | 0 |
| | 100% | 1.00 | 0 |
| | 101% | 0.99 Lead | 0 |
| For voltages above the rated voltage | 102% | 0.98 Lead | 20.30% (from Grid to Generator) |
| | 103% | 0.97 Lead | 25.06% (from Grid to Generator) |
| | 104% | 0.96 Lead | 29.17% (from Grid to Generator) |
| | 105% | 0.95 Lead | 32.87% (from Grid to Generator) |


A response time of 2.5 seconds shall be permitted for the dynamic variation of the reactive power and the Generator shall be intimated to provide dynamic reactive power support as above.

Further, the ESCOM's are required to monitor the VAR exchanges as brought out above for penalizing the Generators which are directly connected to the KPTCL grid (above 66 KV voltage class) and also in respect of Generators connected or getting connected either at 11 KV or 33 KV voltage class, as the case may be, since in the meshed network, any invalid exchange of VAR by Generators even in the Distribution network affects the KPTCL network.

This strict monitoring of VAR exchanges will influence the Generators to be alert and disciplined as far as invalid VAR exchange is concerned, which will help KPTCL in increasing system efficiency and to maintain voltage stability.

In view of the above and to adhere strictly with the directives narrated above, the following procedure shall henceforth be strictly followed:

- 1) The Checks and balances shall be exercised by KPTCL in general and ESCOM's in particular to ensure that Generating stations supply reactive power to the grid whenever the voltage at the point of interconnection is below the rated value and absorbs reactive power whenever the voltage at the point of interconnection is above the rated value duly verifying the VAR exchange with reference to the voltage value using load survey data on monthly basis.
- 2) The cases where import of KVARH is visualized from the grid even when the grid voltage at the point of interconnection is less than the rated value and export of KVARH is visualized when the grid voltage is in excess of the rated voltage both these types of VAR exchange under the specified voltage condition is invalid and undesirable from the voltage stability point of view.
- 3) All valid VAR exchanges even if it's drawn from or supplied to the Grid shall not be penalised and only invalid VAR exchanges shall be penalised at the rates agreed to in the PPA/Wheeling and Banking agreements or such other rates as determined by the Commission from time to time.
- 4) All the Executive Engineers (EI), TL&SS Division, KPTCL and Executive Engineers (EI), O&M Divisions, ESCOM are hereby instructed to check the readings recorded under lag (import), lag (export), lead (import) and lead (export) registers of ETV meter (tariff meter) and validate the KVARH readings recorded with the voltage value recorded in each of the 15 minute time block period so as to ascertain whether the exchange of VAR is valid or invalid before putting up Form-B.
- 5) The analysis of such data of invalid VAR exchanges shall be sent by the concerned EEE TL&SS to SLDC for information.


26/7
Deputy General Manager (Tech)
KPTCL

To:

1. The Managing Director, BESCOM, HESCOM, MESCOM, CESC, GESCOM,
2. The Director(Technical), BESCOM, HESCOM, MESCOM, CESC, GESCOM.
3. The Chief Engineer Electy., SLDC, KPTCL.
4. All Chief Engineers (Electy), KPTCL.
5. All Superintending Engineers (EI), TL&SS/RT/SCADA/W & M/Works Circles, KPTCL.
6. All Executive Engineers (EI), RT/TL&SS Divisions, KPTCL.
7. PS to the Managing Director, KPTCL, Kaveri Bhavan, Bengaluru.
8. PS to the Director(Transmission), KPTCL, Kaveri Bhavan, Bengaluru.

Copy to:

9. The Superintending Engineer (EI), IT & MIS with a request to arrange to upload this Circular in the KPTCL website for view of the officers of KPTCL.