CEER TSO Cost Efficiency Benchmark

Electricity asset reporting guide

Final version

8 March 2018

1. Introduction

1. The CEER benchmarking projects for electricity and gas Transmission System Operators (TSOs) use two data calls to collect the required data:
    1. the financial data call, and
    2. the asset data call.

2. For both calls TSOs report their data in a separate reporting template (Excel) based on separate reporting guides which are meant to explain how the templates have to be filled in. The current guide deals with the electricity asset call and goes with its associated asset reporting template. Basically the asset reporting presents a snapshot of the asset base at a specific date set by project management.

3. Note that this guide (and its associated reporting template) is essentially a further development of the asset reporting guide used in the previous CEER electricity TSO cost efficiency benchmark E3grid (2012-2013).

4. Please fill in all fields of the financial reporting template. To avoid misunderstandings, always fill in an explicit “0” or “N/A” if that is the case.

5. This guide is structured as follows. Chapter 2 of this guide describes the different asset categories that need to be reported. Chapter 3 provides general reporting directions. Chapter 4 contains specific instructions per asset category.

2. Network components (asset categories)

6. To describe the network (grid) several components (asset categories) that can be distinguished. In the reporting template there is a sheet for each asset category.

Transmission system

7. The transmission system is composed of different network layers characterized by their respective voltages. From interconnection level (380 and 400 kV in Europe), down to sub-transmission networks generally being part of the distribution system (in general using voltages under 100 kV). The boundaries between transmission and distribution activities can differ following the system that is considered. Some transmission systems are characterized by a single functional layer, like in the UK (made of 132kV, 275 or 400 kV). Other systems are made of two superimposed layers, in continental Europe these are often made of 380 and 225 kV networks. Transmission systems made of more than two layers also exist, e.g. the French system is made of at least three functional layers, most often 380, 225, and 90 or 63 kV.

8. By default, the installations are considered as being AC operated.

Layer composition

9. Each layer is composed of (and further characterized by):
   1. Substations
      a. Outdoor or indoor.
      b. Air insulated or metal clad (gas insulated, i.e. SF_6).
      c. Single, double or triple bus bars (possibly operated in sections connected via circuit breakers).
   2. Electrical circuits
      a. Overhead lines (single, double, triple, quadruple), all circuits not necessarily being operated at a same voltage level.
      b. Underground or underwater cables.
      c. DC connection (and their converters).
   3. Connections to other layers that are implemented using transformers or auto-transformers:
      a. Presenting 2 or 3 operational windings (connected or connectable to a grid).
      b. Equipped with tap changer:
         - In phase (for implementing voltage control).

- Or in quadrature[1] (phase shifter; for active power control).
- Or both in a compound device.

c. Tap changer operation:
- Off load
- Or on load (OLTC, On Load Tap Changer).

4. This is completed by specific AC devices:
   a. Shunt compensation devices:
   - Capacitive.
   - Inductive.
   - Or both in a single compound device.

   b. Characterized by their control:
   - Continuous (SVC, STATCOM, synchronous compensator).
   - Mechanically switched (synchronously operated).
   - Mechanically switched (non-synchronously operated).

   c. Series components:
   - Series inductance for short-circuit limiting.
   - Series capacitors for increased transfer capacity (fixed, on-off, continuously variable).
5. Converter stations:
   a. HVDC (line commutation).
   b. HVDC (self commutated converters).
6. Control centers.

10. Conceptually systems are roughly developed following two distinct schemes:
    1. A system based on the reactive compensation scheme. In that case the voltage control in the HV system is mainly implemented using HV reactive compensation.
    2. An approach based on transformers with OLTC[2], assuring reactive power transfers between layers while decoupling layers voltages.

    Systems exist where both approaches have been concurrently implemented.

Offshore grids

11. Offshore assets comprise:
    1. Offshore transmission networks, i.e. all assets used to connect off shore wind farms (e.g. cables, platforms, converters), ending with and including the circuit end in the first (seen from the perspective of the off-shore wind farm) onshore AC substation, and

[1] Technologically, the series voltage is not necessarily based on a 90° phase shift (“quadrature” booster).

[2] On Load Tap Charger, sometimes also ULTC for Under Load Tap Changer.

2. Subsea interconnectors, i.e. subsea cables between (and including) two onshore (converter) stations from different countries that for a dominant part lie on the seabed or below it and is used to transport electricity from one country to another, e.g. the electricity interconnector between Norway and the Netherlands).

12. For the purpose of reporting, subsea cables that connect parts of the same network (i.e. intra-TSO) are not considered as offshore assets.

3. General reporting directions

Asset reporting

13. Assets are reported as they appear at a specific moment ("snapshot") defined by project management, see Article 2.

14. Offshore assets are excluded from reporting. Please note that according to Article 12, subsea cables that connect parts of the same network (i.e. intra-TSO) will be reported as cables (see Article 47) and indicated as submerged (ref. Articles 53 and 54).

15. Unless otherwise requested, the assets reported should relate to
    1. The reporting TSO's own assets that have not been decommissioned (i.e. those assets that are permanently not in use anymore by the TSO, no matter if these are removed or not) and that are partly or fully operated by the reporting TSO to fulfil its own supply obligations.
    2. Network components not owned by the reporting TSO, but leased, rented or otherwise made available (fully or partly) to the reporting TSO by third parties and used by the reporting TSO to fulfil its own supply obligations. For sake of asset reporting such components are considered as assets of the reporting TSO.

16. Assets which are owned by the reporting TSO, but not used by the reporting TSO to fulfil its own supply obligations because the assets are fully leased, rented or made available otherwise by the reporting TSO to third parties should be attributed to these third parties and should not be reported here.

17. With reference to Article 15, in case the asset is only used partly by the reporting, the share of usage must be reported. This share is based on capacities granted on a contractual basis and not on property or ownership shares. So, the reporting TSO has the asset to its free disposal for that part, regardless of the actual utilization. In such cases the name(s) of the parties with which the sharing is done will also be reported.

18. In the reporting transformers, circuit ends, compensating devices or series compensation reported must be related to a substation for validation purposes. In some countries, due to interests of national security, this information can only be available for the relevant NRA. If so, this will be ensured by the relevant NRA.

19. For the purpose of reporting towers and substations are not considered as primary assets, unlike all other assets to be reported. Towers and substations will be reported in order to better understand the complexity of the network.

Asset properties

20. Any asset reported must be given a unique ID, unless stated otherwise.

21. Reporting of all assets (except control centers) require information about nominal voltage. Unit of measurement is kV for all assets. The reporting will explicitly state the lowest represented voltage level and its prevalence in circuit km.

22. For circuit ends capacity in terms of breaking current must be reported (in kA). Deviations between nominal values and operational limits (e.g. due to climatic conditions) are neglected.

23. For lines, cables, transformers, compensating devices and series compensation nominal power in MVA must be reported. For transformers, the highest power value has to be considered, this is often the one of the higher voltage winding. For phase shifters the total of the series and shunt power values has to be reported.

24. In case of multiple circuits lines, each circuit must be considered separately. This permits to account for different operational voltages for circuits on the same tower.

25. A cable connection usually consists of multiple cables in a trench or a tunnel, where e.g. a trench can easily be 10 or more meters wide and different cables can be operated at different voltage levels. A cable connection consisting of a number of cables, all being operated at the same voltage level, is reported as a single asset. So, if the cable connection consists of cables operated at two different voltage levels, this is reported as two assets (two cable connections in the same corridor).

Commissioning, acquisition, and rehabilitation

26. The commissioning year of an asset is the year when the asset was put in operation (for the first time), irrespective of this was done by the TSO or a third party.

27. In case the asset has been obtained from a third party, in addition to the commissioning year, the acquisition year (year of investment, or at least the major part of it) also needs to be provided.

28. By default the commissioning year is equal to the acquisition year (in the template indicated as “N/A”).

29. In case the asset has been significantly rehabilitated the rehabilitation year also needs to be provided. Significant rehabilitation means a large incremental investment into an existing asset without change of any characteristics (i.e. its dimensions and properties). Large is defined as at least 25% of the (real) initial investment. Regular preventive and reactive maintenance, e.g. replacement of system components at or before their lifetime is not counted as a “rehabilitation”. Investments changing the characteristics are considered as “upgrades” and not as rehabilitation. The default reporting is “N/A”, i.e. there is no significant rehabilitation.

Generic data to be provided (per asset)

30. For each asset, the following information is asked for in the reporting template:

31. <u>ID:</u> See Article 20.

32. <u>Usage share:</u> A percentage, see Article 17. By default, full usage by the reporting TSO, 100% is filled in explicitly.

33. <u>Third parties:</u> These are the names of the parties the sharing is done with, see Article 17. By default “N/A” is reported to signal that no sharing is done (Usage share in Article 32 is 100%).

34. <u>Commissioning year:</u> See Articles 26 to 29.

35. <u>Acquisition year:</u> See Articles 26 to 29.

36. <u>Rehabilitation year:</u> See Articles 26 to 29.

37. Please refer to Chapter 4 for the required specific information per asset.

4. Specific reporting directions

38. Below, we introduce the data to be provided specifically for each asset.

Lines (Sheet "1. Lines")

39. An item in the overhead transmission line category is defined as a circuit, with a certain nominal current, operated at a certain voltage, installed on towers equipped with a certain number of circuits. Line specifics to report are the following:

40. Length: Length of the circuit (km).

41. Voltage: Nominal voltage (kV).

42. Power: Nominal power (MVA).

43. Number of circuits: Number of circuits per tower (1,2,3,…).

44. AC/DC: AC or DC.

45. Number of sub-conductor: Simplex (1), duplex (2) , or triplex (3).

46. Tower type: Dominant tower type (Wood, Steel, Concrete, Composite).

Cables (Sheet "2. Cables")

47. Definition of cables follow the same principles as lines, but lay underground or under water (submerged). Reporting is done at the level of cable connections, not at the level of individual cables that the connection consists of, see Art. 25 for a further explanation.

48. Offshore cables should not be reported here (see Article 11 for what is meant with offshore). Cable specifics to report are the following:

49. Length: Length of the circuit (km).

50. Voltage: Nominal voltage (kV).

51. Power: Nominal power (MVA).

52. AC/DC: AC or DC.

53. Usage: Land or Submerged. Submerged cables are defined as cables that lie at least 2 meters below the water surface for at least 1.000 meters and for at least 75% of their length.

54. Water crossed: In case the cable is submerged (Usage = Submerged), state the name of the water crossed (otherwise fill in N/A). This is the name as it is known to the public.

55. Number of cables: Number of cables the cable connection consists of (1,2,3,…), see Article 25.

56. Number of conductors: Number of conductors (1,2,3,…) per cable of the of connection. Usually this is 1 or 3. For high voltage cables this is usually 1. In case there are cables with different numbers of conductors, report the dominant type.

57. Insulation: PEX, XLPE, Oil, Gas filled, or Other.

Transformers (Sheet "3. Transformers")

58. All types of transformers playing a role in transmission shall be reported. Transformers supplying substations auxiliaries are excluded here from reporting as these are implicitly taken into account through circuit ends. Transformers of HVDC installations are included within the convertors and must also not be reported under transformers. Transformer specifics to report are the following:

59. Substation: ID of the substation the transformer is located in.

60. Primary: Primary voltage (kV).

61. Secondary: Secondary voltage (kV).

62. Tertiary: Tertiary voltage (kV), if applicable.

63. Power: Nominal power (MVA).

64. Number of transformers: Number of identical transformers in the relevant substation (1,2,3,…). Identical means that they have the same attribute values (voltages, Power, Type, Tap Changer, Phase Shift) and have the same commissioning year.

65. Type: Transformer type (Transformer, or Auto-transformer).

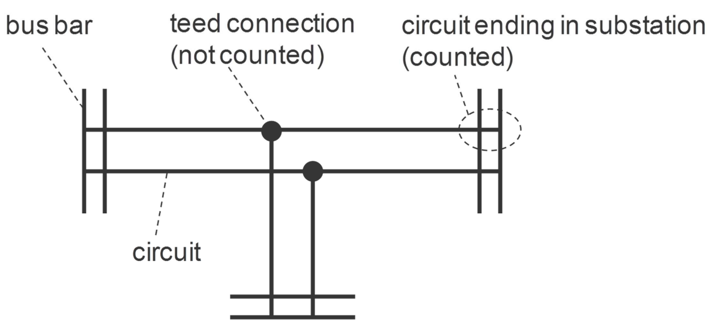
66. Tap Changer: Tap changer type (With or Without), i.e. with or without On Load Tap Changer (OLTC).

67. Phase shift: Phase shift yes/no (Yes or No).

Circuit ends (Sheet "4. Circuit ends")

68. A circuit end is generally a bay in a substation. This applies to all types of devices connected in a substation (e.g. lines, cables, transformers, compensation devices, but also transverse couplers between bus bars, or longitudinal couplers between bus sections). For example, a UHV-HV two windings transformer has two circuit ends, one connected to the UHV bus and the other to the HV bus. "Auxiliary" devices such as earthing switches or measurement units shall not be counted here. Circuit end specifics to report are the following:

69. Circuit ends are only counted if the respective switchgear is owned by the TSO. Teed connections are not specifically taken into account in the present guide. Only the terminals ending in a substation will only be considered (see figure below). For the calculation of circuit length, the total length of the teed structure must be considered, at least when the type of the line is similar. Otherwise the different circuits must be sorted following the type of line. The circuit ends at the connection point on the line is considered as non-existent.



70. Circuit end specifics to report are the following:

71. Substation: ID of the substation the circuit end is located in.

72. Voltage: Nominal voltage (kV).

73. Current: Current breaking capacity (kA).

74. Number of circuit ends: Number of identical circuit ends (1,2,3,…) in the relevant substation. Identical means that they have the same attribute values

(Voltage, Current, Busbar, Coverage, Insulation) and have the same commissioning year.

75. Busbar: Single (1), double (2), triple (3), quadruple (4), Other.

76. Coverage: Outdoor (open air) or Indoor (in a building).

77. Insulation: Air insulated or Metal clad (gas insulated, i.e. SF_6).

Shunt compensating devices (Sheet "5. Compensating devices")

78. There are discrete (bank) and continuous compensating devices, for banks, single (fixed) and multiple steps (adjustable). For shunt reactor compensated lines, where inductance cannot be disconnected, compensating devices are considered as bank of fixed inductive compensation. Shunt compensating device specifics to report are the following:

79. Substation: ID of the substation the device is located in.

80. Voltage: Nominal voltage (kV).

81. Power: Nominal power (MVA).

82. Number of devices: Number of identical compensating devices (1,2,3,…) in the relevant substation. Identical means that they have the same attribute values (Voltage, Power, Type, Fixed or adjustable, Capacitive or inductive) and have the same commissioning year.

83. Type: Type of compensating device, i.e. Banks, SVC, STATCOM, or synchronous compensator (SynComp). See also Article 78 regarding reactors.

84. Fixed or adjustable: Single (Fixed) or multiple steps (Adjustable) for banks.

85. Capacitive or inductive: Capacitive (Cap), Inductive (Ind), or both (Both).

Series compensation (Sheet "6. Series compensations")

86. The series compensations are divided in two categories, inductive (for short-circuit current limiting) on one side and capacitive (for increased transfer capacity) on the other side. Inductive compensation is generally made of fixed components while capacitive series compensation can be made discretely or continuously adjustable. Series compensation specifics to report are the following:

87. Substation: ID of the substation the series compensation is located in.

88. Voltage: Nominal voltage (kV).

89. Power: Nominal power (MVA).

90. Number of devices: Number of identical series compensations (1,2,3,…) in the relevant substation. Identical means that they have the same attribute values (Voltage, Power, Control, Fixed or adjustable, Capacitive or inductive) and have the same commissioning year.

91. Control: (Discrete, or Continuous).

92. Fixed or adjustable: (Fixed, or Adjustable).

93. Capacitive or inductive: Series capacitors for increased transfer capacity, either discretely (CapDis) or continuously adjustable (CapCon), or series inductance (Ind) for short-circuit limiting.

Control centers (Sheet "7. Control centers")

94. Control centers in electricity transmission operations measure, regulate and control electricity flows from sources to consumers. ICT (hard- and software) used in a control centers is seen as integral part of it. This also includes grid related telecommunications (telecommunications solely related to the network). This comprises of transmission of electronic information for metering, control and supervision of the network with means other than through third-party operators. This also includes SCADA and optical fibers and other infrastructure that is used for telecommunication. For control centers the following is reported:

95. Name: Name of the control center.

96. Functions: A description of the main functions and characteristics of the control center.

97. Staffing: The control center is an operational unit that is staffed during normal operations (Yes) or an emergency (reserve or back-up) center that is fully equipped but not normally staffed (No).

Other installations (Sheet "8. Other")

98. FACTS or HVDC conversion stations are very specific installations. Their number worldwide is less than one hundred. Each constitutes a specific plant. To ensure a correct validation, converter stations are reported in a free format, specifying the adequate parameters. Use one line for each station without aggregation.

Other transmission installations of particular values may also be entered here. Specifics to report are the following:

99. Type: Type of installation (e.g. HVDC)

100. Characteristics: Further specification of the installation in terms of its main characteristics (e.g. voltage, capacity, power, etc.)

Towers (Sheet "9. Towers")

101. Reporting of towers differs from the other asset types in that they are not reported item by item but as a sum of identical asset, where identical refers to the attributes being reported. Tower specifics to report are the following:

102. Number: Number of identical towers (1,2,3,…), where identical means that they have the same reported attributes (Usage share, Third parties, Commissioning year, Acquisition year, Rehabilitation year, Voltage, Material, Type).

103. Voltage: Voltage level (kV). In case of towers for multiple circuits the highest voltage level applies (nominal, not operational).

104. Material: Main material the tower is composed of (Wood, Steel, Concrete, Composite, or Other).

105. Type: Type of tower (Suspension, or Angular).

Substations (Sheet "10. Substations")

106. An item in the substation category is generally defined as a grid connection point with transformers, switches, compensating devices or series compensation. Substation specifics to report are the following:

107. Voltage: Highest nominal voltage (kV) in the substation. This is the nominal voltage on the primary side of the highest voltage transformer within the substation. This is also referred to as rated voltage.

108. Type: Transformer, Switching, or Other.