Approved by Decision No. 53-1/2025 of the Management Board of Elering AS dated 01.07.2025

Technical Principles and Solutions for the Transmission System Operator's Electrical Installations

Valid from 31.07.2025

Table of Contents

1 General part and specific principles

1.1 This document describes the technical solutions and principles applied in the construction of substations, transmission lines, and electrical installations belonging to the transmission system operator. These principles are also applied when clients are connected to newly built substations and lines that will remain under the ownership of the transmission system operator. The guide shall be applied together with the standard terms and conditions for connecting to the electricity transmission system of Elering AS (hereinafter the Connection Conditions).

1.2 Not all requirements described herein apply to connections made to existing electrical installations of the transmission system operator. In such cases, the technical solution is developed on a case-by-case basis.

1.3 In the case of a fixed-term connection, the transmission system operator applies the specific technical solutions described in this document if the client concludes a fixed-term network contract valid for no more than 25 years following the connection process.

1.3.1 For fixed-term connections, the starting point of the 25-year validity period of the grid connection is considered to be the date on which the substation built for the initial connection is handed over by the builder to the transmission system operator.

1.3.2 Upon the client's request, the term of the grid connection specified in the network contract may be extended, provided the client covers the renovation costs of all electrical equipment of the transmission system operator built during the connection process, starting from the extension date. The transmission system operator and the client shall conclude a separate agreement for compensating these renovation costs of the transmission system operator’s electrical equipment.

1.3.3 At the client’s request, it is possible to connect to a substation with a pre-determined connection schedule, the construction of which has been agreed upon prior to the client’s connection. In such a case, all clients of the same substation shall share a common connection validity period, which shall commence on the date the substation constructed for the initial connection is handed over by the contractor to the transmission system operator. The transmission system operator. reserves the right to refuse the connection of a new client to a substation with a pre-determined connection schedule based on existing limitations (e.g., technical constraints, land-use issues, etc.), provided that the connection contract for the substation was concluded before 31 July 2025.

1.4 The timeframes for eliminating power outages at the client's point of consumption, and the conditions for reducing the network fee, are established by the Minister of Economic Affairs and Communications regulation "Quality Requirements for Network Services and Conditions for Reducing Network Fees in Case of Breach of Quality Requirements" (hereinafter: quality regulation). The point of consumption is defined as a group of connection points at the same or different voltage levels, located within a single substation.

1.5 According to the Quality Regulation, the transmission system operator must eliminate an interruption caused by a fault within 120 hours at a single-supply point of consumption and within 2 hours at a two-supply point.

1.5.1 To ensure the 2-hour fault recovery time at the client's point of consumption — whether at a new or existing site — the point of consumption must be connected to the transmission grid via at least two mutually backing connection points. The substation must also be connected to the transmission grid by at least two power lines located on completely separate towers (including end towers of the lines);

1.5.2 For existing points of consumption, the 2-hour fault recovery requirement must also be preserved when increasing the generating capacity, provided the desired generation-oriented capacity does not exceed the existing consumption capacity.

2 Conditions for the connection of generation and consumption capacities

2.1 At the transmission system operator's connection point, the maximum generation- or consumption-side connection capacity shall be 100 MVA in the 110 kV network, due to the need to limit rapid voltage changes occurring during the switching on or off of the connection point, and 400 MVA in the 330 kV network, in order to limit the unit capacity simultaneously disconnected from the power system. The transmission system operator's installation shall be designed and constructed in such a way that any N-1 situation (emergency shutdown of any network element) shall not cause a power outage of more than 400 MVA in the 330 kV network.

2.2 For connection capacities exceeding 400 MVA, the transmission system operator substation must be designed with more than one connection point, so that the capacity of any single connection point does not exceed 400 MVA. In the 330 kV substation of the transmission system operator, up to one connection point with a simplex cell can be connected to each 330 kV substation system from the radially connected 330 kV connection points, the remaining connection points must be connected to a duplex cell to ensure N-1 capacity.

2.3 If the client's connection capacity exceeds 400 MVA per connection point, the connection must be made in the transmission system operator substation via two mutually reserving connection points and two mutually reserving lines located separately, so that the disconnection of a single connection point or line does not interrupt power transfer, and the capacities of the connection points and lines are sufficient to maintain uninterrupted transmission. Based on this principle, total capacities of over 800 MW can be connected through two connection points, where the connection points are reserved and N-1 is guaranteed.

2.4 Based on the 400 MVA power limit and the N-1 condition, when connecting to an existing transmission system operator's substation, which is currently connected to the power network either via one line or via two overhead lines located on the same towers, it may be necessary to build an additional line compartment (bay) of the substation for the new input line in addition to the separate new line.

2.5 The equipment at the connection point between the transmission system operator and the client is installed according to the maximum grid connection capacity specified in the connection contract. The basis for the transmission system operator's SCADA measurements is the apparent power fixed in the connection contract.

2.6 The transmission system operator may implement an automation system to monitor the contracted generating capacity, which will disconnect the connection point if the client violates the capacity limits set in the contract and the generating unit does not respond to the transmission system operator's SCADA control.

2.7 When building a new substation due to a connection, in which the client connects to one connection point, the solution for a run-through substation is used, regardless of whether it is a temporary or permanent substation. When constructing a substation with two or more connection points, a 110 kV H-type substation and a 330 kV duplex substation are constructed.

3 Overhead and cable lines

3.1 General part on overhead lines

3.1.1 When designing and constructing new overhead lines, existing overhead line routes/corridors must be used to the maximum extent possible.

3.1.2 When building new overhead lines, towers with up to four circuits are used.

3.1.3 The minimum distance between the axes of parallel overhead lines must be:

3.1.3.1 330 kV and 330 kV overhead line – 33 m;

3.1.3.2 330 kV and 110 kV overhead line – 30 m;

3.1.3.3 110 kV and 110 kV overhead line – 20 m;

3.1.4 In the case of a multi-circuit line with different voltages, circuits with a higher rated voltage are built higher.

3.1.5 At the intersection of an overhead line with main roads, railways and navigable waterways, there must be anchor towers with double insulator chains on both sides of the intersection, consisting of two parallel sets of insulator chains attached independently to the polearm of the anchor tower. This solution must also be used if such a crossing with the line is planned within the next ten (10) years.

3.1.6 Ice-repelling wires must be used at the intersection of an overhead line with a railway, depending on the results of the risk analysis.

3.1.7 When an overhead line crosses a road, railway or navigable waterway, a vertical clearance of 10 m for 330 kV and 8.5 m for 110 kV overhead line wires must be ensured at the intersection. These external dimensions must also be used if a given intersection with the line is planned within the next ten (10) years. In other situations, the standard EVS-EN 50341-2-20 (“Overhead Power Lines with Alternating Voltage Above 1 kV”, part 2–20): from the air gaps given in the Estonian National Special Requirements (SEN)).

3.1.8 The client’s line circuit(s) will not be installed on the transmission system operator's new and existing line towers.

3.1.9 When replacing a line with a larger cross-section, existing towers are used if technically possible.

3.1.10 330 kV mixed lines (330 kV overhead line + 330 kV cable line) shall not be built.

3.2 **330 kV overhead lines**

3.2.1 The cross-section of the current-carrying part of 330 kV overhead lines must be at least 3x400-Al mm².

3.2.2 Free-standing towers must be used on cultivated farmland.

3.2.3 Only glass insulators are used on 330 kV lines, except in the last portal-connected span, where the use of composite insulators may be technically justified in traction chains. Corona rings arcing horns shall be installed on glass insulators. In type I carrier chains, in addition to the insulators required due to the length of the leakage path, one additional insulator with an open profile must be added as the top insulator, the diameter of which is at least 1.5 times the diameter of the lower insulator.

3.2.4 Cables may be installed in the protection zone of a 330 kV overhead line no closer than 10 m from the tower foundation, tensioner, earthing conductor, or wire projection.

3.2.5 It is not planned to connect new lines as branches to existing 330 kV lines.

3.3 **330 kV cable lines**

3.3.1 A 330 kV cable line must start and end at a substation; 330 kV mixed lines (330 kV cable line + 330 kV overhead line) shall not be built.

3.3.2 Only longitudinally and radially watertight cables must be used, with a maximum permissible operating temperature of the core of 90 ºC; a core operating temperature of 65 ºC must be used for transmission capacity calculations.

3.3.3 The cable shield must be usually grounded at both ends.

3.3.4 When installing cables using the open method, they must be covered with 10 mm thick polyethylene plates produced and type-tested for this purpose, and the cable line must be marked with warning tape and ID marker balls.

3.3.5 Cable poles must be used as additional markings along the route at the edge of cultivated land, where the cable line runs into water, in natural parks, meadows, forests, near the road, and in other similar places, as well as in the places where planning, drilling, or excavation work may be carried out without coordination with the route owners.

3.3.6 At intersections with roads and other utility lines and in densely populated areas, the cable line must be laid in PE pipes (each phase must be installed in a separate pipe). The inner diameter of the pipe must be at least 1.5 times the outer diameter of the cable, but not less than 160 mm.

3.3.7 The structures of bridges, viaducts, trestles and other similar structures, as well as people who may be present on the structure, must be additionally protected from the harmful effects of possible electric arcs, short-circuit currents, and contact voltages in the event of a cable fault.

3.3.8 It is prohibited to install additional cables in the protection zone of an existing cable.

3.3.9 Only factory-made cable drum stands with adjustable brakes and a cable winch with an adjustable clutch that stores traction force and limits traction force may be used during installation.

3.4 **110 kV overhead lines**

3.4.1 The cross-section of the current-carrying part of 110 kV overhead lines must be 1x240 Al mm² or 2x240 Al mm²

3.4.2 Glass insulators must be usually applied on 110 kV lines. In type I carrier chains, in addition to the insulators required due to the length of the leakage path, one insulator with an open profile must be added as the top insulator, the diameter of which is at least 1.5 times the diameter of the lower insulator. The installation of composite insulators is not permitted on towers where the polearm has a downward-facing support arm structure.

3.4.3 Cables may be installed in the protection zone of a 110 kV overhead line no closer than 5 m from the tower foundation, tensioner, earthing conductor, or wire projection.

3.4.4 It is not planned to connect new lines as branches to existing 110 kV lines.

3.5 **110 kV cable lines**

3.5.1 Only longitudinally and radially watertight cables must be used, with a maximum permissible operating temperature of the core of 90 ºC; a core operating temperature of 65 ºC must be used for transmission capacity calculations.

3.5.2 The cable shield must be usually grounded at both ends.

3.5.3 When installing cables using the open method, they must be covered with 10 mm thick polyethylene plates produced and type-tested for this purpose, and the cable line must be marked with warning tape and ID marker balls.

3.5.4 Cable poles must be used as additional markings along the route at the edge of cultivated land, where the cable line runs into water, in natural parks, meadows, forests, near the road, and in other similar places, as well as in the places where planning, drilling, or excavation work may be carried out without coordination with the route owners.

3.5.5 At intersections with roads and other utility lines and in densely populated areas, the cable line must be laid in PE pipes (each phase must be installed in a separate pipe). The inner diameter of the pipe must be at least 1.5 times the outer diameter of the cable, but not less than 160 mm.

3.5.6 The structures of bridges, viaducts, trestles and other similar structures, as well as people who may be present on the structure, must be additionally protected from the harmful effects of possible electric arcs, short-circuit currents, and contact voltages in the event of a cable fault.

3.5.7 It is prohibited to install additional cables in the protection zone of an existing cable.

3.5.8 Only factory-made cable drum stands with adjustable brakes and a cable winch with an adjustable clutch that stores traction force and limits traction force may be used during installation.

3.6 **110 kV mixed lines**

3.6.1 Mixed lines (overhead lines + cable lines) must not built when rebuilding electrical installations. If the construction of a mixed line proves to be economically and technically justified, the following conditions must be met when constructing it:

3.6.1.1 the part of the cable section to be installed must not be located between two overhead line sections, i.e. the additional cable line must start either from a substation or from an existing cable;

3.6.1.2 The transmission capacity of the cable section to be installed at 65 ºC must, as a rule, correspond to the transmission capacity of the overhead line;

3.6.1.3 In the case of a reconstruction of an existing mixed line, the overhead line section is generally completely replaced with a cable line.

4 Principles of substation construction

4.1 During the connection, a new 110 kV substation shall be built no closer than 11 km to the existing substation in a sparsely populated area and no closer than 3 km in a densely populated area. The criterion for the construction of a new 330 kV substation is 45 km for connection capacity up to 400 MVA and 22 km for connection capacity over 400 MVA, regardless of the area. The distance is calculated as a radius from the nearest existing substation — i.e. as the crow flies — in both the 330 kV and 110 kV networks.

4.1.1 It is possible to deviate from the distance requirements for the construction of a substation if a fixed-term substation is built and a fixed-term network contract is concluded, and this is reasonable and technically feasible considering the total costs of the client and the transmission system operator.

4.1.2 A newly constructed 110 kV substation must not be located farther than the span length of a single transmission line from an existing overhead line, i.e., a maximum of 200 m, and not farther than 800 m from an existing cable line, which corresponds to the maximum length of a single cable segment that can be pulled into a single cable duct.

4.1.3 A newly constructed 330 kV substation must not be located farther from an existing overhead line than the span length of a single transmission line, i.e., a maximum of 400 m. In the case of an indefinite grid connection, the conditions set out in section 4.1 may be deviated from in the event that the capacity to be connected or some other circumstance, in the opinion of the transmission system operator, requires the construction of a substation closer to the conditions set out above, for example, if the existing substation cannot be expanded for a new connection and therefore a new substation needs to be built. The transmission system operator's assessment is based on a study carried out by agreement between the client and the transmission system operator before submitting the connection application, which compares the total costs of different options for the client and the transmission system operator. Total costs are determined for different options, which take into account investment, operating, maintenance and other (such as losses, reliability, interruption losses, etc.) associated costs during the expected 40-year operating period following commissioning.

4.2 A non-expandable substation is a substation that has at least one of the following limitations:

4.2.1 A technical limitation has been reached in the substation. For a 110 kV substation with two sections, a technical limitation is three 110 kV connection points with different consumption locations per section, or an equivalent arrangement, since a greater number of connection points would prevent maintenance of substation equipment for existing clients within the maximum allowed outage time;

4.2.2 The substation site cannot be expanded legally, physically, or economically. For example, adjacent plots are already developed and in use, or a corresponding detailed plan has been established;

4.2.3 A GIS substation is not expandable due to the lack of technical support from the equipment manufacturer.

4.3 If the substation is built on an existing overhead line that is not equipped with optics (OPGW, ADSS) or the existing optics do not have sufficient resources, then new optics must be installed along the entire length of the line.

4.4 When expanding an existing substation of the transmission system operator, the principle of uniformity of compartments is generally followed, i.e. the schematic and plan solution of the existing substation is used.

4.5 The standard single-line diagrams used in 110 kV and 330 kV substations are provided in Appendix 1, “Single-Line Diagrams of the Transmission System Operator’s 330 kV and 110 kV Substations.”

4.5.1 The prospective part shown in the single-line diagrams is provided solely to determine the required land area; prospective facilities are not constructed under the connection charge.

4.6 **Principles of 110 kV substation schemes**

4.6.1 Up to four connections can be connected to the busbars of a 110 kV H-configuration substation, and the land area of such a new substation must be at least 60 × 50 m.

4.6.2 More than four connections are connected to the busbars of a 110 kV substation with two sections and two systems.

4.6.3 Each 110 kV section/system of the substation must retain the possibility for expansion by one bay, unless the power system development plan provides for more bays.

4.6.4 110 kV two-busbar substation:

4.6.4.1 In a substation with a double-bus system, all connections (lines, power transformers) are connected to both systems via circuit breakers in each bay.

4.6.4.2 A scheme with two busbar systems is used: in 110 kV switchyards of 330/110 kV substations, substations where the existence of the systems ensures security of supply for clients in the event of an emergency when one busbar system is in repair mode, and substations where important 110 kV transit lines are connected to;

4.6.4.3 the connection between systems is made with a disconnector and a circuit breaker with earthing switches;

4.6.5 110 kV run-through substation without line protection

4.6.5.1 Within the connection process, a substation with a predetermined connection schedule is constructed only for an existing overhead line to serve a single connection point. For a 110 kV cable line or hybrid line, an H-configuration substation shall be constructed.

4.6.5.2 The maximum consumption and/or generation capacity of the connection point is 50 MVA.

4.6.5.3 The possibility of establishing a run-through substation depends on technical feasibility (including the location of the substation, the number of existing run-through and tapped substations on the overhead line, and the connection capacity).

4.6.5.4 A maximum of two through substations may be connected to a single 110 kV overhead line with two ends.

4.6.5.5 The run-through substation must be expandable into an H-scheme substation in the future.

4.6.5.6 The land area of the 110 kV substation without run-through line protection to be constructed must be at least 60x50 metres.

4.6.5.7 In the case of a fault-tolerant substation, the transmission system operator cannot guarantee a shorter time to eliminate power outages caused by a fault than 120 hours.

4.6.5.8 In the case of a run-through substation, its construction for the purpose of client connection is permitted only if the client agrees to negotiate an exemption with the transmission system operator regarding the planned interruption duration specified in § 4 of the Quality Regulation. The single duration of a planned outage can be up to 120 hours, and the total annual duration can be up to 240 hours per year.

4.7 **Principles of 330 kV substation schemes**

4.7.1 In the transmission system operator's 330 kV substations, a double-bus configuration is used, with both buses normally in operation. Depending on the connection capacity and the conditions for connection reservation, the client's installation is connected to the transmission system operator substation via either a simplex or duplex bay.

4.7.2 A simplex bay is a bay connected to a single bus through one circuit breaker. A simplex bay does not provide protection against outages affecting the bus to which it is connected. In the event of any internal fault within the bay, the outage duration equals the time required to clear the fault.

4.7.3 A duplex bay is a bay connected to two buses through two circuit breakers. A duplex bay allows the connection to be protected against outages caused by most external faults outside the bay and enables faster restoration of power in the event of most internal faults. The power restoration time in a duplex bay equals the fault localization time for most internal faults, i.e., the client's connection can be restored without interruption while the fault is cleared.

4.7.4 The 330 kV duplex configuration is used for four or more connections and for substations serving international lines:

4.7.4.1 all transmission system operator lines are connected to both buses via two circuit breakers.

4.7.4.2 A client bay is connected either with one circuit breaker to a single bus (fault restoration time 120 hours) or with two circuit breakers to both buses (fault restoration time 120 or 2 hours, depending on the fault scenario).

4.7.4.3 if the client compartment (cell) is connected to one busbar with one circuit breaker, the possibility of installing a second circuit breaker remains;

4.7.4.4 For future lines or power transformers, the possibility of expanding the switchyard is provided in accordance with the power network development plan, but not less than two connections;

4.7.4.5 The land area of the new 330 kV duplex substation must be at least 120x120 metres.

4.7.5 330 kV run-through substation with line protection

4.7.5.1 is constructed only within the connection process and as a substation with a predetermined connection schedule for a single connection bay.

4.7.5.2 A 330 kV through substation is constructed only on a double-ended 330 kV overhead line, and its feasibility depends on several factors (including location, the number of existing through substations on the overhead line, and the connection capacity).

4.7.5.3 A maximum of two through substations may be connected to a 330 kV overhead line.

4.7.5.4 The maximum consumption and/or generation capacity of a through substation is 100 MVA.

4.7.5.5 If there are already, or are under construction, a total of two through substations on a 330 kV overhead line, only a new 330 kV substation with a duplex configuration may be added. The run-through substation must be expandable into a substation with a duplex scheme in the future.

4.7.5.6 The land area for a new 330 kV run-through substation must be at least 90 × 120 meters.

4.7.5.7 In the case of a fault-tolerant substation, the transmission system operator cannot guarantee a shorter time to eliminate power outages caused by a fault than 120 hours.

4.7.5.8 In the case of a run-through substation, its construction for the purpose of client connection is permitted only if the client agrees to negotiate an exemption with the transmission system operator regarding the planned interruption duration specified in § 4 of the Quality Regulation. The single duration of a planned outage can be up to 120 hours, and the total annual duration can be up to 240 hours per year.

5 Substation buildings and facilities

5.1 All land plots of the transmission system operator’s substations (both with and without predetermined connection schedules), including the land under the bays constructed for the client’s connection and the land necessary for operation—such as access roads, fences, and utility corridors—belong to the transmission system operator.

5.2 Depending on the location and local government approval, the substation switchyard can be either an open type (outdoor switchyard) or a closed type switchyard, including a gas-insulated switchyard.

5.3 The gas-insulated switchyard solution is only applied in cases where it is not possible to use other economically and technically more advantageous solutions.

5.4 In the case of an outdoor distribution network, the transmission system operator always builds a separate control building.

5.5 Substation control buildings must be expandable.

5.6 The installation of client-owned equipment in the transmission system operator's control building or switchyard is not intended.

5.7 No common fire protection and security systems shall be installed in the buildings of the transmission system operator and the client.

5.8 The transmission system operator's lightning protection system is not intended to protect the client equipment. The client must provide a separate lightning protection system to protect their equipment.

6 Solutions for the substation alternating current (AC) auxiliary power systems

6.1 The transmission system operator and the client must have separate AC power centers, and their reliability must be ensured independently

6.2 The transmission system operator's AC centre has two sections, and power must be provided from two different power sources.

6.3 The AC centre has backup switching between power inputs to ensure power security.

6.4 A diesel generator shall be installed in all 330 kV substations to provide redundancy for the two auxiliary power sources.

7 Substation direct current (DC) auxiliary power systems

7.1 The transmission system operator and the client must have separate DC centres.

7.2 The transmission system operator uses a 110 V DC auxiliary power system in its 330 kV substations and a 220 V DC auxiliary power system in its 110 kV substations.

7.3 All substations must have at least one battery centre.

7.4 The minimum capacity of one battery must be 100 Ah in 10 h discharge mode.

8 Principles of relay protection and automation design

8.1 Relay protection is designed to be fast, sensitive, selective, and reliable, and to cover all electrical equipment.

8.2 When selecting relay protection devices, the stability requirements of the power system are taken into account, and the devices to be installed must ensure compliance with the RfG requirements.

8.3 The Transmission System Operator’s relay protection devices are not intended to serve as the main protection for the Client’s equipment.

8.4 The client must install a separate primary protection for the equipment and installation owned by the client and connected to the transmission system operator’s substation—including overhead or cable lines, busbars, instrument transformers, and power transformers—using either differential protection or distance protection integrated with communication systems.

8.5 The transmission system operator shall install, in its substation (usually in the bay constructed for the connection), a separate terminal block cabinet, where the following auxiliary contacts are brought for the client’s primary protection and automation:

8.5.1 current circuits from the current transformer of the bay constructed for the connection (accuracy class 5P for 330 kV and 110 kV).

8.5.2 voltage circuits from the voltage transformer of the bay constructed for the connection (accuracy class 0.2S for 330 kV and 0.5S for 110 kV).

8.5.3 control circuits for switching off the circuit breaker of a 110 or 330 kV compartment belonging to the transmission system operator, when connecting to an overhead line and by separate agreement also the circuit breaker switching circuits for the client's automatic reconnection system);

8.6 The limit of all the circuits listed above is the terminal blocks of the boundary terminal cabinet.

8.7 The client must realise and install their own basic protection either on a neighbouring property to the transmission network operator's substation or in a boundary terminal cabinet located on the property of the transmission system operator's substation.

8.8 The length of the measurement and control cables (copper) connected by the client to the boundary terminal cabinet, to the client's basic protection and other devices in the client's installation, must not exceed 1000 m and must not pass through properties belonging to third parties. If the measurement and control cables required for the client’s primary protection exceed 1000 m in length, or if the client cannot install the primary protection in relation to the TSO substation on an adjacent plot, the client must install a terminal block cabinet with either their primary protection or a suitable optical communication device (e.g., a merging unit) along with an optical cable, through which all necessary measurement and control functions for realizing the primary protection can be implemented.

8.9 The boundary terminal cabinet has a designated space for installing the client's basic protection or optical converter with dimensions (L×W×H) of at least 500×500×500 mm. In addition, the cabinet has auxiliary DC voltage supply circuits (110 or 220V, depending on the DC auxiliary power system of the transmission system operator's substation) for the client's basic protection or optical data communication device. The boundary terminal cabinet has a heating element and ventilation holes that prevent condensation from forming in the terminal cabinet, but the terminal cabinet does not maintain a constant temperature and the box lacks cooling. The client must take this into account when selecting the equipment to be installed. A signal is sent to the transmission system operator's SCADA system when the heating element's circuit breaker is in the OFF position. The client is responsible for the environmental compliance, installation, testing, commissioning, maintenance, etc. of the client's device(s).

8.10 The client must take into account that in order to implement basic protection, it may be necessary to install 110 or 330 kV instrument transformers and a circuit breaker in their installation. If the accuracy of the voltage and current measurements provided by the transmission system operator does not meet the client's needs, the client must obtain and install suitable instrument transformers in their electrical installation.

8.11 The transmission system operator shall supplement the relay protection and monitoring equipment of the existing substation to the extent of the connection if a type D generating unit is connected to the distribution network or if the total installed generating capacity of the generating units connected to the existing distribution system operator's connection point exceeds the limit of class D generation modules.

9 Power transformers

9.1 General part

9.1.1 All power transformers must have at least one winding in a delta-connected device.

9.1.2 When installing all devices connected to the power transformer (instrument transformers, circuit breakers, medium-voltage cables), requirements of standard EVS-EN 61936-1, section 8.7.2.1, must be complied.

9.1.3 Fire barriers shall be installed on power transformers in accordance with standard EVS-EN 61936-1, clause 8.7.

9.2 330 kV power transformers

9.2.1 330 kV power transformers must be conventional transformers.

9.2.2 Power transformer selection criteria:

9.2.2.1 rated voltages: 347/117,5/21 kV;

9.2.2.2 rated capacities: 200/200/60 MVA;

9.2.2.3 the tap changer of power transformers must be located on the 330 kV side;

9.2.2.4 the tap changer steps: ±6×1.33%;

9.2.2.5 The 330 kV and 110 kV windings of conventional transformers can operate with a solidly grounded neutral (also through a neutral switch), a reactor-grounded neutral, or an isolated neutral;

9.2.2.6 The insulation level of the 110 kV neutral taps of conventional transformers must be equal to the phase insulation level;

9.2.2.7 The insulation level of the neutral taps and windings of 330 kV conventional transformers must be at least 245 kV.

9.3 110 kV power transformers

9.3.1 Power transformer selection criteria:

9.3.1.1 rated voltages: 115/(38.5; 22; 16.5; 11; 6.6) kV;

9.3.1.2 rated capacities: 63 MVA, 40 MVA, 25 MVA, 16 MVA, 10 MVA, 6.3 MVA, 2.5 MVA;

9.3.1.3 the tap changer steps: ±9×1.67%;

9.3.1.4 the tap changers of power transformers must be located on the 110 kV side;

9.3.1.5 the insulation level of the neutral outlets must be equal to the phase insulation level;

9.3.1.6 The neutral must be grounded via a grounding switch, meaning that a 110 kV transformer may operate with either a solidly grounded or an isolated neutral.

9.3.1.7 The neutral points of the windings in a star-connected power transformer can be rigidly grounded, grounded through an earthing switch, grounded through a reactor, or isolated from ground.

10 Shunt reactors

10.1 Parameters of new shunt reactors:

10.1.1 rated voltages: 362, 123, 21 kV;

10.1.2 rated capacities: per switchable unit: 20 MVAr, 30 MVAr, 50 or 120 MVAr;

10.1.3 Shunt reactors with adjustable power shall be used at rated voltages of 361 and 123 kV.

11 Capacitor banks

11.1 Parameters of new capacitor banks:

11.1.1 operating voltage: 123 kV;

11.1.2 rated capacities at 115 kV voltage: 20 MVAr, 30 MVAr, 50 MVAr;

11.1.3 A capacitor bank (or a module of banks – for example 20+30 Mvar) is connected to a 110 kV switchyard.

12 Substation short-circuit currents and ground loop

12.1 All primary equipment in a 330 kV substation must withstand a short-circuit current of at least 40 kA for 1 s.

12.2 All primary equipment in a 110 kV substation must withstand a short-circuit current of at least 25 kA for 1 s.

12.3 The minimum cross-section of the substation ground loop is Cu 50 mm².

12.4 The client must provide a grounding installation for their equipment, which must be connected to the transmission system operator's grounding installation via at least two independent beams that correspond to the cross-section of the transmission system operator's ground loop. It is not permitted to use grounding conductors with a smaller cross-section connected in parallel to realise the connection between ground loops.

13 Substation control and data mining

13.1 Special telematics equipment (RTU – Remote Terminal Unit, control computer, data communication equipment, etc.) is installed in the substation to control and monitor the substation.

13.2 The transmission system operator and the client must have separate and independent telematics equipment.

14 Network analysis equipment

14.1 External alarm recorder

14.1.1 To ensure measurement of short-circuit currents and analyse the effects of relay protection, external fault recorders must be installed in 110 kV and 330 kV compartments.

14.2 Electricity quality measurement

14.2.1 The quality of electricity is measured at all new 110 kV or 330 kV connection points between the transmission system operator and the client.

14.2.2 At existing connection points of the transmission system operator with the distribution system operator, electricity quality measurement is added to the 110 kV voltage if a class D generating module is connected to the connection point(s) connected to a power transformer belonging to the client or the transmission system operator, or if the total maximum installed capacity of the generating units meets or exceeds the class D limit.

14.2.3 Only EVS-EN 61000-4-30 class A type power quality metering equipment and capacitive instrument transformers with harmonic sensors suitable for this purpose shall be used for quality measurements.

14.3 PMU (Phasor Measurement Unit)

14.3.1 PMU devices shall be installed in all 330 kV line bays and 330 kV connection points for generation-side connections (e.g., wind, solar, and cogeneration plants, etc.). PMU devices shall be installed at 110 kV connection points for generation-side connections of 5 MVA or greater.

15 Measurement of transmitted electricity

15.1 The network service volume and electricity quantity are measured at the connection point, except in existing connection points with the distribution system operator, where, for the purpose of minimizing total societal cost, it is not reasonable to renew the metering points in the medium-voltage bays of the power transformer during substation refurbishment. IIn such cases, a commercial metering point is installed in the 110 kV transformer bay, and a correction factor is used to account for network (transformer) losses between the metering and connection points.

15.2 All AC electricity measuring devices used for commercial metering must comply with the Measurement Act of the Republic of Estonia.

15.3 Only inductive voltage transformers are permitted for commercial measurements. The use of capacitive voltage transformers is not permitted.

15.4 The primary current of the connection point’s current transformer is selected based on the contractual connection capacity.

15.5 Intermediate current transformers and summation of secondary currents of current transformers are not used in measuring circuits. Additional resistances may only be used in measuring circuits in exceptional cases when other technical solutions are not possible. The measuring wiring must not be installed in a common duct, ladder or pipeline with high-voltage conductors. To prevent measurement results from being affected, all terminals of the measuring circuits and the devices therein must be covered and sealed. Meters and their accessories must be located in a separate metering switchboard.

15.6 Meters used for commercial metering at voltages of 6–330 kV must enable bidirectional measurement of active and reactive energy with a measurement period of at least 1 minute.

16 Requirements for the construction of a new substation access road

16.1 The substation access road shall lead from the public road to the substation territory.

16.2 The road must be at least 4 m wide and there must be at least 1 m wide crushed-aggregate roadbed on both sides of the road surface.

16.3 The access road should be built slightly higher at the entrance gate to prevent rainwater from accumulating under the gate.

16.4 The strength of the roads must be calculated based on the axle load of the largest possible transport vehicle (e.g. fire truck).

16.5 If the client uses the same access road as the transmission system operator outside the territory of the transmission system operator's substation to transport its power transformer, the access road must be designed and constructed in accordance with the following requirements:

16.5.1 The turning radius of the axis of the transformer service roads up to the 110 kV transformer tank must be 15 m (transformer capacity up to 25 MVA) and 18 m (transformer capacity 25–63 MVA). An asphalt-covered service road that meets the requirements for a transformer road must continue at least 8 m beyond the foundation of the (last) transformer. The load-bearing capacity of the area between the transformer tank and the service road must be the same as that of the transformer service road. The load-bearing capacity of the area described above must be brought into compliance with the requirements by the time the transformer foundation is completed. 8 m ahead of the transformer tank and after the transformer tank, the 4 m wide crushed aggregate banks along the road must have the same load-bearing capacity as the transformer service road.

16.5.2 The turning radius of the road leading to the transformer up to the 330 kV transformer tank must be 26 m on the inside of the turn and 5 m on the outside of the turn. An asphalt road that meets the requirements for a transformer road must continue at least 12 m beyond the foundation of the (last) transformer. Transformer roads must allow for turning around with a loaded trailer at the substation. The load-bearing capacity of the area between the transformer tank and the road must be the same as the load-bearing capacity of the road leading to the transformer. The load-bearing capacity of the area described above must be brought into compliance with the requirements by the time the transformer foundation is completed. The 5 m wide crushed aggregate banks along the road 12 m ahead of the transformer tank and after the transformer tank must have the same load-bearing capacity as the road leading to the transformer.

16.6 The client's power transformer is not intended to be transported through the territory of the transmission system operator's substation.

16.7 The turning radius of roads must be at least 5 m on the road axis.

16.8 Road gauge marking posts (large white posts with traffic direction reflectors) must be installed on the roads in the substation territory to ensure safe snow removal.

16.9 Marking posts must comply with standard EVS-EN 12899-3 and must be installed at least in the following locations:

16.9.1 at the beginning and end of the turning radius;

16.9.2 in the middle of a straight road section if it exceeds 30 metres in length;

16.9.3 to mark the corners of a cul-de-sac and parking area.

16.10 The pre-excavated and levelled road ditch must be backfilled with earth with good drainage characteristics (gravel, sand or limestone waste) to a thickness of at least 250 mm and compacted to a compaction coefficient of ≥ 0.95.

16.11 All access and service roads to the substation must be constructed with a hard surface to enable substation construction, maintenance, and expansion.

Appendix 1. Single-Line Diagrams of the Transmission System Operator's 330 kV and 110 kV Substations

The following six drawings show the standard single-line diagrams used in 110 kV and 330 kV substations.