

## SUPPLY OF REACTIVE POWER AND MAINTENANCE OF REACTIVE POWER RESERVES

### 1 Introduction

This instruction shall be applied to the supply of reactive power to the Customer from the main grid, to the monitoring of reactive power supply, and to the calculation of the supply limits of reactive power.

In so far as the measures presented in this application instruction concern a generator or network connected directly or indirectly to the Customer's network, the Customer shall agree on the measures specified in this application instruction with the owner of the generator or with the operator of the network.

This application instruction specifies the requirements for the maintenance of reactive power reserves in generators.

### 2 Principles of supply of reactive power

#### 2.1 Supply point of reactive power

The supply point of reactive power is the connection point. Monitoring areas of reactive power are created by Fingrid of the Customer's or customers' connection points which are close to each other in terms of the transmission network. Article 4 defines the basis of calculation of the monitoring areas of reactive power.

The Customer has the right to obtain the measurement information necessary for the monitoring of the Contract. Fingrid reports the volumes of reactive power on its Extranet service.

#### 2.2 Output and input limits of reactive power at the connection point

##### Output limit $Q_S$ of reactive power at the connection point

The output limit (Mvar) of reactive power at the connection point is calculated using two alternative formulas, with the higher resulting value chosen as the output limit on the basis of the calculation:

$$Q_S = W_{\text{Otto}} \cdot 0.16 / t_k + 0.025 \cdot W_{\text{Tuot}} / 5,000, \text{ or}$$

$$Q_S = W_{\text{Otto}} \cdot 0.16 / t_k + 0.1 \cdot S_N$$

where:

$W_{\text{Otto}}$  = output energy (MWh) at the connection point

$W_{\text{Tuot}}$  = net production (MWh) of the power plant at the connection point

- if a generator of a maximum of 10 MVA  $\Rightarrow W_{\text{Tuot}} = 0$

Peak usage time  $t_k = 7,000$  h (process industries)

Peak usage time  $t_k = 6,000$  h (other industries)

Peak usage time  $t_k = 5,000$  h (other consumption)

$S_N$  = largest generator (MVA) at the connection point

- if a generator of a maximum of 10 MVA  $\Rightarrow S_N = 0$
- $0.1 \cdot S_N$  is, however, at the most 30.0 Mvar

##### Input limit $Q_{S1}$ of reactive power at the connection point

The input limit (Mvar) of reactive power at the connection point is calculated using the following formula:

$$Q_{S1} = - 0.25 \bullet Q_S$$

The net production of power plants is determined by deducting from gross production the own consumption energy as defined in Decree 309 by the Finnish Ministry of Trade and Industry, issued on 11 April 2003, or in a replacing decree. At Fingrid's request, the Customer shall deliver the measurement and calculation criteria for own consumption energy used in the determination of net production.

The supply limits of the connection point for the next year shall be verified on the basis of the measurement information annually by the end of November. The supply limits shall be determined on the basis of the measurement readings of active power during a period of time between 1 October in the preceding year and 30 September in the current year.

If, during a monitoring period, significant changes take place in the use of active power or if a new power plant is commissioned or an existing power plant is decommissioned beyond the Customer's connection point, the effect of the changes shall be evaluated and the information contained in Appendix 1 of the main grid contract shall be revised immediately after the change has taken place to correspond to the changed situation. The revised values shall come into force from the beginning of the calendar month following the date of review.

If the consumption of active power and reactive power by train feed stations is included in the measurements of a monitoring area, the filter capacitors at the train feed stations shall be taken into account in the Contract so that the nominal reactive power value of the filter capacitors at the train feed stations located in the monitoring area is deducted from the  $Q_{S1}$  value. If the production of reactive power by filter capacitors at train feed stations has been taken into account in the  $Q_{S1}$  values specified in Appendix 1 of the main grid contract, the owners of the train feed stations have a right, free from the charges specified in the main grid contract, to keep such filter capacitors, which are important in view of the quality of electricity, at their stations.

### **3 Extraordinary situations in the use of reactive power**

#### **3.1 Reactive power of power plants**

There shall be no reactive power fees at the connection point in question for the exceeding of the reactive power window for a short period of time as a result of the disconnection of a generator from the grid due to the starting, disturbance or fault of the generator. A short period of time is considered to be a starting time of a maximum of 5 hours for condensing power plants and back-pressure power plants, and a starting time of a maximum of 1 hour for gas turbine plants and hydropower plants. When the exceeding of the reactive power window is caused by a generator disconnecting from the grid as a result of a disturbance or fault, 2 hours is considered as a short exceeding. Being exempt from paying the reactive power fee shall be subject to the condition that the starting of the generator has been reported to Fingrid in advance, and that the disturbance or fault has been reported to Fingrid without delay afterwards.

So that the reactive power reserves of generators would support the system voltage appropriately during faults at power plants and in the grid, no reactive power fees shall be charged at the connection point for an input of reactive power into the grid in excess of the  $Q_{S1}$  value ( $|Q| > |Q_{S1}|$ ), unless the input of reactive power is permanent by nature. The input of reactive power into the grid in excess of the  $Q_{S1}$  value is deemed to be permanent by nature when it has taken place in more than 30 hours in a calendar month.

### 3.2 Reactive power in consumption

There shall be no reactive power fees at the connection point in question for the exceeding of the reactive power window during the starting or stopping of the Customer's process with a significant scope in terms of grid operation, and during a disturbance resulting in corresponding impacts. Without separate agreement, the length of the period for which no fee is charged shall be a maximum of 2 hours per incident. The condition for no fee being charged is that the Customer notifies Fingrid of the starting and stopping in advance and of disturbances as soon as possible after the disturbance. The notifications shall be made through Fingrid's Extranet service.

In repairs following a fault in a capacitor battery of at least 0.5 Mvar connected directly or indirectly to the Customer's network or in repairs following a fault in a radial network feeding such capacitor battery, the nominal reactive power value of the missing capacitor shall be deducted, at the Customer's suggestion, from the output of reactive power at the connection point in question for the reasonable duration of the repair. A reasonable duration of the repair shall be deemed to be a maximum of 3 days per incident.

## 4 Monitoring of reactive power use and calculation of payments

The monitoring areas of reactive power created of the Customer's or customers' connection points exist for the monitoring of reactive power use. The reactive power limits of a monitoring area shall be calculated applying the formulas given under article 2.2. When calculating the active power output energy  $W_{\text{otto}}$  of a monitoring area, the figures (olisiko values parempi?) (with their signs) for output and input measurements at the connection points belonging to a monitoring area shall be added together hourly. (utilization period of maximum load/power -termi löytyi NetMotista, tuo peak usage time -termi tuntui vähän oudolta)  $t_k$  is specified in accordance with the determining consumption type in the monitoring area, and  $S_N$  is the largest generator (MVA) in the monitoring area.

When the reactive power limits of a monitoring area are exceeded or when the exceeding of the reactive power limit of an individual connection point disturbs the operation of the grid, the use of reactive power shall be negotiated with the owner of the connection point causing such exceeding. If the negotiations do not lead to the controlled use of reactive power, Fingrid has the right to invoice the owner of the connection point causing such exceeding.

The reactive power window specifies the volume of reactive power that can be supplied to and received from the main grid through individual connection points without a separate compensation. The supply of reactive power shall be deemed to take place within the reactive power window when the output of reactive power from the grid and the input of reactive power to the grid takes place within the limits of the  $Q_S$  values specified in accordance with article 2.2 or when the output of reactive power is at the most 16% of the active power olisiko parempi sana? esim. output?.

If the output power or input power of reactive power exceeds the reactive power window, the reason for the exceeding shall be verified before potential invoicing. The exceeding of the window shall not be invoiced if the exceeding is caused by a fault or disturbance in the main grid. If the reactive power window has been exceeded at the Customer's connection point in a total of no more than ten (10) hours per month and the output power or input power of reactive power does not exceed doubly the supply limit, no reactive power fees for exceeding the window shall be charged in that month.

In the extraordinary and short-term special situations of power plants or the main grid and upon separate agreement, even more reactive power than what has been specified in the main grid contract can be supplied or received temporarily without fees being charged for the exceeding of the reactive power window, if there are weighty reasons for this and the operating situation of the grid or of a power plant allows this and if this does not cause significant costs in the main grid.

Output of reactive power ( $Q > 0$ )

If  $P \leq Q_S / 0.16$  and  $Q > Q_S$ , the reactive power fee shall be  $(Q - Q_S) \cdot 3,000 \text{ €/Mvar}$

If  $P > Q_S / 0.16$  and  $Q/P > 0.16$ , the reactive power fee shall be  $(Q - 0.16 \cdot P) \cdot 3,000 \text{ €/Mvar}$

The reactive power fee is determined on the basis of the highest exceeding of the reactive power window in a month.

Reactive energy fee = reactive energy supplied in an area exceeding the reactive power window during the invoicing period (Mvarh)  $\cdot 10 \text{ €/Mvarh}$ .

Input of reactive power ( $Q < 0$ )

If  $|Q| > |Q_{S1}|$ , the reactive power fee shall be  $(|Q| - |Q_{S1}|) \cdot 3,000 \text{ €/Mvar}$

The reactive power fee is determined on the basis of the highest exceeding of the reactive power window in a month.

Reactive energy fee = reactive energy received in an area exceeding the reactive power window during the invoicing period (Mvarh)  $\cdot 10 \text{ €/Mvarh}$ .

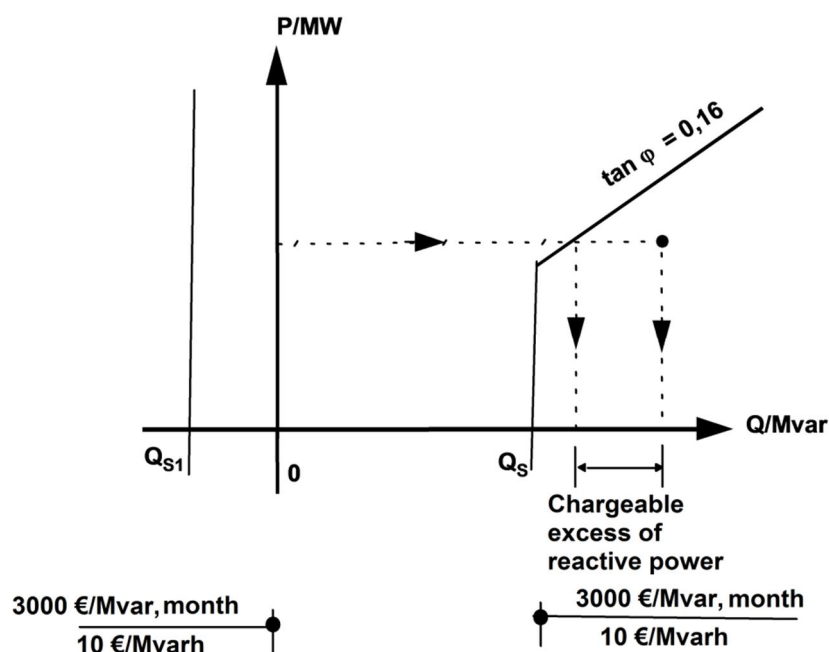
$$Q = Q_M - Q_h$$

$Q_M$  = measured average power of reactive power at the connection point in the examination hour

$Q_h$  = calculated reactive power losses of transformers and branch lines at the connection point. This is taken into account if the measurement is on the low-voltage side. Inductive reactive power is treated as a positive and capacitive reactive power as negative.

$P$  = measured average power of active power at the connection point in the examination hour

The figure below presents the principle of the reactive power window of the connection point, and the fees to be paid for exceeding the use of reactive power.



## **5 Reactive power reserves**

### **5.1 Method of control of generators**

Constant voltage control shall normally be used in generators with an output of over 10 MVA so that the reactive power reserves of the generators would support the system voltage appropriately during faults at power plants and in the grid. If the Customer or a third party connected to the Customer's network wishes to use another control method in the generators, the solution and the control features shall be agreed upon separately with Fingrid.

### **5.2 Reserve requirements imposed on generators**

The reactive power generating capacity and intake capacity of a generator connected to the main grid with a rated voltage of 400 kV through a generator transformer shall, while the generator is connected to the grid, be reserved as reactive power reserve in full, with the exception of the reactive power consumed by the generator transformer and by the own consumption of the power plant.

With other generators in excess of 10 MVA, half of the reactive power generating capacity and intake capacity of the generator, measured at the generator voltage level, shall be reserved as reactive power reserve while the generator is connected to the grid. The reactive power generating capacity and intake capacity of the generator shall be calculated at the nominal power and rated voltage of the generator. If the generator features  $\cos \varphi < 0.9$  (ind.), the reactive power generating capacity shall be calculated on the basis of  $\cos \varphi = 0.9$ .

### **5.3 Maintenance of activated reserve**

The reactive power reserve activated by a voltage change taking place as a result of a disturbance shall not be controlled off without Fingrid's consent.

### **5.4 Voltage support in fault, disturbance and maintenance situations**

Generators in excess of 10 MVA are obliged, while they are connected to the grid, to support the system voltage by means of the reactive power reserves during faults and disturbances at power plants and in the grid, and, if so agreed upon separately, for short periods of time also during repairs and maintenance at power plants and in the grid. Generators in excess of 10 MVA are obliged to follow the guideline value for voltage or reactive power, potentially given by Fingrid.

### **5.5 Follow-up of reserve maintenance**

Fingrid shall be responsible for monitoring the maintenance of reactive power reserves. For monitoring purposes, the Customer shall deliver to Fingrid the necessary measurement and status information on the generators. The measurements used in the monitoring of reactive power reserves are operation control measurements. The measurement and status information and their method of delivery shall be agreed upon separately.

**6 Measurements of reactive power**

Appendix 1 of the main grid contract specifies the measuring points of reactive power. If it is found that a measurement instrument for reactive power has caused a measurement error exceeding an average of  $\pm 5\%$ , the contracting party which has been afflicted because of this error has the right to demand correction.

If a reactive power measurement is not available at the connection point, the measurements can be replaced with calculatory measurements upon separate agreement.

**7 Reactive power of direct current connections**

When a high-voltage direct current (HVDC) connection or equivalent is connected to the main grid, Fingrid and the party connecting to the main grid shall agree on the supply of reactive power and on the reactive power reserves individually in each case.