WHITE PAPER

The future of battery storage in Greece

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List of Acronyms	
ARP	Aggregator Representative Party
BESS	Battery Energy Storage System
BRP	Balancing Responsibility Party
BSP	Balancing Service Party
BtM	Behind the Meter
EFM	Energy Forward Market
ESPMG	Energy Storage Project Management Group
FtM	In Front of the Meter
HEDNO	Hellenic Electricity Distribution Network Operator
HENEX	Hellenic Energy Exchange
IPTO	Independent Power Transmission Operator
MEGR	Greek Ministry of Energy
PPA	Power Purchase Agreement
RAE	Regulatory Authority for Energy
RES	Renewable Energy Sources
RRF	Recovery and Resilience Fund
T&D	Transmission and Distribution

1 Introduction

1.1 White Paper Objective

This paper aims to discuss the latest recommendation of the Greek government [1] regarding the conformation of the institutional and regulatory framework for the development and participation of energy storage units in electricity markets and power mechanisms in Greece. The findings of this recommendation are presented below, with a focus on Battery Energy Storage Systems (BESS). Unless highlighted otherwise, the terms 'BESS', 'energy storage', battery storage', and 'storage' are used interchangeably with the same meaning in the paper.

1.2 Background

The electricity landscape in Greece is in the midst of a transition, not least due to the increasing integration of renewable energy sources and distributed generation. This has sparked growing interest in energy storage development, including BESS plants, which will arguably become an important part of the renewable energy mix.

Battery storage in recent years has faced an extremely high level of multidimensional development, which spans across all levels of the electrical system (production, transmission, distribution, and final use), in sizes ranging from kW to GW and for uses covering a wide range of technical services and market operations. The battery storage technology is a convincing response to several issues that global electricity markets have to deal with, with some of its key benefits being:

- It is an important tool to assist the further integration of Renewable Energy Sources (RES) by enhancing grid stability, the decongestion of saturated grids, the promotion of self-consumption, and overall, the energy transition to a cleaner energy future.

- It is capable of both reducing peak demand and providing flexibility to the network operator, by balancing real-time differences between forecast and actual supply and demand, as it allows any surplus electricity to be temporarily stored, in order to be made available again as electricity when needed. The industry has clearly picked up on this opportunity: the European energy storage market is expanding rapidly, having grown from 0.6 GWh in 2015 in 8.3 GWh in 2021[1], a tremendous 14 times up increase in just 6 years [2].

- It is highly versatile and scalable and can be used for both residential and utility-scale short-duration storage applications in distributed or centralized setups. With the drop in the cost of lithium-ion batteries, there has been an increased demand for battery storage. In particular, the co-location of BESS with PV (Figure 1) or wind farm power plants is a growing global trend nowadays.

[1] These figures are applicable to stationary electrical, electrochemical, and mechanical storage (with the exception of pumped hydro storage).

- Even large-scale BESS plants have minimum space and environmental requirements (Figure 2) and can be installed in a relatively short period of time.

Figure 1: A 20MW/10MWh containerized BESS combined with 570MW of solar PV (source: ccj-online.com)

Figure 2: Artist's impression of the proposed 320MW/640MWh Gateway BESS site, one of the world's largest battery projects (source: intergen.com)

Energy storage can undoubtedly provide Greece's power system with cleaner energy, ensuring safety, flexibility, and stability, while also enabling the reduction of electricity prices for the benefit of the end consumers. However, to enable new services and ensure the security of the power network, the Greek electricity market design, and the legal and regulatory framework for the deployment of battery storage will need to adapt and reflect the flexibility that this technology can offer.

2 Energy Storage Overview in Greece

2.1 Current Situation

Over the past year, Greece has faced an explosion of interest in licensing new electricity storage facilities. This interest concerns both net storage stations to be connected directly to the grid and operate in the markets, as well as installations combined with RES generation units under a variety of synergy models. The total capacity of applications by mid-2021 exceeds the value of 9.000 MW with most of them already converted into production licenses, far exceeding the needs of the Greek interconnected electricity system in the medium term, which were calculated to be between 1.500 and 2.000 MW[2] by 2030 in a study [3] undertaken a year ago on behalf of the Regulatory Authority for Energy (RAE).

To date, RAE has already issued generation licenses for 38 energy storage units with a total capacity of 3.582 MW. In particular, on 4 August 2021 RAE awarded generation licenses to dozens of BESS projects with a total capacity of 1.400 MW. The power of these projects ranges from 18 to 250 MW. Most notably, RAE has recently approved the production licenses for the 'Ptolemaida' and 'Arcadia' large-scale BESS projects by Eunice Energy Group, each with a capacity of 250 MW/1.000 MWh[3]. Licensed and mature storage projects include also the 680 MW Amphilochia pumped-storage station with a duration of 6 hours, which has been integrated into the European Projects of Common Interest (PCI).

At the same time, pilot projects of high battery storage penetration into autonomous systems are evolving. These include the hybrid energy project of Agios Efstratios island, which includes a 900 kW wind turbine, a 220 kW PV, a 1.5 MW/2.6 MWh BESS, as well as a district heating system with electric boilers and storage of hot water. A pilot project to electrify transport with a combined energy supply from RES and BESS units is also under way in Astypalaia island, and there are also discussions about similar applications in various small island systems. These projects regard the development of high-power wind and PV plants, in combination with BESS units and demand management measures, in order to achieve RES penetration of 50-90% on an annual basis. Small battery systems have also been installed on other islands as pilot and research applications.

Furthermore, in order to gain the necessary experience regarding the use of storage systems for the optimal operation of the transmission system to the benefit of the domestic electricity market, the Independent Power Transmission Operator (IPTO) is planning two pilot projects that include the installation of BESS units in transmission system substations.

However, despite the significant investment interest and ongoing research agendas, as well as the numerous granted production licenses, only two small utility-scale storage projects have been implemented to date. With regard to consumer and self-production installations, storage penetration remains negligible. Excluding off-grid applications, only seven known battery systems

[2] From this capacity, two thirds regard long-duration energy storage plants (in the region of 6 hours) and one third in short-duration (below 2 hours) and high-flexibility BESS plants.

[3] https://eunice-group.com/projects/battery-energy-storage-system-bess/

are currently in operation, six of them in combination with rooftop PV stations in buildings and one in combination with a small hydropower station.

2.2 Future Opportunities

The development of energy storage applications necessitates the settlement of licensing issues, network accessibility, effective integration in the markets and possibly the establishment of support mechanisms that will cover the financing gaps of projects. At all four levels, the current institutional and regulatory framework in Greece has either significant gaps or does not exist.

To reverse the current situation, the department of Energy and Mineral Raw Materials of the Ministry of Environment & Energy has recently formed a special governmental committee called Energy Storage Project Management Group (ESPMG), tasked with addressing the aforementioned shortcomings and developing a technologically neutral market framework that will recognize and reward the true value of the services that can be provided with energy storage technology to the Greek electricity system and its consumers. The aim is to make this framework an official law by Q3 2021.

The ministry is also working on creating a subsidy scheme to support energy storage projects in Greece. It is within this scope that Greece aims to tender 700 MW of battery storage within 2021. The goal is also to provide capital expenditure (Capex) assistance for battery projects. Meanwhile, subsidies awarded via the tender mechanism shall represent a top up for any revenue that storage plant owners may generate via the electricity market. Furthermore, it is currently being discussed that from the country's Covid-19 Recovery and Resilience Fund (RRF) comprised of €54.5 billion, at least €10.4 billion will be invested in upgrading energy infrastructure, and the promotion of green energies and smart technologies, like battery storage.

On top of that, the ministry plans to support the battery storage tenders with about €200 million and has assigned this subsidy plan to a Brussels-based legal advisor to make sure this support is in line with the EU's state-aid rules and regulations. This amount will suffice to cover subsidies of up to 40% for the development of energy storage systems, necessary to support the country's increased RES penetration objective set for 2030.

2.3 Storage system categories

The legislative and regulatory framework for the deployment of storage stations, which is currently under development by ESPMG, covers the following three categories of installations:

- Net energy storage stations with a separate Point of Interconnection (POI), which are independent licensing entities and are not combined with other power generation plants or consumer installations. These are referred to as storage stations "in front of the meter" (FtM) (see Figure 3).

- Energy storage stations classified as "behind the meter" (BtM) (see Figure 4) which are either:
    - combined with other power generation plants, typically from RES, to form a single licensing entity, with a common POI and single measurement of the energy and power exchanged with the system; or

- installed inside consumer facilities, with or without self-production, that do not have an independent connection and measurement point.

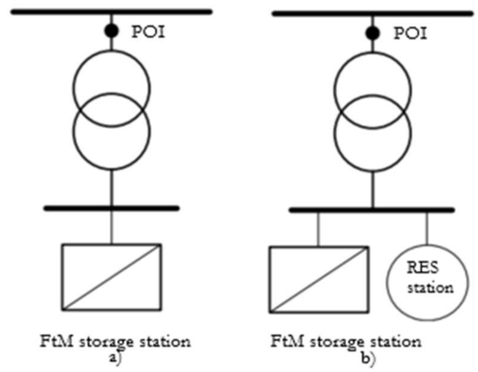


Figure 3: Grid connection of FtM storage facilities: (a) FtM storage station interconnected through independent infrastructure, (b) FtM storage station and RES station, as two independent licencing entities, interconnected via a common transformer HV/MV. (source: ESPMG 's recommendation)

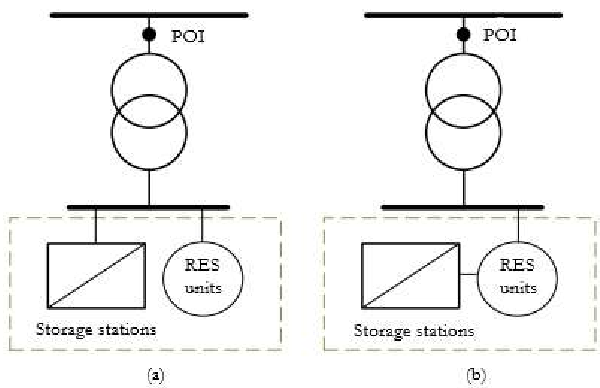


Figure 4: Grid connection of BtM storage facilities combined with RES station as a single licensing entity: (a) Integrated BtM storage, which can operate independently of RES units and (b) Integrated BtM storage, which cannot operate independently of RES units (Source: ESPMG's recommendation)

The above storage station categories may in principle be installed on the interconnected Hellenic Electricity Transmission System (HETS) or the Hellenic Electricity Distribution Network (HEDN), as well as the isolated networks of Non-Interconnected Islands (NIIs). The considerations set out in the rest of this report will focus on the case of the interconnected HETS and HEDN system, where the level of investment interest and the needs to support the energy transition are considerably higher.

3 Storage Licencing

3.1 Comparison between Storage and RES licensing

A detailed presentation of the licensing process for the energy storage plants can be found in the ESPMG recommendation. This section will focus on some key comparison points with RES plants. All types of licences are issued by RAE. It should be noted that the licencing requirement is only applicable to storage stations with a nominal capacity higher than 1 MW. Furthermore, a different procedure needs to be followed for the following types of energy storage stations:

1. FtM storage stations: Licencing requirements shall generally be in accordance with the large-scale RES projects.

2. RES stations with embedded storage (BtM): For stations that will not absorb energy, licencing requirements shall be as per standard RES projects, exclusively for production purposes. For stations that can also absorb energy, the licencing requirements shall be as per FtM stations.

3. Consumption facilities with BtM storage: For stations with no export capacity, no production licence is required, whereas for stations that can export energy to the grid, a production licence of either a registered self-producer or a self-consumer with storage is required.

Overall, the ESPMG's recommendation is trying to simplify the energy storage licensing procedure as much as possible and provide greater flexibility. For example, the installed energy capacity may be differentiated from the one declared in the application by up to 25%, for purposes such as the standardization of equipment and the compensation for the loss of storage capacity due to equipment ageing. Furthermore, the energy exchange at the output of the storage station at POI may deviate up to ±10% from the value recorded in the storage license. Finally, a change within the above limits does not require an amendment to the license.

It is worth mentioning that, in contrast with RES, during energy storage licensing process, there is greater focus on sustainability of the storage business model. The developer will need to prove the financial and technical capability to complete the project, and the following must be provided at the application stage:

- A thorough technical description of the storage station
- A detailed business plan of the project
- A techno-economic study and a detailed financial model

On the other hand, there are also many similarities with RES, such as the duration of the license which is granted for a period of up to 25 years. Similar to RES, special provisions are also available for the modification, transfer, termination, and withdrawal of the storage licence.

3.2 Environmental licensing

The installation of energy storage systems is recommended by ESPMG to be permitted:

- In forested areas (as in the case of PVs)
- On high productivity agricultural land
- Exceptionally in forests, when they belong to RES plants with integrated storage without importing capabilities and are installed within the boundaries of those plants (under the condition that RES technology is permitted to be installed in forests)
- Installation of storage systems in consumption locations, subject to compliance with the relevant technical specifications and safety regulations.

4 Grid Connection Considerations

4.1 General

According to the ESPMG recommendation, the declared export and import power capacities will define the way to connect the energy storage stations to the HETS or HEDN network, as well as the necessary enabling works to strengthen the relevant network. These capacities typically depend on:

- The production and demand profile of the installation
- How the storage facility will be managed commercially or the market remuneration mechanisms the BESS will participate in
- The characteristics/specifications of the storage equipment

Regarding grid connection costs, energy storage stations will be charged the full cost of both the expansion works required to connect them to the grid and the associated reinforcement works, based on the same practice applied to all power generation stations.

4.2 Technical Requirements

For each power station connected to the electrical system, a set of technical requirements need to be fulfilled, which comprise the terms of its connection agreement, and which the power station commits to satisfy during its connection and throughout its operation. These technical requirements are described in detail in RAE Decision 1165/2020, which particularizes the EU Regulation 2016/631 and the "Requirements of Generators" (RfG) for the Greek transmission and distribution (T&D) system. They cover issues of participation in frequency and voltage regulation, ability to monitor active power commands from the network operators, fault-ride through capability, etc., and their content is determined by the maximum capacity of the power station, the voltage level of its connection point and the technology of the generating units according to a Type classification mechanism.

Energy storage plants will replace conventional generation units during the operation of the system, similarly to RES plants, and according to ESPMG recommendations their integration should be realised on the basis of similar technical requirements so that the system security is not compromised, particularly during periods of very high-RES penetration. However, at European level, with the exceptions of some provisions in RfG for pumped storage (treated as a synchronous generator) and some additional guidance provided by Engineering Recommendation G99 in the UK, no specific technical requirements have yet been developed for energy storage stations, similar to those existing for other generation units as per RfG. Although ENTSO-e has set up a working group with the objective to incorporate energy storage stations in the RfG scope, this is not expected to be completed within 2021. This fact, combined with the immediate need to issue connection offers for large-scale energy storage plants and the possibility of rapid development of such projects in Greece, makes it necessary to establish a national technical framework for the assessment of related requirements for energy storage, even prior to the introduction of a respective comprehensive European framework.

With that in mind, both IPTO and the Hellenic Electricity Distribution Network Operator (HEDNO) have recommended that the technical requirements for storage stations should be similar to those of RES stations and fall into the same Type classification mechanism based on their voltage level and registered capacity at the POI, in accordance with the provisions of RAE Decision 1165/2020 and EU RfG requirements.

4.3 Energy Storage Connection Capacity Limits

The selection of voltage level for the connection of energy storage plants, i.e., Low Voltage (LV) at 400 V, Medium Voltage (MV) at 20 kV or High Voltage (HV) at 150 kV or 400 kV, shall depend on the registered capacity of the plant as illustrated in Figure 5 below. This will be documented in both the storage/production license and the grid connection agreement.

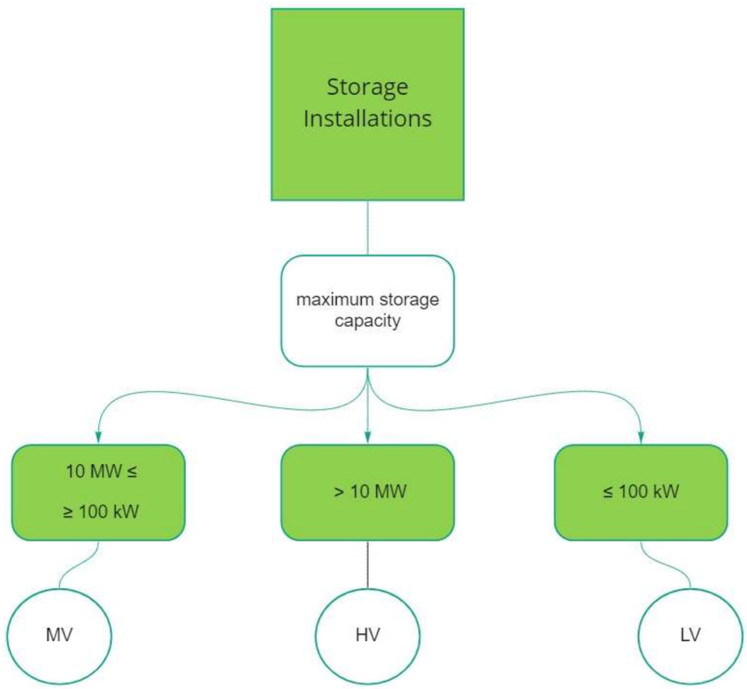


Figure 5: Storage connection capacity limits

4.4 Access of Energy Storage Stations to Congested Networks

The operating profile of the energy storage stations participating in the electricity markets typically leads to energy absorption during low electricity price clearance times, which generally coincides with periods of high-RES production, and energy export during the hours of high clearance values, when production of RES is generally limited. This correlation, which becomes more and more pronounced as the penetration of RES increases, allows energy storage stations to contribute to the decongestion of networks supporting high levels of RES generation, by increasing the available electrical capacity in these areas to accommodate additional RES capacity.

According to ESPMG, it is therefore reasonable that energy storage stations should not be subject to the same treatment with RES plants regarding the allocation of electrical capacity and the order of assessment of the relevant connection requests. Although this general observation is fundamentally justified, situations of counteracting operation, where storage facilities inject energy simultaneously with high local RES generation or absorb energy simultaneously with high local demand, cannot be technically excluded.

To ensure that the connection of energy storage plants does not exacerbate the problem of grid congestion, thereby justifying the prioritisation of their connection over renewables, ESPMG advises that it is necessary to impose restrictions on the operation of these plants in predefined time zones of the 24-hour period, possibly with a seasonal variation, which will ensure that storage plants do not inject energy during periods of high local production. Similarly, if grid congestion is due to high demand, the storage stations will not absorb energy during periods of high demand on the local network.

The exact content of these restrictions will be derived from a technical study of the local network (to be updated regularly for the same area) and reflected in the connection terms which will be published for specific areas of the HETS or HEDN network, designated as congested. The restrictions will be included in the connection offers and contracts of the storage plants, together with a provision for their future relaxation or complete removal, provided that the congestion conditions that imposed them in the first place no longer exist, e.g., due to network upgrades.

The implementation of the above restrictions shall be the responsibility of the operator of the storage plant, which shall be considered when the plant is active on the electricity markets. To this effect, it is necessary to introduce an obligation for the participant to establish a Market Programme compatible with the restrictions imposed (e.g., no injection of energy at midday in areas with congestion due to PV generation), so that their fulfilment is not a product of generation redispatch in the balancing market with additional costs for the system. Compliance with the constraints will be monitored on an accounting basis and any non-compliances will be addressed by imposing discouraging penalties.

Provided that the energy storage stations commit to satisfy the aforementioned operational constraints that ensure they do not exacerbate network congestion, then ESPMG suggests that they should take precedence over renewable energy plants when being considered for connection offers. Not only because they do not occupy electrical capacity, but also because these are resources which, assuming the introduction of an appropriate framework of decongestion services[4], can contribute to remove grid congestion and increase the electrical capacity available for integration of additional RES. However, this prioritisation of storage is not applicable to where the congestion of the local grid is associated with the limit of the short-circuit level, as in these cases the connection of storage facilities, as well as RES plants, exacerbates the problem.

On the other hand, in case of non-compliance of the energy storage stations with the above operational restrictions, the priority of access over RES shall obviously not be applicable. According to ESPMG, in such cases where the storage plant does not undertake operational restrictions, the connection offer will be prepared assuming the extreme scenarios of simultaneous injection from RES and storage plants and simultaneous occurrence of maximum local demand and absorption

[4] Pilot BESS projects for the grid congestion management are already being planned by IPTO.

of the plants. In extreme occasions, consideration shall also be given to refuse access to the congested networks for such storage facilities.

4.5 Co-location of Storage with RES

Under the conditions of ever-increasing difficulty of gaining grid access, but also high costs and long time for the implementation of HV interconnection infrastructures, the use of existing infrastructure or the possibility of accessing RES stations for the connection of storage facilities enables the optimum use of the Greek T&D infrastructure, as well as a faster and more efficient deployment of energy storage projects. This approach is underpinned by the synergies created due to the fact that RES and storage generally operate in a complementary manner (e.g., high-RES generation is typically combined with BESS charging) and therefore no duplication of infrastructure is necessary, instead it is possible to simultaneously use common interconnection networks and share infrastructure costs.

Most importantly, the benefit for the connecting parties and the system is maximized when the electrical capacity can be shared between storage and RES, without the need for the interconnection to be sized for the aggregated capacity of the two types of plants. At the same time, of course, a complexity is introduced in terms of avoiding operational overloading of these elements. In this case, to enable the co-location of storage and RES it is required that:

- The installations are included in appropriate legal entities supported by the relevant licensing framework.
- The market activities of the connected plants consider the capacity limitation imposed by the common interconnection infrastructure.
- Compliance with the capacity constraints of the interconnection elements shall be ensured in real time through an export limiting control scheme.

The following business opportunities of co-located BESS with RES plants are identified in the ESPMG recommendation, in order of implementation complexity:

- A RES station with BtM storage units
- A portfolio including specific RES and BESS plants
- A distinct operation of RES and FtM storage plants

A special and more complex case, which presents similarities with co-location, is the joint submission of connection terms to RES and storage plants connected to the same congested grid, but with different connection points. Given the presence of other RES plants in the area, the only alternative option is to include the connecting plants in a common portfolio, which would not include other plants, in order to ensure that the aggregated installed capacity will comply with the operational constraints resulting from the local network congestion.

4.6 Storage Integration in Consumption Facilities

The new regulatory framework for electricity storage will enable installing BtM storage units in consumer facilities, with or without self-generation, lifting all the restrictions that are currently in force. Storage will serve the user's desired business case, which may concern the following (not exhaustive list):

- Reducing energy costs by energy shifting via a time-variable tariff scheme
- Reducing peak demand and its timing (peak shaving), with a positive impact on network connection and usage costs
- Improving power reliability
- Facilitating self-generation/self-consumption and maximizing the benefit it generates. A storage system in a self-generation installation can also be used to limit the maximum export power of the installation to the grid, a functionality particularly important on congested grids.

Figure 6 is an indicative self-generation plant operational profile with BESS units, illustrating the functionalities mentioned above.

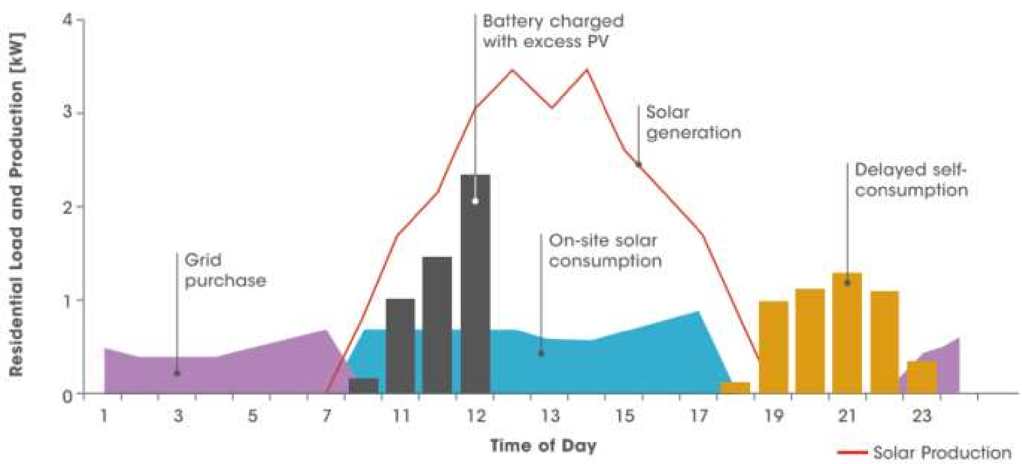


Figure 6 : Typical operation profile of a self-producer with PVs and storage units (source: ESPMG's recommendation)

4.7 Additional Considerations

The ESPMG recommendation has also raised the following additional considerations:

1. <u>Regulated & other non-competitive charges</u>

   a. FtM storage plants shall not be subject to regulated charges, which are based on the energy imported by them to be exported to the grid at a later time. On the contrary, energy consumed by self-consumption stations supplied through an independent meter, and which does not form part of the energy absorbed for charging the storage systems, shall be subject to the same costs as consumers in the respective voltage level and tariff category.

Furthermore, FtM storage stations shall be subject to system and grid usage charges based on the maximum imported power in synchronization with the system's peak demand. They shall not be subject to other regulated charges like the ones that typically demand-serving electricity suppliers and final consumers are subject to, with the exception of self-consumption units supplied through an independent meter.

b. Generators with integrated BtM storage that do not import energy for the purpose of storing it and exporting it to the grid at a later time, are subject to the same charges as other generators of a similar category without storage. For RES plants with energy storage, which have the capacity to import energy from the grid for the purpose of exporting it later, the provisions for FtM stations mentioned above in (a) shall apply, as described previously.

Furthermore, self-producers with integrated BtM storage shall be subject to the same charges as self-producers of the same category without storage. Such are the charges imposed on consumers based on the energy and/or power they import from the grid. The regulated and other charges of consumers with BtM storage units are levied on the energy absorbed by the grid, as is the case in the current net metering framework.

According to ESPMG, in order to be treated on an equal footing with FtM storage plants, it is advisable to pursue the distinction between energy absorbed and stored for re-delivery to the grid (instead of consumption within the user's premises) to exempt it from energy charges, as is the case for net storage stations. However, this distinction will require the implementation of appropriate metering and processing schemes, in a manner that has not yet been assessed as to its feasibility and practical applicability.

2. Auxiliary Power Supplies

a. To distinguish between the energy absorbed for auxiliary internal consumption of the plant with the energy absorbed for storage and re-dispatch, the FtM storage stations shall have separate internal consumption metering.

b. BtM storage stations integrated in RES power plants shall serve their auxiliary consumption needs through their internal power generation and shall not have discrete metering. Similarly, BtM storage stations integrated in consumer facilities shall manage their auxiliary consumption in the same way that supply other loads, i.e., without a separate metering.

5 Participation of Energy Storage in Electricity Markets

5.1 General

Due to the high initial cost of a BESS, the optimal commercial operation of this asset is essential, and this can only be achieved by developing a viable platform for BESS participation in different electricity markets.

Since 01/11/2020 the domestic wholesale electricity market in Greece operates in accordance with the basic principles of the European Target Model and is structured in four distinct markets:

1. the Energy Forward Market;
2. the Day-ahead Market;
3. the Intra-day market; and
4. the Power and Energy Balancing Market.

The first 3 are managed by the electricity market operator in Greece, Hellenic Energy Exchange (HENEX), whereas the 4th is managed by the operator of the Greek transmission system, IPTO. One of the main recommendations and immediate priorities of ESPMG is the integration of energy storage activities in all the above markets. This has highlighted the need for appropriate modification of the licensing framework for the electricity production activities of conventional power plants to ensure equal treatment and access of all participants in the relevant markets.

5.2 Aggregated Representation

The Greek organization system of the wholesale electricity market operates as a central dispatch (unit based) system. To make an optimal allocation of available resources and ensure the safe operation of the transmission system, IPTO distributes separately all Balancing Service (BS) providers.

According to ESPMG, the participation of small- and medium-scale FtM storage stations in the electricity and power markets as distinct entities, may increase the costs of their financial management and hinder their sustainable and efficient operation. Especially for the storage stations connected to the Greek distribution network, the absence of grid distribution control centres is an additional limiting factor for the direct participation of FtM stations in the markets, due to the inability of HEDNO to monitor and control the BESS plants in real time. Similarly, for consumption facilities with BtM storage, their direct participation in the markets faces all the above problems, considering that the majority of them are connected to the distribution network.

With the future entry of smaller BS providers, participation of BESS plants alone as single entities in the markets may not be possible nor optimal. It is therefore appropriate to allow the participation of smaller entities in portfolios of aggregated storage stations, while at the same time maintaining the characteristics of the central dispatch system. For this purpose, ESPMG recommends that an Upper Power Station Limit is established to allow participation in an aggregated portfolio: BS providers with a capacity less than this limit will be able to participate in the Balancing Market within a portfolio, while BS providers with a capacity higher than this limit will only be able to participate in the Balancing Market as single entities. This limit will soon be defined by RAE upon recommendation from IPTO.

Storage station portfolios will be able to participate in the Day-ahead and Intra-day Market like any other entities, while also being able to participate in the Balancing Market, either as Contracting Parties with Balancing Responsibility (BRP, without offering balancing services), or as Balancing Service Parties (BSP). Both are possible, but the portfolio representative should choose a specific category in advance, which will characterize the portfolio. For BSPs the portfolios of the Day-ahead Market and the Intra-day Market will be identical to those of the Balancing Market.

According to ESPMG, an Aggregator Representative Party (ARP) is defined as the legal person, who cumulatively represents one or more RES facilities and/or energy storage facilities in the electricity markets, for one or more connection points and is responsible of the corresponding obligations and requirements arising from the participation in these markets. An ARP may participate in the Balancing Market as a Contracting Party with BRP and/or as a BSP with Balancing Responsibility. An energy storage facility can be represented in the Balancing Market either by its owner, or by an ARP. All installations represented by an ARP may be divided into one or more portfolios with certain limitations.

5.3 Energy Forward Market

Generally, the participation in the Energy Forward Market (EFM) limits the exposure of participants to fluctuations and uncertainties in the clearing prices of Day-ahead and Intra-day markets. The existence of pre-agreed electricity price eliminates both the seller's revenue uncertainties and consumer price volatility, significantly enhancing energy investments. Furthermore, the establishment of Futures Contracts[5], with or without a physical delivery obligation, as well as bilateral Power Purchase Agreements (PPA) between RES plants and consumers (the so called "green PPAs") is expected to be an important tool to integrate them into energy markets and minimise the use of state aid.

In view of the above, ESPMG advises that it is imperative to safeguard that the regulatory and legislative framework of the country will also allow storage facilities to operate freely and efficiently in EFM and establish PPAs. Combining the need for RES plants to secure a sufficient level of remuneration in order to make the projects viable in the context of the markets, with the need for storage plants to negotiate in advance appropriate prices for energy absorption, the engagement of both parties in Futures Contracts will be mutually beneficial. Similar considerations apply to the dispatch of stored energy to demand-serving electricity suppliers.

Furthermore, the current EFM regulations can support the efficient integration of energy storage stations in the same manner as other types of participants, and only some minor amendments are required to allow the participation of legal entities active with energy storage.

[5] Futures Contracts govern the trade of electricity specifying the transaction's time, quantity, and price. They can be established bilaterally (over-the-counter) or through the Energy Exchange (Forward Market).

5.4 Day-ahead Market

The increasing penetration of RES generation in the Greek T&D system limits the residual load (load minus RES generation) that is normally supplied by the fully controlled conventional thermal power plants, which can lead to a reduction in the clearing prices of the energy markets during hours of high-RES generation. This phenomenon is continuously intensifying and can lead to the occurrence of zero or even negative prices at congested period. In extreme occasions these may be followed by curtailment of RES generation due to the system's inability to absorb/export it, given that there is a technical minimum production threshold of the integrated conventional units that provide the necessary reserves for system security. The inability to exploit available renewable energy at essentially zero variable cost is a fundamental challenge, while systematically low market prices during periods of high-RES potential undermine the viability of RES investments.

According to ESPMG, the efficient participation of energy storage stations in the Day-ahead Market with full balancing obligations will help to address all the above issues. Storage stations may balance prices by importing energy during low clearance times and exporting at high-price hours (energy arbitrage). This function can achieve the following:

- hold prices down during periods of high demand by substituting the high-cost thermal units;
- contribute to the modulation of appropriate price signals;
- minimize the rejections of RES over-production, through the additional demand generated; and
- help preventing clearance price spikes during conditions of insufficient generation capacity to meet the demand.

The Day-ahead Market is the most liquid market, with the prices on it reflecting to a greater extent (compared to the other three markets) the variables that shape the short-term value of electricity, thus providing the most representative price signals for investments in the electricity sector. The possibility of effective participation of energy storage stations in this market is therefore critical to gain the expected benefits from their operation, as well as for the sustainability of these investments. It is worth mentioning that very few amendments are needed to the existing spot market regulation to achieve the above.

5.5 Intra-day Market

In the Intraday Market, participants correct/adjust their market trading schedule, considering the data of the system and their installations closer to real time. Especially for RES plants, this market provides the possibility of limiting their forecasting errors, as with the operation of the continuous intraday trading, participants will be able to modify their market position even one hour before real time.

ESPMG suggests that the participation of storage stations in this market is crucial to achieve effective management of their limited energy reserve. The sustainability of energy storage projects and the expected benefits of their operation in the markets presuppose the capability of constantly adjusting their market trading schedule. Furthermore, the existing regulatory framework of the Intra-day Market is estimated to require only small-scale modifications and additions to allow the participation of storage stations with the same rules as the other participants.

5.6 Balancing Market

The provision of power reserves is a fundamental service that can be delivered by energy storage. Often the penetration of RES in the generation balance is limited by the inability to substitute the conventional thermal plants that remain integrated in order to provide the necessary reserves.

However, the provision of power reserves from energy storage plants would reduce the need for synchronised thermal units, particularly in conditions of high-RES penetration. It is therefore necessary to allow storage plants to participate as effectively as possible in the Balancing Market, for the benefit of the system, but also for the sustainability of the projects themselves. The key technical considerations and directions concerning the development of a specific framework for the participation of storage stations in the Greek Balancing Market can be found in the ESPMG recommendation.

5.7 Future Storage Services

In addition to the aforementioned European Target Model's markets, energy storage, like BESS, plants have the possibility to provide other services to support the Greek electrical system, which are not compensated in the context of the currently available markets and could arguably enhance their sustainability even further, as evidenced by recent international experience (e.g., the UK). Figure 7 below lists such services, although the scale of needs concerned and the level of maturity of the respective solutions do not currently justify for many of these services the expectation of immediate implementation and revenue streams for BESS projects that are going to be developed in Greece in the near future.

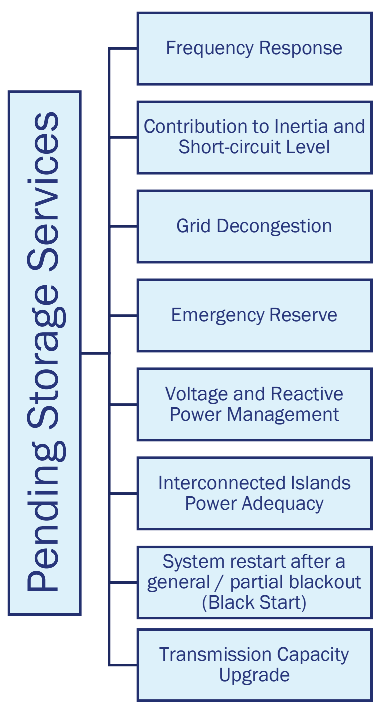


Figure 7: Future storage services

6 Investment Support Schemes

6.1 Background

Despite the benefits they can bring, energy storage facilities globally are struggling to obtain sufficient revenue streams from their participation in competitive markets to ensure the sustainability of their associated investments. This is also a considerable limitation of the current electricity market in Greece, with an estimated funding gap exceeding 70% of the full cost of these stations.

In the few cases internationally where energy storage, and in particular BESS, development was possible in the modern market environment without subsidy schemes, this was because high-value storage services were identified and competitive procedures were established by network operators for the supply of these services, with adequate remuneration for the sustainability of the participating storage stations. Such services are essentially fast response services for frequency regulation, like the UK's Enhanced & Fast Frequency Response services, which are now starting to be introduced in other markets (e.g., Ireland, Italy, Australia).

According to ESPMG, recognizing and rewarding the added value of specific services that storage facilities are able to provide would contribute to revenue stacking, which in turn would reduce the funding gap and ultimately achieve project sustainability. Examples of potential additional services have been presented in section 5.7, but as discussed there is no current prospect for their immediate introduction. Most promising for the Greek market reality would be the management of network congestion, as mentioned in section 4.4, which is an absolute necessity and is estimated to provide considerable remuneration to the relevant service providers. The framework for the utilization of storage projects for this purpose in a manner compatible with the existing markets and the remuneration of grid decongestion services remains an important issue, which should be defined in the near future.

In general, the development of the necessary storage capacity that will support the transition of the Greek energy system to significantly higher RES penetration is not currently possible based only on the expected revenues of projects coming from the available markets and the uncertain prospect of introducing additional paid services in the future, as discussed above. A solution for the timely development of pending large-scale storage projects could be provided by the introduction of storage investment support schemes, which would compensate for the uncertainties of market revenues and fill the financing gap of the projects to make the relevant investments sustainable and fundable. The support may be provided in the form of capital subsidies or through tax exemptions and other investment incentives, as discussed in the following sections.

6.2 Support for FtM Storage Stations

The main options suggested by ESPMG for financially supporting FtM storage stations in Greece would be the following:

1. Participation in the system capacity reserve regime, with a fee proportional to their contribution. The participation of storage facilities in such mechanisms should be through

a discrete capacity quota and not in direct competition with thermal plants, in consideration of the specific characteristics of energy storage and the significant added value it brings to the system.

2. Investment aid, mainly through an appropriate existing financial regime, e.g., the RRF (see references in section 2.2). The aid shall cover sufficient part of the sustainability deficit of the storage projects, in order to ensure the deployment of the necessary capacity to support the RES penetration targets of the country's energy transition plan in the medium term, e.g., 2030-2035.

3. Establishment of a new specific regime to support electricity storage, in recognition of its ability to provide services that no other technology can provide (due to its energy absorption ability). In this regime only storage plants shall be able to participate in a competitive manner and without discrimination between technologies.

The amount of financial support provided through the aforementioned schemes shall be determined by the funding gap of the projects, after considering the revenues from available markets, from bilateral contracts with other participants, and from the provision of remunerated services to the network operators. The part of the sustainability gap covered by the aid schemes shall always be based on an expectation of future revenues, which may deviate significantly from initial estimates. For this reason, support schemes must be combined with effective mechanisms to control and avoid overspending projects, as well as the design of measures to reform the markets in the long-term so that they recognise and reward the value of the services provided by storage stations.

The selection of storage projects to be financially supported should be carried out through competitive tendering procedures to ensure that the provision of the services are provided at the lowest possible cost. The procedure for the selection of projects should in principle be neutral with regard to storage technologies, to the extent that they achieve the provision of the targeted services and in accordance with their effectiveness, as mentioned above. However, it is appropriate that the selected storage fleet should not be one-dimensional in terms of technologies and main characteristics (e.g., duration), as it has been shown that benefits are maximised by appropriate mixes of different technologies and characteristics, but also given that absolute reliance on new technologies that have not been adequately tested constitutes a risk factor for the smooth transition of the system to the targeted high-RES penetration levels.

6.3 Support for BtM Storage Stations

Dispersed storage resources, such as those installed behind the meter in consumer and self-generation facilities, are characterized by relatively increased costs due to their small sizes, more complex models of activity, and limited market opportunities compared to commercial net storage FtM stations. This makes their viability precarious, and it is necessary to provide incentives and support to develop these resources in parallel with the commercial FtM stations. In this way it is possible to achieve the necessary pluralism in the development of storage resources, supporting self-production and self-consumption and enhancing demand flexibility.

According to ESPMG, the strengthening of dispersed resources of small-size units in consumer and self-generation facilities shall not be carried out through the same mechanisms and procedures as for large-scale central systems. Aid programmes shall generally be based on the logic of subsidies on installation costs or on the provision of equivalent tax incentives with simplified eligibility criteria. The design of these schemes requires careful consideration, in order to serve multiple objectives, such as the simultaneous development of self-production from RES that can be facilitated by storage, as well as the necessary energy interventions to promote energy efficiency of the end consumers.

The strengthening of dispersed BtM storage units must be combined with limitations and operating obligations, which would maximize the benefit of developing these systems and the efficiency of the resources allocated. The intended results shall mainly be the increase in the degree of self-consumption of the energy produced and the restriction of its injection into the grid, especially during the periods of high-RES production. To this end, consideration could also be given to a requirement to limit the maximum power exported to the grid in relation to what would be produced in the absence of the storage system, which is a framework already applied to subsidised storage plants in Germany.

6.4 Support for RES with Integrated Storage Stations

The financial support of storage units embedded in RES power plants, in order to upgrade the functionality and ease of participation of the latter in the markets, shall initially be provided through the existing RES support framework.

For RES projects with integrated storage without the possibility of importing energy from the grid, ESPMG recommends:

1. To be able to participate in the formal competitions for the award of operational aid to RES projects without provision for special compensation. The investor shall assess whether the additional costs of such projects can be recovered through more efficient management of the generation and possible connection in congested network areas where saturation is imposing operational constraints.

2. Projects already selected by tenders should be able to proceed with the integration of an internal storage unit, while maintaining the current reference price and methodology for calculating the differential increment.

3. To consider holding special competitive tenders only for projects of this type.

It should be noted that RES stations with BtM storage and the ability to import energy from the grid will not receive operational aid mentioned in point 1 above, as this is excluded for storage projects that perform energy arbitrage, but also because the energy exported to the grid is not 100% renewable.

7 Conclusions and Next Steps

Greece has ambitions to become an energy hub for the South-European region, and the government is aiming at a rapid growth in the green-energy transition. The country's geography and climate suggest significant potential for renewable energy penetration to enable the decarbonization of the Greek T&D power system, and the integration of electricity storage would be a huge step forward for allowing this to happen in a timely and reliable manner.

In order to achieve the 2030 targets of RES penetration levels up to 60% of annual electricity demand, it has been documented [3] that an energy storage capacity of 1.500-2.000 MW will be necessary. This is required to achieve an effective balancing between electricity supply and demand under conditions of RES overproduction, maintaining the security and high competitiveness of the electricity supply with obvious benefits for the final consumers. It was found that the above storage capacity will lead to the maximum benefits, exceeding the full cost for the sustainability of these projects.

This report has highlighted that the development of energy storage solutions and applications in Greece requires, inter alia, that: i) their licensing issues are resolved, ii) they can easily access the networks, iii) they can operate effectively in the markets, and iv) there are available support mechanisms to fill the financing gap for these projects. The implementation of the proposals of ESPMG, a special committee formed by the Greek government to address all the above issues, requires in turn:

- Legislative incorporation of the main pillars of the proposed framework.
- Regulatory decisions on a wide range of issues at all levels.
- Amendments to the electricity markets' regulations, codes, procedures, manuals, and technical guidelines for their implementation.
- Interventions in the information and technical support systems of the electricity markets, as well as system and network operation.

It is clear that the development of the institutional and regulatory framework for electricity storage requires significant reforms to the current model of the organization and operation of the Greek electricity market, and undoubtedly, a united effort in a short period of time will be required by all stakeholders for this to be implemented effectively. The implementation of the action plan needs to be in line with the time constraints imposed by the inclusion of storage projects in the actions of the RRF, which in turn requires the rapid finalization of the proposed framework, practically in less than one year.

In the light of the above, ESPMG considers necessary and highly recommends the central coordination of all stakeholders, the detailed recording of individual actions and deliverables, the systematic monitoring of the implementation, and the provision of concrete milestones for their completion by means of specific legislative and regulatory measures. Key actions by the Relevant System Operators (RSOs), namely IPTO and HEDNO, and other stakeholders have been highlighted in the ESPMG recommendation. More information about the comprehensive action plan and implementation schedule proposed by ESPMG can be found in the Appendix of this report.

8 References

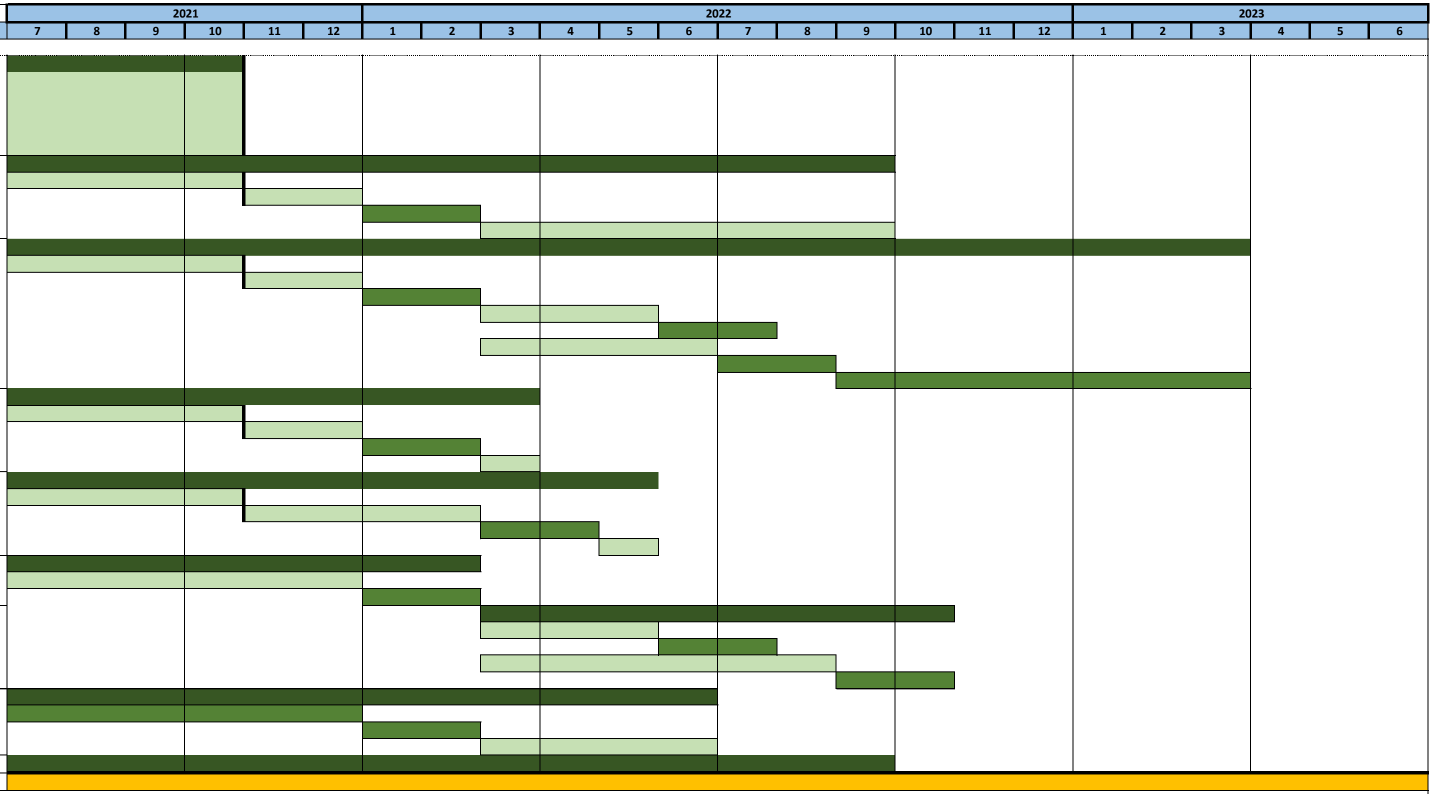
[1] – Εισήγηση της ΟΔΕ: “Διαμόρφωση του θεσμικού και ρυθμιστικού πλαισίου για την ανάπτυξη και συμμετοχή μονάδων αποθήκευσης στις αγορές ηλεκτρικής ενέργειας και σε μηχανισμούς ισχύος”, Ιούνιος 2021

[2] – European Market Monitor on Energy Storage, Delta-ee, March 2021, edition 5.0

[3] – “Προσδιορισμός αναγκών αποθήκευσης ηλεκτρικής ενέργειας του Εθνικού Διασυνδεδεμένου Συστήματος σε μεσοπρόθεσμο ορίζοντα,” ΕΜΠ, Αθήνα, 2019.

Appendix – Action Plan

	Tasks	Aggregator
1	Legislative storage framework	MEGR
	Licensing	
	Participation in the markets	
	Network access	
	Adjustable charges	
	BtM consumers storage	
2	HENEX purchase arrangements	HENEX
	Preparation of amendments	
	Configuration of regulations	
	Approval by RAE	
	Adaptation of market resolution systems	
3	Balancing Market Regulation	IPTO
	Preparation of amendments	
	Configuration of the Rules	
	Approval by RAE	
	Modification of methodologies & other topics	
	Approval by RAE	
	Configuration of technical decisions	
	Approval by RAE	
	Adaptation of Balancing Market resolution systems	
4	Technical requirements for storage installations	IPTO
	Spadework	
	Configuration of requirements	
	Approval by RAE	
	Modification of the HETS Grid Code	
5	HETS Saturated Area Manual	IPTO
	Spadework	
	Configuration of Manual	
	Approval by RAE	
	Modification of the HETS Grid Code	
6	HETS Grid Code	HEDNO
	Adaptation	
	Approval by RAE	
7	Terms of connection to the distribution network	HEDNO
	Customisation of connection bid methodology issue	
	Approval by RAE	
	Configuration of standard connection contracts	
	Approval by RAE	
8	Assessment of feasibility of developing central storage stations in NIIs	
	HEDNO Recommendation	HEDNO
	RAE Opinion	RAE
	Establishment (after positive evaluation)	MEGR
9	Forming FtM storage investment support scheme & tendering procedure	MEGR
10	Management and coordination of actions	MEGR



Basic task duration	
Duration of sub-tasks	
Estimated duration (in the absence of aggregator registration)	

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