Methodology of parameters calculation for Lithuanian Capacity Mechanism

Part 1: Methodology for the calculation of de-rated capacity of physical units

TITLE 1: General Provisions

Article 1: Subject matter and scope

1. The objective of this document is to develop detailed methodologies for calculation of parameters in the Lithuanian capacity remuneration mechanism (CRM) that will be used by LitGrid to calculate parameters necessary for the implementation of Lithuanian CRM, as laid out in Article 4. Amendment of Article 9 of the Law on Electricity of The Republic of Lithuania:
   - 24) approve the methodology for calculating de-rated capacity;
   - 25) approve the methodology for calculating the Maximum Entry capacity of interconnectors (Item 25);
   - 26) approve the methodology for the allocation of congestion rent; and
   - 27) approve the methodology for the calculation of allocated capacity.
2. The methodologies are split this into four Parts presented in separate documents:
   - Part 1 presents the methodologies for de-rating capacity calculation for national generation capacity and foreign capacity participating in Lithuanian CRM;
   - Part 2 presents on the methodology for Maximum Entry Capacity;
   - Part 3 presents the methodology to calculate the Auction Target Capacity; and
   - Part 4 presents the methodology for allocation of the Congestion Rent.

3. The present document addresses Part 1 and focuses on methodology of calculation of de-rating capacity of physical units.

Article 2: Definitions and interpretation

4. For the purposes of the present methodology, the terms used in this document shall have the meaning of the definitions included in Article 2 of Regulation (EU) 2019/943 and Article 1. Amendment of Article 2 of the Law on Electricity of The Republic of Lithuania.

5. In addition, in this methodology, the following definitions and their interpretations shall be used:

   - **Auction Clearing Price** is the Price in the Capacity Auction determined by the Price Setting Bid
   - **Capacity Mechanism** is defined in accordance with Article 2(22) of Regulation (EU) 2019/943.
   - **Capacity Mechanism Contract** means the contract between the CM operator and the capacity provider enabling the capacity provider to get a remuneration for its availability during the Reference period.
   - **Cross-border Physical Unit** is a Generating Physical Unit or DSR located in a Member State of the European Union, the electricity system of which is interconnected directly with the electricity system of Lithuania
   - **Electrical neighbour** means a Member state or a bidding zone which is part of a Member State that has a direct network connection with the bidding zone for which the maximum entry capacity is computed.
   - **Entry Capacity** means the capacity, expressed in MW, that can be allocated to eligible foreign capacity for participation in a capacity mechanism. Its total amount can never exceed the Maximum Entry Capacity.
   - **Foreign Capacity** means a capacity located in a Member State different from the Member State applying the capacity mechanism.
   - **Maximum Entry Capacity** means the maximum allowed foreign capacity (expressed in MW) considered between two Member States that can participate in a capacity mechanism during a certain Delivery Period t.
   - **Net Attainable Capacity of a Generating Physical Unit** means maximum power that can be permanently supplied by the Generating Physical Unit under normal operating conditions (net of the power absorbed by technological devices and systems of the unit necessary for the electricity generation).
   - **Energy Not Served (ENS)** means the amount of energy demand – measured in MWh – which is not supplied in a given zone and in a given time period due to insufficient resources to meet demand.
   - **Physical Unit** is a separate set of technical apparatus with metering points assigned to them in the Lithuanian electricity system.
   - **Scarcity**, also named ’system stress’ refers to a situation during which ENS is strictly greater than zero in a given system and in a given time period because national production, demand reduction measures and total possible imports are insufficient to meet demand.

- **Scarcity hours** for a given bidding zone are defined as hours during which the corresponding bidding zone has an importing position after market clearing coupling and for which the value of the hourly Energy Not Served (ENS) is strictly greater than 0 MWh/hour, after considering the effect of curtailment sharing within the market coupling algorithm. This is based on perfect foresight model as defined in ERAA.
- **Scarce asset** means either the transmission capacity or the electricity resources of neighbouring systems that are operating at their maximum capacity and hence limiting the management by the market of a scarcity situation.
- **Net Transfer Capacity (NTC)** model means a capacity calculation method based on the principle of assessing and defining ex-ante a maximum energy exchange between adjacent bidding zones as referred to in Article 2 of Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management.

TITLE 2: Principles of de-rated capacity

Article 3: The concept of de-rated capacity

6. A Physical Unit is not always 100% available during the system stress events. Its availability can differ from its nominal capacity due to outages (planned or unplanned), limitations on operation (in particular, energy constraints for storage) or weather conditions (in particular for renewables such as wind or PV). As a result, the TSO cannot rely on 100% of nominal capacity of each unit to cover the peak lead.
7. Thus, to avoid over-estimation of the actual contribution to adequacy of each unit, which may threaten security of supply, installed capacity of each Physical Unit shall be adjusted downwards using the corresponding de-rating factor. The de-rating factor is a measure of the expected availability of a Physical Unit in the case of a potential system stress event. It is defined between 0 (a unit which is expected not to be available during stress events) and 1 (a unit expected to be available during the stress events at the level of its net attainable capacity).
8. De-rating factors shall be calculated for all Physical Units participating in the CRM as well as for capacity not participating in CRM but contributing to national adequacy. Units having cleared in the CRM will receive the capacity price for each MW of their de-rated capacity.
9. Participation of Foreign Capacity is allowed to the extent the interconnector capacity contributes to the Lithuanian adequacy, that is, the extent to which the interconnector is expected to provide imports during a stress event in the Lithuanian system. This is reflected in the calculation of Maximum Entry Capacity discussed in Part 2 of the methodologies. Maximum Entry Capacity represents maximum allowed foreign capacity (expressed in MW) considered between two Member States that can participate in a capacity mechanism in a given delivery period. Participation of Foreign Capacity is determined in the Pre-Auctions, in which Foreign Capacity providers compete for the Maximum Entry Capacity of interconnectors on each border. De-rating should apply both to the Foreign Capacity and to the interconnector capacity for the calculation of Maximum Entry Capacity as presented in Part 2 of the methodologies.
10. De-rating factors should be calculated before each capacity auction.

Article 4: Main de-rating methodologies

11. There are two main methodologies to compute the de-rating factors:

    - **The historical (or statistical) approach**, based on a statistical analysis of the historical availability of resources during past stress events. It typically consists in calculating forced outage rates (FOR) for individual units using historical data on forced outages; and
    - **The marginal approach**, based on an analysis of the marginal contribution of the capacity unit to the Lithuanian adequacy. This approach relies on the Adequacy Analysis. Its starting point is an adequate portfolio that reaches the Reliability Standard (8 hours of Loss of Load Expectation in case of Lithuania). The de-rated capacity of a given capacity unit is estimated as the volume of a uniform increase (reduction) of demand allowing to reach the target Reliability Standard after the addition (removal) of the capacity unit.

12. The historical approach is easier to implement as it does not require a complex power system modelling and extensive data. However, the historical approach may produce biased results in cases when FOR is not an accurate estimation of contribution of a capacity unit to system adequacy. This could be the case for:

    - Large units of conventional technologies;
    - Weather-dependent technologies;
    - Energy-limited technologies.

13. We describe these cases below.

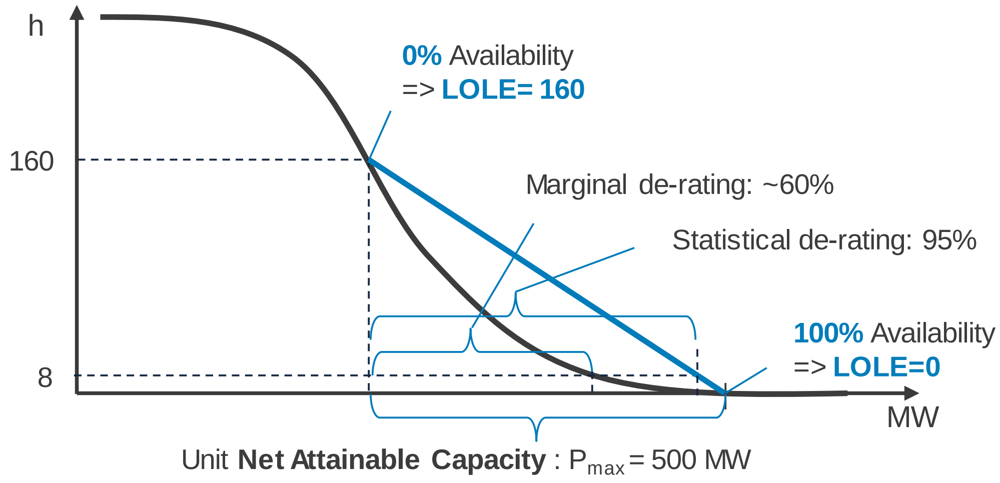
Article 5: De-rating of large units of conventional technologies

14. Conventional units of thermal technologies are expected to be available to contribute to system adequacy whenever they are not in a forced outage (and assuming the maintenance outages are scheduled outside of the possible periods of system stress). The forced outages are random and are generally uncorrelated with demand.

15. However, when the size of a unit is significant as compared to the peak load, the historical de-rating approach can over-estimate the contribution of such units to system adequacy. This is because a small number of expected hours of outage can cause a disproportionate impact on adequacy given the size of the unit, which cannot be measured with the historical approach. This is illustrated in Figure 1 below. Based on a system load duration curve, the figure illustrates the impact on system adequacy of a large unit with 5% FOR. Because of the convexity of the load duration curve relative to the size of the unit, the unit outage has significant impact on adequacy. Without the unit, the LOLE reaches 160 hours and with 5% probability of unit outage, the average LOLE is 8 hours.

16. The equivalent firm capacity that provides the same average LOLE is much lower than 95% and is around 60%. Hence, in this case a marginal approach would provide a more accurate assessment of the impact on adequacy.

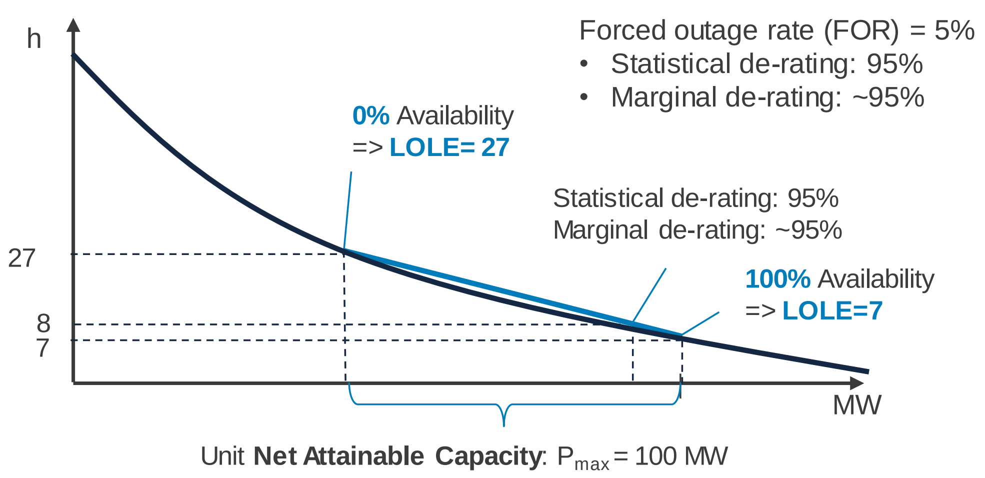
Figure 1: Impact on adequacy of an outage of a large unit relative to the system



Source: Compass Lexecon

17. Figure 2 below illustrates a different case, where the size of the unit is small relative to the system size and the impact of the unit outage on adequacy is almost linear. In this case, the marginal de-rating approach could provide results similar to the statistical de-rating.

Figure 2: Impact on adequacy of an outage of a small unit relative to the system



Source: Compass Lexecon

Article 6: Energy-constrained technologies

18. Furthermore, the historical approach may incorrectly estimate the de-rating factor of energy-constrained technologies (e.g. storage, demand-side response). Indeed, the historical approach mainly focuses on historical availability during past peak events. However, for energy-constrained technologies, actual contribution to adequacy during the stress events depends on the duration of their storage relative to the duration of a stress event. For instance, a battery storage with 2 hours of storage duration has relatively small contribution to system adequacy during a stress event that lasts 6 hours.

19. The marginal approach, based on a more elaborate and fine-tune modelling of the power system, is capable of considering energy constraints explicitly in calculating the impact of capacity on adequacy.

Article 7: Weather-dependent technologies

20. Finally, the historical de-rating approach may also give inaccurate results for weather-dependant technologies, such as PV and wind as well as to some extent, hydro and CHP. Indeed, for these technologies, there could be a strong correlation between their production and demand during stress events. Their contribution to adequacy should account precisely for this correlation. For example, average utilisation of PV during the year could be considerably higher than PV generation during a stress event happening in winter afternoon after the sunset.

21. The marginal approach explicitly considers the correlation between wind and PV generation and demand based on the past climate years data allowing for an accurate estimation of the contribution to adequacy from weather-dependant technologies.

Article 8: De-rating approach proposed for the Lithuanian CRM

22. In the case of Lithuania, the largest units and interconnectors have significant size as compared to the national peak load. Indeed, while the current peak load reaches almost 2000 MW, the largest unit, the Elektrėnai CCGT, has an Net Attainable Capacity of 435 MW and interconnectors have an import Net Transfer Capacity ranging between 500 MW and 950 MW. As shown in the examples above, adequacy is highly sensitive to unavailability of these relatively large units and interconnectors: outages of one of these units would have an impact on adequacy that is higher than could be measured with the historical de-rating approach. Therefore, to ensure the de-rating approach correctly reflects the contribution of each capacity unit to Lithuanian power system adequacy, a marginal approach is proposed to compute de-rating factors for national units, Foreign Capacity and Maximum Entry Capacity of interconnectors. Such calculation is proposed to be done with reference to the Net Attainable Capacity of a unit accounting for the impact of unit size on the adequacy of the Lithuanian power system. This approach implies that the larger the unit size, the lower is the de-rating factor, reflecting the expected contribution to adequacy.

Article 9: Technology, size and storage duration categories

23. The marginal de-rating analysis will be applied differently depending on the technology classes:
    - For RES technologies, such as wind, solar and hydro (run-of-river and reservoir), a single de-rating factor will be assessed based on the existing plants in Lithuanian system matching these categories. A nominal capacity of 100MW will be considered for the calculation of the de-rating factor using the adequacy model;
    - For thermal technologies (CHP, OCGT, CCGT and steam), de-rating factors will be calculated based on the parameters of existing units in the Lithuanian system falling in these technology categories as well as in the ranges of Net Attainable Capacity, such as 1-19MW, 20-99MW, 100-199MW, … , 800+MW. These ranges were chosen to reach a trade-off between a) simplicity of de-rating approach resulting in a small number of de-rating factor values, b) ensuring the span of ranges reflects the sizes of existing and potential units in Lithuania and in neighbouring Member States, and c) ensuring the ranges are sufficiently large to justify a sizeable difference in de-rating factors.

- For energy-limited technologies, such as storage (pumped or battery) or DSR with limited activation time, the de-rating factors will be calculated based on the storage/activation duration (1, 2, 3, 4, 5, 6 or >6 hours). For storage duration exceeding 6 hours, de-rating factors will be calculated by ranges of Net Attainable Capacity, such as 1-19MW, 20-99MW, 100-199MW, and 200+MW.

24. Table 1 below presents the categories of technologies, net attainable capacity ranges and storage and activation durations for which separate marginal de-rating values should be calculated.

Table 1: De-rating categories by net attainable capacity and storage/activation duration

Category	Technology	Storage/ activation duration, hours	Net attainable capacity
RES	Solar power plant	-	
	Onshore wind power plant	-	
	Offshore wind power plant	-	
	Run-of-River hydro power plant	-	
	Reservoir hydro power plant	-	
Thermal	Combined Heat and Power (CHP) plant	-	1-19MW, 20-99MW, 100-199MW, … , 800+MW
	Open Cycle Gas Turbine (OCGT) and reciprocating engines	-	1-19MW, 20-99MW, 100-199MW, … , 800+MW
	Combined Cycle Gas Turbine (CCGT)	-	1-19MW, 20-99MW, 100-199MW, … , 800+MW
	Steam generators (gas, coal, biomass), fuel cells and other.	-	1-19MW, 20-99MW, 100-199MW, … , 800+MW
	Nuclear	-	<500, 500-599, … 800+MW
Energy-limited technology	DSR (demand-side response)	1, 2, …, 6	
	DSR (demand-side response)	> 6	1-19MW, 20-99MW, 100-199MW, and 200+MW
	Pump-storage hydro	1, 2, …, 6	
	Pump-storage hydro	> 6	1-19MW, 20-99MW, 100-199MW, and 200+MW
	Battery Storage	1, 2, …, 6	
	Battery Storage	> 6	1-19MW, 20-99MW, 100-199MW, and 200+MW
Interconnector	Interconnector LV->LT		
	Interconnector PL->LT		
	Interconnector SE->LT		

Article 10: Steps of the marginal de-rating approach

25. The marginal de-rating should be calculated as follows:

- The marginal de-rating calculation uses as the main tool the Adequacy Assessment developed according to ENTSO-E methodology.
- For each scenario of demand considered in the Adequacy Assessment, several adequacy portfolio scenarios should be considered representing the likely future existing and new

capacity allowing to reach the Reliability Standard expressed in terms of target hours of LOLE.

- De-rating of a given capacity element should be calculated by re-running the Adequacy Assessment in each demand and adequate portfolio scenario having removed the capacity element (in case of existing capacity) or having added the capacity element (in case of new capacity) and calculating the shift of demand in MW that would be necessary to reach the Reliability Standard. This shift of demand represents the de-rated capacity of the given capacity element.
- The modelling of de-rated capacity of a capacity element should take into account the forced and maintenance outages of the capacity element, weather dependency of its production, energy constraints as well as situations where the net attainable capacity is higher than the power allowable for discharge to the grid.
- A de-rating coefficient is calculated as a ratio between the de-rated capacity and the net attainable capacity of the capacity element.

Appendix

A Approach to de-rating methodology for the 2025 delivery auction

Introduction

A.1 This appendix presents the de-rating approach to be used for the 2025 delivery auction. A marginal approach is used for the calculation of the de-rating factors for the national capacity and the de-rated entry capacity of interconnectors. The appendix presents the adequacy model used by LitGrid for the marginal de-rating capacity calculation as well as the scenarios under which de-rating factors are calculated. The appendix also provides options for the de-rating approach for Foreign Capacity.

Marginal de-rating of national capacity and interconnectors

A.2 The marginal de-rating methodology is based on TSO analysis of the marginal contribution of the relevant unit to the capacity requirement. The marginal methodology starts from an adequate portfolio, that is, a portfolio that according to the adequacy model results in an average LOLE meeting the Reliability Standard currently considered to be 8 hours of LOLE in Lithuania. Then, the marginal de-rating of various units is calculated as the volume of a change in demand that needs to be implemented to replace the examined unit so that the system could reach the same level of average LOLE corresponding to the Reliability Standard.

A.3 The marginal de-rating methodology is applied in a number of scenarios of the future system development and an average de-rating calculated across different scenarios is eventually retained for each unit.

A.4 Below we present the elements of the marginal de-rating methodology, including:

- Adequacy assessment study for 2025 auction;
- Scenarios considered; and
- Capacity de-rating values calculated for the 2025 delivery auction.

Adequacy Assessment study for 2025 delivery auction

A.5 As the basis for the marginal de-rating methodology, LitGrid used the Adequacy Assessment study for 2025 auction developed by Kaunas Technical University (KTU). This study's model uses the projected national Lithuanian installed capacity in the delivery year of the CRM auction for which the parameters are being calculated (e.g. 2025 as delivery period for the first CRM auction expected in 2021) and runs a model of dispatch of the Lithuanian power system to meet the projected hourly demand. The dispatch model optimises the dispatch of storage and takes the production profiles of RES as a given based on the climate data.

A.6 Three representative climate samples of demand and RES production hourly profiles are used in the model based on the clustered analysis of ENTSO-E, reflecting the climate years, 1982, 1984 and 2007.

A.7 In addition to the climate variation of demand and RES production, the model allows random outages of thermal capacity and transmission interconnectors according to the historical statistics of the forced outages. With respect to the interconnectors, the model considers the maximum NTC adjusted for the coincident stress as explained in Part 2 of this work.

A.8 The model calculates the parameters of adequacy, such as the Expected energy Not Served (EENS), reflecting the volume of demand in MWh that cannot be met through national resources and imports and Loss of Load Expectation (LOLE), reflecting the number of hours when EENS is positive. The model calculates these parameters through the Monte-Carlo simulations across different random samples of forced outages of national capacity and interconnectors.

Scenarios considered

A.9 The marginal de-rating factor calculation for the capacity auction in Lithuania with delivery in 2025 is based on three scenarios comprised of variations of interconnectors, peak demand, reserves, and energy storage.

- **Demand scenarios**. LitGrid considers two scenarios of forecasted demand. The first demand scenario (Scenario 0) assumes peak demand of 1822, 1930, 2020 MW in 2020, 2025 and 2030 respectively. The second demand scenario (Scenario 1) considers peak demand of 1902, 2190, 2553 MW in 2020, 2025 and 2030 respectively. The main driver is the assumption on electrification of the Lithuanian rail system.
- **Reserves scenario**. LitGrid considers one scenario (Scenario a) of reserve requirement, which is equal to 700 MW of Replacement Reserve required at all times in Lithuania in addition to FCR and FRR provided by 2 units of pumped storage.
- **Energy storage.** LitGrid considers two scenarios one with 200MW capacity and 600MWh storage (Scenario 2) and another without storage (Scenario 0).

A.10 The Adequacy Assessment 2025 considers the NTC of the Lithuanian interconnectors adjusted for coincident stress based on the methodology described in Part 2 of these methodologies: NordBalt – 588 MW, Harmony Link – 287 MW, and LV – LT 760 MW.

A.11 The three scenarios considered are listed below, including the average LOLE values across three climate years:

- Scenario A0a0 (Demand Scenario 0, Storage scenario 0): LOLE in 2025 = 47h; LOLE in 2030 = 36h
- Scenario A1a0 (Demand Scenario 1, Storage scenario 0): LOLE in 2025 = 162h; LOLE in 2030 = 364h
- Scenario A1a2 (Demand Scenario 1, Storage scenario 1): LOLE in 2025 = 130h; LOLE in 2030 = 287h

A.12 The results of the adequacy assessment study for 2025 auction with variations across scenarios confirm that from 2025 onwards Lithuania would not reach the reliability standard equal to LOLE 8h and would experiment high ENS in the absence of additional capacity.

A.13 The additional capacity scenarios needed to reach LOLE 8h in 2025 has been calculated as follows:

- In the scenario of peak demand of 1930MW, one conventional unit of 280MW Net Attainable Capacity or two conventional units of 140MW Net Attainable Capacity;
- In the scenario of peak demand of 2190MW, two conventional units of 255MW Net Attainable Capacity or to conventional units of 225MW Net Attainable Capacity and one battery of 200MW capacity and 600MWh storage capacity.

Capacity de-rating values calculated for the 2025 delivery auction

A.14 Table 2 below provides average de-rating factors calculated for RES technologies falling in the technology categories of Table 1 above.

Table 2: De-rating factors calculated for RES technology categories, 2025 delivery year

De-rating categories	De-rating factor, %
Solar	5%
Onshore wind	6%
Offshore wind	10%
Run-of-River hydro	10%
Reservoir hydro	74%

Note: *Presented values are obtained for the high demand scenario. The high demand scenario is chosen according to the approach presented in Part 3. The de-rating factors for solar, wind and run-of-river hydro were estimated by applying the marginal methodology to a notional unit of 100MW capacity with Lithuanian production profiles. For reservoir hydro category that is not present in Lithuania, historical monthly peak production of Sweden was used.*

A.15 Table 3 below provides examples of de-rating factors calculated for conventional technology categories of Table 1 above.

Table 3: De-rating factors calculated for conventional technology categories by capacity range, 2025 delivery year

Net Attainable Capacity range, MW	Modelled Net Attainable Capacity, MW	Combined Heat and Power (CHP) plant	OCGT and CCGT	Steam generators (gas, coal, biomass), fuel cells and other	Nuclear
1-19	10	0.830	0.950	0.920	
20-99	20	0.830	0.950	0.920	
100-199	100	0.785	0.910	0.850	
200-299	200	0.763	0.875	0.815	
300-399	300	0.750	0.833	0.767	
400-499	400	0.738	0.775	0.708	0.750
500-599	500	0.700	0.710	0.646	0.680
600-699	600	0.671	0.642	0.567	0.592
700-799	700	0.650	0.571	0.500	0.529
800+	800	0.619	0.519	0.450	0.475

Note: *Presented values are obtained for the high demand scenario. The high demand scenario is chosen according to the approach presented in Part 3. The de-rating factors for OCGT, CCGT, steam and nuclear categories are calculated based on the forced outage rates and maintenance schedules provided in ENTSO-E MAF 2019. The de-rating factors for CHP are calculated using Lithuanian CHP production profiles.*

A.1 Table 4 below provides examples of de-rating factors calculated for energy-limited technology categories of Table 1 above with more than 6 hours storage/activation time.

Table 4: De-rating factors calculated for energy-limited technology categories with more than 6 hours storage/activation duration, 2025 delivery year

Net Attainable Capacity range, MW	DSR	Pump-storage hydro	Battery Storage
1-19	0.750	0.750	0.750
20-99	0.750	0.750	0.750
100-199	0.600	0.600	0.600
200+	0.525	0.525	0.525

Notes: *Presented values are obtained for the high demand scenario. The high demand scenario is chosen according to the approach presented in Part 3. De-rating factors for energy-limited technologies are calculated using identical storage/activation duration time and capacity parameters.*

A.2 Table 5 below provides examples of de-rating factors calculated for energy-limited technology categories of Table 1 above with less than 6 hours storage/activation time.

Table 5: De-rating factors calculated for energy-limited technology categories with less than 6 hours storage/activation duration, 2025 delivery year

Storage/activation duration, hours	DSR	Pump-storage hydro	Battery Storage
1	0.100	0.100	0.100
2	0.228	0.228	0.228
3	0.354	0.354	0.354
4	0.400	0.400	0.400
5	0.433	0.433	0.433
6	0.464	0.464	0.464

Notes: *Presented values are obtained for the high demand scenario. The high demand scenario is chosen according to the approach presented in Part 3. De-rating factors for energy-limited technologies are calculated using identical storage/activation duration time and capacity parameters.*

De-rating of Foreign Capacity

A.16 The contribution to Lithuanian adequacy from Foreign Capacity is captured through the Maximum Entry Capacity of interconnectors addressed in Part 2. This volume, in MW, will limit the participation of foreign physical units in the Lithuanian CRM. However, de-rating of individual Foreign Capacity is necessary to define the extent each Foreign Capacity can participate in the Pre-Auction within the limits of Maximum Entry Capacity and subsequently and conditionally on the qualification process, in the Main Auction.

A.17 Applying a marginal approach described above to Foreign Capacity in the same way as Lithuanian capacity would require using a regional Adequacy Assessment model. Although the Adequacy Assessment currently used by LitGrid has a national scope and does not allow a direct calculation of marginal de-rating for Foreign Capacity, we propose for the de-rating of Foreign Capacity for the auction with 2025 delivery to apply the marginal de-rating factors calculated for Lithuania to Foreign Capacity.