



REGULATION (EU) 2019/943

ON THE INTERNAL MARKET FOR

ELECTRICITY- ARTICLE 19E

July 2026

Report Reference 03/2026

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FLEXIBILITY NEEDS ASSESSMENT REPORT IN ACCORDANCE WITH ARTICLE 19(E) OF REGULATION (EU) 2019/943 ON THE INTERNAL MARKET FOR ELECTRICITY

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1. INTRODUCTION

Regulation (EU) 2019/943 of the European Parliament and of the Council on the internal market for electricity, sets the basis for an efficient achievement of the objectives of the Energy Union regarding the climate and energy framework for 2030, by enabling market signals to be delivered for increased efficiency, higher share of renewable energy sources, security of supply, flexibility, sustainability, decarbonisation and innovation and sets fundamental principles for well-functioning, integrated electricity markets.

While decarbonisation of the electricity sector renders energy from renewable sources a major part of the market, it is crucial that the market encourages investments that support infrastructure, such as more flexible generation, interconnection, demand response and energy storage. More specifically, in order to integrate the growing share of renewable energy, the electricity system needs to use all available sources of flexibility, particularly demand side solutions and energy storage, and should make use of digitalisation through the integration of innovative technologies with the electricity system.

Regulation (EU) 2019/943 was amended by Regulation (EU) 2024/1747 as regards improving the Union's electricity market design. One of the relevant objectives was to provide specific investment incentives to achieve decarbonisation objectives through supporting long-term investment in renewable energy generation, flexibility and grids and as such has laid down a framework for the assessment of flexibility needs (FNA).

Based on Article 19e of Regulation (EU) 209/943, no later than the 25th of July 2026, the regulatory authority or another authority or entity designated by a Member State (MS), shall adopt a report on the estimated flexibility needs for a period of at least the next 5 to 10 years at national level, in view of the need to cost effectively achieve security and reliability of supply and decarbonize the electricity system, taking into account the integration of variable renewable energy sources (RES) and the different sectors, as well as the interconnected

nature of the electricity market, including interconnection targets and potential availability of cross- border flexibility.

Besides, as per paragraph 6 of the Article 19e, the European Union Agency for the Cooperation of Energy Regulators (ACER) has approved the proposal of the European Network of Transmission System Operators (ENTSO) for Electricity and the EU DSO entity regarding the type of data and format to be submitted to a regulatory authority or another authority or entity designated to adopt the FNA Report, through the Decision on the approval of the FNA Methodology (ACER Decision No.05/2025). ACER's FNA Methodology aims on a harmonized assessment of the flexibility needs of the electricity systems of the European MS.

The FNA reports are necessary in view of the need to cost-effectively achieve security and reliability of supply and decarbonize the electricity system and as per Article 19f, will support the MS in setting their indicative national objectives for non-fossil flexibility.

Furthermore, as indicated in paragraph 7 of the Article 19e, the national FNA reports will be submitted to the Commission and to ACER and will be published. Within 12 months of receipt of the reports, ACER shall issue a report analysing them and providing recommendations on issues of cross-border relevance regarding the findings of the regulatory authority or another authority or entity designated pursuant to paragraph 1, including recommendations on removing barriers to the entry of non-fossil flexibility resources.

2. ROLE AND ACTIONS OF THE CYPRUS ENERGY REGULATORY AUTHORITY

The Cyprus Energy Regulatory Authority (CERA) has been designated as the competent authority for the preparation of the National Assessment Report on the Estimated Flexibility Needs (FNA Report) in accordance with the Article 19e of the Regulation (EU) 2019/943 “on the internal market of electricity”.

Based on paragraph 1 of the above mentioned Article, CERA shall adopt no later than one year after the approval by ACER of the FNA methodology (ACER Decision No.05/2025, dated on the 25th of July 2025) and every two years thereafter, a report on the estimated flexibility needs for a period of at least the next 5 to 10 years at national level, in view of the need to cost effectively achieve security and reliability of supply and decarbonization of the electricity system.

The FNA Report shall:

- (a) be consistent with the European Resource Adequacy Assessment (ERAA) and National Resource Adequacy Assessments (NRAA) conducted pursuant to Articles 23 and 24; and
- (b) be based on the data and analyses provided by the transmission system operators and distribution system operators of each Member State pursuant to paragraph 3 of Article 19e and using the common methodology pursuant to paragraph 4 of Article 19e and, where duly justified, additional data and analysis.

Furthermore, the FNA Report shall:

- (a) evaluate the different types of flexibility needs, at least on a seasonal, daily and hourly basis, to integrate electricity generated from renewable sources in the electricity system, inter alia, different assumptions in respect to electricity market prices, generation and demand;

- (b) consider the potential of non-fossil flexibility resources such as demand response and energy storage, including aggregation and interconnection, to fulfil the flexibility needs, both at transmission and distribution levels;
- (c) evaluate the barriers for flexibility in the market and propose relevant mitigation measures and incentives, including the removal of regulatory barriers and possible improvements to markets and system operation services or products;
- (d) evaluate the contribution of digitalization of electricity transmission and distribution networks; and
- (e) take into account sources of flexibility that are expected to be available in other Member States.

In alignment with the provisions of paragraphs 2 and of 3 of Article 19e, the data and analysis that are needed for the preparation of the report should be provided by the Transmission System Operator and the Distributing System in the type, the format and the analysis defined in ACER's Decision on the FNA Methodology: Annex I – “Type and format of data and the methodology for TSOs’ and DSOs’ flexibility needs analysis”.

In this respect, and as per the provisions of Article 4 of the FNA Methodology, on the 2nd of March 2026, CERA held a meeting with the Transmission System Operator of Cyprus (TSOC) and the Distribution System Operator of Cyprus (DSO), in order to agree among others on the following:

- The exact scope of data and analysis that the TSOC and the DSO intend to provide at national level;
- Their respective roles and responsibilities in provided the data and analysis;
- Estimated timeline for the exchange of data;
- Common target years for the purpose of data and analysis pursuant to Article 6(1) of the FNA Methodology,
- Temporal, spatial and voltage granularity of DSO data pursuant to Articles 6 and 10 of the FNA Methodology,

- Additional assumptions to be used for the purpose of the FNA methodology.

During the above mentioned meeting and as per Article 6 of the FNA Methodology, it was agreed that the TSOC and the DSO will provide the data and analysis for the two following target years:

- Year 2028, which is already being assessed for the preparation of both the European Resource Adequacy Assessment Report (ERAA) and the National Resource Adequacy Assessment (NRAA), as requested in paragraph 1 of the Regulation (EU) 2019/943 and Article 7 of the FNA Methodology, and
- Year 2030, which is an EU policy target year, as requested in Article 19 (4) (b) (iii) of the Regulation (EU) 2019/943.

With regards to ERAA, it is specified that the Republic of Cyprus currently obtains exemption for Articles 23 and 24 of the Regulation (EU) 2019/943.

Furthermore, it was agreed that the TSOC will provide data and analysis for three climate years and in particular for the years 2023, 2024, 2025, since these data are the most recent available data and have been considered in the NRAA for the target year 2028.

In addition to the above, during the meeting the following were agreed:

- Flexibility resources will be assessed with technological neutrality, but considering realistic deployment capabilities in Cyprus by 2030. Thus, Battery Energy Storage Systems (BESS) with an energy-to-power ratio of 2 and 4 hours will be examined, as these configurations are considered realistic for implementation in Cyprus within the specific time horizon.
- The TSOC will not perform analyses under Article 12 (“TSO Network Flexibility Needs”) of the ACER’s FNA Methodology since:

- a) RES curtailments to be considered in the report arise from surplus RES generation relative to total system demand. RES curtailments resulting from transmission system constraints are not examined, as the Cypriot electricity system does not currently experience—nor is it expected to experience—significant local curtailments due to network congestion;
 - b) There is optionality to conduct analyses under Article 12;
 - c) Article 13 analysis is required only if congestion related curtailments exceed 10% of total curtailments, which is not applicable in our case.
- iii. The scenarios and assumptions to be used for the FNA will be the same with the scenario and assumptions of the NRAA. Among these the most important assumptions are that there will not be an electric interconnection in operation by 2030 and that the natural gas will be available for commercial operation of conventional generation units by 01/07/2030.
 - iv. The DSO will perform analysis as per the FNA Methodology requirements only for Medium Voltage level of the distribution system, as the Low Voltage level is not modeled in the analysis software used by the DSO.
 - v. The DSO will not incorporate demand and response as input data in the flexibility assessment analysis since relevant data are not available.

Another important decision taken during the above mentioned meeting, was the following timeline for the exchange of data :

- by the 6th of March 2026 the DSO will inform in writing the TSOC of the data required to be able to proceed with the DSO's FNA analysis;
- by the end of March the TSOC will provide the above specified data to the DSO;
- by the end of May 2026 both TSOC and DSO will provide the required data and analysis to CERA (as per Article 4 (2) of the FNA Methodology) in order to proceed with timely adoption of the National Assessment Report on the Estimated Flexibility Needs.

The table below summarizes the data, assumption and responsibilities that were agreed between the National Regulatory Authority (CERA), the TSOC and the DSO.

Type of Data or Timeline	Relevant Article in the FNA Methodology	Data or Timeline	Responsible Entity
Timeline for the exchange of data	Art 4 (2)	Exchange of data to be concluded by the end of May 2026	TSO, DSO
Target years	Art 6(1)	2028 and 2030	TSO, DSO
Climate years	Art 6(5)	2023, 2024, 2025	TSO
Temporal Granularity	Art 11	TSO: Seasonal, Weekdays – Weekend, Hourly DSO: Hourly	TSO, DSO
Spatial Granularity	Art 11	Member State Area	TSO, DSO
Voltage Granularity	Art 11	Medium Voltage	DSO
Barriers	Art 15		NRA

3. DATA AND METHODOLOGY

The assessment of the flexibility needs in the Republic of Cyprus was conducted based on the data and analyses provided by the TSOC and the DSO in accordance to the relevant ACER's Methodology, as described in the Annex I of the ACER's Decision No.05/2025.

The current Section of the FNA Report specifies the sources of data, the specific assumptions taken and the scenarios used by the TSOC and DSO, taking into account the specific characteristics of the Cyprus electricity system as a small and isolated system without electrical interconnection.

As mentioned in Section 2 of the FNA Report, analyses were performed for the target years 2028 and 2030, using climatological years 2023, 2024 and 2025, in order to capture weather-related variability affecting both demand and RES generation.

3.1. Data and analysis provided by the TSOC

The input data and the FNA analysis provided by the TSOC are provided in the Appendix I of the present Report.

The set of input data in the format indicated in the Tables of Annex 1 of the FNA Methodology (with exemption of Tables 4, 9 and 13 that are not applicable for the Republic of Cyprus as described in the present Report), along with the FNA results in the format indicated by Table 14 of the above mentioned Annex, will be provided through the dedicated ACER Platform.

3.1.1 Methodology

The TSOC's study was based on a time series with an one-hour resolution and on assumptions and scenarios aligned with those of the NRAA for the period 2027-2030. Analyses were conducted through chronological simulations of system operation, considering technical constraints of conventional units, storage characteristics, reserve requirements, and RES/demand variability. Results were

used to identify flexibility gaps, quantify storage needs, evaluate RES curtailment reduction, and assess the contribution of flexibility resources to achieve a secure and efficient electricity system.

RES curtailments considered in the study arise from surplus RES generation relative to total system demand. RES curtailments resulting from transmission system constraints are not examined, as the Cypriot electricity system does not currently experience—nor is it expected to experience—significant local curtailments due to network congestion. Besides, taking into account that there is optionality to conduct analyses under Article 12 and the fact that Article 13 analysis is required only if congestion-related curtailments exceed a certain share of total curtailments (10%), it was decided during the meeting among CERA, TSOC and DSO that the TSOC will not perform analyses under Article 12 (“TSO Network Flexibility Needs”) of the ACER’s FNA Methodology.

Flexibility resources were assessed with technological neutrality, but taking into account realistic deployment capabilities of such flexibility resources in the Republic of Cyprus by 2030. Thus, Battery Energy Storage Systems (BESS) of 2-hours duration was examined, with a sensitivity analysis of BESS of 4-hours duration, as these configurations are considered realistic for implementation in Cyprus within the specific time horizon, with 2-hours duration being the most realistic option for the following 3-4 years. In addition, this technology can accommodate the system demand curve characteristics, night peak duration and implementation timelines of alternative storage technologies. Furthermore, it is not foreseen to have mature pumped-storage projects and high demand hydrogen projects in the Republic of Cyprus before 2030.

More details on the TSOC’s Methodology are provided below.

3.1.1.1 Forecast Time Series for Demand and RES Generation

In order to incorporate stochasticity in the forecast of RES generation and electricity demand for the target years the analysis took into account as a time series the historical demand data and the RES generation data of the years 2023,

2024, 2025 based on the extrapolation used for the NRAA. Additional constant base loads were added. In particular, 50MW for new desalination units were taken into account for each of the year under study as well as 95MW in year 2030 for cold ironing purposes (70MW for Limassol Port and 25MW for Larnaca Port).

Regarding the RES generation, the installed capacity of windfarms was considered to remain unchanged for the period of the analysis (167.1MW). Biomass and small conventional units were treated as negative demand. The installed capacity of PV systems was considered to increase by 120MW on an annual basis and this increase was distributed equally on a monthly basis. As such the expected installed capacity of PV systems for each month of the years under consideration is presented below:

Month	PV Capacity 2028 (MW)	PV Capacity 2030 (MW)
January	1200	1440
February	1210	1450
March	1220	1460
April	1230	1470
May	1240	1480
June	1250	1490
July	1260	1500
August	1270	1510
September	1280	1520
October	1290	1530
November	1300	1540
December	1310	1550

3.1.1.2 Generation Units Availability

The availability of the conventional generation units currently under operation was determined using the preliminary maintenance schedule provided by the Electricity Authority of Cyprus (EAC). The availability of the conventional generation units to be installed within the period of the analysis is also taking into consideration the expected timeline of natural gas being available for power production (taking into account commissioning and testing period required). Unplanned outages were included using statistical data provided by EAC.

Regarding energy storage systems, year round availability was considered. Additionally, their power supply capability was considered to be time-constrained by their available capacity.

Under ERAA Methodology, one hundred (100) independent production units availability scenarios were assessed for each basis year (2023, 2024, 2025). For the NRAA Study, the values of the adequacy indicators (LOLE, EENS) for each of the above mentioned years were calculated as the average of the adequacy indicators values per the 100 independent scenarios.

For the FNA Report, only one scenario was used for each basis year, a “representative scenario”, in order to reduce computational constraints. More specifically, since the NRAA Study results were available during the flexibility needs assessment, the scenario selected for each basis year was the one providing adequacy indicators values similar to the average values for each basis year.

3.1.1.3 Operating Margin

In addition to the obligation to cover demand, it was considered necessary to add a minimum reserve margin of 60 MW to demand, representing Frequency Containment Reserve (FCR) and Frequency Replacement Reserve (FRR), according to the TSOC’s Operating Margin Policy.

3.1.1.4 UCED Computational Tool

The KOIOS Research Center of the University of Cyprus, has developed a Unit Commitment and Economic Dispatch (UCED) tool to enable the assessment of flexibility through the use of UCED models. For the FNA Report the approach of Mixed Integer Linear Programming (MILP) without relaxations was used, enabling accurate simulation of the electricity system operation and detailed representation of technical constraints of the generation units.

3.1.1.5 Flexibility Needs Calculation Methodology

Demand and RES time series (wind and PV) were used as input data into the UCED tool. Based on generation unit availability, as indicated by the representative scenario used for each basis year, the daily commitment program and economic dispatch of the generation units were determined on an hourly basis. The output data/results of the UCED tool consist of times series data that are used at a later stage for the analysis and assessment of the system operation and the flexibility needs under different operating conditions and RES penetration levels.

More detail is provided in the excel sheets provided by the TSOC, which capture the analysis required as per Articles 8, 9 and 10 of the FNA Methodology. These sheets are provided in the Appendix I. In summary, the following are mentioned.

Article 8 – System Needs-RES Integration Needs

According to **Articles 8(2) and 8(3)**, the RES curtailment time series used for the RES integration needs assessment is derived from UCED-based RES curtailment and adjusted, where applicable, to reflect additional downward flexibility related to curtailment components identified under Article 9 and Article 10. The final RES curtailment is calculated at hourly granularity as:

$$\text{Final RES Curtailment} = \text{UCED RES Curtailment} + \text{MAX (Downward Ramping Add-on, Downward Short-Term Add-on)}$$

The MAX operator is applied hourly to avoid double counting between the Article 9 downward ramping-related add-on and the Article 10 downward short-term flexibility-related add-on. The annual Total Final RES Curtailment is calculated by summing the hourly final RES curtailment values. In each hour, only the larger of the Article 9 downward ramping add-on and the Article 10 downward short-term add-on is applied. Therefore, the annual totals of the two add-ons are shown for transparency, but they are not directly summed together.

According to **Article 8(4)(a)**, the RES curtailment time series is characterised through summary indicators describing the level, duration and severity of RES curtailment for each scenario. There is a relevant table in Appendix I which summarizes the main RES curtailment indicators, including PV curtailment, wind curtailment, total UCED-based RES curtailment, downward flexibility-related add-ons, final RES curtailment, curtailment hours, hourly curtailment statistics, absorbed RES generation, available RES generation, curtailment share and residual load indicators.

The total final RES curtailment values include all hourly final RES curtailment values, including very small values below 1 MWh. The 1 MWh per hour threshold is applied only for curtailment-hour, minimum/average curtailment during significant curtailment hours, and event-related statistics. Total final RES curtailment energy and maximum hourly curtailment are not affected by this threshold.

Total available RES generation is calculated as absorbed RES generation plus final RES curtailment. The final RES curtailment share is calculated as total final RES curtailment divided by total available RES generation.

According to **Article 8(4)(b)**, the RES curtailment time series shall be characterized through probability distribution and relevant percentiles. As per the relevant excel sheet, provided in Appendix I, the TSOC reports selected percentiles of the final RES curtailment time series for each scenario. The final RES curtailment values include UCED-based RES curtailment and the applicable downward flexibility-related add-on calculated at hourly granularity.

According to **Article 8(4)(d)**, the RES curtailment time series was analyzed in relation to relevant system conditions, including demand, solar generation and wind generation. The relevant excel sheet in Appendix I reports correlation coefficients between the final RES curtailment time series and selected system variables for each scenario. The final RES curtailment time series includes UCED-based RES curtailment and the applicable downward flexibility-related add-on calculated at hourly granularity.

Correlation values range from -1 to +1. Positive values indicate that RES curtailment tends to increase when the corresponding system variable increases. Negative values indicate an inverse relationship, while values close to zero indicate weak linear relationship.

The curtailment flag used in the correlation analysis is based on the significant curtailment threshold of 1 MWh per hour. Therefore, the flag-based correlations describe the relationship between the occurrence of significant RES curtailment and the corresponding system variables.

Must-run generation is constant in this assessment and is therefore reported as not applicable for correlation analysis.

According to **Article 8(5)**, the residual load time series shall be characterized in terms of variability across the relevant timeframes. The relevant excel sheet in Appendix I summarizes the residual load variability indicators for each scenario, including average, minimum and maximum residual load, average absolute hourly residual load change, maximum hourly increase and decrease, average and maximum daily residual load range, and the number and share of hours with negative residual load. Residual load is calculated as:

$$\text{Residual Load} = \text{Load} - \text{PV Generation} - \text{Wind Generation} - \text{Must-Run Generation}$$

Negative residual load hours indicate periods where PV generation, wind generation and must-run generation exceed system load, creating conditions that may require RES curtailment or additional downward flexibility.

Furthermore, as per the same paragraph of Article 8, residual load variability shall be characterised using established decomposition methodologies, such as time decomposition and Fourier decomposition.

In the time decomposition analysis, the residual load time series is characterised through hourly, daily and seasonal indicators. The hourly decomposition indicator is calculated as the sum of absolute deviations between hourly residual load and the corresponding daily average residual load. The daily decomposition indicator is calculated as the sum of absolute deviations between daily average residual load and the corresponding weekly average. The seasonal decomposition indicator is calculated as the sum of absolute deviations between monthly average residual load and the annual average residual load.

As a supplementary assessment, a Fourier harmonic decomposition is applied to selected periodic components of the residual load time series, including semi-daily, daily, weekly and annual/seasonal components. The main Fourier-based indicators are the Fourier Amplitude and the Approximate Variance Share. The Fourier Amplitude indicates the strength of the corresponding periodic component in MW, while the Approximate Variance Share indicates the relative contribution of that component to the overall residual load variability.

According to Articles 8(6)–8(9), the RES curtailment results are compared against the RES penetration target in order to assess whether the expected RES integration target is achieved and whether uncovered RES integration needs remain.

The RES penetration target is applied as a percentage of total consumed energy. The required integrated RES energy is calculated as Total Consumed Energy multiplied by the RES penetration target. In this assessment, **the RES penetration targets used are 28.9% for 2028 and 37.6% for 2030.**

Effective RES penetration is calculated using absorbed RES generation after curtailment. Available RES penetration is calculated using total available RES generation before curtailment.

Maximum Acceptable RES Curtailment represents the amount of available RES generation that could be curtailed while still meeting the RES penetration target. Curtailment-related Uncovered RES Integration Need is calculated as the amount of final RES curtailment exceeding this maximum acceptable curtailment.

Where the Available RES Penetration is below the RES penetration target, the target is not achievable even in the absence of RES curtailment. This reflects a residual RES target gap related to insufficient available RES generation in the scenario, rather than a curtailment-related RES integration need alone.

In accordance with **Article 8(10)–8(12)**, the assessment of additional resources focuses on flexibility resources required to reduce RES curtailment where positive curtailment-related uncovered RES integration needs are identified. The quantification of additional RES capacity required to increase available RES generation is outside the scope of the Article 8 flexibility-resource assessment and would need to be addressed through generation expansion / RES development assumptions.

For the Cypriot isolated power system, the Article 8(10)–8(12) flexibility assessment was implemented through UCED scenarios including adding new flexibility resources to the system and in particular BESS configurations with energy-to-power ratio of 2-hours and 4-hours, in line with the realistic scope agreed with CERA (see Section 2). The 2-hours BESS configuration is represented in six scenarios, while the 4-hours BESS configuration is represented through two additional scenarios, one for each target year.

Higher energy-to-power ratios were not modelled as separate UCED cases in the present analysis, as they were not considered realistically deployable in the Republic of Cyprus within the analysis time period.

Article 8(13)–8(17) relate to fine-tuning, network-related constraints, unavailability, derating and avoidance of double counting. In the present analysis, no separate quantified network-related RES curtailment or unavailability time series was applied. Therefore, as indicated above, the Article 8 results are based

on the UCED-derived RES curtailment time series and the applicable downward flexibility-related add-ons from Article 9 and Article 10.

Article 9 – Ramping Needs

The ramping needs assessment is performed under Article 9(11) of the FNA Methodology. Since the UCED simulations used by TSOC embed ramping constraints, the assessment is limited to extracting and analysing the impact of ramping constraints directly from the economic dispatch simulation results.

As the simulation tool does not explicitly report uncovered ramping needs, the impact of ramping constraints is assessed by comparing two UCED simulations for each target year and weather/base-year scenario:

1. a full-constraints UCED simulation, where ramping constraints are applied; and
2. a relaxed-ramping UCED simulation, where ramping constraints are relaxed while keeping all other input assumptions unchanged.

Comparing ENS and RES curtailment between the two cases reveals additional flexibility needs caused by ramping constraints. The additional ENS observed in the full-constraints scenario compared with the relaxed-ramping scenario is interpreted as an upward ramping-related impact. The additional RES curtailment observed in the full-constraints scenario compared with the relaxed-ramping scenario is interpreted as a downward ramping-related impact, relevant for the RES integration needs assessment under Article 8.

Article 10 – Short-Term Flexibility Needs

Short-term flexibility needs were assessed by analyzing deviations between forecasted and actual residual load, driven by forecasting errors in demand and RES generation. Upward and downward flexibility requirements were derived from the distribution of forecast errors, using the 0.1% and 99.9% percentiles.

Available flexibility was evaluated from UCED results, considering technical limits of conventional generation units and BESS.

More specifically, according to **Article 10(2)**, the dispatch of flexible resources was extracted from the economic dispatch results for each MTU, weather/base-year scenario and target year. In this assessment, the relevant flexible resources considered in the residual margin calculation include dispatchable conventional generation units and battery storage assets represented in the UCED results.

For dispatchable generation units, the short-term residual margins were calculated using the difference between the dispatched power output and the technical minimum and maximum power limits of each unit. Only units that were online in the UCED dispatch were considered as immediately available for short-term residual margin provision. A unit was considered online when its dispatch was greater than zero.

For battery storage assets, the residual margins were calculated as net adjustment margins from the current charging or discharging operating point. The upward battery residual margin represents the ability of the battery to move from its current position towards maximum discharging capability, while the downward battery residual margin represents the ability to move from its current position towards maximum charging capability.

These battery margins represent the possible change in the net position of the battery and do not imply that the battery can inject power above its rated MW capacity. The total upward and downward residual margins were then calculated as the sum of the generation and battery residual margins for each hour.

The relevant table in Appendix I summarizes, for each scenario, the average, minimum and maximum upward and downward residual margins calculated from the hourly UCED-based residual margin time series. The 2-hours and 4-hours BESS are compared on the basis of the same BESS power rating but different energy capacities; therefore, differences between these cases arise from the

UCED dispatch and state-of-charge profile rather than from increased instantaneous power capability.

The calculation also supports the technical characterization required under **Article 10(3)**, as the residual margins are linked to unit-level technical assumptions such as Pmin, Pmax and storage power/energy constraints. Further dynamic constraints, such as ramp rates, start-up/shut-down times and minimum up/down times, are documented in the following sub-section “Assumptions” where available.

According to **Article 10(4)**, the upward and downward uncovered short-term flexibility needs were calculated for each MTU and weather/base-year scenario by comparing the short-term flexibility needs derived under Article 10(1) with the available residual margins calculated under Article 10(2) and characterised under Article 10(3).

The uncovered short-term flexibility needs were calculated as follows:

Uncovered Upward ST Need = MAX(Upward ST Need – Total Upward Residual Margin, 0)

Uncovered Downward ST Need = MAX(Downward ST Need – Total Downward Residual Margin, 0)

A positive uncovered upward value indicates that the available upward residual margin is insufficient to cover the upward short-term flexibility need. A positive uncovered downward value indicates that the available downward residual margin is insufficient to cover the downward short-term flexibility need. A zero value indicates that the available residual margin is sufficient for the corresponding direction.

The relevant table in Appendix I summarises the uncovered short-term flexibility needs per scenario. The “Upward Hours” and “Downward Hours” columns show the number of hours where the corresponding uncovered need is greater than zero. The “Upward Events” and “Downward Events” columns show the number

of continuous event periods identified within each scenario. An event is defined as a continuous sequence of hours, within the same scenario, during which the uncovered need remains greater than zero.

The event duration indicators show the average and maximum duration of these continuous uncovered need events. The maximum uncovered capacity indicators show the highest hourly uncovered upward or downward need observed within each scenario. The average event capacity indicators represent the average capacity of the identified uncovered need events.

In accordance with **Article 10(5)**, downward uncovered short-term flexibility needs are also relevant for the assessment of RES integration needs under Article 8, since insufficient downward flexibility may lead to additional RES curtailment. Therefore, the downward uncovered needs and their expected energy are retained as input for the subsequent RES integration needs assessment.

In line with **Article 10(6)**, the expected energy associated with uncovered short-term flexibility needs was calculated as the uncovered capacity multiplied by the associated probability of occurrence of the event. Since the short-term flexibility needs in this assessment are based on the 0.1 and 99.9 percentile approach of Article 10(1), the associated tail probability was taken as 0.1%, i.e. 0.001. As the analysis is performed at hourly granularity, the MTU duration is 1 hour.

$$\text{Expected Energy MWh} = \text{Uncovered Need MW} \times 1\text{h} \times 0.001$$

The resulting expected energy values represent probability-weighted expected energy and not the raw hourly energy volume of the uncovered need.

It is mentioned that, in the present assessment, no quantified hourly unavailability time series or derating factors were available/applied. Therefore, the Article 10(2)–10(6) calculations were not repeated with derated residual margins, and **no separate derated residual margin time series is reported under Article 10(9)**.

Besides, **Article 10(10) is not applicable**, as the short-term flexibility needs were not extracted directly from an economic dispatch simulation embedding forecast errors. Instead, the short-term needs were calculated separately from residual load forecast error percentiles under Article 10(1) and then compared with UCED-based residual margins under Article 10(4).

3.1.2. Assumptions

The main assumptions used to incorporate the specific characteristics of the Cypriot electricity power system are indicated below.

3.1.2.1 Availability of Generation Units

Generation Units	2028	2030
Vasilikos Power Station	1x Steam Turbine1 – 120MW 1x Steam Turbine2 – 120MW 1x Steam Turbine3 – 120MW 2x CCGT- 220MW	1x Steam Turbine1 – 120MW (1500 hours) 1x Steam Turbine2 – 120MW (1500 hours) 1x Steam Turbine3 – 120MW 2x CCGT- 220MW
Moni Power Station	5x Gas Turbine - 37.5MW	5x Gas Turbine 37.5MW
Dhekelia Power Station	6x Steam Turbine - 60MW 6x ICE – 17MW	6x ICE – 17MW
New Conventional Units (operating on natural gas)	-	1x CGT – 260MW 1x CGT- 160MW (Vasilikos Power Station) 1x ICE – 102MW
Wind Turbines	167.1MW	167.1MW
PVs	1200MW	1440MW
Energy Storage Systems	200MW/400MWh	400MW/800Mwh

Comments:

- The assumptions used for the FNA Report were intended to be exactly the same as the ones used for the NRAA, but a deviation was needed regarding the availability of the conventional generation units. More specifically, in the NRAA it was assumed that the conventional generation units operating on natural gas would be tested during the first six months of 2030, thus being commercially operational on 01/07/2030. The results of the NRAA indicate potential Resource Adequacy issues for 2030 due to the fact that 720MW from the existing conventional generation units will not be available from 01/01/2030 due to incompliance with the emission limits as per the Industrial Emissions Directive (Directive 2010/75/EU, amended by Directive 2024/1785) and the relevant National Industrial Emissions Laws of 2013 to 2021 (L.184(I)/2013). Thus, in order to be able to provide an assessment on the flexibility needs for 2030, it was necessary to assume that the new conventional generation units will be commercially operational (using natural gas) on 01/01/2023. In any case, the relevant authorities of the Republic of Cyprus will proceed with the designated procedures to ensure the electricity resource adequacy for 2030.
- The restrictions on Steam Turbines 1 & 2 of Vasilikos Power Station to operate up to 1500 hours per year in 2030, as well as the decommissioning of the Steam Turbines in of Dhekelia Power Station are driven by the obligation of the Republic of Cyprus to comply with the provisions of the Industrial Emissions Directive and the National Industrial Emissions Laws.

3.1.2.2 Short Circuit Currents

The constraints due the Short Circuit Currents in the Vasilikos area have been taken into account, estimating an upper limit of 850MW, which is going to be resolved by 1/1/2030.

3.1.2.3 Installed Capacity of Battery Energy Storage Systems

The analysis took into account the installation of energy storage systems, which are expected to significantly contribute in the operations of the electricity system in the following years. In order to evaluate their contribution in a realistic way, as already indicated in Section 2 of the Report, the energy-to-power ratios considered were 2 and 4. For these cases the power and energy capacity taken into consideration are indicated below:

Year	Max. Power Capacity (MW)	Energy Capacity (MWh)	Ratio Energy/Power
2028	200	400	2
2028	200	800	4
2030	400	800	2
2030	400	1600	4

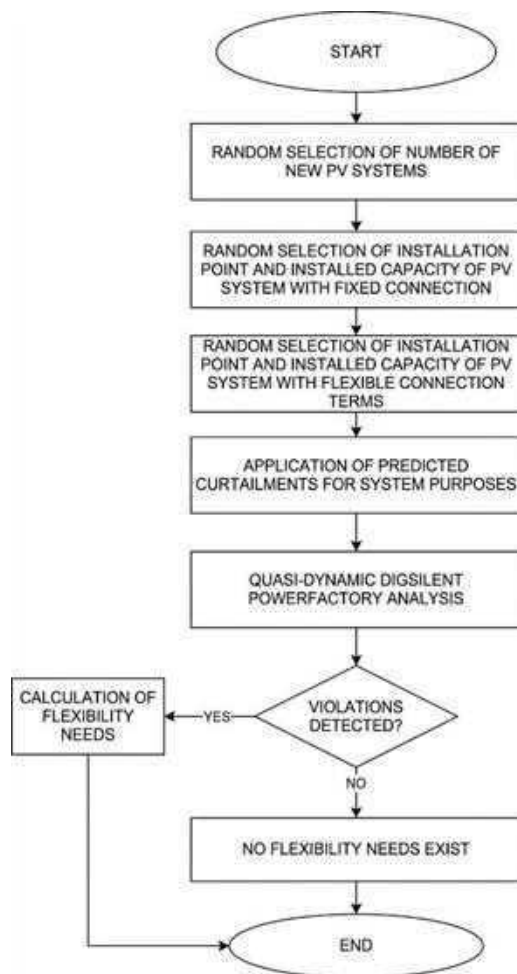
3.2. Data and analysis provided by the DSO

3.2.1 Methodology

In order to assess the flexibility needs, the below parameters were determined for the distribution system, using the Monte Carlo method:

- Number of RES Systems per Transmission Substation
- Number of RES Systems per MV (Medium Voltage) Feeder
- Installed Capacity of each RES System
- Location of each RES System

Then, the below methodology presented in the below flow chart was used:



3.2.1.1 Technical Constraints and Network Limitations

The below technical constraints and network limitation were taken into account:

Constraint	Description	Value
MV Line Loading	Utilization rate of medium voltage lines, to check for overloads	100%
MV Bus Voltage	Voltage level at the medium voltage busbars, to check for deviations from allowable limits.	+/- 10%

LV Bus Voltage	Voltage level at the low voltage busbars, to check for deviations from allowable limits.	+/- 10%
N-1 Reliability Criterion		In each Transmission Substation (TS), the total installed capacity of RES Systems with a fixed connection shall not exceed the firm capacity of the TS. In each TS, the total installed capacity of RES Systems with flexible connection shall not exceed the firm capacity of the TS. In each TS, the total installed capacity of RES Systems with a fixed and flexible connection shall not exceed the nominal capacity of the TS.

3.2.1.2 Flexibility Needs Calculation

In cases where violations of the distribution network's operating limits were detected, the flexibility needs were calculated.

All flexibility needs are downward, as only problems due to increased RES penetration were examined.

When an overload of any equipment in the distribution network was detected, the power curtailment factor sf was calculated as per the below equation.

$$s_f(t) = \begin{cases} \frac{100}{L_f(t)}, & L_f(t) > 100\%, \\ 1, & \text{otherwise,} \end{cases}$$

This factor represents the maximum allowable percentage of power injection from RES to avoid overloading.

Subsequently, the flexibility need in MW ($F(t)$) was calculated, as per the below equation,

$$F_f(t) = (1 - s_f(t)) P_{PV,f}(t),$$

Finally, the total flexibility in MWh (E) required was calculated, as per the below equation,

$$E_f = \sum_t F_f(t) \Delta t.$$

Where:

- $L(t)$: the percentage loading value of the MV feeder
- $P_{PV,f}(t)$: the total active power from PV systems of feeder
- $f(t) \Delta t$: the duration for which flexibility needs are detected

3.2.2 Assumptions

The below assumptions were taken into consideration:

- The analysis took into account only the Medium Voltage (MV) level of the distribution system, as the Low Voltage (LV) level is not modeled in the analysis software used by the DSO.
- The target for Total Installed Capacity of PV Systems in the distribution system for 2028 was 1300MW and the target for 2030 was 1600MW. This assumption was based on the approved TYNDP (Ten-Year Network

Development Plan) 2025–2034 and on existing connection applications under consideration.

- The analysis took into account eight (8) Transmission Substations (TS) that exhibit particularly high RES penetration and subsequently flexibility needs may arise. The maximum predicted installed capacity of PV systems with constant and flexible connections for the target years, are presented in the following table, limited to the nominal capacity of each TS. The installed capacity for each substation is a forecast based on the connection requests already submitted.

H/V Substation	RES Systems with fixed connection terms (MW)	RES Systems with flexible connection terms (MW)
2028		
Agios Nikolaos	40	20
Athienou	16	16
Alambra	40	20
Ergates	40	20
Kokkinotrimithia	40	20
Kofinou	40	20
Orounta	40	20
Tempria	16	16
2030		
Agios Nikolaos	40	40
Athienou	16	16
Alambra	40	30
Ergates	40	40
Kokkinotrimithia	40	40
Kofinou	60	40
Orounta	60	40
Tempria	16	16

- The analysis took into account the expected required by the system RES curtailments (as per the relevant data sent by the TSOC to the DSO) since they limit the magnitude of active power injection and, consequently, may reduce flexibility needs.
- The analysis assumes that flexible connections of RES systems to be installed to saturated TS with be provided on the following connection terms:
 - Compliance with the N-1 reliability criterion set by the TSOC to be maintained.
 - Active power injection: From 19:00 to 22:00.

This assumption was based on the peak wholesale electricity market prices in Cyprus for the period from 01/10/2025 to 30/04/2026.

- Installed with an integrated BESS of at least three hours and a maximum output power equal to the installed capacity of the respective RES system. The BESS duration for hybrid PV systems was set to three hours instead of two or four hours, required by the FNA Methodology, as this represents the average value of the connection requests already submitted.

4. RESULTS

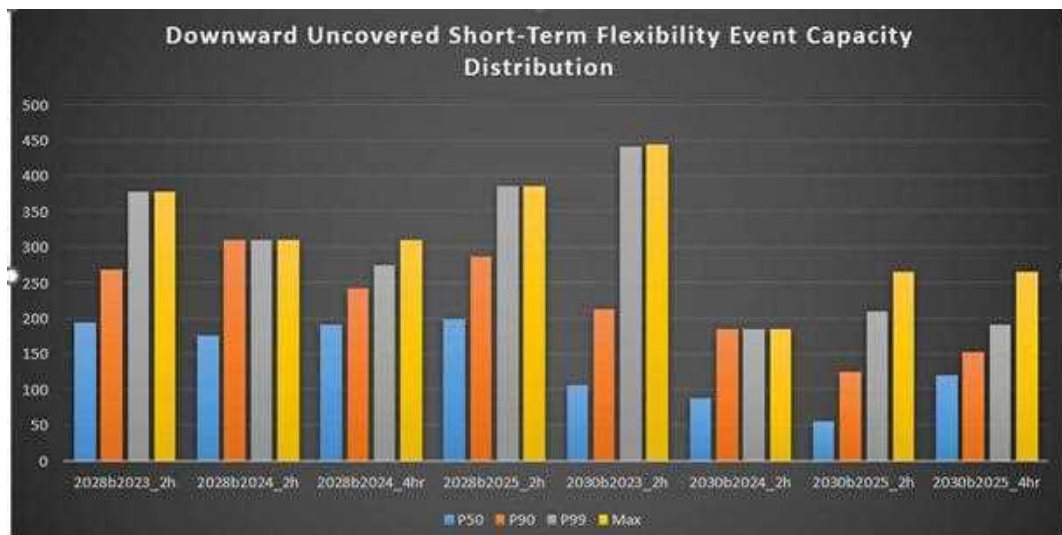
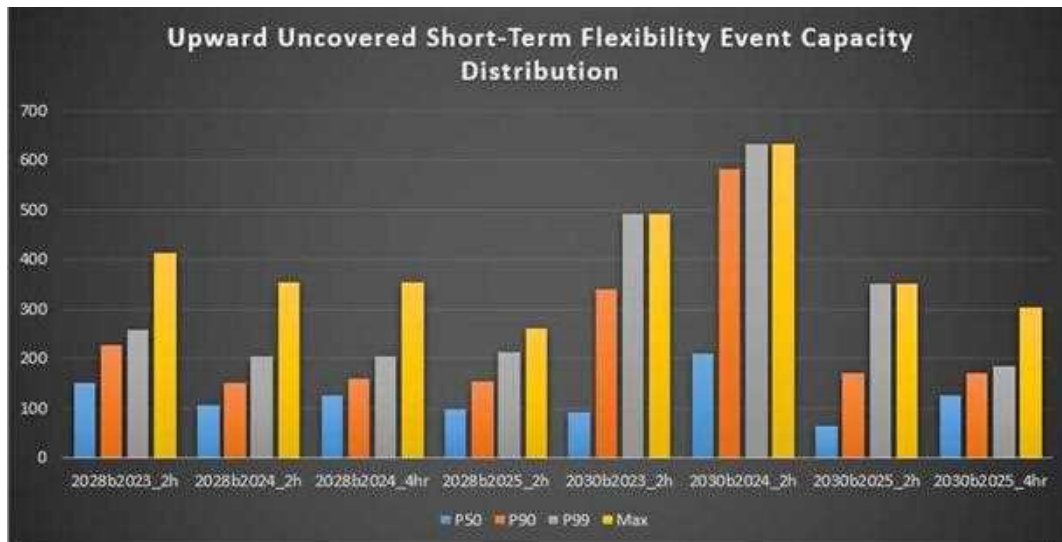
4.1. TSOC Results

The results of the TSOC FNA Analysis, as per the Methodology described in Section 3, are presented in detail the Appendix I and are provided in summary in the following table:

Target Year	Base Year	Battery (h)	Total Final RES Curtailment (MWh)	Curtailment-related Uncovered RES Integration Need (MWh)	Residual RES Target Gap (MWh)	Target Status
2028	2023	2	171927.7	0.0	0.0	Target met after curtailment
2028	2024	2	322774.2	0.0	0.0	Target met after curtailment
2028	2024	4	235417.7	0.0	0.0	Target met after curtailment
2028	2025	2	237026.3	0.0	0.0	Target met after curtailment
2030	2023	2	92013.3	92013.3	73145.4	Target not achievable with available RES
2030	2024	2	205284.8	152905.7	0.0	Target achievable before curtailment
2030	2025	2	51171.6	51171.6	134919.6	Target not achievable with available RES
2030	2025	4	5164.1	5164.1	134639.9	Target not achievable with available RES

The FNA results will also be provided in the format requirement indicated by the Table 14 of Annex 1 of the FNA Methodology, through the dedicated ACER Platform.

Furthermore, the following two charts provide a visual representation of the event capacity distribution required under Article 10(6)(b). The percentiles represent the distribution of average uncovered capacity per event, while the maximum value shows the highest hourly uncovered capacity observed within the events for each scenario and direction.



Regarding the assumption of the additional constant base loads, it should be noted that the TSOC has recently received updated data for the needs of the ports of Limassol and Larnaca. Based on this information, the total demand of these loads after 01/01/2030 is estimated to be approximately half of the demand assumed in the Report. As a result, total system demand for the year 2030 is expected to be lower than that considered in the Report. This reduction is expected to lead to a higher RES penetration rate and contribute positively to the achievement of the relevant 2030 target.

4.2. DSO Results

DSO carried out an analysis of the current state of the selected TS mentioned in Section 3, without taking into account future RES penetration. The results of this analysis showed that in the current state the system can operate securely and that there are no flexibility needs. The following table provides the results of the worst-case equipment loading and voltage values for each TS over the entire year (2026). Then, the flexibility needs were calculated for each substation, for the target years 2028 and 2030.

Current State (2026):

H/V Substation	Maximum MV Feeder Loading	Minimum MV System Voltage	Maximum MV System Voltage
Agios Nikolaos	96%	0.91 p.u	1.05 p.u.
Athienou	91%	0.91 p.u	1.05 p.u.
Alambra	82%	0.91 p.u	1.05 p.u.
Ergates	95%	0.95 p.u	1.04 p.u.
Kokkinotrimithia	56%	0.95 p.u	1.07 p.u.
Kofinou	73%	0.91 p.u	1.03 p.u.
Orounta	59%	0.91 p.u	1.03 p.u.
Tempria	88%	0.93 p.u	1.07 p.u.

Foreseen needs:

H/V Substation	2028	2030	Comments
Agios Nikolaos	No flexibility needs	Maximum Monthly Flexibility Requirement: 3.2 MW / 208 MWh	Overloading and overvoltage issues during the year 2030, due to the fact that the total installed capacity of RES systems is expected to reach 80 MW, of which 40 MW concerns systems with a firm connection and the remaining 40 MW systems with flexible connection terms. The issues are mainly identified between 19:00 and 21:00, a time period during which the BESS have been modeled to

			export power. The violations appear consistently across all months of the year.
Athienou	No flexibility needs		Due to the limited firm capacity of the TS, the maximum total installed capacity of RES systems cannot exceed 32 MW, of which 16 MW corresponds to systems with a firm connection and the remaining 16 MW to systems with flexible connection terms.
Alambra	No flexibility needs	Maximum Monthly Flexibility Requirement: 1.09 MW/ 54.5 MWh	Overloading and overvoltage issues during year 2030, due to the fact that the total installed capacity of RES systems is expected to reach 71 MW, of which 40 MW concerns systems with a firm connection and the remaining 31 MW systems with flexible connection terms. Out of the 31 MW the 20MW will be connected on MV bus voltage of 22kV and the remaining 11 MW will be connected on MV bus voltage of 11kV. The issues are mainly identified between 19:00 and 21:00, a time period during which the BESS have been modeled to export power. The violations appear consistently across all months of the year.
Ergates	No flexibility needs		Due to the limited firm capacity of the TS, the maximum total installed capacity of RES systems cannot exceed 80 MW, of which 40 MW corresponds to systems with a firm connection and the remaining 40 MW

			to systems with flexible connection terms.
Kokkinotrimithia	No flexibility needs		Due to the limited firm capacity of the TS, the maximum total installed capacity of RES systems cannot exceed 80MW- taking into account the minimum load of the TS, of which 40 MW corresponds to systems with a firm connection and the remaining 40 MW to systems with flexible connection terms.
Kofinou	No flexibility needs	Maximum Monthly Flexibility Requirement: 1.8 MW / 228 MWh	Overloading and overvoltage issues during the year 2030, due to the fact that the total installed capacity of RES systems is expected to reach 100 MW, of which 60 MW concerns systems with a firm connection and the remaining 40 MW systems with flexible connection terms. The issues are mainly identified between 19:00 and 21:00, a time period during which the BESS have been modeled to export power. The violations appear consistently across all months of the year.
Orounta	No flexibility needs	Maximum Monthly Flexibility Requirement: 0.74 MW / 10 MWh	Overloading and overvoltage issues during the year 2030, due to the fact that the total installed capacity of RES systems is expected to reach 100 MW, of which 60 MW concerns systems with a firm connection and the remaining 40 MW systems with flexible connection terms. The issues are mainly identified between 19:00 and 21:00, a time period during which the BESS have been modeled to

			export power. The violations appear consistently across all months of the year.
Tempria	No flexibility needs		Due to the limited firm capacity of the TS, the maximum total installed capacity of RES systems cannot exceed 32 MW, of which 16 MW corresponds to systems with a firm connection and the remaining 16 MW to systems with flexible connection terms.

The FNA results are also provided in the Appendix II of the present Report, as per the format requirement indicated by the Table 15 of Annex 2 of the FNA Methodology.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Potential Market Barriers

5.1.1 Lack of proper legal framework for markets access to new entrants and small actors

The existing legal and regulatory framework provides an adequate basis for market access and, therefore, is not currently considered as a barrier to the participation of new entrants or smaller market participants.

More specifically:

- The roles, rights and responsibilities of all market participants are clearly defined in the Electricity Market Rules, providing transparency and legal certainty.
- Market participation is permitted both on an individual basis and through aggregation, enabling the participation of smaller actors and flexibility providers.
- Participation in the organized electricity markets is not subject to discriminatory restrictions. However, it should be noted that the Intraday Market has not yet become operational. Pursuant to the relevant Regulatory Decision No.02/2026, the Market Operator is required to establish and commence operation of the Intraday Market within two years from the commencement of the fully competitive electricity market, which began operating in October 2025.

Overall, while some market segments are still under development, the legal framework itself does not represent a material barrier to market access.

5.1.2 Lack of enablers and incentives to provide flexibility

Cyprus is progressing towards the establishment of the necessary regulatory, technical and market arrangements to facilitate the broad participation of flexibility resources in the electricity system. Nevertheless, the absence of certain key enablers continues to constitute a significant barrier to the effective deployment

of flexibility services. The main enabling areas concern improvements of electricity market operating and observability systems as outlined below:

- Market Management System

Although the regulatory framework is established, the current Market Management System (MMS) does not yet support the processes and transactions required for the participation of Demand-Response resources. In addition, the existing system does not fully accommodate the capabilities and functionalities of Energy Storage Systems, thereby limiting their participation across the different electricity markets.

The Market Operator has initiated the procurement of a new MMS, which is expected to enable the full integration of Demand-Response and Energy Storage resources by the end of 2028.

- Advanced Metering Infrastructure

The deployment of Advanced Metering Infrastructure (AMI) is progressing. However, limited network observability, particularly at the medium-voltage and low-voltage levels, remains a significant obstacle to the efficient utilisation of flexibility services.

As flexibility is a relatively new concept within the electricity sector of the Republic of Cyprus, investments in network monitoring and observability have not yet been fully prioritised. Nevertheless, it is expected that the network operators will progressively enhance network visibility, initially focusing on areas experiencing operational constraints, thereby enabling the effective utilisation of flexibility resources.

5.1.3 Restrictive requirements to provide balancing services

The Electricity Market Rules currently in application foresee for the procurement of market based Balancing Services, with limited participation of Energy Storage Systems and no participation of Demand Response due to MMS restrictions. Once the new MMS is available, a revised version of Electricity Market Rules will

be applied (they are already approved by CERA), enabling participation of Energy Storage System at full capacity and participation of Demand and Response resources. On this basis, the above mentioned restrictions for Balancing Services are due to the current version of the MMS and not to restrictive requirements to provide Balancing Services.

5.1.4 Restrictive requirements to provide congestion management

To date, neither the TSOC nor the DSO have identified network congestion, thus the issue is not addressed and no market-based congestion management measures are in place. Consequently, congestion management is not currently considered a barrier to the deployment of flexibility.

Nevertheless, it should be noted that the existing Electricity Market Rules do not provide for market-based congestion management mechanisms, and no local flexibility markets are currently operational. If the need for congestion management evolves, the development of such mechanisms may need to be considered.

5.1.5 Complex, lengthy, and discriminatory administrative requirements

Administrative procedures are not considered a significant barrier to the participation of flexibility resources.

Grid connection procedures are transparent and proportionate, while any delays experienced are primarily attributable to network capacity constraints rather than to administrative processes. Likewise, the technical and administrative requirements for grid connection and market participation are considered appropriate and non-discriminatory.

5.1.6 Lack of regulatory incentives to system operators to consider non-wire alternatives

CERA recently issued the Regulatory Decision No. 02/2026 (dated 26/06/2026), which establishes the regulatory framework for the development of local flexibility markets and introduces incentives for the DSO to procure flexibility services as an alternative to conventional network reinforcement (non-wire alternatives).

Although the Regulatory Decision provides for an implementation period of up to 18 months before its provisions become fully applicable, it is expected that, once implemented, the established incentive framework will adequately encourage the DSO to consider flexibility resources. Consequently, the lack of regulatory incentives for the DSO is soon to be resolved, thus it is not expected to constitute a long-term barrier to the deployment of flexibility resources.

5.2. Contribution of digitalisation

Digitalisation is recognized as a key enabler for the efficient integration and utilisation of flexibility resources in the electricity system of the Republic of Cyprus. The increasing penetration of distributed renewable energy sources and electric vehicles, as well as the expected installation of energy storage systems, require enhanced visibility of the electricity network and the capability to monitor, forecast and manage system conditions in near real time. In this respect, the ongoing deployment of AMI and modernisation of network observability, will provide the data and operational capabilities necessary to support the participation of flexibility resources in electricity markets and system operation. At the same time, the planned upgrade of the Market Management System (MMS) will facilitate the market integration of demand response and energy storage, enabling these resources to participate more effectively in the various electricity market timeframes.

Digitalisation will also play an important role in allowing the TSO and the DSO to utilize flexibility as a cost-effective alternative to conventional network reinforcement, where appropriate. Enhanced data analytics, forecasting tools, automated control systems and improved communication infrastructure will

support the identification of network constraints, the procurement of local flexibility services and the secure operation of an increasingly decentralized electricity system. Although digitalisation in Cyprus is still at a relatively early stage, the implementation of the relevant regulatory framework is expected to establish the foundations for the widespread deployment of flexibility services, contributing to a more resilient, efficient and decarbonised electricity system.

5.3. TSO Conclusions

As a general conclusion of the assessment, the results indicate that the system's flexibility needs and RES curtailments occur primarily during periods of high RES penetration, reduced residual demand, and limited availability of downward flexibility. Enhancing the capability of BESS by increasing storage duration from two (2) to four (4) hours leads to a substantial reduction in RES curtailments in the scenarios where a comparative assessment was carried out, highlighting the contribution of storage to a more effective integration of renewable energy generation.

At the same time, the results indicate that in certain scenarios for the year 2030, the RES penetration target is not achieved, regardless of the level of RES curtailment. This finding is mainly attributable to the significant increase in electricity demand projected for 2030, which is not accompanied by a corresponding increase in installed RES capacity in the scenarios examined. Consequently, the RES penetration rate remains at relatively low levels, despite the reduction in curtailments achieved through the addition of flexibility resources. In this context, the contribution of BESS to achieving the RES penetration target is limited, as the main constraining factor is not the ability to absorb the renewable energy generated, but rather the overall available RES generation potential relative to the system's projected demand.

In addition to the above, taking into account the recently updated data the TSOC received for the expected needs of the ports of Limassol and Larnaca (which has been considered in the present Report as additional constant base loads), the total demand of these loads after 01/01/2030 is estimated to be approximately

half of the demand assumed in the study. As a result, total system demand for the year 2030 is expected to be lower than that considered in the TSOC analysis. This reduction is expected to lead to a higher RES penetration rate and contribute positively to the achievement of the relevant 2030 target.

5.4. DSO Conclusions

The DSO flexibility needs are highly dependent on the location of RES generation units, the timing and duration of active power injection and the total installed RES capacity. Consequently, the flexibility requirements identified in the DSO analysis should be considered indicative, as they are subject to the underlying assumptions and network development scenarios.

Flexibility needs can be significantly reduced through the connection of new RES plants to dedicated medium-voltage feeders located close to transmission substations, by extending the energy injection hours or by reducing the injected energy thorough Energy Storage Systems, or by limiting their injection below the installed RES capacity. In addition, higher levels of renewable curtailment and lower overall RES penetration further reduce the need for flexibility services.

Overall, the DSO analysis concludes that the expected flexibility requirements of the distribution network are relatively limited. This is expected primarily because the total installed RES capacity connected to each transmission substation is constrained by its rated capacity, while flexible connection arrangements create temporal diversity between firm and flexible RES connections, increasing renewable integration without proportionally increasing flexibility procurement needs. In cases where persistent network constraints were identified, the DSO analysis indicated that targeted grid reinforcements and network upgrades could provide a long-term solution and at the same time the relevant regulatory framework could facilitate and promote the procurement of local flexibility services, allowing for the efficient planning of those long term developments. Furthermore, the construction of new 22 kV feeders could enable the connection of large-scale RES projects without violating distribution network operational limits or requiring additional flexibility procurement.

The DSO analysis also highlights that renewable energy curtailments, due to safety/stability of the system, substantially mitigate distribution-level flexibility needs, as they coincide with periods of maximum RES generation when network operational limits violations are most likely to occur. Consequently, any significant reduction in curtailment levels could increase these violations and lead to higher flexibility requirements. Voltage-related flexibility needs were found to be negligible due to the mandatory implementation of the Q(U) and P(U) voltage control functions prescribed in the DSO's technical requirements for RES installations. Finally, the DSO notes that this analysis represents its first comprehensive assessment of flexibility needs and, in the absence of established methodological guidance from the EU DSO Entity, the results should be regarded as an initial estimate that may be refined as methodologies and industry practices evolve.

6. ACKNOWLEDGEMENT

The “FNA Report” was prepared by the Cyprus Energy Regulatory Authority in accordance with the Article 19e of the Regulation (EU) 2019/943 “on the internal market for electricity”, as amended by Regulation (EU) 2024/1747 as regards improving the Union’s electricity market design, and with the provisions of ACER approved FNA Methodology.

The contribution and collaborative efforts of both the Transmission System Operator of Cyprus and the Distribution System Operator of Cyprus is greatly acknowledged.

7. LIST OF ACRONYMS AND ABBREVIATIONS

FNA	Flexibility Needs Assessment
MS	Member State
RES	Renewable Energy Resources
ACER	European Union Agency for the Cooperation of Energy Regulators
ENTSO	European Network of Transmission System Operators
CERA	Cyprus Energy Regulatory Authority
ERRA	European Resource Adequacy Assessment
NRAA	National Resource Adequacy Assessment
TSOC	Transmission System Operator of Cyprus
DSO	Distribution System Operator of Cyprus
BESS	Battery Energy Storage Systems
EAC	Electricity Authority of Cyprus
FCR	Frequency Containment Reserve
FRR	Frequency Replacement Reserve
UCED	Unit Commitment and Economic Dispatch
MILP	Mixed Integer Linear Programming
MV	Medium Voltage
LV	Low Voltage
TS	Transmission Substation
TYNDP	Ten-Year Network Development Plan
MMS	Market Management System
AMI	Advanced Metering Infrastructure

APPENDIX I

Deliverable:	FNA Article 8 – RES Integration Needs
Submitted to:	CERA
Prepared by:	TSOC
Target Years:	2028, 2030
Weather/Base Years:	2023, 2024, 2025
Battery Cases:	2h and 4h BESS cases where applicable
Methodology Reference:	FNA Methodology – Article 8
Calculation Basis	UCED results, Article 9 ramping add-ons, Article 10 downward short-term add-ons

Scenario	Target Year	Base Year	Battery h	Description
2028b2023_2h	2028	2023	2	2028 target year using 2023 base/weather year and 2-hour BESS
2028b2024_2h	2028	2024	2	2028 target year using 2024 base/weather year and 2-hour BESS
2028b2024_4hr	2028	2024	4	2028 target year using 2024 base/weather year and 4-hour BESS
2028b2025_2h	2028	2025	2	2028 target year using 2025 base/weather year and 2-hour BESS
2030b2023_2h	2030	2023	2	2030 target year using 2023 base/weather year and 2-hour BESS
2030b2024_2h	2030	2024	2	2030 target year using 2024 base/weather year and 2-hour BESS
2030b2025_2h	2030	2025	2	2030 target year using 2025 base/weather year and 2-hour BESS
2030b2025_4hr	2030	2025	4	2030 target year using 2025 base/weather year and 4-hour BESS

Input / Indicator	Description	Source / Calculation
Load	Hourly system load used in the UCED scenario	UCED / scenario input
PV Generation	Hourly PV generation absorbed by the system	UCED results
Wind Generation	Hourly wind generation absorbed by the system	UCED results
PV Curtailment	Hourly PV curtailment	UCED results
Wind Curtailment	Hourly wind curtailment	UCED results
UCED RES Curtailment	PV and Wind curtailment	UCED results
Article 9 Add-on	Downward ramping-related additional RES curtailment	Article 9(11) hourly comparison
Article 10 Add-on	Downward short-term flexibility-related additional RES curtailment	Article 10 results
Must Run	Minimum synchronous / must-run generation assumption	210 MW
Residual Load	Load minus PV generation, wind generation and must-run generation	Calculated
Final RES Curtailment	UCED RES curtailment plus applicable downward add-on	Calculated

This sheet summarises the input data and calculated indicators used for the Article 8 RES integration needs assessment. The detailed hourly input time series are retained in the working calculation file and are not included in the submission workbook in order to keep the submitted file focused on the final methodology outputs and results.

Scenario	Target Year	Base Year	Battery #	Total PV Curtailment (MW)	Total Wind Curtailment (MW)	Total UCED RES Curtailment (MW)	Total Renewable Ramping Add-on (MW)	Total Downward of Add-on (MW)	Total Annual Downward Add-on (GWh)	Total Final RES Curtailment (MW)	Formula / Treatment
2028a2022_2h	2028	2022	3	150102.7	6345.8	166541.0	4015.6	747.0	5386.7	171917.7	Final RES Curtailment = UCED RES Curtailment + MAX(Downward Ramping Add-on, Downward ST Add-on), applied hourly to avoid double counting.
2028b2024_2h	2028	2024	3	299531.4	7751.1	307282.6	14845.6	505.2	15201.6	322774.2	
2028c2026_4h	2028	2026	4	213858.9	5886.7	222245.6	13682.1	596.5	14175.1	235417.7	
2028d2025_2h	2028	2025	2	193517.7	7640.1	201997.8	35255.1	495.6	36028.4	237016.9	
2028e2023_2h	2028	2023	3	88215.6	3130.6	91326.2	107.5	581.4	687.2	87013.9	
2028f2024_2h	2028	2024	3	200153.0	4017.9	204180.9	1026.4	81.3	1103.8	205264.8	
2028g2025_2h	2028	2025	2	49551.9	1889.3	50921.4	167.3	88.8	250.2	51171.6	
2028h2025_4h	2028	2025	4	4573.7	360.4	4734.1	180.0	250.2	430.0	5164.1	

According to Articles 8(3) and 8(5), the RES curtailment time series used for the RES integration needs assessment is derived from UCED-based RES curtailment and adjusted, where applicable, to reflect additional downward flexibility-related curtailment components identified under Article 9 and Article 10. The final RES curtailment is calculated at hourly granularity as:

$$\text{Final RES Curtailment} = \text{UCED RES Curtailment} + \text{MAX}(\text{Downward Ramping Add-on, Downward Short-Term Add-on})$$

The MAX operator is applied hourly to avoid double counting between the Article 9 downward ramping-related add-on and the Article 10 downward short-term flexibility-related add-on. The annual Total Final RES Curtailment is calculated by summing the hourly final RES curtailment values. In each hour, only the larger of the Article 9 downward ramping add-on and the Article 10 downward short-term add-on is applied. Therefore, the annual totals of the two add-ons are shown for transparency, but they are not directly summed together.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Scenario	Target Year	Base Year	Industry %	Gen Total RES Contribution to Load	Gen Total RES Contribution to PV	Gen Total RES Contribution to Wind Generation	Gen Total RES Contribution to Total RES Generation	Gen Total RES Contribution to Residential Load	Gen Total RES Contribution to Mini-Bus	Gen Contribution to PV Generation	Gen Contribution to Residential Load
2028/2023_2h	2028	2023	2	0.02	0.16	-0.09	0.15	-0.36	N/A - constant value	0.37	0.38
2028/2024_2h	2028	2024	2	-0.03	0.11	-0.17	0.20	-0.24	N/A - constant value	0.67	0.51
2028/2024_4h	2028	2024	4	-0.05	0.26	-0.13	0.25	-0.31	N/A - constant value	0.49	0.55
2028/2025_2h	2028	2025	2	0.03	0.16	-0.14	0.14	-0.33	N/A - constant value	0.37	0.37
2028/2025_4h	2028	2025	4	0.00	0.34	-0.07	0.23	-0.68	N/A - constant value	0.35	0.18
2038/2024_2h	2038	2024	2	-0.04	0.05	-0.14	0.04	-0.67	N/A - constant value	0.26	0.31
2038/2025_2h	2038	2025	2	-0.03	0.02	-0.08	0.02	-0.01	N/A - constant value	0.10	0.17
2038/2025_4h	2038	2025	4	-0.01	0.04	-0.02	0.04	-0.65	N/A - constant value	0.07	0.09

According to Article 8(4)(d), the RES curtailment time series is analyzed in relation to relevant system conditions, including demand, solar generation and wind generation.

This table reports correlation coefficients between the Total RES curtailment time series and selected system variables for each scenario. The Total RES curtailment time series includes LCCO-based RES curtailment and the applicable demand-based RES curtailment as calculated at hourly granularity.

Correlation values range from -1 to +1. Positive values indicate that RES curtailment tends to increase when the corresponding system variable increases. Negative values indicate an inverse relationship, while values close to zero indicate weak linear relationships.

The correlation flag used in the correlation analysis is based on the significance criterion threshold of 1 MWh per hour. Therefore, the flag-based correlation describes the relationship between the occurrence of significant RES curtailment and the corresponding system variables.

Multi-run generation is constant at this assessment and is therefore reported as not applicable for correlation analysis.

Scenario	Target Year	Base Year	Barriers	Avg Residual Load MW	Min Residual Load MW	Max Residual Load MW	Avg Absolute Hourly Change MW	Max Hourly Increase MW	Min Hourly Decrease MW	Avg Daily Range MW	Max Daily Range MW	Hours with Negative Residual Load	Share of Hours with Negative Residual Load
020802023_2	2028	2023	2	248.2	-286.0	925.3	91.2	400.0	-463.0	718.8	1027.1	1636	16.0%
020802024_2	2028	2024	2	252.3	-286.0	933.0	98.4	505.0	-463.0	715.7	943.1	1473	16.8%
020802024_M	2028	2024	4	242.5	-286.0	933.0	80.7	505.0	-486.0	715.1	929.6	1709	15.5%
020802025_2	2028	2025	2	261.4	-276.0	1033.7	94.3	505.0	-490.0	686.0	1061.6	1322	15.1%
030602023_2	2030	2023	2	321.4	-482.0	1021.5	98.2	800.0	-800.0	888.8	1352.5	1759	20.1%
030602024_2	2030	2024	2	320.0	-496.0	1035.2	118.1	800.0	-853.0	942.3	1207.1	1610	18.4%
030602025_2	2030	2025	2	316.7	-440.0	1144.2	94.7	767.8	-768.1	805.4	1198.8	1423	16.2%
030602025_M	2030	2025	4	311.4	-436.1	1146.2	75.5	422.2	-558.2	805.8	1198.8	1500	17.1%

According to Article 8(5), the residual load time series shall be characterised in terms of variability across the relevant timeframes. This table summarises the residual load variability indicators for each scenario, including average, minimum and maximum residual load, average absolute hourly residual load change, maximum hourly increase and decrease, average and maximum daily residual load range, and the number and share of hours with negative residual load.

Residual load is calculated as:

Residual Load = Load - PV Generation - Wind Generation - Must-Run Generation

Negative residual load hours indicate periods where PV generation, wind generation and must-run generation exceed system load, creating conditions that may require RES curtailment or additional downward flexibility.

Time Decomposition									
Scenario	Target Year	Base Year	Battery h	Hourly Rt Decomposition Indicator	Hourly Rt Decomposition Indicator	Seasonal Rt Decomposition Indicator	Avg Hourly Rt Range Std	Max Daily Rt Range Std	Approximate Negative Residual Load %
2018/2023_2h	2018	2023	2	1010842.9	1010842.9	955.8	718.8	1017.1	18.8%
2018/2024_2h	2018	2024	2	1162711.6	1162711.6	1104.2	715.7	943.1	16.8%
2018/2025_2h	2018	2025	2	1246093.9	1246093.9	1153.4	715.1	979.6	15.2%
2018/2026_2h	2018	2026	2	132465.5	132465.5	1075.5	698.0	1091.5	15.1%
2018/2027_2h	2018	2027	2	14409.9	14409.9	959.4	888.1	1252.5	20.3%
2018/2028_2h	2018	2028	2	13416.1	13416.1	1088.5	943.1	1207.1	18.4%
2018/2029_2h	2018	2029	2	13728.7	13728.7	1152.8	855.4	1198.8	16.2%
2018/2030_2h	2018	2030	2	1338735.1	1338735.1	1205.9	805.8	1198.8	17.1%
Fourier Decomposition									
Scenario	Target Year	Base Year	Battery h	Fourier Component	Period h	Avg Residual Load MW	Cos Coefficient MW	Sin Coefficient MW	Approximate Negative Residual Load %
2018/2023_2h	2018	2023	2	Daily 24h	24	248.2	199.0	152.8	47.4%
2018/2024_2h	2018	2024	2	Semi-daily 12h	12	248.2	-111.2	9.3	13.8%
2018/2025_2h	2018	2025	2	Weekly 168h	168	248.2	-21.1	-6.5	0.4%
2018/2026_2h	2018	2026	2	Annual/Seasonal	8760	248.2	-20.1	-75.9	4.9%
2018/2027_2h	2018	2027	2	Daily 24h	24	252.3	-145.5	-145.5	42.0%
2018/2028_2h	2018	2028	2	Semi-daily 12h	12	252.3	-139.6	-2.6	15.3%
2018/2029_2h	2018	2029	2	Weekly 168h	168	252.3	-4.7	26.9	0.5%
2018/2030_2h	2018	2030	2	Annual/Seasonal	8760	252.3	-61.1	-64.7	6.2%
2018/2023_2h	2018	2023	2	Daily 24h	24	248.2	199.0	152.8	47.4%
2018/2024_2h	2018	2024	2	Semi-daily 12h	12	248.2	-111.2	9.3	13.8%
2018/2025_2h	2018	2025	2	Weekly 168h	168	248.2	-21.1	-6.5	0.4%
2018/2026_2h	2018	2026	2	Annual/Seasonal	8760	248.2	-20.1	-75.9	4.9%
2018/2027_2h	2018	2027	2	Daily 24h	24	252.3	-145.5	-145.5	42.0%
2018/2028_2h	2018	2028	2	Semi-daily 12h	12	252.3	-139.6	-2.6	15.3%
2018/2029_2h	2018	2029	2	Weekly 168h	168	252.3	-4.7	26.9	0.5%
2018/2030_2h	2018	2030	2	Annual/Seasonal	8760	252.3	-61.1	-64.7	6.2%
2018/2023_2h	2018	2023	2	Daily 24h	24	248.2	199.0	152.8	47.4%
2018/2024_2h	2018	2024	2	Semi-daily 12h	12	248.2	-111.2	9.3	13.8%
2018/2025_2h	2018	2025	2	Weekly 168h	168	248.2	-21.1	-6.5	0.4%
2018/2026_2h	2018	2026	2	Annual/Seasonal	8760	248.2	-20.1	-75.9	4.9%
2018/2027_2h	2018	2027	2	Daily 24h	24	252.3	-145.5	-145.5	42.0%
2018/2028_2h	2018	2028	2	Semi-daily 12h	12	252.3	-139.6	-2.6	15.3%
2018/2029_2h	2018	2029	2	Weekly 168h	168	252.3	-4.7	26.9	0.5%
2018/2030_2h	2018	2030	2	Annual/Seasonal	8760	252.3	-61.1	-64.7	6.2%

According to Article 8(5), residual load variability shall be characterised using established decomposition methodologies, such as time decomposition and Fourier decomposition. In the time decomposition analysis, the residual load time series is characterised through hourly, daily and seasonal indicators. The hourly decomposition indicator is calculated as the sum of absolute deviations between hourly residual load and the corresponding daily average residual load. The daily decomposition indicator is calculated as the sum of absolute deviations between daily average residual load and the corresponding weekly average. The seasonal decomposition indicator is calculated as the sum of absolute deviations between monthly average residual load and the annual average residual load.

As a supplementary assessment, a Fourier harmonic decomposition is applied to selected periodic components of the residual load time series, including semi-daily, daily, weekly and annual/seasonal components. The main Fourier-based indicators are the Fourier Amplitude and the Approximate Variance Share. The Fourier Amplitude indicates the strength of the corresponding periodic component in MW, while the Approximate Variance Share indicates the relative contribution of that component to the overall residual load variability.

For the purpose of this study, the following definitions were used:

The study was conducted in a cross-sectional manner, meaning that data was collected at a single point in time.

The study was conducted in a descriptive manner, meaning that the purpose was to describe the characteristics of the population being studied.

The study was conducted in a quantitative manner, meaning that data was collected in numerical form.

Variable	Mean	Standard Deviation	Minimum	Maximum
Age	35.2	12.5	18	65
Gender				
Male	15			
Female	15			
Marital Status				
Married	10			
Single	10			
Divorced	5			
Widowed	5			
Education Level				
High School	10			
College	10			
Postgraduate	5			
Occupation				
Manager	10			
Engineer	10			
Teacher	5			
Healthcare	5			
Other	10			

Sub-Article	Requirement	TRAC Implementation / Points
Article 8(12)	Consider additional downward trends related to network constraints, unavailability or other relevant limitations, where indicated.	No separate quantified network-related RES curtailment, unavailability or derating time series was applied in this Article 8 attachment. The RES curtailment assessment is based on UCED results and the applicable Article 8 / Article 10 downward flexibility-related add-ons.
Article 8(14)	Reserve relevant short and peak dispatch capacity where additional flexibility needs are expected.	Since no separate network/unavailability time series were applied, no additional repetition of the Article 8 calculation was required. Double counting between Article 9 and Article 10 downward add-on is avoided through the 'keep' logic overlay.
Article 8(15)	Apply capping of flexible resources where relevant.	No additional derating factors for flexible resources were applied in the present Article 8 calculation. RES capacity is reflected through the UCED generation constraints.
Article 8(16)	Revert the impact of derating assumptions where applicable.	Not applicable, as no additional derating factors were applied outside the UCED capacity constraints.
Article 8(17)	Ensure that flexibility resources already considered in other needs assessments are not double counted.	Applied. Article 9 downward ramping add-ons and Article 10 downward Curtailment Add-on are kept and kept by the Article 8 Total RES curtailment time series using MAX(Article 9 add-on, Article 10 add-on), not by summation.

Item	Treatment
Article 9 downward ramping add-on	Included in the hourly Article 8 Total RES curtailment calculation.
Article 10 downward generation add-on	Included in the hourly Article 8 Total RES curtailment calculation.
Combination of Article 9 and Article 10 add-ons	Combined through hourly MAX operation, not by summation.
Article 10 Total RES Curtailment	Calculated as the sum of hourly Total RES curtailment values. The 8 MWs threshold is used only for curtailed-hour and immediate addition, not for annual Total Final RES curtailment threshold.

Sub-Article	Requirement	TRAC Implementation / Points
Article 9(1)	Consider additional downward trends related to network constraints, unavailability or other relevant limitations, where indicated.	No separate quantified network-related RES curtailment, unavailability or derating time series was applied in this Article 9 attachment. The RES curtailment assessment is based on UCED results and the applicable Article 8 / Article 10 downward flexibility-related add-ons.
Article 9(2)	Reserve relevant short and peak dispatch capacity where additional flexibility needs are expected.	Since no separate network/unavailability time series were applied, no additional repetition of the Article 9 calculation was required. Double counting between Article 9 and Article 10 downward add-on is avoided through the 'keep' logic overlay.
Article 9(3)	Apply capping of flexible resources where relevant.	No additional derating factors for flexible resources were applied in the present Article 9 calculation. RES capacity is reflected through the UCED generation constraints.
Article 9(4)	Revert the impact of derating assumptions where applicable.	Not applicable, as no additional derating factors were applied outside the UCED capacity constraints.
Article 9(5)	Ensure that flexibility resources already considered in other needs assessments are not double counted.	Applied. Article 9 downward ramping add-ons and Article 10 downward Curtailment Add-on are kept and kept by the Article 8 Total RES curtailment time series using MAX(Article 9 add-on, Article 10 add-on), not by summation.

Item	Treatment
Article 9 downward ramping add-on	Included in the hourly Article 8 Total RES curtailment calculation.
Article 10 downward generation add-on	Included in the hourly Article 8 Total RES curtailment calculation.
Combination of Article 9 and Article 10 add-ons	Combined through hourly MAX operation, not by summation.
Article 10 Total RES Curtailment	Calculated as the sum of hourly Total RES curtailment values. The 8 MWs threshold is used only for curtailed-hour and immediate addition, not for annual Total Final RES curtailment threshold.

Sub-Article	Requirement	TRAC Implementation / Points
Article 10(1)	Consider additional downward trends related to network constraints, unavailability or other relevant limitations, where indicated.	No separate quantified network-related RES curtailment, unavailability or derating time series was applied in this Article 10 attachment. The RES curtailment assessment is based on UCED results and the applicable Article 8 / Article 9 downward flexibility-related add-ons.
Article 10(2)	Reserve relevant short and peak dispatch capacity where additional flexibility needs are expected.	Since no separate network/unavailability time series were applied, no additional repetition of the Article 10 calculation was required. Double counting between Article 9 and Article 10 downward add-on is avoided through the 'keep' logic overlay.
Article 10(3)	Apply capping of flexible resources where relevant.	No additional derating factors for flexible resources were applied in the present Article 10 calculation. RES capacity is reflected through the UCED generation constraints.
Article 10(4)	Revert the impact of derating assumptions where applicable.	Not applicable, as no additional derating factors were applied outside the UCED capacity constraints.
Article 10(5)	Ensure that flexibility resources already considered in other needs assessments are not double counted.	Applied. Article 9 downward ramping add-ons and Article 10 downward Curtailment Add-on are kept and kept by the Article 8 Total RES curtailment time series using MAX(Article 9 add-on, Article 10 add-on), not by summation.

Item	Treatment
Article 9 downward ramping add-on	Included in the hourly Article 8 Total RES curtailment calculation.
Article 10 downward generation add-on	Included in the hourly Article 8 Total RES curtailment calculation.
Combination of Article 9 and Article 10 add-ons	Combined through hourly MAX operation, not by summation.
Article 10 Total RES Curtailment	Calculated as the sum of hourly Total RES curtailment values. The 8 MWs threshold is used only for curtailed-hour and immediate addition, not for annual Total Final RES curtailment threshold.

Sub-Article	Requirement	TRAC Implementation / Points
Article 11(1)	Consider additional downward trends related to network constraints, unavailability or other relevant limitations, where indicated.	No separate quantified network-related RES curtailment, unavailability or derating time series was applied in this Article 11 attachment. The RES curtailment assessment is based on UCED results and the applicable Article 8 / Article 9 downward flexibility-related add-ons.
Article 11(2)	Reserve relevant short and peak dispatch capacity where additional flexibility needs are expected.	Since no separate network/unavailability time series were applied, no additional repetition of the Article 11 calculation was required. Double counting between Article 9 and Article 10 downward add-on is avoided through the 'keep' logic overlay.
Article 11(3)	Apply capping of flexible resources where relevant.	No additional derating factors for flexible resources were applied in the present Article 11 calculation. RES capacity is reflected through the UCED generation constraints.
Article 11(4)	Revert the impact of derating assumptions where applicable.	Not applicable, as no additional derating factors were applied outside the UCED capacity constraints.
Article 11(5)	Ensure that flexibility resources already considered in other needs assessments are not double counted.	Applied. Article 9 downward ramping add-ons and Article 10 downward Curtailment Add-on are kept and kept by the Article 8 Total RES curtailment time series using MAX(Article 9 add-on, Article 10 add-on), not by summation.

Item	Treatment
Article 9 downward ramping add-on	Included in the hourly Article 8 Total RES curtailment calculation.
Article 10 downward generation add-on	Included in the hourly Article 8 Total RES curtailment calculation.
Combination of Article 9 and Article 10 add-ons	Combined through hourly MAX operation, not by summation.
Article 10 Total RES Curtailment	Calculated as the sum of hourly Total RES curtailment values. The 8 MWs threshold is used only for curtailed-hour and immediate addition, not for annual Total Final RES curtailment threshold.

Field	Value
Deliverable	FNA Article 9 – Ramping Needs
Submitted to	CERA
Prepared by	TSOC
Methodology Route	Article 9(11)
Target Years	2028, 2030
Weather/Base Years	2023, 2024, 2025
Battery Cases	2h and 4h BESS cases where available

Scenario	Target Year	Base / Weather Year	Battery h	Source UCED / Input	Description
2028b2023_2h	2028	2023	2	UCED_2028b2023	2028 target year using 2023 weather/base year and 2h BESS
2028b2024_2h	2028	2024	2	UCED_2028b2024	2028 target year using 2024 weather/base year and 2h BESS
2028b2024_4hr	2028	2024	4	UCED_2028b2024_4hr	2028 target year using 2024 weather/base year and 4h BESS
2028b2025_2h	2028	2025	2	UCED_2028b2025	2028 target year using 2025 weather/base year and 2h BESS
2030b2023_2h	2030	2023	2	UCED_2030b2023	2030 target year using 2023 weather/base year and 2h BESS
2030b2024_2h	2030	2024	2	UCED_2030b2024	2030 target year using 2024 weather/base year and 2h BESS
2030b2025_2h	2030	2025	2	UCED_2030b2025	2030 target year using 2025 weather/base year and 2h BESS
2030b2025_4hr	2030	2025	4	UCED_2030b2025_4hr	2030 target year using 2025 weather/base year and 4h BESS

Methodological approach under Article 9(11)

The ramping needs assessment is performed under Article 9(11) of the FNA Methodology. Since the UCED simulations used by TSOs embed ramping constraints, the assessment is limited to extracting and analysing the impact of ramping constraints directly from the economic dispatch simulation results.

As the simulation tool does not explicitly report uncovered ramping needs, the impact of ramping constraints is assessed by comparing two UCED simulations for each target year and weather/base-year scenario:

1. a full-constraints UCED simulation, where ramping constraints are applied; and
2. a relaxed-ramping UCED simulation, where ramping constraints are relaxed while keeping all other input assumptions unchanged.

The additional ENS observed in the full-constraints case compared with the relaxed-ramping case is interpreted as an upward ramping-related impact. The additional RES curtailment observed in the full-constraints case compared with the relaxed-ramping case is interpreted as a downward ramping-related impact, relevant for the RES integration needs assessment under Article 8.

Scenario	Additional RES Curtailment due to Ramping MWh	Used for Article 8 RES Integration?	Treatment in Article 8
2028b2023_2h	4675.6	Yes	Considered in Article 8 assessment
2028b2024_2h	14845.6	Yes	Considered in Article 8 assessment
2028b2024_4hr	13662.1	Yes	Considered in Article 8 assessment
2028b2025_2h	35255.1	Yes	Considered in Article 8 assessment
2030b2023_2h	107.5	Yes	Considered in Article 8 assessment
2030b2024_2h	1026.4	Yes	Considered in Article 8 assessment
2030b2025_2h	167.3	Yes	Considered in Article 8 assessment
2030b2025_4hr	180.0	Yes	Considered in Article 8 assessment

Field	Value
Deliverable	FNA Article 10 – Short-Term Flexibility Needs
Submitted to	CERA
Prepared by	TSOC
Target Years	2028, 2030
Weather/Base Years	2023, 2024, 2025
Battery Cases	2h and 4h BESS cases where available
Methodology Reference	ACER Decision 05/2025 – FNA Methodology Annex I
Version	1st
Date	02/05/2026

Scenario	Target Year	Base / Weather Year	Battery h	Source UCED / Input	Description
2028b2023_2h	2028	2023	2	UCED_2028b2023	2028 target year using 2023 weather/base year and 2h BESS
2028b2024_2h	2028	2024	2	UCED_2028b2024	2028 target year using 2024 weather/base year and 2h BESS
2028b2024_4hr	2028	2024	4	UCED_2028b2024_4hr	2028 target year using 2024 weather/base year and 4h BESS
2028b2025_2h	2028	2025	2	UCED_2028b2025	2028 target year using 2025 weather/base year and 2h BESS
2030b2023_2h	2030	2023	2	UCED_2030b2023	2030 target year using 2023 weather/base year and 2h BESS
2030b2024_2h	2030	2024	2	UCED_2030b2024	2030 target year using 2024 weather/base year and 2h BESS
2030b2025_2h	2030	2025	2	UCED_2030b2025	2030 target year using 2025 weather/base year and 2h BESS
2030b2025_4hr	2030	2025	4	UCED_2030b2025_4hr	2030 target year using 2025 weather/base year and 4h BESS

Year	Revenue	Operating Profit	Operating Profit Margin	Operating Profit per Share	Operating Profit per Share
2003	\$20.1B	\$1.8B	8.9%	\$1.80	\$1.80
2004	\$20.1B	\$1.8B	8.9%	\$1.80	\$1.80

Important Notice – Do Not Remove – Official Version
This music sample pack does not contain any distribution-free samples that have previously using Digital Audio Workstations from 2012, 2014 and 2015. The included samples, 30 and 60 sec time series for Oldies pop songs were created using a new sampling technique of using only 30 and 60 sec samples. The licensing agreement for this pack was not signed by the artist, but by the publisher, so the artist's name is not included.

According to Article 12(1)(b), the probability distributions of randomised forecast errors were further analysed using separate time-series representing different time periods and seasons of the year.

6. General Equilibrium High Risk / Low Loss, Low Mps / High Loss Defect

The W_2 parameter of the modified two-beam model also describes the potential surface plasmon mode and corresponds to the second plasmon in the W_1 mode. The W_3 parameter corresponds to the surface plasmon mode and is interpreted as the plasmon oscillation frequency.

Negative R² = Squared short-term flexibility cost
Positive R² = Squared short-term flexibility benefit

The relationship between short-term flexibility and short-term costs and benefits is complex. The relationship between short-term flexibility and short-term costs is negative, while the relationship between short-term flexibility and short-term benefits is positive. This is because short-term flexibility allows a firm to adjust its production levels in response to changes in demand, which can lead to lower costs and higher revenues. However, short-term flexibility also involves the cost of maintaining a flexible production system, which can be higher than the cost of a rigid system. Therefore, the net effect of short-term flexibility on short-term costs and benefits depends on the specific circumstances of the firm.

[illegible]

Article 10 (2) Residual Margin Summary									
Scenario	Length Year	Base Year	Battery h	Avg Upward RM MW	Avg Downward RM MW	Min Upward RM MW	Min Downward RM MW	Max Upward RM MW	Max Downward RM MW
2028a2023_2h	2028	2023	2	325.9	345.2	0.0	0	688.1	773.9
2028b2024_2h	2028	2024	2	331.3	340.2	0.0	0	723.6	744.8
2028c2025_4hr	2028	2025	4	330.8	337.4	0.0	0	758.3	763.2
2028d2025_2h	2028	2025	2	367.3	335.6	106.9	0	735.0	828.0
2030a2023_2h	2030	2023	2	470.6	429.1	0.0	0	987.0	844.7
2030b2024_2h	2030	2024	2	471.8	428.6	0.0	0	1060.5	823.5
2030c2025_2h	2030	2025	2	462.5	422.0	0.0	0	991.6	949.8
2030d2025_4hr	2030	2025	4	457.0	412.9	48.2	0	923.7	957.8

Methodological note – Article 10(2)-(3)

According to Article 10(2), the dispatch of flexible resources was extracted from the economic dispatch results for each MTU, weather/batter-year scenario and target year. In this assessment, the relevant flexible resources considered in the residual margin calculation include dispatchable conventional generation units and battery storage assets represented in the UCED results.

For dispatchable generation units, the short-term residual margins were calculated using the difference between the dispatched power output and the technical minimum and maximum power limits of each unit:

$$\text{Upward Generation Residual Margin} = P_{\text{max}} - \text{Dispatch}$$

$$\text{Downward Generation Residual Margin} = \text{Dispatch} - P_{\text{min}}$$

Only units that were online in the UCED dispatch were considered as immediately available for short-term residual margin provision. A unit was considered online when its dispatch was greater than zero. For battery storage assets, the residual margins were calculated as net adjustment margins from the current charging or discharging operating point. The *upward battery residual margin* represents the ability of the battery to move from its current position towards maximum charging capability.

$$\text{Upward Battery Residual Margin} = \text{MAX(BESS Power - Discharging Power, 0)} + \text{Charging Power}$$

$$\text{Downward Battery Residual Margin} = \text{MAX(BESS Power - Charging Power, 0)} + \text{Discharging Power}$$

These battery margins represent the possible change in the net position of the battery and do not imply that the battery can inject power above its rated MW capacity. The total upward and downward residual margins were then calculated as the sum of the generation and battery residual margins for each hour:

$$\text{Total Upward Residual Margin} = \text{Upward Generation RM} + \text{Upward Battery RM}$$

$$\text{Total Downward Residual Margin} = \text{Downward Generation RM} + \text{Downward Battery RM}$$

The present table summarises, for each scenario, the average, minimum and maximum upward and downward residual margins calculated from the hourly UCED-based residual margin time series. The 2-hour and 4-hour battery cases are compared on the basis of the same BESS power rating but different energy capacities; therefore, differences between these cases arise from the UCED dispatch and state-of-charge profile rather than from increased instantaneous power capability.

The calculation also supports the technical characterisation required under Article 10(3) as the residual margins are linked to unit-level technical assumptions such as P_{min} , P_{max} and storage power/energy constraints. Further dynamic constraints, such as ramp rates, start-up/shut-down times and minimum up/down times, are documented in the assumptions where available and may be further refined in subsequent implementation cycles if additional detailed data are required.

Notes:
The grant provides that funded members have responsibility for **operational** (not financial) needs. As such, it is not a condition precedent of being within the parameters where the open is considered a need grant challenge. The award level indicates support for the requirements of before DOE, including a study per award, required for all events and a study of a completed need award.

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1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232	1233	1234	1235	1236	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246	1247	1248	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259	1260	1261	1262	1263	1264	1265	1266	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276	1277	1278	1279	1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1295	1296	1297	1298	1299	1300	1301	1302	1303	1304	1305	1306	1307	1308	1309	1310	1311	1312	1313	1314	1315	1316	1317	1318	1319	1320	1321	1322	1323	1324	1325	1326	1327	1328	1329	1330	1331	1332	1333	1334	1335	1336	1337	1338	1339	1340	1341	1342	1343	1344	1345	1346	1347	1348	1349	1350	1351	1352	1353	1354	1355	1356	1357	1358	1359	1360	1361	1362	1363	1364	1365	1366	1367	1368	1369	1370	1371	1372	1373	1374	1375	1376	1377	1378	1379	1380	1381	1382	1383	1384	1385	1386	1387	1388	1389	1390	1391	1392	1393	1394	1395	1396	1397	1398	1399	1400	1401	1402	1403	1404	1405	1406	1407	1408	1409	1410	1411	1412	1413	1414	1415	1416	1417	1418	1419	1420	1421	1422	1423	1424	1425	1426	1427	1428	1429	1430	1431	1432	1433	1434	1435	1436	1437	1438	1439	1440	1441	1442	1443	1444	1445	1446	1447	1448	1449	1450	1451	1452	1453	1454	1455	1456	1457	1458	1459	1460	1461	1462	1463	1464	1465	1466	1467	1468	1469	1470	1471	1472	1473	1474	1475	1476	1477	1478	1479	1480	1481	1482	1483	1484	1485	1486	1487	1488	1489	1490	1491	1492	1493	1494	1495	1496	1497	1498	1499	1500	1501	1502	1503	1504	1505	1506	1507	1508	1509	1510	1511	1512	1513	1514	1515	1516	1517	1518	1519	1520	1521	1522	1523	1524	1525	1526	1527	1528	1529	1530	1531	1532	1533	1534	1535	1536	1537	1538	1539	1540	1541	1542	1543	1544	1545	1546	1547	1548	1549	1550	1551	1552	1553	1554	1555	1556	1557	1558	1559	1560	1561	1562	1563	1564	1565	1566	1567	1568	1569	1570	1571	1572	1573	1574	1575	1576	1577	1578	1579	1580	1581	1582	1583	1584	1585	1586	1587	1588	1589	1590	1591	1592	1593	1594	1595	1596	1597	1598	1599	1600	1601	1602	1603	1604	1605	1606	1607	1608	1609	1610	1611	1612	1613	1614	1615	1616	1617	1618	1619	1620	1621	1622	1623	1624	1625	1626	1627	1628	1629	1630	1631	1632	1633	1634	1635	1636	1637	1638	1639	1640	1641	1642	1643	1644	1645	1646	1647	1648	1649	1650	1651	1652	1653	1654	1655	1656	1657	1658	1659	1660	1661	1662	1663	1664	1665	1666	1667	1668	1669	1670	1671	1672	1673	1674	1675	1676	1677	1678	1679	1680	1681	1682	1683	1684	1685	1686	1687	1688	1689	1690	1691	1692	1693	1694	1695	1696	1697	1698	1699	1700	1701	1702	1703	1704	1705	1706	1707	1708	1709	1710	1711	1712	1713	1714	1715	1716	1717	1718	1719	1720	1721	1722	1723	1724	1725	1726	1727	1728	1729	1730	1731	1732	1733	1734	1735	1736	1737	1738	1739	1740	1741	1742	1743	1744	1745	1746	1747	1748	1749	1750	1751	1752	1753	1754	1755	1756	1757	1758	1759	1760	1761	1762	1763	1764	1765	1766	1767	1768	1769	1770	1771	1772	1773	1774	1775	1776	1777	1778	1779	1780	1781	1782	1783	1784	1785	1786	1787	1788	1789	1790	1791	1792	1793	1794	1795	1796	1797	1798	1799	1800	1801	1802	1803	1804	1805	1806	1807	1808	1809	1810	1811	1812	1813	1814	1815	1816	1817	1818	1819	1820	1821	1822	1823	1824	1825	1826	1827	1828	1829	1830	1831	1832	1833	1834	1835	1836	1837	1838	1839	1840	1841	1842	1843	1844	1845	1846	1847	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858	1859	1860	1861	1862	1863	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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3000	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	21	374.7	189.4	0.0	80.8	181.5	48.1	90
3001	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	2	409.3	194.6	0.0	80.8	181.5	47.7	87.6
3002	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	3	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3003	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	4	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3004	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	5	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3005	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	6	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3006	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	7	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3007	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	8	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3008	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	9	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3009	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	10	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3010	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	11	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3011	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	12	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3012	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	13	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3013	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	14	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3014	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	15	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3015	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	16	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3016	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	17	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3017	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	18	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3018	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	19	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3019	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	20	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3020	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	21	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3021	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	22	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3022	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	23	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3023	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	24	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3024	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	25	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3025	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	26	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3026	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	27	381.2	191.3	0.0	77.8	178.8	47.6	88.0
3027	1024	1	2002-04-02 13:20:00	2002-04-02 13:20:00	28	381.2	191.3	0.0				

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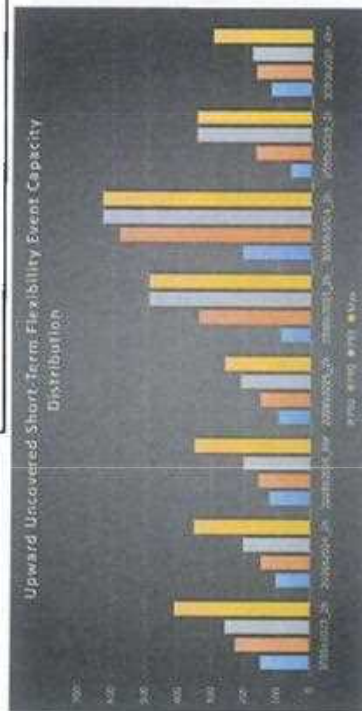
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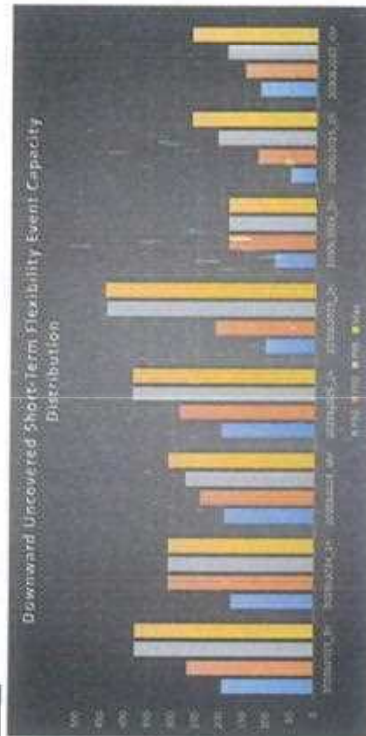
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Scenario	Direction	Full Event Capacity (MW)	Probabilistic Capacity (MW)	P95 Event Capacity (MW)	P99 Event Capacity (MW)	Max Event Capacity (MW)	Number of Events
2026b2032_2h	Upward	351.0	179.7	127.9	156.8	254.8	728
2026b2032_2h	Downward	354.4	238.0	167.8	335.2	378.5	744
2028b2034_2h	Upward	306.8	132.9	151.1	196.5	251.6	890
2028b2034_2h	Downward	376.9	215.9	309.5	309.5	329.5	876
2028b2034_4hr	Upward	324.7	140.0	158.4	221.3	253.7	647
2028b2034_4hr	Downward	351.3	222.1	142.7	253.5	278.9	653
2028b2035_2h	Upward	384.1	221.2	154.6	254.8	283.1	903
2028b2035_2h	Downward	386.5	237.4	287.5	341.0	385.9	736
2030b2032_2h	Upward	392.6	126.1	341.0	431.2	491.2	763
2030b2032_2h	Downward	306.3	154.6	212.0	314.4	441.9	593
2030b2034_2h	Upward	269.0	477.2	581.7	632.8	611.8	549
2030b2034_2h	Downward	385.2	148.7	195.4	185.4	185.4	572
2030b2035_2h	Upward	363.2	83.6	172.0	285.7	350.8	560
2030b2035_2h	Downward	354.2	84.2	124.4	352.7	291.5	429
2030b2035_4hr	Upward	328.5	147.8	173.5	178.0	284.8	411
2030b2035_4hr	Downward	320.5	139.3	153.0	171.9	290.8	379

According to Article 10(6)(b), a probabilistic distribution of the capacity of recovered short-term flexibility needs events shall be provided. In this table, the capacity distribution is represented through selected percentiles of the event capacity per scenario and direction. This event capacity is defined as the **average uncovered capacity** within each identified event. The maximum hourly uncovered capacity observed within the events is also reported separately as the maximum event capacity. This provides a compact representation of the distribution of upward and downward uncovered short-term flexibility need event sizes.



The charts provide a visual representation of the event capacity distribution required under Article 10(6)(b). The percentiles represent the distribution of **average uncovered capacity per event**, while the maximum value shows the highest hourly uncovered capacity observed within the events for each scenario and direction.



Scenario	Corr Upward Need vs Load	Corr Upward Need vs PV	Corr Upward Need vs Wind	Corr Downward Need vs Load	Corr Downward Need vs PV	Corr Downward Need vs Wind
2028b2023_2h	0.0	-0.7	0.0	0.1	0.8	0.0
2028b2024_2h	0.1	-0.6	0.0	0.1	0.8	-0.1
2028b2024_4hr	0.1	-0.6	0.0	0.1	0.8	-0.1
2028b2025_2h	0.1	-0.5	-0.1	0.0	0.8	0.0
2030b2023_2h	0.1	-0.4	0.0	0.1	0.8	0.0
2030b2024_2h	0.0	-0.6	0.0	0.0	0.5	-0.1
2030b2025_2h	0.1	-0.2	0.0	0.1	0.6	-0.1
2030b2025_4hr	0.2	-0.4	0.1	0.3	0.8	-0.1

According to Article 10(6)(g), the uncovered short-term flexibility needs shall be correlated with specific system conditions, including at least wind generation, solar generation and demand. The present table reports the correlation coefficients between uncovered upward and downward short-term flexibility needs and the corresponding system conditions for each scenario.

The correlation coefficients range from -1 to +1. A positive value indicates that the uncovered need tends to increase when the corresponding system variable increases, while a negative value indicates an inverse relationship. Values close to zero indicate weak or no linear relationship.

The analysis shows that downward uncovered short-term flexibility needs are strongly associated with PV generation in most scenarios, which is consistent with high solar generation reducing residual load and increasing the requirement for downward flexibility. Upward uncovered needs generally show a negative relationship with PV generation and weaker relationships with load and wind generation.

Sub-Article	Requirement	Implementation	Status
10(7)	Determine unavailability due to grid prequalification / temporary limits where relevant and data are available	No quantified hourly unavailability time series or derating factors were applied at this stage	Not applied
10(8)	Repeat Article 10(2)–10(6) with derated residual margins if fine-tuning is required	Not repeated because no derating factors were applied	Not applicable
10(9)	Report derated residual margins	No separate derated residual margin time series is reported	Not applicable
10(10)	Alternative approach if economic dispatch embeds forecast errors	Not used; percentile-based RLFE approach under Article 10(1) was applied	Not applicable

A10_Finetuning (10.7-10.10)

Articles 10(7)–10(9) relate to the fine-tuning of short-term flexibility needs by reflecting the unavailability of flexible resources due to grid prequalification or temporary limits. In the present assessment, no quantified hourly unavailability time series or derating factors were available/applied for this purpose. Therefore, the Article 10(2)–10(6) calculations were not repeated with derated residual margins, and no separate derated residual margin time series is reported under Article 10(9).

Article 10(10) is not applicable to the current implementation, as the short-term flexibility needs were not extracted directly from an economic dispatch simulation embedding forecast errors. Instead, the short-term needs were calculated separately from residual load forecast error percentiles under Article 10(1) and then compared with UCED-based residual margins under Article 10(4).

APPENDIX II

Line number	Direction of need	Target year	Time block	Spatial granularity	Voltage level of congestion or voltage issue	Type of value	Network flexibility needs	Share of downward flexibility needs pertaining to RES generation curtailment	Expected contractual means to access flexibility
1	Downwards	2030	Jan-Dec Mon-Sun: 19:00-22:00	Binding zone - Republic of Cyprus	medium voltage 11kV network	total energy over the year	4704MWh	100%	local service
						summation of maximum power	59.88MW		
2	Downwards	2028	Jan-Dec Mon-Sun: 06:00 - 19:00	Binding zone - Republic of Cyprus	medium voltage 11kV or 22kV network	total energy over the year	426MWh	100%	flexible connection agreements
						summation of maximum power	142MW		
3	Downwards	2030	Jan-Dec Mon-Sun: 06:00 - 19:00	Binding zone - Republic of Cyprus	medium voltage 11kV or 22kV network	total energy over the year	759MWh	100%	flexible connection agreements
						summation of maximum power	253MW		